

Clean Development Mechanism in Biofuel Sector in India: Opportunities and Challenges

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ABSTRACT

Clean Development Mechanism is a market based trading mechanism created by the Kyoto Protocol, functions by delivering a subsidy to the developing world in return for lower emissions of green house gases. The subsidy offsets the cost of reducing green house gas emissions, thereby encouraging developing countries to emit less GHG than they otherwise would. Biofuel related projects have good potential to earn carbon credits because it reduces the emissions from transport / power generation sector in comparison with burning of fossil fuels. This article describes about clean development mechanism, its project cycle, development of CDM based biodiesel projects and certified emission reduction calculation. Moreover it emphasizes on carbon credit earning potential in Indian markets, typical biofuel projects and its challenges.

INTRODUCTION

The challenges of climate changes and sustainable development are presently at the top of political agenda among the World's leading nations. Majority of developed countries have committed to targeted emission reduction through the Kyoto Protocol of 1997, which entered into force in February 2005. Human Development Report 2007 says that developed countries should cut their carbon emissions at least by 80% by the year 2050, 20-30% cuts by 2030. If emissions continue to rise following current trends then stocks of the green house emissions will be increasing at 4–5 ppm per year, by the year 2035 it may almost double the current rate. Accumulated stock will have risen to 550 ppm. Even without further increases in the rate of emissions, stocks would reach over 600 ppm by 2050 and 800 ppm by the end of the 21st Century. India accounts for 5.5% of CO₂ emission with the population of 17.2% world share. Human Resource Development report also says that the developing countries like India should cut their emissions by 20%. It would stabilize CO₂ equivalent concentration

at 450 ppm in the atmosphere, which is currently at 379 ppm [1].

Most human activities energy sector, which includes fossil fuel combustion for electric power generation, transport, manufacturing, agriculture and industrial processes generate green house emissions gases. Figure 1 shows the breakup of greenhouse gas emissions in Giga Tons of CO₂ eq. Major portion of energy sector consists of heat and electricity, manufacturing and transportation sector contributes emissions.

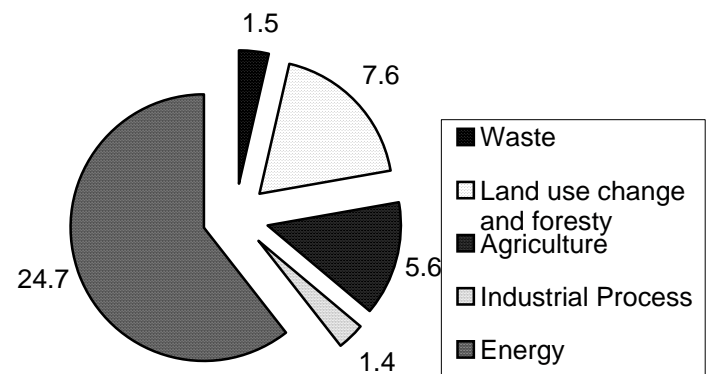


Figure 1. Breakup of green house gas emission in Giga Tons of CO₂ [1]

European countries having fixed targets for emissions under UN mandated Kyoto protocol; they have to buy more carbon credits from the developing countries to offset increased emissions. Carbon market is developing rapidly as a step towards the stabilization of green house gas concentrations in the atmosphere to avoid global warming. Clean development mechanism (CDM) is a part of this carbon market and aims to achieve both sustainable development in developing countries and

cost-effective reduction of green houses in developed countries [2].

France Agency for the Environmental and Control of Energy (ADEME) reported that Transport sector alone causes a quarter of global green house gas emissions, and even though automakers are making efforts to reduce carbon dioxide in new vehicles, the clean air still does not exist. On journeys of around 1000 kms in France, an express train emits roughly a quarter less CO₂ than an aircraft per passenger. A bus emits 10-20 times less CO₂ than a car [3].

Climatic change effect includes flooding of coastal areas, crop failures, epidemics, severe water scarcity and increase in natural disasters. Human Development Report 2007 suggests to reduce CO₂ emissions from transport through stronger fuel efficiency standards in the European Union, with a target of 120g CO₂/km by 2012 and 80g CO₂/km by 2020, and more stringent Corporate Average Fuel Economy Standards (CAFE) in the United States with the introduction of taxation on aviation. To achieve these targets, Human Development report proposes a set of policies which include carbon taxation, cap-and-trade programmes, reduction in emission quotas, encouraging renewable energy through economic incentives, stringent implementation of efficient measures in industry, buildings and transport and support to breakthrough technologies for carbon capture and storage [1].

Transport sector, which uses petroleum products, on combustion of these fuels, emits CO₂ emissions are accumulated in the atmosphere. Combustion of biofuels also emits CO₂ but it is absorbed by the growing trees for its photosynthesis process i.e. biofuel completes the CO₂ cycle and hence reduces the global warming. Biofuels can be used as substitute for petroleum fuels, under transport sector of CDM. Biofuel projects have the potential to earn carbon credits on approval of CDM Executive board. This article describes about clean development mechanism, its project cycle, CDM benefits from biofuels, CDM based biodiesel project development, methodologies, typical biodiesel projects and barriers or challenges of CDM projects.

CLEAN DEVELOPMENT MECHANISM – AN OVERVIEW

In the Kyoto (Japan) Conference, 38 industrialized countries and 11 countries in Central and Eastern Europe were agreed to reduce their Green House Gas (GHG) emission to an average of approximately 5.2% below their 1990 levels over the commitment period 2008-2012. This is called convention of the Kyoto Protocol. The Protocol entered into force in February 16, 2005 and targets six main greenhouse gases: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydro fluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF₆).

Kyoto protocol offers flexibility in achieving the targeted carbon reduction by three mechanisms [4,5].

1. Joint Implementation (JI) which allows countries to claim carbon credit for emission reduction that arise from investment in other industrialized countries, which result in a transfer of 'emission reduction units' between countries (Developed countries)
2. Emission Trading (ET) which permits countries to transfer parts of their allowed emissions units (Emission credit through special market)
3. Clean Development mechanism through which industrialized countries can finance mitigation projects in developing countries contributing to their sustainable development. (Developing countries)

CDM is aimed at helping industrialized countries to meet their greenhouse gas reduction targets. CDM enables the Parties to meet their reduction commitments in a flexible and cost-effective manner. It is a project-based mechanism that allows public or private entities from countries with emission reduction targets to invest in emission reduction projects in developing countries. In return the investing parties receive credits or certified emission reductions (CERs), which they can use to meet their targets under the Kyoto Protocol. These credits can be used against domestic emission reduction targets or sold to other interested parties. The financing country can use these units to offset its own emissions of greenhouse gases during a given period, or sell them to another country. Developed countries can meet their Green house gas (GHG) reduction targets at lower cost through projects in developing countries. At the same time the recipient country gains from an increase in investment - which may be from private or public sources - in sustainable development.

CDM is also meant to help developing countries achieve sustainable development by, for example, facilitating the transfer and/or development of low-emission technologies. The CDM thus offers an incentive for developing countries to maintain their active participation in the Kyoto Protocol. It would be exceedingly difficult that meeting Kyoto targets in the absence of the CDM.

Through CDM, the developed countries can implement GHG mitigation process in developing countries at reduced costs. For example; it requires US \$50 for mitigating one ton of CO₂ eq in developed countries whilst in developing countries the same can be done at the rate of US \$15 per ton of CO₂ equivalent. Each credit is currently selling for 10 – 17 Euros. A Deutsch bank report suggests that prices of carbon credits could go up to 35 euros by 2012 [6,7].

India is the global market leader in CDM already generated 32 million carbon credits and has another 139 million in the pipeline for sale. Table 1 shows the carbon credits earned by the developing countries in the world.

One CER equals one ton CO₂ equivalent (CO₂e). For Kyoto Protocol gases other than CO₂ namely CH₄, N₂O, HFCs, PFCs and SF₆ conversion factors (Global Warming Potentials - GWPs) are to be applied to calculate the corresponding CO₂ equivalents.

Table 1. CERs issued by the host country [8]

Country	CER's Issued
Brazil	15,373,565
Chile	2,088,741
China	25,721,981
India	32,210,460
Mexico	1,910,664
Others	3,468,015
Republic of Korea	17,760,032
TOTAL	98,533,458

CDM can be implemented in energy industries, energy distribution, transport sector, energy demand, manufacturing industries, construction, mining / mineral production and metal production.

CDM PROJECT CYCLE

CDM projects are supervised by Executive Board, which comprises 10 members elected by the Conference of Parties (COP). A CDM Project Entity, which is developing a respective project, needs to go through various stages of a Project Cycle. This is required in order to have the project registered with the CDM Executive Board, which forms a precondition for the certification of greenhouse gas emission reductions generated. Figure - 2 illustrates the CDM project cycle and summarizes the activities to be taken [9].

CDM project entity has to identify the project and prepare the Project design documentation (PDD) as per the guidelines of United Nations Framework Convention on Climatic Change (UNFCCC). There are simplified modalities and procedures for small-scale projects, which are defined as <15 MW in case of renewable energy projects. For large-scale projects, it is required to develop methodology for calculation of emission reduction, which needs to be cleared by Math panel of UNFCCC Executive Board. CDM project entity has to get the host country as well as investor country approval for carbon trading. Designated Operational Entity (DOE) accredited by UNFCCC validates the PDD submitted by project entity. After approval of DOE, the CDM project will be registered as CDM Project at UNFCCC level. CDM project entity implements the project and monitor the GHG emissions reductions. DOE will review, confirm the GHG emission reductions generated by the implementation of this project. UNFCCC CDM executive board issues the CERs upon approval of the verification report [7].

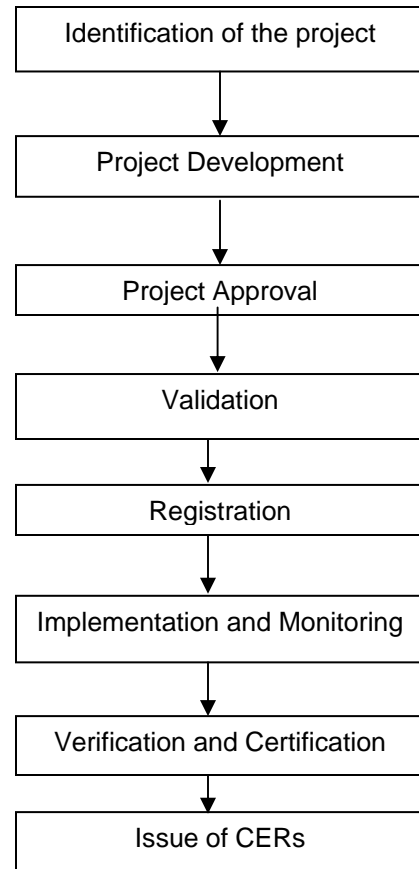


Figure 2. CDM project cycle [7]

CDM BASED BIODIESEL PROJECTS DEVELOPMENT

Biodiesel is produced from edible or non-edible oils derived from tree borne oil bearing seeds, fatty acids, animal fats etc. for substituting petro-diesel or using as a blend in petro-diesel. Biodiesel is a renewable energy source and contributes to the sustainable development of the region. This project promotes mitigation of greenhouse gas emissions by partially or fully substituting the petro-diesel in transportation vehicles.

Ministry of Environment and Forest of Government of India is the designated National Authority for approval of CDM projects / climatic change issues in India. The guidelines for the approval of Indian CDM projects are summarized as follows [10].

1. Social: In India commonly used biomass feed stock for production of biodiesel is Jatropha, karanja seeds. Biodiesel projects generate rural employment by cultivation of trees, collection of seeds and transportation of seeds to crushing units/ biodiesel plants. It helps in alleviation of poverty by providing new employment opportunities and increase in income.
2. Economic: Biodiesel projects i.e. substitution of diesel, help in reducing the import of petroleum products, which is currently approximately 70% of our requirement and

improves our national economy also. These projects create investment opportunities for the local entrepreneurs in small oil seed crushing units that supply raw vegetable oil to the project site. The major portion of cost of biodiesel i.e. raw material cost goes to villages and improves their economy.

3.Environmental: Biodiesel is clean, safe, biodegradable, almost free of sulphur, good lubricity and environmentally fuel as compared to that of diesel. Combustion of biodiesel reduces air pollutants such as soot, particulates, carbon monoxide, hydrocarbons and air toxics as compared to diesel combustion. Thus, biodiesel can be used in transportation diesel vehicles and stationary diesel engine applications.

4.Technological: The transfer of technology from laboratories to industry makes commercialization of biodiesel projects in India.

BIODIESEL PROJECT BASELINE METHODOLOGY

Biodiesel projects should meet the following baseline methodology guidelines as specified by UNFCCC [10].

1. Biodiesel production plant includes esterification/ transesterification unit, oil pretreatment unit, storage and blending. Storage and treatment of feedstock and products of the plant do not result in any methane emissions.

2. Biodiesel should be used as transport fuel and/or as stationery engine combustion fuel. Biodiesel may be used as neat biodiesel (B100) or as blended with diesel. The price and technical performance characteristics blends of biodiesel-diesel do not differ significantly from those of diesel.

3. While calculating carbon credits, transportation of vegetable oil from village to biodiesel production plant and transportation of biodiesel from plant to blending unit / end user site are also to be considered.

4. Project participants claim CERs only for the direct CO₂ emissions from fossil fuels displaced by biodiesel. They do not claim CERs for the following:

- (i) Biodiesel consumed for non-energy purposes
- (ii) Reductions in life-cycle emissions associated with the production of the displaced fossil fuels
- (iii) Utilization of the by-products of biodiesel production, such as glycerol and de-oiled seed cake. Also, project participants should prove that the producer of the alcohol does not claim CERs where the biodiesel plant uses alcohols derived from biomass for esterification.

BIODIESEL PROJECT CERTIFIED EMISSION REDUCTION CALCULATION

Biodiesel is produced by transesterification of vegetable oil with alcohol with / without presence of catalyst. Alkaline, acid, enzymatic, supercritical and ultra sonic methods are used for producing biodiesel [11]. However, alkaline catalyzed transesterification process is commercialized used all over the world. For biodiesel production process, vegetable oil – alcohol mixture requires continuous heating and stirring. While calculating carbon credit or certified emissions reduction (CER), emission incurred for the production of biodiesel and transport to end user to be considered. The calculation of certified emission reduction is explained as follows [12].

PROJECT EMISSIONS:

Biodiesel project activity includes CO₂ emission from consumption of fuel in the biodiesel plant (E_{fuel}), CO₂ emissions from consumption of electricity in the biodiesel plant (E_{elect}), CO₂ emissions from combustion of fossil carbon contained in the alcohols which is chemically bound in the biodiesel and released upon combustion (E_{alcohol}) and CO₂ from transport of both oil to plant and biodiesel from plant to blending unit / end user (E_{trans}).

Project emission PE = E_{fuel} + E_{elect} + E_{alcohol} + E_{trans} in tons of CO₂ per annum

Emission from fuel consumption:

Emissions from fuel consumption are calculated on the basis of fuel consumption at project site or its external supplier site.

$$E_{fuel} = FC * CV * EF_{co2,fuel}$$

Where

FC - Fuel consumption in tons

CV - Net calorific value of fuel / MJ

EF_{co2,fuel} - Carbon dioxide emission factor

Emission factor for diesel = 72.0 g CO₂/ MJ

Emissions from electricity consumption:

Emission from electricity consumption is calculated on the basis of electricity consumed at project site or its external supplier site.

$$E_{elect} = EC * EF_{co2,elct}$$

Where

EC - Electricity consumption in MWh

EF_{co2,elect} - Emission for grid electricity in tons of CO₂ / MWh (1.178 kg/kWh in Southern India)

Emissions from alcohol:

The emissions from combustion of methanol are based on the measured consumption of methanol in the biodiesel plant. Methanol spilled and evaporated on the

project site should be considered as consumption for estimating the emissions.

$$E_{\text{alcohol}} = MC_{\text{alcohol}} * EF_{\text{alcohol}} * 44/12$$

MC – Mass of alcohol consumed

EF_{alcohol} – Emission factor of alcohol, based on molecular weight, in tons of carbon / tons of alcohol (i.e. 2 g/kg of methanol)

Emissions from transportation:

It is calculated from the amount of fuel consumed for transportation i.e. raw material to plant and biodiesel to blending unit.

$$E_{\text{fuel}} = FC * CV * EF_{\text{co2,fuel}}$$

Where

EF_{co2, fuel} – Emission factor for fuel, in tons of CO₂ / ton of fuel used

Emission factor for diesel = 2.66 kg of CO₂ / lit

BASELINE EMISSIONS:

Baseline emissions (BE) of the biodiesel projects are calculated on the basis of displaced diesel by using biodiesel.

$$BE = BD * CF_{\text{diesel}} * EF_{\text{co2,diesel}} * CV_{\text{diesel}}$$

BD - quantity of production of biodiesel in tons

CF_{diesel} = Conversion factor, ratio of net calorific value of biodiesel to petro diesel

EF_{co2, diesel} – Emission factor for diesel, in tons of CO₂ / MJ

CV_{diesel} – Calorific value of diesel in MJ/ton

CERTIFIED EMISSION REDUCTION:

Certified Emission reduction (CER) is calculated as the difference between baseline emissions and project emissions.

$$CER = BE - PE \text{ in tons of CO}_2/\text{year}$$

CDM BENEFITS FROM BIODIESEL PROJECTS

There is a good potential for CDM based on biofuel projects. Crushing of oil seeds produces vegetable oil. The oil cakes can be used for generating biogas / producer gas and the final slurry in the biogas plant can be used as fertilizer. These biofuels can be used as substitute for diesel. The main source of raw materials for biodiesel production in India is jatropha, poongami pinnata tree seeds. Cultivation of oil yielding trees, oil seed collection and crushing creates rural employment. Biodiesel production and its application contribute to reduction in green house gas emissions. Combustion of biomass / biofuel generates carbon dioxide and these are absorbed by growing trees, hence it completes the carbon dioxide cycle. Gasification process generated producer gas can be used for electric power generation.

Use of biofertiliser reduces the power requirement for production of chemical fertilizers. Table 2. shows the green house gas reduction potential with the use of biofuels. Here approximately 3.7 tons of CO₂ equal 1 unit of Carbon.

Table 2. Green house reduction potential activities associated with the use of biofuels [9]

Activity	Per unit CER potential
Growing of jatropha	3-3.5 tons of Carbon / hectare / year
For use in transport sector	0.89 tons of Carbon/ ton of diesel replaced
Biogas to replace kerosene	0.85 tons of Carbon / ton of furnace oil replaced
Outer shell to replace furnace oil in boilers/ furnaces	0.85 tons of Carbon / ton of furnace oil replaced
Biofertilisers	0.72 tons of Carbon / ton of fertiliser

CDM BASED BIODIESEL PROJECTS INITIATIVES IN INDIA

India has good potential to capture the carbon trading market. 772 projects have got approval of host country under CDM. Among these 231 projects in energy efficiency has the potential of 132 million CERs. So far, CDM Executive Board registers 80 Indian projects generating carbon credits [6,7].

Mostly due to lack of funding for investment in modern, more efficient equipment, biofuels are used in a very unsustainable, often simply very inefficient way (for example in cooking or heating applications). Increasing the efficiency of biomass use would not only have positive effects on greenhouse-gas emissions, but would also contribute to the sustainable development of project areas and the host countries.

Alternative low carbon fuel options to current energy sources are major mitigation option. Short-run options include fuel switching to lower carbon fuels, which to some extent will be taken up by the economy on its own. In the medium and long run, the use of renewable energy, both centralized and decentralized, is an important mitigation option. With a vast rural population and several remote areas, renewable energy could be the means to clean energy and prosperity in India [13].

Transport sector is the major contributor of air pollutants especially in regions of large human population like in urban areas. Fuel switching option is one of the CER earning project. Monitoring process, which includes fuel consumption, mile driven, number of vehicles and measured emissions. Emission factors are highly uncertain due to inherent complexities like differences in vehicle technologies, maintenance of vehicles, differences in fuel types and fuel qualities etc. ARAI has

already developed emission factors for in-use vehicles in India. Emission factor in engines depends upon chemical composition of fuel, air fuel ratio and fuel consumption at different speeds. Concentration and mass emission factors of CO, CO₂, SO₂, NO and HC in the exhaust emissions from different kinds of vehicle plying on roads are computed using basic principles of combustion [14].

Reduction in CO₂ of 3.11 kg for each kg of diesel replaced by biodiesel, assuming that it required 1.1 liter of biodiesel for each liter of diesel replaced [15].

1 kg of biodiesel reduces 3.11 kg of CO₂.

For 1 ton of CO₂ reduction, 0.32 ton of biodiesel is required.

At current exchange rates (1US\$=Rs.40), 0.32 ton of biodiesel (or 1 CER) earns \$15 or Rs. 600

i.e.1 kg of biodiesel can earn Rs.1.88

As per the report of the committee on development of biofuels published by the planning commission of India, the projected diesel consumption in 2011-2012 will be of the order of 67 MMT [16]. Based on this, the projected CER earning potential by blending of biodiesel with diesel is calculated and is given in Table-3.

Table 3. Projected CER earning potential by biodiesel blending with diesel

	Biodiesel 5%	Biodiesel 10%	Biodiesel 20%
Quantity (MMT)	3.35	6.70	13.4
CER Units (Million)	10.4	20.8	41.6
US \$ (Million)	156	312	614
Rs Cr.	624	1248	2496

TYPICAL BIODIESEL PROJECTS

Sun Care Fuel Thailand Co has set up the biodiesel plant in Thailand. The project capacity is to produce 15,000 tons of biodiesel per year. This project comes under transport sector. The base line could be estimated by considering the differences in fuel consumption and combustion efficiency between biodiesel and petroleum diesel. The energy content of 1 m³ of biodiesel is equal to 0.889 m³ (0.776 t) of petroleum diesel. The estimated emission reduction by this project is 33,000 tons CO₂ equivalent per year [17].

The bio-diesel plant, with a capacity of 10,000 tons per year, is India's first commercial-size bio-diesel plant (Southern online Biotechnologies Ltd, Hyderabad). It is proposed to use pongamia, jatropha, neem, and other oilseeds grown mainly in degraded areas. This biodiesel plant will avoid 27,000 tons of harmful greenhouse gases. The project has received "host country approval"

from India's Ministry of Environment. These types of biodiesel projects are fall under "Switching fossil fuels" category. According to the CDM modalities and procedures, the sectoral scope of the project activities is proposed under "Transport" sector, as the application of the biodiesel is projected in transport vehicles. The project has benefited from a contribution of Rs. 18 lakhs from the German Government through GTZ, the German Technical Cooperation in support of detailed environmental studies to meet the terms of the Clean Development Mechanism of the Kyoto Protocol. An additional Rs. 2 crores (Euro 380,000) has just been approved by the German government (BMZ) in support of the project as part of Public-Private Partnership environment, which entitles the company to sell carbon after receiving appropriate approvals [18].

Naturol Bioenergy has inked strategic technology partnership with De Smet Ballestra Group of Belgium for implementing its Rs 140 Crore integrated biodiesel plant at Kakinada in Andhra Pradesh. It plans on building a 300 tons/day (about 90,000 tons/year) biodiesel plant in Kakinada. Under the project, about 1.20-lakh acre of dry wastelands can be taken up for cultivation based on vegetable oil seed plantations as a part of rural poverty alleviation programme and had potential to create 12,000 jobs in agro sector [19]

CDM PROJECTS CHALLENGES

CDM appears to be developing in a way that favors large industrial projects that can quickly generate a substantial number of credits from the reduction of industrial gases with a high global warming potential (e.g., nitrous oxide, hydrofluorocarbons). This trend may be to the disadvantage of smaller projects that incorporate low-emission technologies and promote the sustainable development of impoverished communities. In other words, while the CDM may enable some entities to lower their Kyoto compliance costs over the coming years, it is felt that it may not in fact do much to promote sustainable development at the community level. The high costs associated with the convoluted project approval process and administrative delays further hinder the development of small, community-based CDM projects. Prospective buyers of CERs are also hesitant to enter into contracts with developers of small projects for fear that the emission reductions might not materialize, leaving them without the CERs they need to meet their targets [20,21].

Biodiesel CDM projects enable the project promoters to reduce the sale price of the biodiesel in proportion to the benefits received by selling emission reductions. This reduced price enables the biodiesel to penetrate into the market and remove the barriers and motivate to switch over to the biodiesel. Though fleet trials conducted by various organization/ research institutes, there is a lack of will to change from diesel to biodiesel because of the absence of automotive vehicular manufacturer's

warranty for biodiesel fuel. However, biodiesel quality to be ensured as per IS 15607 or ASTM D 6751 specification before blending with diesel for commercial use.

Since there is no tailor made baseline data available for biodiesel related projects detailed development of methodology and collection of supporting documents are essential and critical. Project developers have to submit a methodology together with their project design document, unless an approved methodology already exists for that project type. The methodology panel makes recommendation to the executive board, which makes the final decision. However, life cycle analysis of biodiesel from oil yielding tree to tailpipe emissions needs to be analyzed in detail for accounting as per UNFCCC protocol [22].

CONCLUSION

CDM is much beneficial to the developing countries to improve their economy and also for the developed countries to offset their emission levels. Most of the developing countries are promoting CDM based biofuel projects to obtain the benefit of carbon credits. Cultivation of oil yielding trees, biodiesel in transport use, biogas for power generation and biofertilizer have the potential to earn carbon credits. Biodiesel projects that come in transport sector / energy sector category could reduce the atmospheric pollution and improves national fuel security. Biofuel projects can earn carbon credits, if proper baseline data is analyzed and got approval from CDM board.

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