CHAPTER 1

INTRODUCTION

1.1 BACKGROUND AND MOTIVATION

India ranks sixth in the world in terms of energy demand accounting for 3.5% of world commercial energy demand. The energy demand is expected to grow at 4.8% per annum. A large part of India’s population, mostly in the rural areas, does not have access to it. Hence a program for the development of energy from raw material which grows in the rural areas will go a long way in providing energy security to the rural people. The growth in energy demand in all forms is expected to continue unabated owing to increasing urbanization, standard of living and expanding population with stabilization not before mid of the current century. The demand of High Speed Diesel (HSD) is projected to be 52.32 million metric tons in 2010 and is expected to grow @5.6% per annum. India’s crude oil production as per the Tenth Plan Working Group is estimated around 33 to 34 million metric tons per annum even though there will be increase in gas production of 103 million standard cubic meters per day in 2010. Only with joint venture abroad, there is a hope for oil production of about 41 million metric tons by 2017.

The gas production would decline by this period to 73 million standard cubic meters per day. The increasing gap between demand and domestically produced petroleum is a matter of serious concern. India’s dependence on import of oil may increase in the foreseeable future. The working group has estimated the import of crude oil shall go up to 147 million
metric tons per annum by 2010 that correspondingly increases the import bill to $15.7 billion at today’s prices. Transport sector remains the most problem sector as no alternative to petroleum based fuel has been successful so far. Therefore petroleum based fuels particularly HSD will dominate the transport sector in the foreseeable future but its consumption can be minimized if the biodiesel usage is enforced in the transportation sector.

This background gives the motto to undertake research study to identify the thrust area that could solve the fuel crisis when the fossil fuels completely deplete in nature. This thesis report thrashes out a new process for producing biodiesel from jatropha oil to tackle the atmospheric pollution problem. Biodiesel from jatropha oil is produced by the process of transesterification using methyl alcohol with sodium hydroxide as catalyst. The study is carried with one liter oil at laboratory scale. Just like petroleum diesel, biodiesel operates in compression ignition (diesel) engines, which essentially require very little or no engine modifications.

Various conversion routes are available that include direct conversion processes such as extraction of vegetable oils followed by esterification (biodiesel), fermentation of sugar-rich crops (ethanol), pyrolysis of wood (pyrolysis oil derived diesel equivalent) and Hydro Thermal Upgrading (HTU) of wet biofuels (methanol, DiMethylEther) from gas synthesis that results from gasification of biomass (Humkeai 1981). Most of these biofuels will not be commercially available on short term. Although technological developments and commercial availability of these fuels are changing continuously, it can be stated that these biofuels will probably not be produced and applied on a commercial scale before 2010. Currently, only ethanol and its derivative produced from food crops and biodiesel from rapeseed methyl ester are applied on a commercial basis in the European
market. They will remain the dominant biofuels in the coming decade as alternative biofuel technologies are still in the development stage.

1.2 BIODIESEL AS AN OPTION FOR ENERGY SECURITY

Targets need to be set up for biodiesel production to achieve blending ratios of 5, 10 and 20 percent in phased manner. The use of biodiesel as the fuel for internal combustion engines has an opportunity to play a fundamental role in the future of energy usage as it relates to the environment, availability, benefits to farmers and to other industries as well. Both crude and refined petroleum usually consist of hundreds of chemical substances. Chemically, the components of crude petroleum can be divided into two classes: alkanes and aromatic hydro carbons. The aromatic hydro carbons include the environmentally suspect Polycyclic Aromatic Hydrocarbons (PAHs). Refined petroleum products contain alkenes which are prepared synthetically and are somewhat similar to the alkanes in environmental properties (Srinivasa Rao 1991). Proper classification and understanding of the chemical and physical properties of crude oils and their refined petroleum products will help to determine the hazard to personnel and wild life. The objective of the study is to reduce the pollution from IC engines by adding additives.

The petroleum fuel is mainly used for transportation and operating agricultural machinery. These are getting depleted gradually from the world petroleum reserves and these fuels may run out within few decades. The exhaust emissions are increasing day by day and making an impact on the environmental pollution. Under these conditions, there is urgent need to find out an alternate fuel for use in internal combustion engines.
1.3 BIODIESEL AS FUEL ADDITIVE

Biodiesel is registered as a fuel and fuel additive with the US Environmental Protection Agency and meets clean diesel standards established by the California Air Resources Board. Neat (100%) biodiesel has been designated as an alternative fuel by the Department of Energy and the Department of Transportation of US.

India with just 2.4% of global area, supports more than 16% of the human population and 17% of the cattle population. India is one of the largest importers of edible oil. According to the Indian Economic Survey (1995-96) out of the cultivable land area, about 100-150 million hectares are classified as waste or degraded land. Jatropha (Jatropha curcas, Ratanjyot, wild castor) thrives on any type of soil and needs minimal inputs or management. In Tamilnadu, the District Rural Development Agency (DRDA) of Coimbatore plans to promote biodiesel production with the help of the tribals of the Anaikatti region who have started jatropha cultivation in a big way. The district administration intends to plant about seventy five lakh jatropha saplings to produce biodiesel. The tribals have already taken up planting of about seven lakh saplings. Each plant would yield nearly 3 kg of seeds.

1.4 BIODIESEL IN INDIA

Government of India has decided to achieve energy independence by the year 2012 by using biodiesel as alternate fuel. India is keen on reducing its dependence on coal and petroleum to meet its increasing energy demand and encouraging jatropha cultivation is a crucial component of its energy policy. In general, India’s strategy is to encourage the development of renewable sources of energy through incentives by the federal and state governments. Government of India has identified 4,00,000 square kilometers of land where Jatropha can be grown, hoping it will replace 20% of India’s
diesel consumption by 2011. This has provided much needed employment to
the rural people and also a means to energy independence of India.

Dr. A.P.J. Abdul Kalam advocates Jatropha cultivation for
diesel production. The former President said that out of the 60 million
hectares of waste land available in India, nearly 30 million hectares are
suitable for Jatropha cultivation. Once this plant is grown, it has a useful life
span of several decades. During its life, Jatropha requires very little water
compared to other cash crops.

1.4.1 Species of Jatropha in India

The Botany of the Jatropha plant is as follows:

Common Name : Purging nut, Physic nut
Family Name : Euphorbiaceous
Vernacular Name : Kattamanakku

There are four species of jatropha in India:

i) Jatropha curcas L. a native of tropical America, occurs in
various parts of India, particularly in the Coromandel, Konkan
and Malabar coastal areas. PNJ 233 Curcas clone is the one
that is used as a substitute to diesel as its properties match
with that of diesel.

ii) Jatropha glandulifera Roxb L. is also a native of tropical
America naturalized in Bengal, Northern circars, Deccan,
Carnatic and rarely found in Punjab.

iii) Jatropha gossypifolia L. is a native of Brazil, naturalized in
many parts of India.

iv) Jatropha multifida L. The coral plant from tropical America.
Figure 1.1 shows Jatropha nursery. *Jatropha curcas* is a shrub or a small tree with smooth grey outer layer called bark. It normally grows between two and four meters in height which can go up to seven meters in height which can go up to seven meters under favorable conditions. It has large green to pale green leaves. The length of the flower ranges from six to twenty three millimeters. The plants shed the leaves in the dry season annually. Flowering occurs in the wet season and two flowering peaks often seen. In permanently humid regions, the flowering occurs throughout the year. The seeds mature about three months after flowering.

![Jatropha nursery](image1.png)

**Figure 1.1 Jatropha nursery**

Figure 1.2 shows the Jatropha plant. Nursery plants may bear fruits after the first rainy season. The flowers are fertilized with pollen by insects especially honey bees. The flowers are formed terminally with female flowers slightly larger and occur in the hot seasons. In conditions where continuous
growth occurs, the flower productions results in higher number of female flowers. Jatropha fruits are produced in winter when the shrub is leafless, or it may produce several crops during the year if soil moisture is adequate and the temperatures are sufficiently high. The seeds become mature when the capsule changes from green to yellow, after two or four months.

Figure 1.2 Jatropha plant

Figure 1.3 shows Jatropha plantations. It has no insect, pests and not browsed by cattle or sheep. It can survive long periods of drought. Propagation is easy and the yield is from the third year onwards and continues for 25-30 years. 25% oil can be obtained from seeds by expelling and 30% by solvent extraction. The meal after extraction is excellent organic manure (38% protein). According to the study by Agro-Forestry Federation - Maharashtra (1991) Jatropha is a hardy plant. It is well adapted to dry conditions and low fertility and moisture demand. It grows on stony, shallow or even calcareous
soil and propagated through seed or cuttings. It can tolerate to scanty to heavy rainfall. If 10 million hectares of waste land is brought under jatropha cultivation, it can yield 15 million tons of seed at the rate of 5 tons per hectare. It will give 4.0 million tons of oil that is an equivalent amount of biodiesel, almost one tenth requirement of diesel in the country (Wealth of India 2008).

![Jatropha plantations](image1.jpg)

**Figure 1.3 Jatropha plantations**

There is enormous employment generation potential in rural areas. If only one person per family is employed per 5 hectares for jatropha cultivation, additional 2 million new jobs will be created.

Figure 1.4 shows the jatropha seeds. There is need for 200 new oil extraction units of 250 tons per day capacity to crush the jatropha seeds. The by-products are 11 million tons of excellent organic manure and 0.4 million tons of technical grade glycerol used to produce detergents. Its effect on rural economy will be tremendous. On an average of 5 hectare plantation per family, it can give a seed yield of 3000 kg per hectare. At the rate of Rs. 4 per kg, it will fetch an income of Rs.60,000 per annum. Additionally the
waste lands will be converted to productive national assets creating jobs in downstream processing with gainful employment in rural sector. Most important of all, it will contribute to national energy pool.

![Jatropha seeds](image)

**Figure 1.4 Jatropha seeds**

### 1.4.2 Oil Seed Project Origin

This project was originally conceived in 1995 as a collaborative endeavour between Tribhuvan University, Kathmandu, Oxford Brookes University and University College Northampton to investigate the viability of meeting village-level energy requirements from the oil of waste nuts and seeds and has been supported with private funding since conception. The project envisaged the construction of a pilot plant incorporating a locally produced screw-type oil expeller driven by a compression-ignition engine fuelled on a portion of the oil expelled and monitoring of the impacts of this new technology.
Although Rudolf Diesel originally envisaged his machine to run on pure plant oils, performance is poor in most contemporary engines designed to operate on diesel fuels and so laboratory facilities in Britain were modified to permit investigation of the performance of suitable engines fuelled on indigenous oils. The project attracted financial support from the British universities to conduct the above work in 1996. During 1997 an academic link was formed between the universities with financial support from the UK Department for International Development (DFID)/the British Council which has since enhanced the management, monitoring and operation of the project and advanced collaboration in research, teaching, curriculum development and technical transfer.

A Biomass and Biofuels Group has been established recently to manage growth and developments in the botanical, agricultural, silvicultural, social and technical aspects of the work. The Group is accommodated in space provided by the RECAST at Tribhuvan University with financial support from the British Embassy and the DFID/the British Council for the purchase of associated machinery for an experimental test facility and a pilot plant. Whilst fuel supply is recognized as a pressing imperative, in this project the supply of fuel from seeds and nuts is a single, albeit a vital, component in a fuel-producing system which addresses broader socio- and environmental-economic issues in an integrated and complementary way.

Figure 1.5 illustrates the oil seed plant to produce seed oil from jatropha seeds and oil cake as the byproduct. As far as possible locally-produced technology has been the preferred option in this project and although our attention had been focused initially on a single pilot plant, comparative and optimization studies are now also being conducted with other screw-type oil expellers and improved traditional devices supplied by
local manufacturers which have so far been used infrequently to expel oil from the non-conventional seeds abundant in Nepal.

In Britain data obtained from a range of Nepali oils in our engine and fuel testing facilities suggest the suitability of using unrefined *Jatropha curcas* oil as a fuel in certain types of the Diesel engine. Diesel engines have performed perfectly in short term tests using unrefined oil with comparable combustion characteristics, efficiencies and power production to diesel fuelled engines. Work is currently focusing on fuel pre-treatment and the phenomenon of injector coking which is a major limitation to the long term performance of compression-ignition engines fuelled on pure plant-oils. In addition to the work conducted by the Group at the RECAST, a field site has also been established on marginal lands provided by the Institute of Forestry, Tribhuvan University in rural Nepal. This land is being utilized by the Group for experimental plantations focusing on cultivation techniques, species

**Figure 1.5 Oil seed plant**
selection, soil erosion control etc. with the objectives of enhancing oil and biomass yields from the plants and monitoring their effects on soil integrity.

The project has been actively encouraging the involvement of women to promote their economic empowerment through cultivation and collection of seeds, soap production and marketing of oil and other by-products. The collection of seeds for research purposes, dissemination and other promotional work has been in progress in rural Nepal for some time now under the auspices of the Women's Development Section of the Ministry of Local Development. We are currently working together to provide ‘hands-on action training’ in the propagation, establishment and cultivation of an additional 120,000 oil bearing plants (*Jatropha curcas* L.) on 20 ha of marginal land at the field site as well as training in the harvesting and post-harvest processing of seeds from mature plants in the District. The initiative provides for demonstration and dissemination of oil expelling techniques and end uses for the oil and process by-products and continues to provide encouragement for the marketing of the seeds and oil and soap and other by-products.

1.5 **BIODIESEL AROUND THE WORLD**

Sunflower, rapeseed oils etc. are used as raw material in Europe whereas soya bean oil is used in USA. Thailand uses palm oil, Ireland uses frying oil and animal fats.

Biodiesel is available and used around the world in the countries such as:

i) Australia  
ii) Brazil  
iii) Belgium  
iiii) Finland  
vi) Germany  
vii) Estonia  
viii) Finland  
ix) Germany  
x) Singapore  
xii) Norway  
xiii) Norwey  
xiv) Spain  
xv) Singapore
In Australia, the fuel standard (biodiesel from rapeseed oil) Determination 2003 was signed by the minister for the environment and Heritage on 18th September, 2006. The Determination sets out the physical and chemical parameters of the Biodiesel standard. All of the metropolitan trains and most of the metropolitan buses in Adelaide (Capital of South Australia) operate on a B5 blend. The Australian Government has stated that it will soon move to B20. In February 2005, the first retail outlet opened in the Sydney suburb of Marrickville. It offers B20 blend to the general public, and caters to qualified fleets. 2006 saw the second rollout of biodiesel by a service station network. Gull, a Western Australian based company introduced B20 biodiesel to several Gull Service Stations that has since expanded to a total of 21 sites of purchase. Gull is also involved with the Western Australian Government to provide B5 biodiesel for use in Transperth buses. Currently seven percent of Transperth’s bus fleet is running on biodiesel. More recent news is that in September 2006 about 50,000 litres of biodiesel per week was sold into a community of about 1,60,000. This is believed to be the highest penetration of biodiesel per capita in Australia.