CDM and biofuels

Can the CDM assist biofuel production and deployment?

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Abstract
The Clean Development Mechanism under the Kyoto Protocol provides an opportunity to direct financing to projects in developing countries that reduce greenhouse gas emissions. The current portfolio of over 800 projects includes several different renewable energy technologies, but no biofuel projects. This paper gives an analysis of the current state of affairs regarding CDM and biofuel. It also discusses the barriers and opportunities relevant to developing biofuel projects under the CDM. It is concluded that approval of baseline and monitoring methodologies is the most crucial step in this respect. Another conclusion is that biofuel project may provide an opportunity to strengthen the sustainable development goal of the CDM.

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Summary

Both the Clean Development Mechanism and production of bio-based liquid fuels receive a lot of attention in current days and appear to be centrepieces of energy and climate change policy around the globe. However, the combination of the two - biofuel CDM projects - is to date not very successful. This paper gives an overview of the current state of affairs regarding biofuels in the CDM and analyses the barriers and opportunities in the future.

The Kyoto Protocol under the United Nations Framework Convention on Climate Change is designed to curb global greenhouse gas (GHG) emissions and puts emission targets on industrialised countries. These targets can be met by domestic action and by the so-called flexible mechanisms, of which one is the Clean Development Mechanism (CDM). Under this mechanism a project developer may implement clean technology in a developing country and sell the resulting ‘carbon credits’ to a country that can use these to meet their GHG target. Another goal of the CDM is to promote sustainable development in the host country.

As of mid-2006, over 800 projects are in an advanced stage of development: validated projects. They account for more than 1000 $MtCO_2$-eq reduction up to 2012. The largest share of the GHG reduction is taken up by non-CO_2 projects, while in terms of numbers renewable electricity projects have the largest share. The project pipeline is increasing fast.

To date no biofuel projects are included in the CDM project portfolio. The main reason is that no biofuel baseline and monitoring methodology has been approved by the CDM Executive Board, which is a necessary requirement for validation. Five such methodologies have been submitted. Other barriers include high abatement cost, additionality prove and calculation of the GHG reduction by the project. On the other hand, biofuel projects may have clear co-benefits in terms of energy security of supply, employment, natural resources and possibly air pollution. Therefore, biofuel CDM project have the potential to strengthen the sustainable development goal of the CDM, which is currently under-achieved.

Future developments in the CDM may increase opportunities for biofuels. These include a possible stronger demand for carbon credits and extension of the scope of eligible activities into sectors and/or programmes or policies.

1. Introduction

In 1997, the Kyoto Protocol was agreed (UNFCCC, 1997), which defined the Clean Development Mechanism (CDM). The Clean Development Mechanism is a means for developed countries to achieve part of their Kyoto target by purchasing Certified Emission Reductions (CERs) from greenhouse gas reducing projects in developing countries. A prerequisite for a CDM project is that it must contribute to sustainable development in the host country. It is up to each host country government to decide and define their criteria for sustainable development. A UNFCCC body called the CDM Executive Board decides on the validity of the methodology for generating CERs of each project.

The CDM has a dual goal:
- To help industrialised countries in achieving their GHG target under the Protocol.
- To assist developing countries in achieving sustainable development.

Several authors (e.g. Sutter, 2003) have pointed at the trade-off that exists between these two goals. This paper aims to evaluate the possibilities for and barriers to the use of CDM for implementation of biofuel production and utilisation, which might contribute significantly to both goals of the CDM. A number of issues needs to be taken into account.

Using CDM for biofuel projects has a number of advantages. The CDM offers an incentive for developing countries to implement climate-friendly projects. Project developers can implement such projects and sell the generated Certified Emission Reductions (CERs) to industrialised countries. In addition to financial benefits, technology cooperation between western and developing countries is an important aspect. For example, biofuel-processing equipment may be supplied by western companies. Using the CDM may help lowering other barriers such as reluctance to use a new technology, increase possibility to attract loans, and cooperation from local and national governments.

Other specific characteristics of the CDM are:
- Participation in a CDM project activity is voluntary and CDM investments will be market driven. Both public and private parties are eligible to participate.
- CDM activities must lead to measurable reductions in emissions, which will be transferable to the investor in the form of certified emission reductions, or CERs, upon quantification and certification by a third party.
- The reduction in emissions must be additional to any that would occur in the absence of the approved project activity.
- Contributions to sustainable development in the host country are a primary aim of CDM projects. The definition of sustainable development or how CDM projects should contribute to it is the host country’s prerogative.

In this report biofuel are defined as liquid fuels produced from biomass with the purpose of utilisation in vehicle engines.

Chapter 2 gives an overview of recent development in the CDM market, while Chapter 3 provides the state of affairs for biofuels in the CDM. In Chapter 4 a number of barriers and issues are summarised. Chapter 5 deals with the future of CDM and how it may impact biofuel projects. This report ends with a set of short conclusions.

2. Current state of the CDM market

This chapter aims to give an overview of the current status of the CDM market. Several aspects are highlighted: the project pipeline (number and types of project in different stages of the CDM project cycle), emission credits generated, buyers and sellers, baseline methodologies and small-scale projects.

2.1 CDM project cycle

A CDM project is subject to a rather complex set of rules[1] as laid down in the Marrakesh Accords in 2001 (UNFCCC, 2001). It basically comprises two phases: project design and project implementation and can be further subdivided into[2]:

- Project Idea Note: first outline from project developer to potential buyers (not mandatory).
- Project Design Document (PDD): elaborate description of project, estimated GHG reduction, environmental and social impact, stakeholder comments, and including Baseline Methodology and Monitoring Plan.
- Project validation by a Designated Operational Entity (DOE) and comments on PDD.
- Registration of project by CDM Executive Board (EB).
- Implementation of the project.
- Monitoring by the project developer and verification by DOE
- Issuance of Certified Emission Reductions (CERs) by CDM EB.

2.2 Project pipeline

As of June 2006, more than 800 projects have reached validation stage[3] (UNEP/Risø, 2006). These are project using an approved baseline methodology. In addition, there are over 50 projects proposing new baseline and monitoring methodologies, which is particularly relevant for biofuel project (see next chapter). Table 2.1 shows a breakdown of these projects to five different types. Appendix B and Figure 2.1 give a more detailed overview.

Table 2.1 *Technology breakdown of CDM project in validation stage as of June 2006*

Type	Number	[%]	CERs/yr (10^6)	[%]	Accumulated 2012 CERs (10^6)	[%]
HFC & N_2O reduction	19	2	79	52	511	49
CH_4 reduction & cement	197	23	32	21	226	22
Renewables	483	56	31	20	214	21
Energy efficiency	127	15	93	6	70	7
Fuel switch	32	4	1.7	1	141	1
Afforestation & reforestation	2	0	0.072	0	0.6	0
Total	860	100	153	100	1034	100

Source: UNEP/Risø (2006).

1 For this reason the CDM is sometimes also dubbed as the 'Complicated Development Mechanism'.
2 See Appendix A for a more detailed overview of the CDM project cycle.
3 This does not include projects for which a new baseline methodology has been submitted but not yet approved.

We can observe a striking difference between projects that reduce CO_2 and those that abate other GHGs. In number, the renewables, energy efficiency and fuel switch (+cement) far outstrip the 'high global warming potential' projects: CH_4, HFC and N_2O. However, looking at the generation of CERs, the exact opposite is true. This is also shown in Figure 2.1.

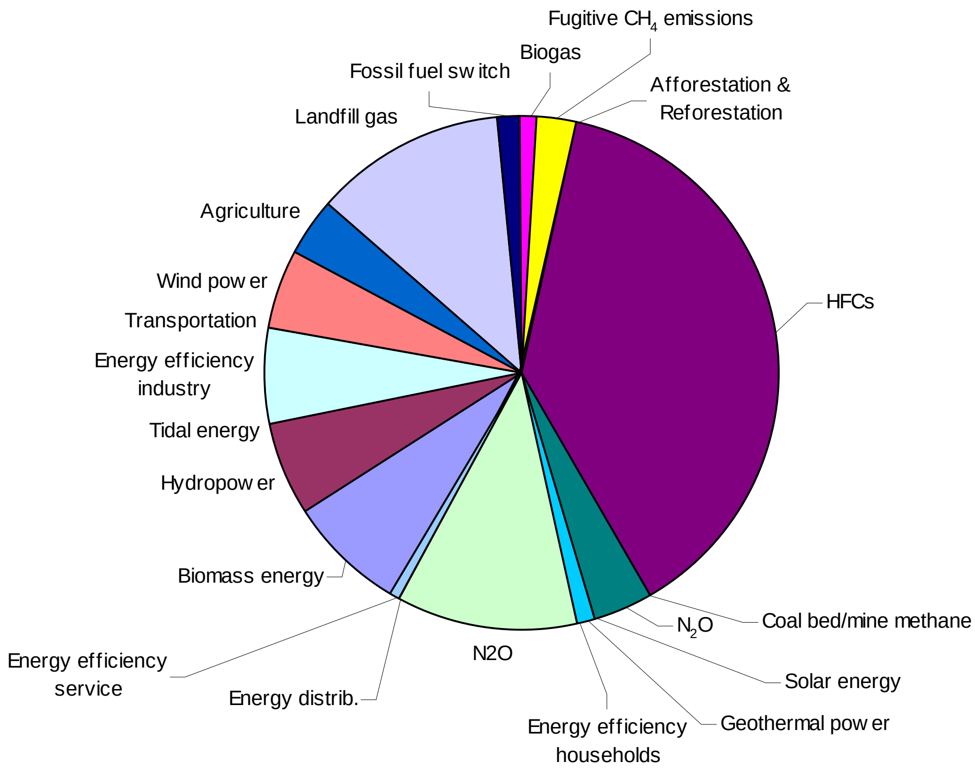

Figure 2.1 *Breakdown of CDM project to type, based on annual CER generation*
Source: UNEP/Risø, 2006.

The project pipeline is currently steadily increasing, with often over ten projects each week being published on the UNFCCC website in the validation stage, and open for public comments.

When a project using an approved baseline and monitoring methodology is validated and opened for public comments, it can be submitted to the CDM EB for registration. As of June 2006, more than 200 projects have been registered since November 2004. The registration of 30 projects in May 2006 alone indicates that the CDM project cycle is becoming more streamlined. The first CERs have also recently been issued.

2.3 Host countries and buyers

Figure 2.2 shows host country distribution in Asia, the continent in total taking approximately 60% of the market[4]. The rest is mainly taken by Latin America, while Africa takes only 3%. The figure is based on number of projects in validation stage. If annual CER generation would be the basis, those countries that have many HFC-23 destruction projects - China mainly - have a larger share.

4 In terms of CERs up to 2012.

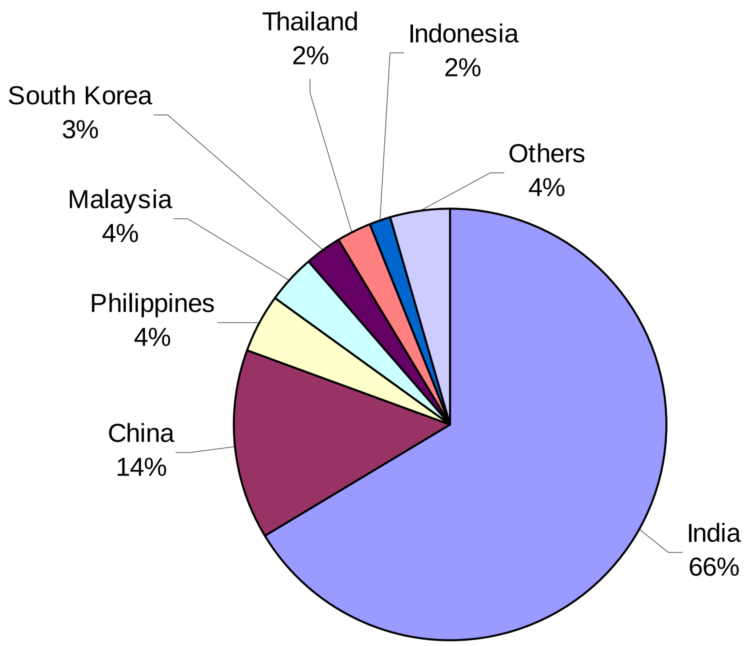

Figure 2.2 *Host country distribution in Asia, based on number of projects*
Source: UNEP/Risø, 2006.

The expected total CERs by the projects in the validation stage up to 2012 exceed 1000 $MtCO_2$-eq, which is a significant share of the expected shortfall in emission levels of the countries that have a target under the Protocol[5]. Currently buyers of CERs (i.e. parties that have contracted project developers to buy emission credits) can be divided into:

- Country governments - mainly EU countries such as, Austria, Denmark, Finland, the Netherlands, Sweden, Italy, Spain.
- Private buyers - companies intending to use CERs for compliance under the EU Emission Trading Scheme (ETS), as well as Japanese companies aiming to use credits to comply with their voluntary agreements.
- Multilateral funds under the World Bank - such as Community Development Carbon Fund, Prototype Carbon Fund, WB Carbon Facility, etc.

In this light the EU ETS deserves some special attention. Under this scheme, 12,000 installations in the industrial and power sector are subjected to a mandatory CO_2 cap-and-trade system since January 1, 2005. The first trading period runs until the end of 2007, while the second is from 2008-2012. Between mid-2005 and mid-2006, CO_2 prices in the scheme have variant been between approximately 10 and 30 €/tCO_2 with rather high volatility and intensive trading (1-3 $MtCO_2$ per day) (PointCarbon, 2006b). Companies are also allowed to use CDM and JI (Joint Implementation) credits to comply with their annual allowances, which is expected to play a substantial role in the second trading period. Therefore, ETS allowances (EUA) and CER prices will be linked to each other to some extent, but it is likely that a difference between the two will remain. Reasons for this can be found in the different characteristics of the markets, which results in different risks to the buyer and the transaction cost. In 2005, EUA prices have risen steadily from less than 10 €/tCO_2 up to over 30 €/tCO_2 in early 2006, while the CER prices also increased, but less dramatically. Following a steep drop of the EUA price in April 2006, the CER price has varied between 12 and 20 €/tCO_2.

[5] These are basically all industrialised countries and economies in transition, excluding the US and Australia, which have not ratified the Kyoto Protocol.

2.4 Baseline methodologies

As outlined above, only projects using an approved baseline methodology[6] can be registered. Drawing upon the experience over the last years, this appears to be a major hurdle in the CDM process, and for some project types it is the main bottleneck.

To date, 166 methodologies for different types of projects[7] have been submitted to the CDM Executive Board. Of these, 29 methodologies have been approved, while the remainder has been rejected, revised (and resubmitted), or is under consideration. Table 2.2 shows a classification of Approved Methodologies (AMs) to project types.

Table 2.2 *Approved baseline and monitoring methodologies as of June 2006*

Project types	Number of AMs
HFC destruction	1
N_2O destruction	2
CH_4 capture (from landfill gas, agriculture or mining)	11
Fuel switch (coal/oil to natural gas)	1
Renewable electricity (excl. biomass)	3
Renewable biomass for electricity	1
Energy efficiency	5
Other	5

Source: UNFCCC (2006), own classification.

Several reasons explain the difficult process of having baseline methodologies approved:
- The principle problem of establishing a baseline (which is counter-factual and therefore has to be determined ex-ante).
- Data availability (especially important for projects where the GHG reduction is very sensitive to certain parameters).
- Unknown impacts of policy on investment decisions;
- Lack of resources with the CDM Executive Board and its Panels.

2.5 Small-scale CDM projects

Every CDM project is required to go through the entire project cycle, regardless of the scale and GHG reduction resulting from it. As completing the project cycle itself puts a large financial burden on the project, economies-of-scale are very relevant in the CDM. However, projects generating large amounts of CERs (e.g. >0.1 $MtCO_2$/yr) are less burdened by the transaction cost than smaller projects. In order to increase success for such smaller projects - that often exhibit larger sustainable development benefits as outlined later - the UNFCCC have defined simplified and streamlined procedures for the small-scale project types shown in the following table.

6 Actually baseline and monitoring methodology, but the latter appears to be a minor issue compared to the former

7 This includes similar types of technologies applied in different conditions regarding national policy, economic aspects, etc.

Table 2.3 *Small-scale CDM projects defined*

Project type	Brief description
Type I	Renewable energy projects with a maximum output capacity of 15 MW
Type II	Energy efficiency improvement that reduce energy consumption, on the supply and/or the demand side, by up to the equivalent of 15 GWh per year.
Type III	Other project activities that reduce anthropogenic emissions by sources, and directly emit less than 15 ktonnes CO_2 equivalent annually.

Each project type is further divided into more specific categories, thirteen in total. For each of these, simplified baseline and monitoring methodologies have been developed. Type III.C is for ‘low greenhouse gas emitting vehicles’, and the only relevant category for biofuels. The simplified modalities and procedures as defined by the CDM Executive Board (UNFCCC, 2002) lower several barriers for projects in the CDM project cycle:

- Project activities may be bundled at various stage in the project cycle, reducing transaction cost (see later).
- Reduced requirements for the PDD.
- Simplified baseline methodologies may be used.
- Simplified monitoring plans and reduce monitoring requirements.
- The same Operational Entity may undertake validation, and verification and certification.

The significance of these projects can be derived from the fact that currently nearly 50% of the number of projects up to validation stage is small-scale. In terms of annual GHG reduction, its share is obviously much smaller: approximately 7% (UNEP/Risø, 2006).

3. Current state of biofuels in CDM

As of June 2006 no baseline methodologies for biofuel production and utilisation have been approved by the CDM Executive Board. However, five methodologies have been submitted and are under review. Approval of one or more of these would improve chances for biofuel CDM projects significantly[8]. Therefore, it is useful to have a look at which types of biofuel projects with which features are currently being reviewed. Table 3.1 gives an overview of these projects. One of the projects is small-scale, and therefore can use the simplified standardised baseline procedure.

Apart from these projects that have been validated, the project pipeline is likely to include a larger set of Project Idea Notes (that may develop into PDDs and finally, registered projects). However, on these projects no reliable information was available at the time of writing.

[8] Which can be seen by looking at e.g. afforestation and reforestation activities: soon after the first methodology had been approved in December 2005, two such projects were opened for comments and may request registration.

Table 3.1 *Biofuel CDM projects at validation stage as of June 2006*

Methodology	Title/description	Source	Capacity	Biofuel type	Host country	Emission reduction (kCERs/yr)	% GHG reduction[9]	Remarks, technology transfer/ additionality, etc
NM180	Biolux Benji Biodiesel Beijing project: production and sale in 20% blend with petrodiesel; cooking collected from restaurants	Waste cooking oil	140 t/d	Biodiesel	China	123	83% (prod; methanol leakage; transport)	PM/HC/CO reduction claimed; waste management;
NM142 (B)	Palm Methyl Ester - Biodiesel Fuel (PME-BDF) production and use for transportation near Bangkok	Palm oil	300 t/d	Biodiesel	Thailand	218	74 (prod; leakage N_2O)	PM/HC/CO reduction claimed; IRR[10] from 3 to 12%
NM129 (B)	Sunflower Methyl-Ester Biodiesel Project in NE-Thailand; sold to fuel supplier; to be used in pure form (!)	Sunflower	45 t/d	Biodiesel	Thailand	34	70 (N_2O, prod.)	Pure BDF-ME claimed new technology; renewable fuel used
NM108 (B-revised)	Biodiesel production and switching fossil fuels; delivery to fuel stations for 5-20% blend with petrodiesel	Oil seeds, waste fats, etc	30 t/d	Biodiesel	India (Andhra Pradesh)	27	97 (power, transport)	Only power and transport; plantation of production trees in wastelands; esterification technology from Germany
NM082 (B-revised)	Khon Kaen fuel ethanol project; from sugar cane, to be blended with gasoline 10%	Sugar cane	85 kL/d	Ethanol	Thailand	46	83 (transport, N_2O/CH_4)	Renewable fuel in production; dehydration technology new; IRR from 5 to 11%
III-B (small-scale)	Biodiesel fuel production (small-scale); to be used in factories replacing diesel (East Sumatra)	Palm oil waste	7 t/d	Biodiesel	Indonesia	5.5	86 (transport)	Waste reduction, renewable power

NM: new (baseline and monitoring) methodology; B: B-case (can be resubmitted and approved subject to required changes by CDM EB).

9 In project boundaries, as calculated by: 1-(total project emissions)/(baseline emissions); in brackets the counted GHG sources: transportation of fuels, agricultural emissions (CO_2, N_2O and CH_4; sometimes also called leakage), fuel and power for biofuel production.

10 Financial Internal Rate of Return of the project.

We can make the following observations from the table:

- Most projects are in Thailand, and all of them in Asia.
- Most projects produce biodiesel, only one ethanol.
- Biofuel sources differ much, including palm oil and different types of waste.
- The project scale (in terms of CER generation) is comparable to most other CO_2 projects, such as energy efficiency and many biomass projects, i.e. 50 - 200 ktCO_2/yr.
- CO_2 reduction, as claimed on a life-cycle basis, is between 70-97%; often agricultural, transportation, and biofuel production emissions are considered (the latter is renewable in several cases). If we compare this to (short-term) biodiesel and ethanol figures in Appendix C in this report, the reductions claimed are substantially higher.
- Reduction in air pollution due to biodiesel is claimed in three cases.
- Four methodologies have received a ‘B’-comment from the CDM EB, implying that the methodology can be resubmitted subject to required changes[11].

[11] Which, if done with care, in practice means the methodology is likely to be approved in a later stage.

4. Suitability analysis of biofuel projects under the CDM

In this chapter biofuel projects are analysed (4.2) on CDM suitability criteria (4.1) on a general level. Also some barriers for biofuels in general are highlighted (5.3).

4.1 Assessment criteria

The approach followed in De Coninck et al (2005), which analyses eligibility of clean coal technologies under CDM and JI, is also applied here. The criteria to determine suitability of biofuel projects under the CDM are derived from the standard Project Design Document.
The criteria are:

1) *Significant greenhouse gas reduction:*
Determination of a baseline against which the GHG reduction is to be measured is required. Establishing a baseline for CDM projects has proven to be a complicated task in which a lot of uncertainties play a role. The baseline has to be determined with reasonable certainty against reasonable cost. In addition, the question of 'leakage' must be addressed: GHG reduction within the project boundary should not lead to an increase in GHG emissions outside the project boundary. For example, emissions from transport with a biomass power plant may increase because of the lower energy content of biomass relative to baseline coal.

2) *Additionality:*
A key element for a CDM/JI project is proving additionality. It must be clearly explained and indicated why registration of the project as a CDM or JI project is required to make the project feasible. For new technologies, for example, it can be assumed that use of CDM or JI is required to make the project financially viable for investors. Because of the essential nature of additionality for the purpose of CDM and JI, and at the same time the room for multiple interpretations, additionality and its interpretation in general remain delicate issues to all stakeholders involved.

Therefore, a tool comprising five steps has been developed that can be used to demonstrate additionality (UNFCCC, 2005). The tool has shown to help a great deal in this process, but still demonstrating additionality may not be easy. Important points are economic analyses for project proponents as well as end-users and the barrier analysis, which entails technological, policy, social or other barriers faced by the project proponents.

Many have pointed at the 'perverse incentive' the additionality criterion of CDM appears to give to a host country against implementing climate-friendly policies. E.g. a target for renewable electricity in a developing country would put the additionality of a new wind project under the CDM into question (assuming the target is not yet reached). Even though in practice it is difficult to substantiate this claim, there appears to be some empirical evidence for this (e.g. Figueres, 2005).

3) *Monitor-ability:*
In the years that the project 'generates' emission reductions, the variables that determine the emission (reduction) have to be monitored accurately, in order to assure real climate benefits. Verification by a Designated Operational Entity increases transparency and provides robust evidence of real benefits.

4) *Sustainable development contribution:*
In addition to GHG reduction, projects may result in other benefits: reduction of (air) pollutants, enhancing energy security of supply by reducing dependency on fossil fuels, promoting em-

ployment, and transfer of new technologies. Typically, if defined in these terms, renewable energy projects contribute significantly to sustainable development.

These elements refer to the second aim of the CDM: contributing to sustainable development in the host country. How sustainable development should be defined is largely unclear and is determined by the host country government. The Indian government, for instance, distinguishes net employment generation, equal income distribution, Internal Rate of Return, contribution to national balance of payments, saving of resources such as water or fossil fuels, and reduction in air polluting emissions as sustainable development indicators. The project proponents should assure that the project does not affect the local and national environment and society in a negative way, but preferably positively. The NGO CDM Gold Standard has developed a set of sustainability criteria and a tool for project developers which can be used for projects in order to be eligible for a Gold Standard project (The Gold Standard, 2005)[12]. These projects are then certified with the Gold Standard label ensuring high sustainability benefits.

The current CDM modalities and procedures lay down that the sustainability assessment of a project is a prerogative of the host country (UNFCCC, 2002b in Sutter 2003). The Designated National Authority (DNA) of the country develops sustainability criteria and evaluates the project's contribution to its sustainable development goals. In the early stages of CDM, several NGOs highlighted that this would lead to a 'race to the bottom': the host country with the 'lowest' sustainable development criteria would attract the most projects.

Looking at sustainable development criteria of several Asian countries (e.g. Bakker, 2005), this has not happened: most countries have developed a set of criteria that includes a general or detailed list of social, economic, and environmental aspects of sustainable development. In practice however - considering the DNA usually approves all proposed (types of) projects - these criteria do not appear to play a major role. In this light, it is interesting to observe that most non-CO_2 projects (see sections above) do not contribute significantly to sustainable development, whereas most CO_2 reduction projects exhibit much larger benefits (especially biomass, transportation and energy efficiency in the buildings sector) (Kessels & Bakker, 2005).

5) *Overall viability of CDM*:
This refers to how the additional investment and transaction cost of developing the project under the flexible mechanisms compare to the actual revenues from selling Certified Emission Reductions. The overall viability is defined as:

Overall viability = total CDM revenues[13]/(upfront) project costs

These costs differ substantially for the technologies currently used in CDM/JI projects. For most projects abating methane, nitrous oxide or HFCs developed so far, the revenues from emission reduction credits cover a large part (over 50%) of the investment cost. The transaction costs are also very low compared to the emission reduction credit revenues (<1%), as the GHG emission reductions can be relatively large (0.5-10 $MtCO_2$-eq/y). On the other side of the spectrum are renewable energy projects, for instance wind energy, where the credit sales typically cover around 5% of the investment cost and transaction costs could be more than 10% of the total revenues from carbon credits. For photovoltaic energy this number is even less favourable. There is not one CDM or JI project making use of photovoltaic technology, which could be an indicator that the overall viability is an important determinant.

[12] Recently there was a proposal for a law in the Dutch government requesting that CDM projects be assessed in a like-minded fashion before CER purchasing contract would be signed.
[13] Undiscounted and for one crediting period only; in this case, ten years in the case of CDM.

4.2 Suitability analysis

4.2.1 Significant greenhouse gas reduction

Though utilisation of biofuel is considered CO_2 neutral, the well-to-wheel fuel cycle is not. Most important GHG emission sources in the biofuel cycle are nitrogen based fertiliser utilisation, transport of biofuel, land use, land-use change, and the biofuel processing plant. Providing a conservative estimate of the project's emission reduction requires a very careful estimate of these, and possibly other, emission sources. Table 4.1 shows the GHG sources that should be considered. In cases where fuel or power is from renewable energy sources, emissions can be neglected.

Table 4.1 *GHG sources in well-to-wheel analysis*

Source	GHG	Explanation
Biomass cultivation	CO_2	May be positive
	CH_4	Anaerobic digestion
	N_2O	From fertiliser production
Biomass transportation	CO_2	From plantation to plant
Fuel	CO_2	Biofuel processing plant
Power	CO_2	Biofuel processing plant
Biofuel transportation	CO_2	From plant to distribution station

The baseline GHG emissions are those that would occur in absence of the proposed CDM project. In order to determine emission reductions by the project a credible baseline has to be established (ex-ante and ex-post, in the monitoring methodology). To this day, five such baseline methodologies for biofuel projects have been proposed and submitted to the CDM Executive Board (see above). None has been approved to date, but 29 for other types of projects have (UNFCCC, 2006). Approved methodologies are a crucial step in successful implementation of biofuel projects. Most difficult point is to make plausible which fuel is the baseline fuel.

4.2.2 Additionality

Based on financial investment analysis biofuels will be cost-effective only in rare cases. In general financial support will be required to make production and utilisation of biofuels financially attractive. Therefore CER revenues may contribute significantly (see 4.2.5) to the attractiveness of the biofuel project and additionality can be proven based on conventional investment analysis.

The additionality test can also be carried out based on a barrier analysis. The arguments of technological barriers and prevailing practice may be highlighted here. The production of biofuels is a relatively new technology with which more experience is necessary to create confidence among project developers and investors. Also utilisation of biofuels is not common practice in most developing countries. A biofuel project needs to overcome both technological barriers and additionality can be based on this.

4.2.3 Monitor-ability

The monitoring requirements for biofuel project may be substantial. As indicated in Table 4.1 there are many sources of GHGs that contribute to emissions of the project emission and all of these should be monitored in order to establish reliable emission reductions. This may be an important issue for reasons of: 1) difficulty in establishing an approved monitoring methodology and 2) costs of monitoring.

The first point is overcome once appropriate baseline and monitoring methodologies have been approved and can be used by other projects. The reason that the methodologies submitted to the CDM Executive Board thus far have not been approved can be found both in the baseline and the monitoring part of the methodologies, as indicated in the Methodology Panel recommendations to the submitted methodologies (UNFCCC, 2006). Apparently establishing a credible methodology for both baseline determination and monitoring is difficult.

When the project is implemented (using an approved monitoring methodology) all of the variables in the monitoring methodology need to be measured and verified by a Designated Operational Entity. As the list of variables to be monitored can be quite extensive (as shown in the submitted methodologies), this may imply a relatively large cost to the project as compared to most other types of CDM projects. However compared to the total project cost these operational transaction cost are likely to be small: in the order of 0.2 €t/CO_2 for medium-scale projects (Bhardwaj et al, 2004) and are therefore not a significant barrier.

4.2.4 Sustainable development

In this regard, it is important to note that biofuel projects may be one way the sustainable development component of CDM can be enhanced. This entails several aspects (see Sutter, 2003), who uses 12 criteria, for a more detailed overview):

- Energy security of supply: Biofuel production and utilisation is widely touted as a promising alternative for oil, mostly for reasons of reduction of dependency on imports from politically instable countries. Even though the concept of energy security of supply should not be narrowed to just import dependency, in practice this is a popular theme. In addition, biofuel also contributes to diversity of energy sources (Kessels & Bakker, 2005).
- Air pollution: the impact of utilising biofuel on (well-to-wheel or urban) air emissions depends on the type of fuel. Biodiesel has little or no impact on PM and NO_x emissions[14], but as sulphur content is much lower compared to diesel, SO_2 emissions are reduced, which is important in the urban environment. Ethanol replacing gasoline results in lower PM and slightly lower NO_x emissions, with little impact on SO_2. Future biofuels replacing diesel have the potential to reduce PM and NO_x even more. With the pollution load increasing in many Asian (mega)cities, this co-benefit of using biofuels may become important.
- Employment: several studies and current CDM Project Design Documents point to a significant contribution to local employment of biomass or biofuel projects. A general conclusion regarding the impact on employment is not possible, as the economic relations are complex and can be debated (Jansen & Bakker, 2006). However, it should be acknowledged that biofuel projects could contribute to national and local employment.
- Natural environment: the impact of biofuel production on natural resources depends on the source of biomass. Examples of possible negative impacts on biodiversity are unsustainable palm oil production in rainforest sites. As well, care should be taken that using organic 'waste' (e.g. rice husk) does not compromise possible other uses, such as fertiliser for local agriculture. On the other hand, if biomass is produced from sustainably managed land or forest, the impact on biodiversity and water resources may be positive.

Whether in the future the projects with higher sustainable development benefits stand a better chance depends on several factors. Firstly, the potential for projects with low benefits (that are often cheaper) may be lower, particularly for N_2O and HFC projects. If demand for CERs does not decrease, this would of course greatly stimulate the CO_2 projects. Secondly, different carbon markets for different types of project - each with its own price and buyer characteristics - may develop, as is currently happening with the Gold Standard on a relatively small scale. Indications for this possible development are not widespread, but the Dutch law proposal is one such example.

[14] Even though in some PDDs reduction in these air pollutants when using biodiesel is claimed, more authoritative literature (e.g. IEA, 2004) indicate only a small negative or positive impact.

4.2.5 Overall viability

The CDM project cycle, from project idea to final issue of the CERs, may be rather bureaucratic and requires careful work. As a result, transaction cost for developing a project under the CDM may be substantial, taking a significant share of the CER revenues (Bhardwaj et al, 2004). This depends on the project size, technology and rates of consultancies acting as Designated Operational Entities.

Some options exist to reduce transaction cost for small-scale projects. This includes bundling of multiple projects into one small-scale project, where the bundled project still needs to meet the small-scale definitions (see above). Another option to reduce cost would be hiring a DOE from a developing country, which in general charges lower rates. However, currently only two DOEs from non-Annex I countries are accredited by the UNFCCC, both from South Korea. Consultants from Colombia, South Africa, Malaysia and Brazil have requested accreditation (UNEP/Risø, 2006).

Current CER prices are in the range of 5-20 €/tCO_2-eq, depending on buyer, host country, technology applied, sustainability issues, and CER delivery risk (PointCarbon, 2006). It is uncertain how prices develop over the coming years and decades, due to developments in the EU Emissions Trading Scheme and CDM after 2012. Considering the possible range in future prices, CER revenues for CDM projects may vary substantially.

CO_2 abatement cost for both biodiesel and ethanol for current technologies are for most world regions estimated to be higher than US\$ 100/tCO_2-eq[15] (IEA, 2004). An exception is Brazil with cost between 10 and 30 US\$/tCO_2-eq. It is clear that with current CER prices the incremental cost of biofuel will not be met by the carbon revenues alone. However, if some certainty for continued CER demand and prospect for favourable price ranges can be given, then the CDM may cover a significant part of the gap. The remainder will have to be covered by appropriate economic policy, e.g. biofuel subsidies (if deemed appropriate). Clearly, there is an intricate interaction between these subsidies and the additionality requirement of CDM project. Subsidies making biofuel projects profitable without carbon revenues may be rejected as CDM project on the basis of non-additionality. The 'perverse incentive' of the CDM - the disincentive for governments to stimulate climate-friendly technologies - applies. The extent to which the CDM contributes to the financial viability of biofuel projects however will be very difficult to determine. This will be comparable to other renewable energy projects such as wind energy, where subsidy schemes are also in place in many countries. Looking at the current CDM project portfolio there does not appear to be strong evidence that these policies have prevented renewable energy project to be developed and approved under the CDM.

It should also be noted that the CDM may improve the (financial) viability of climate change mitigation projects in different ways (Gouvello & Coto, 2002):

- Achieve a minimum internal rate of return. CER revenues may be used to improve profitability of the project by covering part of the initial investment cost (by up-front CER purchase agreements) attract private investors by assuring a minimum IRR. Also carbon revenue involves different and reduced risk compared to usual risks in such activities, which helps in attracting investors.
- Help in long-term sustainability of the project. Carbon revenues can be used to cover operating & maintenance cost, which is particularly useful in the case of renewable energy projects.
- Overcoming other barriers, such as attracting agents more familiar with new technology. This is often a side effect of an international mechanism like CDM.

[15] However for 2nd generation biofuels there is potential for lower abatement cost provided these technologies and biomass sources become commercial available after 2010.

4.3 General barriers

Apart from barriers specific to CDM projects, several barriers applicable to biofuel production and utilisation in general should be mentioned. This is a short summary of the barriers discussed extensively in ProBIOS (2006).

- *Regulatory barriers*. These relate to (local) environmental policy, use of waste (in case of waste used as input), international trade of biomass, and licences for biofuel conversion plants.
- *Technological barriers*. The technologies for conversion of biomass into biofuels are well-established, but further improvement and experience is needed. In end-use, the engine technology may be the limiting factor for blending higher percentages of biofuels. Adaptations to current engine design is required to make higher blending shares possible.
- *Market potential.* The high price of biofuels is largely determined by feedstock costs and is therefore likely to remain relatively high compared to conventional fuels. Attaining and maintaining continued demand and supply of biofuels may also be challenge.
- *Biomass supply*. Currently no specifications for biomass supply exist which implies that the quality of biomass is constantly under discussion. Supply routes from source to plant and end-user need to be established. Biomass sources are also in competition with other uses than biofuels, such as food production.

Despite these barriers, the ProBIOS project considers the potential for biofuel production and deployment considerable. Appendix D elaborates on the potential for biofuel projects in India.

4.4 Institutional aspects

The 2001 Marrakech Accords laid down that “Parties participating in the CDM shall designate a national authority for the CDM”. This Designated National Authority (DNA) can submit a Letter of Approval to the CDM Executive Board in order to have a proposed CDM project registered. The typical set-up of the DNA is a special body within the ministry of environment, with a secretariat. It also contains members from other relevant ministries that deal with energy, economy, forests, trade, foreign affairs, agriculture, transportation, health and water. It may be supported by special committees such the Energy Technical and Forests Technical Committee in Malaysia. As of June 2006 most Asian countries have established a DNA. The approval procedure however can still be rather complex and may take up to several months.

5. Future of CDM

With the Kyoto Protocol coming into Force in early 2005 and a considerable shortfall in emission reductions projected for the Annex-I countries that have ratified the protocol, the CDM is set to play an important role up to 2012. However, uncertainty regarding what will happen after 2012 in international climate policy has a large impact on current incentives for development of CDM projects. New projects have a lead-time up to several years, which means that the CER revenues that can be gained up to 2012 are diminishing. The question for project developers is then: what will be the value of emission reduction after 2012? Another significant matter is which activities will be eligible under the CDM?

5.1 Future of climate policy

Regarding the first question, the main issue relates to agreement among key world regions about the future of climate policy. The debate focuses on the feasibility and impacts of mandatory greenhouse gas target for industrialised countries, and step-wise commitment for developing countries. Currently there is a great divide among nations about future commitments and only slow progress is made towards bridging the divide. A ‘Dialogue on long-term cooperative action’ and an Ad Hoc Working Group on Future Commitments for Annex-I Parties has been established under the UNFCCC to explore options to come to agreement. The first meetings have been held in May 2006 and had an open and explorative character. Anything to be said regarding the outcome of these 2-year processes will be highly speculative.

For CDM, agreement about GHG targets for industrialised countries would almost certainly mean a large impetus, as demand for emission reductions from developing countries would be substantial. The role that CDM is allowed to play in meeting reduction targets could be subject to international negotiations. It also depends on the role of the more advanced developing countries: if these are subject to targets themselves, this will impact possibilities to develop activities under the CDM.

On the other hand, if no such agreement would be reached, but international climate policy would focus more on voluntary actions and technology cooperation, the future for CDM is much more uncertain. CER demand could plummet in that scenario. Hybrid scenarios between these two options are also possible: reduction targets among a set of committed (industrialised) countries including CDM relations with (selected) developing countries, and agreement on technology development and deployment among (other) countries.

5.2 Eligible activities

The role of CDM also depends strongly on the role of the more advanced developing countries: if these are subject to targets themselves, this will impact possibilities to develop activities under the CDM. For example, if China accepts a ‘no-lose’ target[16] for its cement industry, less reduction measures will be eligible in this sector compared to a situation with no targets at all, as this target already acts as an incentive to implement GHG saving technology.

A second important issue in this light is broadening of the scope of eligible activities. Currently there is debate about including avoided deforestation and nuclear energy projects in the range of activities. Also at the CoP/MoP in Montreal it was decided that programmes as CDM projects

[16] A no-lose target implies that GHG emission reduction below this level can be sold as CERs, while overshooting of the target will not be punished.

are accepted. Programmatic CDM is defined as ‘multiple activities executed over time as result of a government measure of private sector initiative (PointCarbon, 2006). Programmatic CDM or sector-CDM can then be part of the ‘current’ CDM but probably new roads have to be taken also to address new issues that will arise.

The central idea behind the sectoral approach to the CDM is to define a baseline with a greater scope than that of a single project. Two main types are distinguished (Sterk & Wittneben, 2005):

1. Policy-based CDM, in which a Non-Annex I government develops policy that results in lower GHG emission in a particular sector, and the CERs flow directly to the host government, which has the option of passing on (part of) the revenues to affected industries or households.
2. Clustered approach, in which a private actor may combine potential GHG reduction projects within a certain sector, using a single baseline for these projects.

Regarding sectoral CDM, a set of issues needs to be addressed:

- Sector definition (many options).
- Who receives the benefit from CERs (especially for policy CDM).
- Baseline more complex to establish.
- Policy-CDM: baseline/target binding or non-binding for host government.
- Additionality.
- Double counting, project boundaries, leakage.
- Project approval.

For biofuel, both types can be highly relevant. For example, a national or regional government may decide to adopt a certain target for biofuel consumption. The measures actually implemented lead to GHG reduction (against the baseline of no biofuel policy) reduction and certain CERs. These flow principally to the government implementing the policy, but it can be chosen to recycle the revenues (partly) to biofuel producers and consumers to relieve the financial burden being put on them by the policy.

In the clustered approach, it is the private actors implementing the biofuel production projects (which again results in emission reduction compared to the baseline) who receive the CER revenues. This can be carried out in much the same way as is currently done, but the scope of the activity will not be restricted to one single project, but extends to a region/district, transportation subsector, etc. The main difference with current biofuel CDM project will be extending the baseline to cover all intended activities.

6. Conclusions

Currently the CDM market is taking off, with many projects coming on-line, CERs issued and methodologies approved. Especially India is a popular host country, while China and ASEAN countries are increasingly important. For biofuel projects, no baseline methodology has been approved till the time of writing, while five are under review. As a result, the project pipeline for biofuels is limited.

From the five biofuel CDM projects up to PDD stage, it can be observed that 1) biomass sources are very different, 2) most projects are about biodiesel, 3) host countries are all in South/South-East Asia and 4) the claimed well-to-wheel GHG reduction is between 70 and 97%.

From the suitability analysis, it is concluded that biofuel projects are in principle eligible under the CDM. The most important barriers to further development of biofuel CDM project are establishing approved baseline and monitoring methodologies. CER revenues will in most cases only cover part of the additional cost of biofuels compared to conventional fuels. Monitoring requirements may also be substantial. On the other hand, biofuel projects may be an opportunity to develop projects with strong sustainable development components, and as such contribute strongly to the twin-objective of the CDM.

CO_2 abatement costs of biofuels are in general higher than current CER prices, which are in the range of 5-20 €/tCO_2. Future CER price trends are uncertain due to uncertainties in the current and post-2012 international climate policy developments.

Sectoral CDM may improve the options to develop biofuel projects under the CDM. In the case of policy CDM, also the perverse incentive of the current CDM not to implement GHG reduction policies may be overcome.

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Abbreviations used

AM	Approved (baseline & monitoring) methodology
Annex-I countries	Countries included in Annex-I of the UNFCCC (i.e. industrialised countries and economies in transition)
BDF	Biodiesel fuel
CDM	Clean Development Mechanism (KP flexible mechanism)
CER	Certified Emission Reduction (CDM unit)
CH_4	Methane
DNA	Designated National Authority (host country body approving CDM projects
DOE	Designated Operational Entity (validator of CDM projects)
EB	(CDM) Executive Board
EE	Energy efficiency
GHG	Greenhouse gas
GWP	Global warming potential (tCO_2-eq)
HC	Hydrocarbons
HFC	Hydrofluorocarbon
IRR	Internal rate of return
KP	Kyoto Protocol
$MtCO_2$	Million tonnes of CO_2
N_2O	Nitrous oxide
NGO	Non-governmental organisation
Non-Annex I countries	Countries not included in Annex-I of the UNFCCC (i.e. developing countries)
NO_x	Oxides of nitrogen
PDD	Project Design Document
PIN	Project Idea Note
PM	Particulate matter
Rs	(Indian) rupees
SO_2	Sulphur dioxide
UNFCCC	United Nations Framework Convention on Climate Change

Appendix A CDM project cycle

	CDM Project Cycle	Responsibility
Project Design	Project design documents, baseline study, estimation emissions reduction, environmental impact, monitoring plan, stakeholder comments	Project Participants, including stakeholders who can comment
	Validation of project design document	Designated Operational Entity; Approval from national CDM authority
	Comments on validation	UNFCCC party stakeholders, accredited NGOs
	Registration	CDM Executive Board
Project Implementation	Implementation of the project	Project Participants
	Monitoring emissions reduction & reporting	Project Participants
	Verification of monitoring report (resulting in verification report)	Designated Operational Entity
	Issuance of CERs (based on certification report OE)	CDM Executive Board
Project Revenues	CERs sold or banked	Project Participants

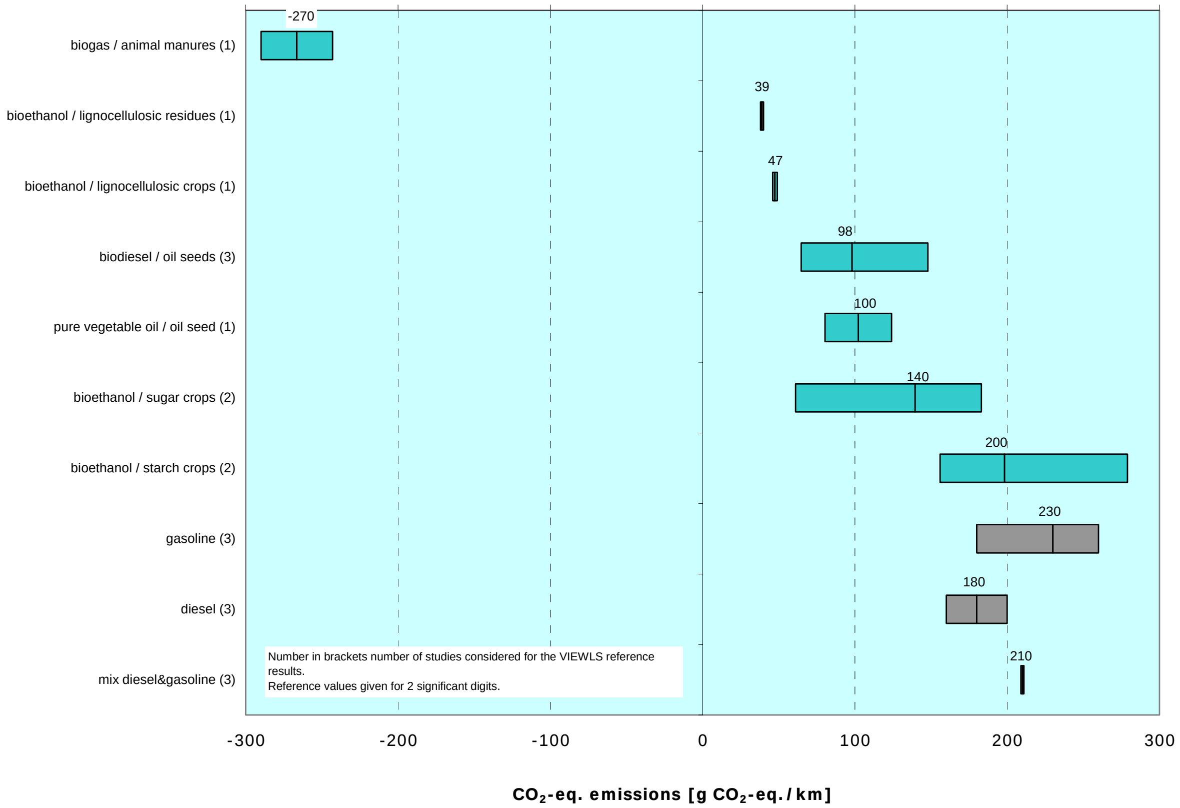
Source: De Coninck et al, 2005.

Appendix B Detailed technology break-down of validated CDM projects (as of June 2006)

Type	number		CERs/yr (000)		Accumul. 2012 CERs (000)	
Biomass energy	194	23%	10794	7%	78690	8%
Hydropower	145	17%	8883	6%	59111	6%
Energy efficiency industry	110	13%	8394	5%	62824	6%
Wind power	100	12%	7261	5%	52789	5%
Agriculture	91	11%	4820	3%	34788	3%
Landfill gas	75	9%	18798	12%	127910	12%
Fossil fuel switch	32	4%	1715	1%	14069	1%
Biogas	32	4%	1728	1%	12471	1%
Cement	22	3%	2847	2%	25689	2%
HFCs	13	2%	59609	39%	392567	38%
Fugitive CH4 emissions	7	1%	5571	4%	37419	4%
Solar energy	5	1%	56	0%	354	0%
Geothermal power	6	1%	1545	1%	9817	1%
Energy efficiency households	4	0%	87	0%	510	0%
N_2O	6	1%	19292	13%	118345	11%
Energy distrib.	2	0%	209	0%	1509	0%
Energy efficiency service	10	1%	600	0%	4666	0%
Coal bed/mine methane	2	0%	59	0%	541	0%
Tidal energy	1	0%	315	0%	1104	0%
Transportation	1	0%	7	0%	59	0%
Afforestation & Reforestation	2	0%	72	0%	619	0%
Total	860	100%	152661	100%	1035851	88%

Source: (UNEP/Risø, 2006)

Appendix C   Specific GHG emissions - current technology



Reference values and ranges of $CO_{2\text{-}eq}$ emissions (g $CO_{2\text{-}eq}$/km) - Current technology (review of 73 studies under the VIEWLS project)

Appendix D Potential for biofuel projects under CDM in India

There exists a good potential for projects based on biofuels under CDM. After extraction of oil from the biomass, the remaining biomass can be used as biogas and the final slurry after extraction of biogas is a very good fertiliser. The biofuels can be used as replacement of fossil fuel. CDM benefits can be availed from both sequestration as well as abatement by promoting biofuels in India. The main sources of raw materials for biodiesel manufacturing in India are oil-bearing seeds of Jatropha and Pongamia tree species. Production and deployment of biofuels in India may lead to alleviation of poverty and improve the social status in rural areas as it creates ample employment opportunities for producing and collecting raw material during biofuels production.

Biofuel production and consumption projects may contribute to climate change mitigation in different ways:

- CO_2 sequestration by biomass in case the average stock of carbon in the project situation is larger compared to the baseline.
- Biofuel replacement of fossil fuel consumption, as biofuel life cycle GHG emissions are likely to be lower than those of fossil fuel.
- Biogas generated from fermenting the oil cakes after extraction of biofuels can be used as a fuel in rural home to replace kerosene.
- Biofertilisers replaces chemical fertilisers and hence saves power that would have been otherwise used to produce the fertilisers.

A list of GHG reduction potential from various activities associated with the use of biofuel as compiled from the Report on National Mission on Biodiesel, by Planning Commission, Government of India (Government of India, 2003), is presented in Table D.1.

Table D.1 *GHG reduction potential of activities associated with the use of biofuel*

Activity	Per unit CER potential
Growing of Jatropha	3-3.5 tonnes per hectare/ year
For replacing fossil fuel in transport sector	0.89 tC/tonne of fossil fuel replaced
Biogas to replace kerosene	0.85 tC/ tonne of fuel replaced
Outer shell to replace furnace oil in boilers/furnaces	0.85 tC/ tonne of furnace oil replaced
Biofertilisers	0.72 tC/ tonne of fertiliser.

Each tonne of biodiesel produced or consumed leads to a reduction of approximately 3 tonnes of CO_2-eq. At a market price of carbon credits of US$ 5 per CER, this translates into additional revenue of Rs 700 (US$16) per ton of biodiesel consumed or Rs 0.75 per litre, of biodiesel consumed (Panigrahi, 2004). With 2006 CER prices of approximately 10 €/tCO_2, the revenue will be more than Rs 1.5 (US$0.034) per litre. To illustrate, below are two examples of experience in India, including economics.

According to the National Mission on Biofuels, around 3 Mt of biodiesel is required for 5% blending of biodiesel in petro-diesel and around 14 Mt of biodiesel is required for 20% blending, by the year 2011-12. This translates into a reduction of greenhouse gas emissions to an extent of 40 million tCO_2-eq during 2011-12, with 20% biodiesel blend, which offers great potential for greenhouse gas emission reductions in the long run (Government of India, 2003).

In early 2005, Gujarat became the first state to put biodiesel to commercial use. Gujarat State Road Transport Corporation, a state-owned transport utility, began commercial service of buses that run on a diesel blend containing 5 percent biodiesel from Jatropha. There are plans for constructing biofuel plants and some firms have set targets for planting Jatropha. In October 2005, Minister for Petroleum and Natural Gas Mani Shankar Aiyar announced that, beginning January 1, 2006, the public sector oil marketing companies will be purchasing biodiesel, using oil from Jatropha and Pongamia plants, at Rs 25 (US$0.57) per litre. Initially, B5 will be marketed during trial runs, and the percentage of biodiesel blended will be increased in stages to 20.

Prior to this, the Karnataka State Road Transport Corporation (KSRTC) used state vegetable oil (SVO) as transport fuel. About 3 years ago KSRTC, a public transport corporation under the Government of Karnataka started trials by using pongamia oil in its buses. After initial testing on old buses, in 2004, trials were taken up in 2 new buses with 10% oil blend. The performance of these 2 buses was compared with the 2 new buses running on diesel on the same route. Initially, some problems came up in proper mixing of pongamia oil with diesel, which was solved by adding an enzyme-based additive. The cost of the additive is Rs 2200/litre and 1 litre of additive is added in 6000 litres of fuel. According to KSRTC, an overall efficiency (mileage) improvement of 12.5% has been observed in comparison with diesel. However, KSRTC has estimated an overall saving of Rs 3/litre by using the blend with diesel even with the additional cost of Rs 3.67/litre for the enzyme-based additive, in addition to the costs for more frequent replacement of fuel filters.