CHAPTER-1

INTRODUCTION

In this modern world, energy economy and environment are the most important things on which everyone and every nation are concerned. It is very much essential to maintain always a balance between these three very important factors. Today we live in a world called economic world. The word economic nation is implied for all nations where there is a rapid transition in its economy with a rise in its gross domestic product(GDP) per capita with good standard human living conditions and along with a persistent growth rate. Developing nations are working hard, taking several initiatives to pace up their economies so that they can be one among economic nations. Every nations economic growth has got its own limitations, but one such common limitation is its available resources of energy to drive its economy. Sources of energy are not uniformly distributed throughout the world. For a nation with good resources of energy is a boon and for the nations deprived of such resources is never ending process of spending their exchequer in procuring them. In this world among all available sources of energy, fossil fuels play a dominant role and they are accounted for nearly 75% of total primary energy supply. Fossil fuels are formed from organic matter, take some millions of years to form and so called as non renewable. There has been huge and careless development of fossil fuel based energy systems to generate energy due to dramatic increase in the energy demand of the world. This happened with the invention of engines which was a technological breakthrough that has transformed human life, ushered an era of huge business and production. Diesel engines are very efficient in generating electricity, transportation of goods, to power much world's equipment in a more economical than the other devices of their size. These engines had a great impact in transforming human society.

In the 20th century diesel engine vehicles became principal means of land transport bringing in much more comfort, luxury and safety. Agricultural sector improved due to mechanization of farm machinery with diesel engines lead to increase in farm productivity. On the other side these engines are a source of pollution contributors to environment. Next, it also influenced oil producing countries to
harness enormous wealth and to play a key role in world affairs. With the world population increasing day by day demand for energy is also gaining momentum.

Energy consumption is expected to increase by 84% by 2035 in most of the developing countries. In this scenario India's challenge is to procure sufficient energy in a preferred qualitative at competitive prices to meet its energy needs. To bring about decent living standard of people and for other human developmental activities, India needs to achieve a sustained growth rate of 8% to 10% in its economy over the next 25 years. This is possible, if its primary energy supplies are increased by 3 or 4 times. New sources of energy like bio fuels can be helpful in meeting the necessary energy requirement.

1.1 ALTERNATE SOURCES OF FUEL ENERGY

Biofuel sources have turned out to be more effective in the recent days because of the insufficiency of conventional fossil fuels, their price hike and increased emissions of pollutants generated during combustion. The petroleum-based fuel reserves are concentrated in only some parts of the world and these resources are depleting day by day. The likelihood of producing biofuels from locally grown sources and using them as an alternative for various petroleum products is one of the best attractive method to overcome the energy crisis. Any investments in biofuels will lead to a considerable boost in economic development.

Biofuel is a fuel produced by biological process such as agricultural or anaerobic digestion rather than by geological process involved in formation of fossil fuels like coal and petroleum. Biofuels can be derived from biomass as solid, gaseous and liquid fuels. Liquid biofuels are of primary importance as it is used as transport fuel and focus is on deriving biofuels from plant oils. Biofuels are broadly classified as first generation and second generation fuels. Pure vegetable oil, bioethanol, biodiesel and biogas are primarily derived from crops that are consumed as food by humans and animals are categorised under first generation fuels. Lignocellulosic ethanol, syngas based fuels, pyrolysis-based fuels comes under second generation biofuels with no food conflict. Major advantage of utilising biofuels is, it does not have any detrimental effect on climate like global warming because energy from these sources is said to be carbon neutral. Undoubtedly carbon dioxide gas is released on
combustion of any kind of biomass fuel but at the same time released \( \text{CO}_2 \) gas is utilised by growing plants during photosynthesis process. Net concentration levels of carbon dioxide in atmosphere can be well balanced by development of large plantations that are to be used as biomass feedstock. Out of many explored biofuel energy resources a few of them are biomass and biogas fuels, primary alcohols, vegetable oils, biodiesel etc. Some fuels can be directly used where as some are processed by different methods for betterment in their properties for their suitability as fuel in comparison with conventional fuels.

1.1.1 **BIOMASS**

Biomass, is an organic matter abundant in supply, used as a fuel in solid form, renewable in nature and considered as sustainable source of energy. It consists of farm crops and products, wood, forestry products, water plants, waste and residual matter. Wood from trees is most common source of biomass energy primarily used for cooking and also used to produce steam which in turn used to generate electricity. For thousands of years, charcoal is produced by partial-pyrolysis of biomass and it also served as the backbone of the early industrial revolution. Biomass is one of the dependable renewable energy source offering most significant consumer and environmental benefits by protecting air quality and also improving forest health.

1.1.2 **BIOGAS**

Biogas is renewable and clean burning fuel as it is produced from organic material that has been created from atmospheric carbon by growing plants in recent growing seasons. It is produced by bacteria and archea microorganisms by anaerobic decomposition of liable decayable organic matter. Biogas produced mainly consists of methane and carbon dioxide gases with small amounts of hydrogen or nitrogen gas. Biomethanation is other name for creation process of biogas. Methane gas, a source of sustainable energy is harnessed and fed to biogas engines coupled with alternator to produce electricity. Comprehensive benefits of production of biogas by anaerobic digestive process is production of renewable power, producing a low carbon fertilizer, solving disposal of problematic wastes, diversion of waste from landfill, avoiding the escape of landfill gases and reduction in carbon emissions.
1.1.3 ALCOHOL

In the modern world alcohol fuels are still considered excellent fuels as they can be produced from renewable sources like plant material, agricultural waste, paper waste etc with lesser impact on environment. Over the history alcohol has been used as fuel because of their higher octane rating, higher flame speed and wide flammability limits in comparison with fossil fuels. Methanol, ethanol, propanol and butanol are the first four aliphatic alcohols, however alcohols like methanol and ethanol with much simple molecular structure are technically and economically suitable to be used as fuel in internal combustion engines. Alcohols are considered to be clean burning fuel than conventional fuels due to lesser carbon monoxide emissions.

Methanol can be made from biomass, municipal waste and even from coal. It has the simplest molecular structure, with low carbon content and high hydrogen content. It can be used as a fuel for spark ignition engines, compared to gasoline it gives better efficiency and increased power output. Ethanol is currently produced from sugar beets and molasses. Owing to its low molecular weight, high octane rating ethanol had replaced other additive octane boosters in automotive fuels. When blended with petroleum fuels complete combustion of fuel takes place because of availability of oxygen, resulting in high thermal efficiency and ultimately reducing emissions. Ethanol is non toxic and less corrosive in nature compared to methanol.

1.1.4 COMPRESSED NATURAL GAS(CNG)

Compressed natural gas is a colourless, odourless and non corrosive natural gas stored in thick walled steel, aluminium or composite pressurised tanks. It consists of methane and is drawn from natural gas wells, oil wells and porous bed methane wells. Vehicles can use CNG in liquid or gaseous form, but most of them use gaseous form compressed to 21 to 25 MPa in their storage tanks. In India natural gas reserves are available in Bombay high basin, Gujarat, North eastern states of Assam and Tripura, Krishna Godavari basin in Andhra Pradesh and Cauvery basin in Tamilnadu. CNG is successful alternative fuel with wide acceptance throughout the world. It is extensively used in public transport systems as it is cheaper compared to gasoline and diesel, saves money on vehicle maintenance as it does not react with metals, longer
life of lubricating oils as it does not contaminate or dilute crank case oil and due to its few green house gas emissions

1.1.5 LIQUIFIED PETROLEUM GAS (LPG)

LPG is mostly made up of propane and it is obtained during refining process of crude oil or extracted during natural gas processing. LPG simply called propane or autogas can be stored in pressure tanks in liquid form at moderate pressures, once it is drawn from tank it turns into gaseous form helps in activating combustion process inside engine. LPG is used as an alternative fuel for gasoline engines but due to its low energy density more fuel consumption takes place for the same power output. Many governments tax reductions on LPG offsets more fuel consumption making it cheaper than conventional fuels. Finally it is a clean burning fuel with no formation of soot and with very few emissions of sulphur. Its extreme volatile nature requires proper safety measures in handling it.

1.1.6 VEGETABLE OIL

Vegetable oil as a fuel to diesel engines dates back to year 1893 when Dr. Rudolf Diesel developed first diesel engine which was capable of running on various fuels. In the year 1900 he demonstrated the engine fuelled with peanut oil and he wanted farmers to get benefited by using their own made vegetable oils to be used as engine fuels. Vegetable oil usage was overlooked because of availability of cheap petroleum fuels. After many years due to fluctuating crude oil prices, energy security and stringent emission norms now focus is on vegetable oils as alternative fuels for their renewable nature and low emissions. Benefits of vegetable oil, its production from plant material which is renewable, easy availability, low sulphur content, risk free transportation, biodegradability, less emissions etc. Now many countries are encouraging research on straight usage of vegetable oils and also for invention of technologies to process vegetable oils to be blended with conventional fuels.

Vegetable oils pose some problems to be run directly in diesel engines due to their high viscous nature. They can be utilised in diesel engines but only after modification of fuel properties or engine modification. One such property is viscosity which is very high for vegetable oils because of their complex chemical structure and
molecular weight. Viscosity leads to pumping problems, injector chocking, incomplete combustion, carbon deposits, poor cold starting etc. For many years, conventional diesel engines are fine tuned to run on diesel fuel so it becomes necessary to modify fuel to suit combustion properties with that of diesel fuel. Previously direct usage of vegetable oil by preheating before injection into engine and mixing small proportions of vegetable oil in conventional fuel normally called blending are tested due to problems encountered over long operation period of engine other methods like emulsification, pyrolysis, transesterification and catalytic cracking are tried upon by many researchers. Properties of vegetable oils like viscosity, flash point, density etc. can be made comparable to conventional fuel by implementing above methods. Considerable success has been achieved in transforming vegetable oil into near quality fuel like diesel which was named as biodiesel.

1.1.7 BIODIESEL

Many countries are importing more crude oil year by year to satisfy needs of its increasing population. Much of the petroleum reserves in the world are located in politically unstable countries. Due to instability of governance crude oil supplies are disrupted. This kind of discontinuity of crude oil supply affected many nations. To overcome this dependency many nations were in search of solution, such kind of solution is an alternate fuel that is biodiesel one cannot strongly say it completely addresses the problem but to some extent it has proved to be remedy to this problem. Biodiesel is a fatty acid methyl ester or mono-alkyl esters extracted from vegetable oils or animal fat and from other sources of biomass that are renewable in nature. Biodiesel harnessed should satisfy certain quality parameters laid down by American Society for Testing and Materials(ASTM). Sources of biodiesel are abundant in supply and available throughout the world. Every country is working towards building a better society and a stronger nation, should utilize these sources to strike a balance between socio-economic and environmental factors. Vegetable oil find its usage dated back to the year 1900 in history when Dr. Rudolph Diesel at the World's Exhibition in Paris demonstrated diesel engine fuelled with peanut oil. It has got its own advantages compared to diesel like easy availability, biodegradability as well renewability, low sulphur and aromatic content. Main intention of using vegetable oil was to use diesel engines at the remote areas of nation for people's better living
standards. In the early stages of introduction of vegetable oil as fuel, their higher cost and availability of petroleum products at cheaper prices has turned down their large scale usage. Now every nation is looking forward in utilization of biodiesel due to inherent advantages that are possessed by it. Out of many advantages to name a few, are its availability, ease of production, low carbon content compared to fossil fuels. Biodiesel substantially cuts down emissions of hydrocarbons, carbon monoxide, sulfates and particulate matter. With increase in percentage of biodiesel blend into diesel fuel emissions are reduced. Pure biodiesel gives best reduced emissions. Many researchers concluded that 20-25% of biodiesel blend with 70-75% diesel gave best results in engine performance and emissions compared to diesel fuelled engines.

Biodiesel maintains the percentage of carbon content in atmosphere. Essential components for growth of any plant are sunlight and Carbon dioxide gas. Carbon that is released during combustion process is same as that of stored by plants during their growth. Biodiesel as it is produced from plant material has high energy balance. Fuel energy balance is a ratio of energy required for its production, refining and distribution to that of energy released at the time of combustion. Reducing sulfur in diesel by the amendment of federal regulations effected the lubricity of diesel but even with very low percentage say 1% blend of biodiesel maintains proper lubrication of moving parts by safe guarding them from premature wear and tear.

Biodiesel is non-toxic in nature so there will not be any serious problems. There is no fear of contamination or even catching fire if it is spilled over or accidentally exposed to environment. Flash point of biodiesel is higher in comparison to petroleum diesel. It is safe to handle while transporting and storing it. Biodiesel has got rapid degradability in environment, it is comparable to that of sugar degradability. Proper storage facilities of biodiesel gives energy security at the time of crises. Large investments have been made on the current engine technology, major changes to this would not have been admissible and adaptability of biodiesel to the conventional diesel engines had saved present infrastructure from becoming obsolete.

1.2 NATIONAL FOCUS ON BIODIESEL

India's focus on biodiesel is concentrated on plantations, biodiesel processing, production technologies and utilization of by-products. India started using biodiesel to
reduce spending on imports of crude oil to save its foreign exchange reserves. Indian approach to biodiesel is different from that of international approaches because of its commitment towards food security of nation. It is mainly concentrating on raising of non feed stocks on waste lands or degraded lands not suitable for normal agricultural purposes. It is estimated that India needs nearly seven million tonnes of this fuel annually for its increasing automobile industry. Government had already taken steps in this regard, one such step is its "National Biofuel Policy" and also implementation of ethanol-blending program. Indian railways is successfully running its locomotive engines using biodiesel blended with diesel in its southern region. Due to increasing awareness on biodiesel many projects are taking shape. Private sector started investing a lot on growing jatropha plantations which is a good source of biodiesel and also on production technologies of biodiesel. In country like India many incentives are to be facilitated for its success at the starting phase to encourage many towards biodiesel projects until people get used to biodiesel rather than fueling their automobiles with conventional fuel.

Sources for producing biodiesel can be vegetable oils, animal fats, used cooking oils, agricultural and municipal wastes. In order to know which vegetable oil is best suited for the production of biodiesel, certain factors like geography, climate, and economics must be considered. Vegetable oils are considered as the renewable forms of fuel, they are well accepted once converted into biodiesel as their properties are within ASTM D6751 range and also for their environmental benefits. So focus is on production of biodiesel from vegetable oils.

Vegetable oils produced from greener oil resources are differentiated into two categories, one which is used for human food consumption is called as edible oils and the other which is not used in food preparation is considered as non edible oils. Edible oils from sesame seeds, palm, rapeseed safflower, soybeans, coconut, sunflower seeds, olives, mustard seeds, groundnut seeds, pumpkin seeds, mango seed, simarouba, ben etc. and non-edible oils like sal seeds, mohua, linseed, soap nut, jatropha seed, pongamia pinnata, rubber seed, papaya seed, grape seed, eucalyptus, nicker seed, thumba, algae, black plum seed, sea lemon oil, tobacco seed etc. are found to be suitable for producing biodiesel. Nowadays non-edible oils are more of focus, research is on in these oils and other sources of oil for production of biodiesel.
Research on extracting oil from left over fruit seeds, conversion of so produced oil into biodiesel to be used as a fuel to power engines is gaining significance. This adds much more economic value to them if energy is harnessed from left over fruit seeds which otherwise would have polluted premises by foul odour where they are discarded or left to decay. This indirectly helps farmers to gain some more from the products of their hard work. So fruit seeds that are easily procured and based upon their oil content two fruit seeds are concentrated. Grapes and mango are most liked fruits, largely consumed by many people because of their inherent health benefits. Discarded seeds are just thrown away, later dumped into dump yards letting them to biodegrade. With better oil content they are now slowly getting noticed and accepted as a potential source of energy. Oil can be extracted from these seeds by different techniques and further treated with chemicals to convert seed oil into an oil with good fuel properties called biodiesel. Biodiesel is one such an alternative and most promising fuel to cater to some extent the never ending demand for fuel, to overcome dependency on crude oils and to convert the unwanted biodegradable byproducts into useful products. A brief description on selected fruits, their importance and oil content of their seeds.

Grape is a smooth skinned fruit or berry which is pulpy with seeds inside grows in clusters on vines. It can be eaten raw and can be used for many purposes after deseeding like making jam, juice, jelly, wine etc. Tons of by-product grape seeds from wine manufacturing industry and other sources is a source of energy which earlier had no value but after its usage as a source of biodiesel has become subject of research. Modern Indian wine market is one such promising solution, although it is very small compared to international level. Indian wine industry is steadily growing at a healthy pace due to increasing people's awareness of fact that consumption of wine is good for health. Second thing is love for quality wine and crave to taste unique wine has become a lucrative business for many people. Reports state that there is increase in demand at the rate of 20-30% annually. This demand lead to increase in grape plantations with added advantage of favourable Indian climatic conditions in some states like Andhra Pradesh, Tamil nadu, Karnataka. Crop can be produced twice a year from grapevines. In the month of February harvesting is normally done through handpicking. For many years, wine manufacturing industry, tons of this
unviable by-product grape seeds was a concern. So plentiful of available grape seed by-product can be used for extracting oil. Concept of biodiesel, bringing into utilization of this oil as biodiesel is economically affordable to some developing nations like our country in particular. It is an added value to utilize by product for oil extraction which consists of major amounts of unsaturated fatty acid content like linoleic acid and oleic acid to produce biodiesel by processing with best possible methods to get good quantity and quality biodiesel.

Mango, a national fruit of our country India is said to be king of fruits. India is producing nearly half of the worldwide production. Our country is largest producer as well consumer of this wonderful fruit. Mangoes are available in varying shapes, colours, flesh and also in taste. These are fleshy delicious fruits that are edible, consumable by humans and inside it has got a leathery endocarp encapsulating a single seed that is valuable and source of interest. Mangoes are used as fruits for food, for juices and also processed for canning. Once after consumption of fleshy part kernel seed or stone is considered as waste is to be converted for useful purposes. One such purpose is extraction of oil from kernel seed, it is pale yellow in colour. An index of oil quality is free fatty acid content and peroxide values. It consists of Stearic acid, plamitic acid, oleic acid, linoleic acid, first two are major saturated fatty acids and remaining two are unsaturated fatty acids. Unsaponifiable matter of fatty acids in oil is of importance as it does not form soap with sodium hydroxide. Fatty acid composition of mango seed kernel oil is important because it makes it more stable, suitable for biodiesel and for blending with vegetable oils. In the present work conventional method of transesterification and alternate method called catalytic cracking is used to produce biodiesel, so produced biodiesel is fuelled to a diesel engine to test for its performance, combustion characteristics and emission effects.