

# Impacts and Challenges of Biodiesel Use in Transport sector – An overview

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**ABSTRACT:** The purpose of this paper is to provide a broad overview of impacts and challenges of bio-fuels. The major factors that will determine the impacts and challenges of bio-fuels are technical issues related to different blending ratio, power, torque, specific fuel consumption in engine, and another issue of environment related to greenhouse gas emissions and pollutions. Bio fuel and it blending with conventional fuels may decrease the dependency of import and emit less pollutant. Biodiesel can be blended in any proportion with mineral diesel to create a biodiesel blend. In comparison with fossil diesel, bio-diesel shows better emission parameters. It improves the environmental performance of road transport, including decreased greenhouse emissions: substantial reduction in emission of unburned hydrocarbons, carbon monoxide and particulate. It is possible to adopt the methods to reduce dependency on imported oil, improve the energy security of the nation and reduction in emission pollutant of fossil fuel by use of alternative fuel in engine.

**KEYWORDS:** Biodiesel, blending ration, green house gases, pollution, emission

## I. INTRODUCTION

Increasing greenhouse gas emissions, growing energy dependency and supply of fossil fuel problems arise due to rapidly growing fossil energy consumption in the transport sector in the last two centuries. But world-wide production of bio fuel has been increasing rapidly in the last decade. The viability of first-generation bio-fuels, which are produced primarily from food crops such as grains, sugar cane and vegetable oils, has been increasingly questioned over concerns such as reported displacement of food-crops, effects on the environment and climate change. Second-generation bio-fuel have potential to provide benefits such as promote rural development and improve economic conditions in emerging and developing regions and making use of abandoned land (Anselm, 2010). Second-generation bio fuel production could become unsustainable if they compete with food crops for available land. Second-generation bio-fuel are not yet produced commercially, but a considerable number of pilot and demonstration plants have been announced or set up in recent years, with research activities taking place mainly in developing countries like India (Fargione et al, 2008; Searchinger et al., 2008).

The increase in oil price are major drivers for increase production and demand of bio-fuel, the heightened worldwide concern over global climate change, improvement of energy security and a decreased dependency on unstable oil suppliers, and benefits to agriculture and rural areas and an opportunity for increasing economic development in many developing countries, due largely to the abundant availability of land and cheaper costs of labour (Francis et al., 2008). This is very important in India specifically, where in spite of impressive economic growth rates over recent years, the vast majority of the population is mired in abject poverty (Banse et al., 2007). Bio fuel viability typically measured in terms of: GHG Mitigation Potential & Net Energy Balance, Impact on Food/Energy Security, Economic Viability, Employment Generation & Poverty Reduction Potential, and Rural Development (Sethi, 2009).

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Policy makers can adopt the methods to reduce dependency on imported oil, improve the energy security of the nation and reduction in emission pollutant of fossil fuel by reduce the use of it and use of alternative fuel i.e. bio fuel and it blending with conventional fuels which decrease the dependency of import and emit less pollutant as compare to that. Such fuels can be used directly or need some sort of modification before they are used as substitute of conventional fuels.

Government of India adopted a national level unified policy on bio fuel utilisation consisting of 20% bio-fuel blending mandate in 2008, but this policy was soon withdrawn due to a serious criticism against a lack of understanding about the economy wide impacts of the policy (Kojima, 2010). The major policy instrument is very ambitious blending mandate, i.e. a minimum 20 per cent blending mandate across the country by 2017. This demand side policy is combined with supply side policy such as setting minimum purchase prices for bio-fuels and minimum support prices for feedstock to encourage bio-fuel and fuel crop production and to promote rural development. Considering the potential impacts of the National Policy on Bio-fuels on Indian sustainable development, it is important to conduct policy impact assessment reflecting the above uncertainty.

## II. SUSTAINABILITY STUDIES OF BIODIESEL AND BIO-FUELS PRODUCTION

Many aspects related to technical and environment sustainability of biodiesel and bio-fuels production, including using different blending ratio in I C Engine of various vehicles and their performance in terms of power, torque and specific fuel consumption have investigated in previous studies (Mayer, 1995; Karthikeyan, 2007; Senthil, 2003; Ramadhas, 2004; Sinha, 2005; Pramanik, 2003; Ajav, 1999; Carraretto et al., 2004; Bhattacharyya, 1994; Graboski, 1998; Constantine, 2007), and environmental impacts & greenhouse gas emissions (Hong Yang et al., 2009; Avinash, 2007; Carraretto et al., 2004; J. Narayana Reddy et al., 2006; Rajagopal & Zilberman, 2007; Ramadhas, 2004; Rakopoulos et al., 2008; V. Makareviciene et al., 2003; Searchinger et al., 2007). A technical and environment sustainability assessment of bio-fuel energy system and their impacts are reviewed in this section.

## III. TECHNICAL SUSTAINABILITY

Biodiesel can be easily used in existing diesel engines in its pure form or in any blend ratio with conventional diesel fuels. It can be directly used in diesel engines without any modifications for short term with slightly inferior performance than that of diesel. Bio-fuel costs and the impact of their use on oil demand and greenhouse gas emissions are important components in the overall assessment of bio-fuels for transport. But there are other important factors, such as the impact of bio-fuels on the vehicles that use them and the pollutant emissions from these vehicles, which are also relevant to this analysis. Standard compression-ignition engines designed to operate on petroleum-based diesel fuel is suitable for biodiesel. A blend of 20% bio-diesel fuel in diesel does not affect any of the measured performance (Murugesan et al., 2007; Agarwal, 2007). A 20% or less biodiesel blends or low level can be used as a direct substitute for diesel fuel in all heavy-duty diesel vehicles without any adjustment to the engine or fuel system (Rakopoulos et al., 2008; Agarwal et al., 2008; Stan, 2005).

There are significant improvements observed in engine and emission characteristics for the biodiesel-fuelled engine compared to diesel-fuelled engine. Thermal efficiency of the engine improved, brake specific energy consumption reduced and a considerable reduction in the exhaust emission was observed (R. Karthikeyana et al., 2007; Narayana Reddy et al., 2006; Agarwal, 1998; Souligny, 2004; Karthikeyan, 2007; C. Arcoumanis et al., 2007; Carraretto et al., 2004).

Bio-diesel is not compatible with certain types of natural rubber compounds and can degrade them over time due to it acts as a mild solvent (Agarwal, 2007). However, many vehicle manufacturers have constructed engines with gaskets and seals that are generally biodiesel-resistant with the trend towards lower-sulphur diesel fuel. Biodiesel can begin to degrade and form deposits that can damage fuel injection systems due to long-term operation (Barnwal et al., 2005). Therefore, depending on the blend level and the typical use patterns of the vehicle, special considerations may be necessary for long-term operation on biodiesel fuel (Siddharth et al., 2010).

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Lubrication also improved by biodiesel blends which reducing engine wear and tear and enabling engine components to last longer (Powell et al., 2007; Fergusson, 2001). Biodiesel also has a fairly high cetane number, which helps ensure smooth diesel engine operation. In cold weather, the difficulty of starting a cold engine increases as the fuel cetane number decreases. Precautions beyond those already employed for petroleum diesel are not needed when using B20, but for B100 certain simple preventative measures are recommended, including utilising a block heater to keep the engine warm; utilising a tank heater to keep fuel warm during driving; and blending with a diesel fuel winterising agent (Murugesan et al., 2007). Moreover, additives are now available that improve biodiesel's ability to start up engines in cold weather.

The engine performance with the bio-diesel blends of sunflower or cottonseed oil bio-diesels is similar to that of the neat diesel fuel, with nearly the same brake thermal efficiency and showing higher brake specific fuel consumption (Rakopoulos et al., 2008). The main items influencing the operating cost are the economic cost of the fuel, the different density and the engine performance, described by the specific fuel consumption (SFC). The cost of bio-diesel for ICE is slightly greater than that of diesel oil. The SFC, a function of the engine speed, is higher in bio-diesel than in diesel oil (Carraretto et al., 2004).

Advancing the injection timing by 31 crank angles resulted in increase in the brake thermal efficiency from 25.7% to 27.3% at full load in the case of Jatropha oil as compared to base diesel. Increasing the injector opening pressure from the rated value for diesel to 220 bars resulted in a significant improvement in performance and emissions with Jatropha oil due to better spray formation. The Brake thermal efficiency increases from 26.2% to 28.9% at full output at a static injection timing of 321bTDC. It is also found that the brake thermal efficiency increases when the injection rate is lowered with Jatropha oil. Though enhancing the swirl level does not improve brake thermal efficiency significantly, it slightly reduces HC and smoke levels. By optimizing the injection rate and injection timing the performance and emissions of the engine with Jatropha oil can be improved significantly. Peak pressure, maximum rate of pressure rise and heat release rate are lower than diesel. The brake thermal efficiency is 32.1% with diesel and 28.9% with Jatropha oil (J. Narayana Reddy et al., 2006).

The results from the detailed test conducted by R. Karthikeyana et al. (2007) with turpentine–diesel engine are: The brake baseline (DBL), Increased SFC is reported at full load due to the presence of knock, Maximum of 8% drop in volumetric efficiency is reported in DF engine at full load. F thermal efficiency of Dual Fuel (DF) engine at 75% load is 1–2% higher than that of diesel rom the above results, it is concluded that 60–65% replacement of diesel with turpentine is quite possible within 75% load.

The performance and emission parameter for different fuel blends are found to be very close to diesel. Smoke density and BSFC are slightly higher for vegetable oil blends compared to diesel. However, BSEC for all oil blends is found to be lower than diesel. Vegetable oil blends showed performance characteristics close to diesel. Therefore, vegetable oil blends can be used in compression ignition engines in rural areas for agriculture, irrigation and electricity generation. Modified maintenance schedule may be adopted to control carbon deposits formed during long-term usage of vegetable oil blends. Using primary ester of vegetable oil also eliminates the durability problems associated with the vegetable oil thus making it a safe and suitable fuel for long-term usage in CI engine (Agarwal et al., 2008).

The viscosity and relative density of fuel goes decreases with the blends of 25% vegetable oil with 75% diesel fuel, 50% vegetable oil with 50% diesel fuel, 75% vegetable oil with 25% diesel fuel and 100% vegetable oil respectively. The diesel fuel has the highest gross calorific value and lowest viscosity, when compared with various blends. It is found that the higher percentages of vegetable oil in the blends increases the viscosity and lowers the gross calorific value. The pure vegetable oil has lowest gross calorific value and highest viscosity (Murugesan el al., et al., 2007).

The average value of SFC for bio-diesel is 17% greater than that of diesel oil. Other tests on different engines show that the increase ranges from 5% to 20%. Performances are slightly reduced while SFC is notably increased using bio-diesel. The increase of biodiesel percentage in the blend involves a slight decrease of both power and torque over

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the entire speed range. In particular, with pure biodiesel there is a reduction by about 3% of the maximum power and about 5% of the maximum torque. By reducing the injection advance, it is possible to optimize combustion, improving performances especially at low and medium speed, with respect to nominal injection advance operation; by reducing the injection angle, power and torque are increased up to almost pure diesel oil levels while SFC is reduced (C. Carraretto et al., 2004).

In the case of agricultural applications, fuels that can be produced in rural areas in a decentralized manner, near the consumption points will be favoured. Vegetable oils are easily available in rural areas, are renewable, have a reasonably high cetane number to be used in CI engines with simple modifications and can be easily blended with diesel in the neat and esterified (bio diesel) forms. Jatropha oil, Karanji oil, coconut oil, sunflower oil, rapeseed oil and neem oil are some of the vegetable oils that have been tried as fuels in internal combustion engines (J. Narayana Reddy et al., 2006).

From technical and technological point of view, blended application of bio-diesel is more promising and feasible alternative, than utilisation of pure bio-diesel. A general conclusion from above is that all the bio-diesel blends can be used safely and advantageously in the present diesel engine. A diesel engine can perform satisfactorily on bio-diesel blends without any engine hardware modifications. Bio-diesel is a technologically feasible alternative to fossil diesel, but it is as a fuel for road transport is the need of engine modifications, when pure bio-diesel is applied (Marina, 2002). All the above work suggests biodiesel as a promising alternative fuel for diesel engines in terms of fuel consumption and engine performance without or less engine modifications.

#### IV. ENVIRONMENTAL SUSTAINABILITY

Reduction in the emission of particulate matter, hydrocarbons and carbon monoxide, in addition to a reduction in the emission of carbon dioxide, a significant element in the greenhouse gas effect are some environmental benefits from the use of biodiesel in engines. Many studies highlight the use of alternative fuels as being one of the technical solutions for reducing the emission of pollutants in the transport sector. Studies showed that CO, CO<sub>2</sub>, and PM emissions were lower than the emissions from diesel oil. The emissions of NO<sub>x</sub> only were higher with different types of biodiesel. With regard to emissions, biodiesel reduces net CO<sub>2</sub> emissions by 78.45%, particulate matter by 32%, CO by 35%, and SO<sub>x</sub> by 8%, relative to petroleum diesel life cycle, while NO<sub>x</sub> and unburnt HC emissions increase by 13.35% and 35%, respectively (Agarwal, 2007).

Various studies have shown the environmental advantages of the use of biodiesel, among which the reduction in emissions of CO, PM and sulfur oxides (SO<sub>x</sub>) stand out, as do the reduction in emissions of carbon dioxide (CO<sub>2</sub>), because this is a renewable energy source. Studies carried out show that emissions of NO<sub>x</sub> are also related to the power that the engine develops. When accelerating, emissions increase, at cruising speed emissions reduce. This occurs because heavy loads demand greater fuel mass which causes high pressure and temperature peaks in the combustion chamber, favoring the formation of nitrogen oxides. Therefore, NO<sub>x</sub> emissions are also related to the mass of fuel injected. The author also observed that NO<sub>x</sub> emissions are directly related to the power developed by the engine. When the power is increased the emission of NO<sub>x</sub> also increases, and when the engine is working at moderate power NO<sub>x</sub> emissions reduce. Therefore, unlike CO emissions that remain practically the same at moderate power, emissions of NO<sub>x</sub> tend to be directly proportional to the power developed in the moderate bands.

Emissions of nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO) and smoke density, rapeseed oil ethyl ester had less negative effect on the environment in comparison with that of rapeseed oil methyl ester. When fuelled with rapeseed oil ethyl ester, the emissions of NO<sub>x</sub> showed an increase of 8.3% over those of fossil diesel fuel. When operated on 25–50% bio-ester mixed with fossil diesel fuel, NO<sub>x</sub> emissions marginally decreased. When fuelled with pure rapeseed oil ethyl ester, HC emissions decreased by 53%, CO emissions by 7.2% and smoke density 72.6% when compared with emissions when fossil diesel fuel is used (Makareviciene et al., 2003). Carbon dioxide (CO<sub>2</sub>) emissions,

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which cause greenhouse effect, decreased by 782.87 g/kWh when rapeseed oil ethyl ester is used and by 782.26 g/kWh when rapeseed oil methyl ester is used instead of fossil diesel fuel.

Rakopoulos et al., 2008 studied that the smoke density and CO emissions are reduced with the use of all bio-diesel blends with respect to that of the neat diesel fuel, with this reduction being higher the higher the percentage of bio-diesel in the blend. The cottonseed bio-diesel blends tended to produce lower emitted soot values than the corresponding ones for the sunflower case. The NO<sub>x</sub> and HC emissions are slightly increased with the use of all bio-diesel blends with respect to those of the neat diesel fuel, with this increase being higher the higher the percentage of bio-diesel in the blend. The cottonseed bio-diesel blends tended to produce lower emitted CO values than the corresponding ones for the sunflower case.

Advancing the injection timing by 31 crank angle resulted in reduction in the HC level from 2350 to 2068 ppm and also reduction in smoke level from 3.9BSU to 3.3BSU at full load in the case of Jatropha oil as compared to base diesel. HC reduced from 2220 to 1638 ppm and Smoke level reduced from 3.6 BSU to 2.1 BSU at full output at a static injection timing of 321bTDC. HC emission is 532 ppm with Jatropha oil as against 798 ppm with diesel, NO level with Jatropha oil is 1162 ppm and with diesel it is 1760 ppm and Smoke with Jatropha oil is 2 BSU where as with diesel it is 2.7 BSU are observed at full load (J. Narayana Reddy et al., 2006).

Stamatov et al., 2006 studied that the chemical and physical properties of pyrolysis bio-oil adversely affect their combustion properties and result in difficulties in storage and handling. Bio-oil is characterized by high viscosity, acidity and electrical conductivity, presence of water and various oxygenated compounds, ash and other solid impurities. While low in sulphur, bio oil contains nitrogen. This result in increased emission of NO<sub>x</sub> from bio-oil flames compared to NO<sub>x</sub> emission from standard diesel fuel flames.

Carraretto et al., 2004 studied that bio-diesel contains very small amounts of phosphorus and sulphur; therefore SO<sub>x</sub> emissions are almost negligible and the temperature of the flue gases at the stack can be considerably reduced, since acid condensation is not a problem of major concern. No aromatic compounds are present. The presence of oxygen in biodiesel leads to more complete combustion processes, resulting in lower emissions of CO, particulates and visible smoke. By reducing the injection advance, CO emission is reduced up to medium speed; this could be related to improved combustion over this low speed range; at higher speeds CO emissions increase since the previous effect is probably not evident any longer.

EGT and NO<sub>x</sub> are found lower than that of DBL up to 50% load beyond which they start increasing due to the occurrence of knock. Approximately 35% of higher CO emission is reported at full load of DF engine and 48% of higher UBHC emission and 45% reduced smoke are reported at full load of DF engine (R. Karthikeyana et al., 2007).

Exhaust gas recirculation can be used to give NO<sub>x</sub> reduction up to 15% effectively without much adverse effect on the performance, smoke and other emissions. Higher EGR of 20 and 25% resulted in inferior performance and heavy smoke Because of the increased inlet charge temperature due to HOT EGR and dynamic injection advance, 5 and 10% EGR levels are not sufficient to reduce NO emission at all loads for JBD. However, these EGR levels significantly reduced NO at peak loads. About 15% of EGR, on JBD is found to be effective in reducing NO emission to values lower than that of diesel, without EGR, at all loads. Full load NO emission from JBD with 15% EGR, is found to be lower than that of corresponding diesel NO emission. Inherent oxygen present in the bio-diesel structure is believed to have played a significant role in compensating for oxygen deficient operation under EGR. JBD is found to be environmental friendly as far as CO and HC are considered. Smoke emission from JBD is found to be lower than diesel at peak loads with and without EGR. Smoke emissions are found to be higher for JBD in the lower load region because of slightly higher viscosity, low volatility and probably due to the presence of water content. NO emission from JBD is found to be comparatively higher than the diesel fuel (V. Pradeep et al., 2007).

In comparison with fossil diesel, bio-diesel shows better emission parameters. It improves the environmental performance of road transport, including decreased greenhouse emissions.

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## V. CONCLUSION

Biodiesel offers excellent promise as an alternative fuel for compression-ignition engine in the transportation sector have indicated by above various investigations and studies of technical and environment. Bio-fuel has been found to be an alternative fuel for compression-ignition engines with different blending ratio with diesel, improved thermal efficiency, brake specific energy consumption reduced and a considerable reduction in the exhaust emission; it thus merits further research and development before a final decision is taken on its potential as a mass production fuel for the transportation sector.

This study provides some insights into the possible consequences of bio-fuel development under various alternatives regarding technical and environmental impacts of bio-fuels. Blends are the most feasible way for enhancing the bio-diesel share on the fuel market, giving an appropriate income to farmers, competitive prices to end-users and requiring less taxation incentives and exemptions and reduction in imports fossil due to use of bio-fuel and energy prices can have significant impacts on bio-fuel development.

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