

FINANCIAL ANALYSIS OF USING JATROPHA OIL AS FUEL IN DIESEL ENGINES

FAZAL UM MIN ALLAH
PHD STUDENT
FACULTY OF MECHANICS
UNIVERSITY OF CRAIOVA,
e-mail:fazaluminallah@hotmail.com

Abstract

Romania depends heavily upon conventional energy resources. Biofuels obtained from edible crops are already being used in diesel engines. These biofuels increase fuel security at the expense of food security. This problem can be solved by using non edible crops to produce biofuel. *Jatropha* is a non edible crop whose oil is used to produce biodiesel. Power consumption, equipment, climate conditions, time period and economic resources are the factors of influence for financial analysis. Economic analysis of using *jatropha* oil as a substitute to diesel fuel is done by using RETScreen software.

Key words: *jatropha* oil, financial analysis, diesel engine, RETScreens,

1. Introduction

Fuel security and global climate changes have motivated scientists to find alternate energy resources. Romanian fuel market depends upon conventional energy resources. Country has to explore renewable energy resources to acquire energy independence. Modern technologies in biofuel industry are being adopted throughout the developed world. Unfortunately, Romanian biofuel production is at low level compared with other european countries [1]. Romania has a potential of producing 400000tonnes/year for biodiesel and 120000tonnes/year for bioethanol. Romania produced approximately 161000 tonnes of biofuels in 2011 [2].

Romania produces most of its biofuels from edible crops. Biofuels obtained from edible crops increase fuel security at the expense of food security [3]. *Jatropha* is a non-edible crop whose oil is used to produce biodiesel. *Jatropha* is a member of Euphorbiaceae family. It has characteristics of making milky soap and production of phytotoxins. *Jatropha* is a tree which has the height of approximately 5 meters. Its growth depends upon the environmental and soil conditions. Its leaves are of 4-5 cm length and width. Vascular tissues from branches and stems contain white latex [4].

Considering the global status of *jatropha* crop, it is important to cover all aspects regarding its usage. From the literature, it can be concluded that biodiesel is an environment friendly fuel which can be used in diesel engines. *Jatropha* oil provides sustained green house gas facilities over other biodiesel fuels. *Jatropha* is claimed to enhance rural economics and to reduce green house gasses. It has more productivity in better climate conditions; it is one of the cheapest non-edible biofuel resources. Biodiesel production from *jatropha* oil is expected to be increased with better climatic conditions and availability of land. Carbon emissions can be reduced by using *jatropha* biodiesel as fuel. Positive growth can be seen if production is done on mass scale. Therefore, proper strategies and government incentives are to be prompted to enhance the use of biodiesel fuel especially in road transport sector and electricity generation. Government initiatives are needed to avoid the use of edible oil to produce biodiesel due to a big gap in the demand and supply of such oils for consumption in food industry. There is a need to put more emphasizes on non edible oils like *Jatropha* [5].

There are number of traits that could be targeted for crop improvement. The crop improvement can be done in a cordial way by the collaboration of major *Jatropha* cultivators like India, China, Malaysia, Indonesia, Brazil, Mexico, South Africa etc. The research and development expertise and the lessons learned by these countries during last several years on *Jatropha* cultivation can be shared and used for designing genetic and molecular breeding strategies. The collaboration and cooperation of major national and international petroleum or biofuel companies could also seek for this venture. Molecular breeding should be primarily targeted to increase the seed yield, oil content, drought tolerance and disease resistance. Genetic improvement is necessary for developing optimum sized varieties for easy harvesting. The presence of toxic substances like curcin and phorbol esters from the seeds of *Jatropha* should be removed with the help of biochemical process [6].

Viscosity of *jatropha* biodiesel blends can be reduced by heating it before injection. A comparison was carried out between unheated *jatropha* oil, heated *jatropha* oil and diesel fuel. Preheated *jatropha* oil provides higher thermal

efficiency than unheated jatropha oil. It is concluded that heated jatropha oil and its blends can be used for compression ignition engines for irrigation in rural areas for agriculture [7].

Finance of fuel is another area of concern. Present estimated cost of jatropha biodiesel is 0.95€ per liter even after ignoring the taxes and profit margins. This indicates requirement for initial budgetary support from the government for any effective adoption of jatropha biodiesel till petro-diesel economics favors the self-adoption of biodiesel. On social front, biofuels may be promoted as community fuel, cultivated and produced on co-operative model with budgetary support from government sponsored social schemes. States collect substantial part of their revenue from taxes on petro-products like: petrol and petro-diesel. Promotion of any biofuel without further central government assistance for revenue losses to the states may not find favor by the states. Any large scale adoption effort of jatropha oil requires research of associated technological problems like: oxidations, poor lubrication properties, increase in NO_x and CO emissions and problem of cold starting. Problem of high sludge formation in long term performance evaluation leading to injector nozzle replacement indicates high maintenance costs of engine. Government initiatives and policies are required to promote biodiesel based diesel engines addressing the concerned technical issues. Reduction in excise duties or lower road taxes may be some steps supporting the additional production/maintenance cost of biodiesel engine. Biofuel promotion policy should be such that it is acceptable globally falling in line to Kyoto protocol providing sufficient cushion in costing terms by earning carbon credits. An institutional mechanism is required to be developed for transferring the benefits of the carbon credits for jatropha plantations [8], [9].

2. Materials and methods

For experimental purposes, jatropha seeds are imported from thailand. Oil is extracted by solvent extraction method. Density, kinematic viscosity, iodine value, oxidation stability index, acidity and refractive index are measured in the laboratory according to Romanian standards. Density and kinematic viscosity are found to be higher than that of diesel fuel. These higher values of density and viscosity can cause problems in injection system. To avoid these problems jatropha oil is heated upto 90°C before injection. Economics of using jatropha oil for production of electricity is very important to be taken into consideration. Following are the factors which affect the economics of using jatropha oil in diesel generator.

2.1. Occupancy and power consumption

Number of occupants , their behaviour and intalled equipment have a huge impact on the economics of fuel consumption. In the present work, an area near Craiova is selected to distribute power with diesel engine. Maximum power consumption of area is 300,000kWh/month. It is calculated by following formula.

$$E_{\text{(month)}} = \frac{P_w \times T_{\text{(hr/day)}}}{1000 \text{ W/kW}} \times \text{Number of days in a month} \quad (1)$$

Where,

P_w = Power in watts

T_(hr/day) = Time in hours per day

2.2. Diesel generator specifications

Tabel nr. 1 Diesel engine specifications

Model	KDE 6500E
Rated frequency	60Hz
Engine Type	Single cylinder vertical four stroke direct injection
Rated Voltage	230V
Engine Model	KM186FA
Fuel type	Diesel, Jatropha oil (unmodified)
Cylinder Capacity	418ml
Compression ratio	19:1

2.3. Fuel consumption and quality

Quality of fuel depends upon its physical and chemical properties. A comparison of physical and chemical properties of jatropa oil is given below [10], [11].

Tabel nr. 2 Comparison between properties of diesel fuel and jatropa oil

Property	Diesel fuel	Jatropa oil
Density (g/cm ³)	0.82	0.921
Kinematic viscosity (cSt)	4.1	40.1
Oxidation stability index (minutes)	-	179
Acidity (mgKOH/g)	-	1.4
Cetane number	>50	39
Iodine value (mgIod/g)	-	103
Flash point (°C)	>61	149

Jatropa oil has higher density and viscosity values than diesel fuel. The experiments showed that engine performance can be increased by preheating Jatropa oil. The oil can be heated by using exhaust gas heat. Preheated jatropa oil has improved quality so it can be used directly as substitute to diesel fuel [12]. Fuel consumption per hour can be calculated by following equation.

$$D_r = \frac{D_s - D_e}{T/60} \quad (2)$$

Where:

D_r = Diesel use rate, liters per hour

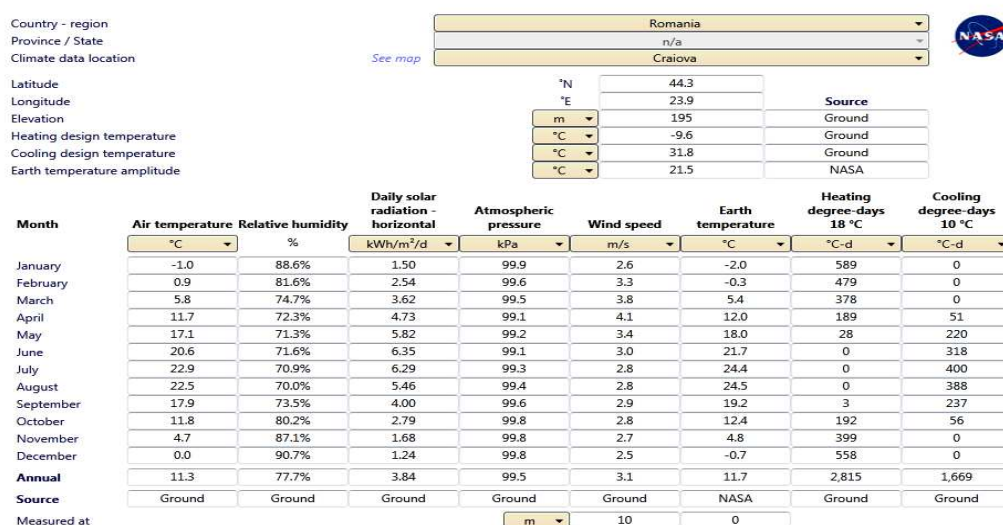
D_s = Amount of diesel at the start of operation in liters

D_e = Amount of diesel at the end of operation in liters

T = Time in minutes

2.4. Climate Conditions

Climate conditions have direct impact on power consumption. Average annual values for air temperature, Relative humidity, daily solar radiation, atmospheric pressure, wind speed, earth temperature are given in the figure below.



Source: RETScreen plus software

Figure 1. Climate conditions of selected area

2.5. Time period

Estimated time period for Jatropha fuel project is 11 months. This period started from 1st January 2014 and remained operational until 30th November 2014. Time period is important parameter to determine the cost of fuel. Total power consumed depends upon operational hours per day.

2.6. Financial resources

Capital cost, maintenance cost and fuel cost are important parameters to be considered for financial analysis. Cost of jatropha oil per liter is 5.46 Ron while for diesel it is 5.56Ron per liter. Cost of jatropha oil is lower than diesel fuel but its consumption rate is much higher than that of diesel fuel. This consumption rate is higher due to lower calorific value. Project is funded by private financial resources.

3. Results and discussion

Field data is collected and submitted in RETScreen software to evaluate results. Following results are obtained in graphical form.

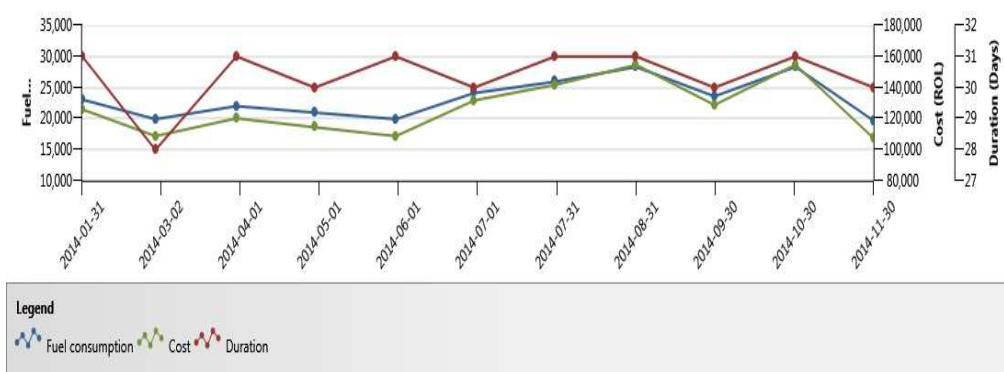


Figure 2. Jatropha oil consumption (liters/month), Cost in lei and number of days in a month

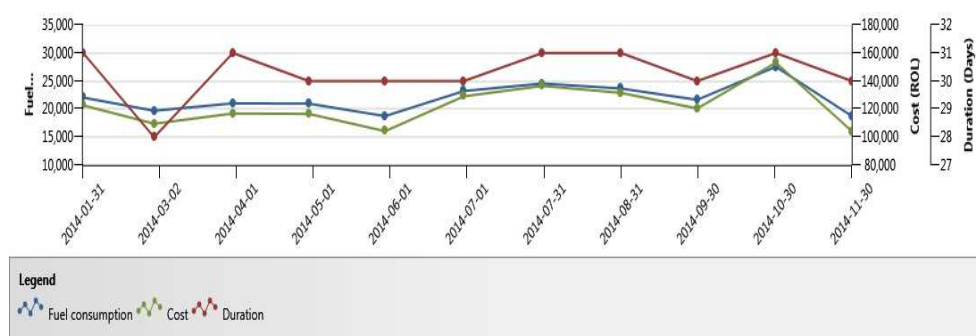


Figure 3. Diesel oil consumption (liters/month), cost in lei and number of days in a month

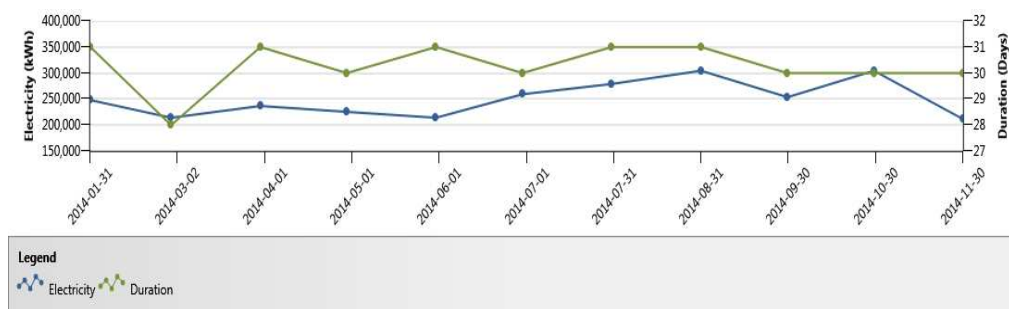


Figure 4. Electricity production for jatropha oil (kWh)

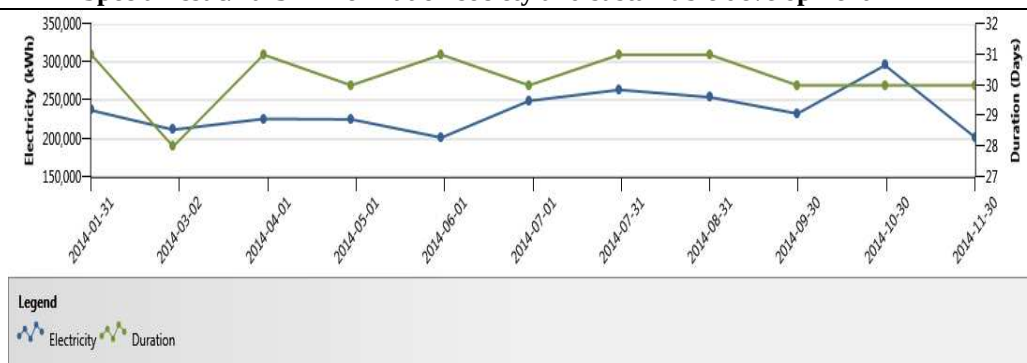


Figure 5. Electricity production for diesel oil (kWh)

Fuel consumption and cost for jatropha oil is higher than that of diesel fuel. Electricity production by using diesel fuel is higher than that of jatropha oil. These higher values are due to the fact that engine is designed for diesel fuel. Local production of jatropha oil on industrial scale can decrease the price of jatropha oil. Production can be increased by improving oil extraction method and genetics of seeds. Besides higher costs of jatropha oil, it is an attractive fuel due to its sustainability and environmental benefits.

4. Scope of the present work

Experiences of jatropha cultivation, industrial extraction and its usage in diesel engines have shown positive financial impacts on economies [13], [14]. Increasing price of conventional energy resources, global climate change and socio-economic benefits of jatropha cultivation and oil production will make it more important fuel in the future [15]. Biodiesel obtained from jatropha oil can also be used as fuel in transport sector. Developing countries like Pakistan, Egypt, India and Indonesia are facing energy shortages. Present financial analysis can help these countries to evaluate their jatropha potential in the fuel market.

5. Conclusion

As a non-edible renewable energy fuel, jatropha has bright future prospects in the fuel market. Jatropha oil has higher kinematic viscosity and density than diesel fuel. Preheated jatropha oil can be used as direct fuel in diesel engines. Financial analysis has shown higher cost of jatropha oil compared to that of diesel fuel. Romania has to import petroleum fuels. Romania has vast agricultural land to cultivate jatropha. Climate conditions, genetic improvement and better extraction techniques make it economically feasible for Romania.

Educational institutions and industries have to play its role to exploit full potential of jatropha biofuel. Growth of jatropha oil market can create jobs and new areas of research. Previous experiences of jatropha oil production have positive outcomes. Romania can learn from previous experiences to explore new horizons in the field of jatropha biofuel production and usage.

6. References

- [1] Olteanu, A.P., Analysis of the Romanian Biofuels industry under the Current Economic Conditions Using PESTEL. Vol. 12 The 9th International Conference on Investment and Economic Recovery, 2009; p. 159-167
- [2] Colesca, S.E., Ciocoiu, C.N., An Overview of the Romanian Renewable Energy Sector, Vol. 24 Renewable and Sustainable Energy Reviews, 2013; p. 149-158.
- [3] Nonhebel, S., Global Food Supply and the Impacts of Increased use of Biofuels, Vol. 37 Energy, 2012; p. 115-121.
- [4] FACT Foundation, The Jatropha Handbook from Cultivation to Application, 2010, ISBN: 978-90-815219-1-8
- [5] Mofijur, M., Masjuki, H.H., Kalam, M.A., Hazrat, M. A., Liaquat, A.M., Shahabuddin, M., Varman, M., Prospects of Biodiesel from Jatropha in Malaysia, 2012, vol. 16 Renewable and Sustainable Energy Reviews, p. 5007-5020.
- [6] Edrisi, S.A., Dubey, R.K., Tripathy, V., Bakshi, M., Srivastava, P., Jamil, S., Singh, H.B., Singh, N., Abhilash, P.C., Jatropha Curcas L.: A crucified Plant Waiting for Resurgence., 2015, vol. 41 Renewable and Sustainable Energy Reviews, p. 855-862.
- [7] Kumar, S., Chaube, A., Jain, S.K., Critical Review of Jatropha Biodiesel Promotion Policies in India, 2012, vol. 41 Energy Policy, p. 775-781.

- [8] **Cynthia, O.B., Teong, L.K.**, Feasibility of Jatropha Oil for Biodiesel: Economic Analysis, 2011, In: World Renewable Energy Congress, p. 463-470.
- [9] **Montobbio, P.A., Lele, S.**, Jatropha Plantation for Biodiesel in Tamil Nadu, India: Viability, Livelihood trade-offs, and Latent Conflict, 2010, Vol. 70 Ecological Economies, p. 189-195.
- [10] **Blin, J., Brunschwig, C., Chapuis, A., Changotade, O., Sidibe, S.S., Noumi, E.S., Girard, P.**, Characteristics of Vegetable Oils for Use as Fuel in Stationary Diesel Engines-Towards Specifications for a Standard in West Africa. 2013, Vol. 22 Renewable and Sustainable Energy Reviews, p. 580-597.
- [11] **Allah, F.U.M.**, Comparative Analysis of Physical and Chemical Properties of Jatropha Oil, 2015, In: 9th International Conference on Materials Science and Engineering, II.O.37. Book of Abstracts, p. 88.
- [12] **Pradhan, P., Raheman, H., Padhee, D.**, Combustion and Performance of a Diesel Engine with Preheated Jatropha Curcas Oil using Waste Heat from Exhaust Gas, 2014, Vol. 115 Fuel, p. 527-533.
- [13] **Soto, I., Achten, W.M.J., Muys, B., Mathijs, E.**, Who Benefits from Energy Policy Incentives? The Case of jatropha adoption by Small Holders in Mexico, 2015, Vol. 79 Energy Policy, p. 37-47.
- [14] **Rathore, V., Tyagi, S., Newalkar, B., Badoni, R. P.**, Jatropha and Karanja Oil Derived DMC-Biodiesel Synthesis: A Kinetics Study, 2015, Vol. 140 Fuel, p. 597-608.
- [15] **Achten, W.M.J., Trabucco, A., Maes, W.H., Verchot, L.V., Aerts, R., Mathijs, E., Vantomme, P., Singh, V.P., Muys, B.**, Global Greenhouse gas Implications of Land Conversion to Biofuel Crop Cultivation in Arid and Semi-Arid Lands-Lessons Learned from Jatropha, 2013, Vol. 98 Journal of Arid Environments, p. 135-145.