Are Managed Forest and Soils an effective Strategy for Climate Change Mitigation – an Example from Sweden

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ABSTRACT

Managed forest land has a potential to reduce GHG emissions through production of biomass for fossil fuel substitution, and sequestration and conservation of C. This is the case in Sweden, where managed forest land amounts to 52% of the total land area. The main strategy for GHG reductions is considered to be sustainable use of biofuels to replace fossil fuels. The use of forest biomass for this purpose is presently replacing around 4 Mton C of oil C emissions, approximately 25 % of present emissions of fossil fuel C. More effective use of harvest residues could replace another 3-4 Mton C. Other strategies are e.g. to afforest set-aside farm land and to fertilise forests. This would result in higher production and more harvest residues to replace fossil fuels, However, any strategy for biomass fuel production has to be evaluated regarding its consequences for sequestration and conservation.

Thus, harvesting residues, afforestation and fertilising have both positive and negative implications on GHG sequestering and conservation. The effects are time dependent. In the short perspective, sequestration is important whereas in a longer perspective substitution will be more important. We estimate that the implementation of new strategies in managed forests might replace oil-C and sequester C in an amount equal to > 30 % of the present C emissions from fossil fuels. If also business-as-usual is included, than managed forestry could reduce emissions corresponding to near 100% of present emissions from fossil fuels.

Carbon Pools in an Eucalyptus Forest Managed for Production or Conservation

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PowerPoint presentation: www.joanneum.ac.at/iea-bioenergy-task38/workshop/canberradata/payne.ppt

ABSTRACT

The idea behind using forests as carbon sinks relies upon knowledge of how forest management affects the associated carbon pools. It is essential to take into account not only the carbon storage capacity of forests ecosystems, but also the rate at which carbon is sequestered.

Information on the storage and sequestration of carbon is limited in native forest management in Australia. Collection of further information is essential in our commitment to the Kyoto Protocol. By using date collected from a native Blackbutt (Eucalyptus pilularis) forest before and after harvest, the amount of carbon stored can be calculated and modelled for conservation management or timber production. Modelling involved the use of CAMFor to simulate different harvesting and conservation parameters.

Actual Harvesting reduced the above ground biomass by approximately 50%. Of which 15% was removed offsite as wood products for short or long term storage. The relative amount of carbon stored by the forest ecosystem changed substantially as the remaining 35% is subsequently burnt.

The implications of this and alternative management practices for carbon sequestration are discussed.

Sustainable Steel Production – the Role of Forest Biomass

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PowerPoint presentation: www.joanneum.ac.at/iea-bioenergy-task38/workshop/canberradata/jason.ppt

ABSTRACT

With funding from the New South Wales State Government's Sustainable Energy Research Development Fund (SERDF), a project has been undertaken by BHP Minerals Technology and NSW State Forests to evaluate the use of forest biomass for steel production in Australia. The main driver for the study was to reduce Greenhouse Gas Emissions (GGE) from steel production, by partial replacement of coal.

A range of tree species from both native forests and plantations, were assessed for charcoal production, and the factors affecting charcoal properties defined. A tonnage quantity of charcoal was produced and used for full-scale trials as a source of carbon in electric arc furnace steelmaking (a market of around 10,000 tpa in Australia). Large-scale uses (such as an injectant in blast furnace ironmaking) were also considered.

Life cycle analysis was used to assess greenhouse gas emissions from the entire process chain (forestry operations, transportation, charcoal manufacture and steel production). These emissions are compared for steel produced from current steelmaking practice

Linkages between Carbon Sinks and Bioenergy: Trade-offs and Synergies

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PowerPoint presentation: www.joanneum.at/iea-bioenergy-task38/workshop/canberradata/schlamadinger.ppt

ABSTRACT

Forest management-related carbon sinks in Article 3.4 of the Kyoto Protocol, and sinks in general under the Clean Development Mechanism were among the contentious issues that contributed to the breakdown of negotiations at COP6 in The Hague (November 2000). Forests and other lands fulfill many important roles besides being a carbon reservoir and possibly a carbon source or sink. Some of these roles can be valued economically, and some of the functions are correlated with the carbon source/sink function of the land. For example, new afforestation and reforestation activities on agricultural land will lead to greater future availability of woody material, and at the same time increase carbon stocks on the land. Increased levels of harvesting in existing forests may have a diminishing effect on carbon stocks, whereas decreased harvest levels could enhance carbon stocks over and above a reference scenario.

Carbon crediting for existing forests under Article 3.4 may introduce an economic incentive to maximize carbon stocks on the land. Continued sustainable management of existing forests, with the aim of producing timber and biofuels, would incur an "opportunity cost" that could partly offset the gains achieved through substituting fossil fuels with biomass fuels and energy intensive materials such as steel, glass and concrete, with wood-based materials.

Ways must be found which provide incentives for better management of the terrestrial biosphere, supporting (or at least not compromising) the substitution options such as using bioenergy as a replacement for fossil energy. This paper focuses particularly on options for linking bioenergy projects in the Clean Development Mechanism with crediting of carbon accumulation through afforestation and reforestation (and possibly revegetation with non-forest crops), by allowing bioenergy projects to include carbon stock changes on the associated lands from which the biofuels are derived.

Keywords: Carbon sinks, carbon sequestration, biomass, bioenergy, forest management, afforestation, reforestation, Kyoto Protocol, Clean Development Mechanism

INTRODUCTION

Biomass can play a dual role in greenhouse-gas mitigation related to the objectives of the UNFCCC, i.e. as an energy source to substitute for fossil fuels and as a carbon store. Modern bioenergy systems offer significant opportunities towards reducing greenhouse-gas emissions while providing additional benefits. Moreover, via the sustainable use of the accumulated carbon, bioenergy has the potential of resolving some of the critical issues surrounding long-term maintenance of biotic carbon

stocks (IEA Bioenergy, 1998). This paper discusses the impacts of various sinks-crediting provisions under the Kyoto Protocol on biomass energy, including possible trade-offs and synergies.
The matrix (Table 1) shows different bioenergy options, depending on a) whether biomass fuels are derived form forest or non-forest systems, and b) whether these options are implemented on former forest or non-forest lands. The matrix also shows which Articles of the Kyoto Protocol could apply.

Table 1: Overview of different biomass energy categories, and their relationship to the land-use related Articles of the Kyoto Protocol

	Previous forested land	**Previous unforested land**
Woody biomass	Managed forest extraction: (a) additional extraction (b) greater use of existing forest industry by-products • *Article 3.4 (forest management) for (a)* • *(b) does not directly impact forest C stocks.* • *CDM (forest protection)*	Coppice or Short Rotation for energy • *Article 3.3 (afforestation, reforestation), provided that these crop are "forests"* • *CDM (afforestation and reforestation)*
Non-woody biomass	This option is not recommended from a carbon balance perspective because there is likely to be a decrease in carbon stocks on the land (deforestation). There may be some exceptions like agroforestry systems.	E.g. switchgrass for power / liquid fuels • *Article 3.4 (either cropland/ rangeland management, or revegetation)* • *CDM (activities other than afforestation and reforestation)*

ARTICLE 3.3 AND THE USE OF NEW FORESTS AND THEIR RESIDUES FOR ENERGY

Stock changes in the 2008-2012 commitment period, resulting from afforestation / reforestation / deforestation activities since 1990, are accounted under Article 3.3. Following discussion on the definitions of terms like "forest" and "reforestation", and with information from the IPCC Special Report on land use, land-use change and forestry (LULUCF) (IPCC, 2000) and recent technical papers (UNFCCC, 2001) it is likely that afforestation and reforestation will be defined as conversion of non-forest to forest, and deforestation as conversion of forest to non-forest; the term "forest" will be defined as land that has a crown cover above an agreed threshold (e.g. 10-30%) or that will reach such a status with continuation of ongoing management (i.e., bare land after clear cut, but planned for regeneration, is also considered forest). With these definitions the regeneration of forests after clear-cut harvest does not qualify as reforestation because it is part of an ongoing forest management regime.

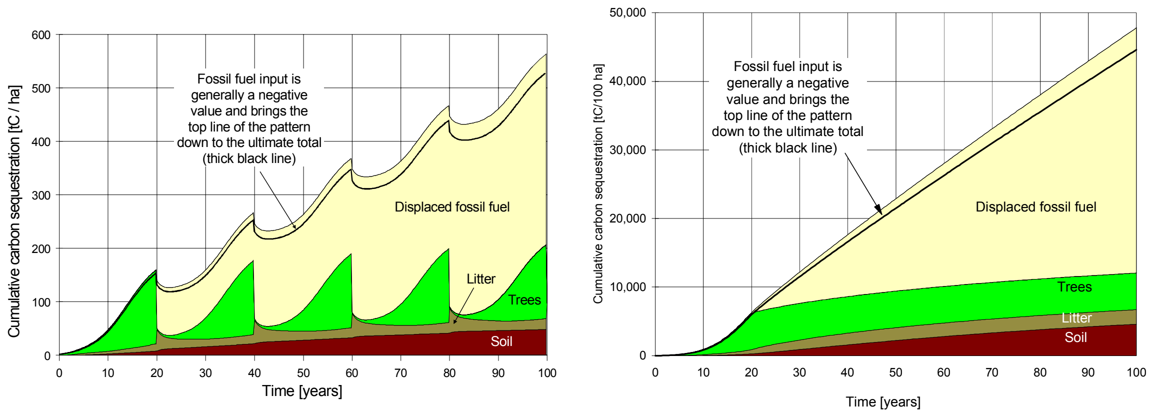
How might Article 3.3 affect bioenergy?

Article 3.3 provides an additional incentive to establish new biomass plantations if they fulfill the definition of a "forest" and are created since 1990 on former cropland, pasture land, or other non-forest land. Carbon credits (in addition to credits for any emissions reduction due to biomass fuels displacing fossil fuel) would be equal to carbons stock increases on such lands between 2008 and 2012. If the plantation is in equilibrium by the year 2008, i.e., harvest equals regrowth, there would be no LULUCF credits and thus no additional incentive. A net increase of carbon in the plantation would occur if a) it is not yet harvested during the commitment period, b) the rate of harvest is lower than the rate of growth, or c) if the harvest equals regrowth but there is a net increase in soil carbon. Obviously any increase in the level of harvesting for biofuels or other forest products will be at the expense of LULUCF credits that can be earned for afforestation or reforestation in the first commitment period and in practice owners of plantations would be free to balance carbon stock increases and bioenergy sales to maximise returns. There would of course be a general increase in time average carbon stocks from the plantations, consistent with the concept of the normal forest (box 1) and because of this Article 3.3 is generally favorable for biomass energy - in the long term the incentives for afforestation and reforestation will create a new source for bioenergy and timber.

Box 1: The concept of a "normal forest"

Energy (and other) plantations will usually not consist of one single stand that is harvested every n years, but of an ensemble of n stands, n equaling the rotation length in years. This allows one stand to be harvested each year, while n-1 stands are regrowing. Such a system is often referred to as "normal forest". If, for example, each stand is growing from zero tC carbon to 50 tC carbon per ha, then the average carbon per hectare in the normal forest is 25 tC/ha. This is the time-average, as well the spatial average, of carbon stocks per hectare. Therefore, if carbon accounting is done for the full normal forest, there will be no debit as would be the case for an individual stand. Carbon credits in the first commitment period would accrue to the extent that the carbon stock in the normal forest is still increasing during the commitment period. Figure 1 shows the carbon stored in trees (in green) for a stand (left) and a normal forest (right) managed with 20-year rotation length.

Figure 1: Reforestation with subsequent use of harvested biomass for energy on the stand level (left) and landscape level – that is a plantation system producing a constant stream of biomass (right).



The carbon stock in standing trees reaches equilibrium after 20 years. Credits for C sequestration in trees will occur if the equilibrium state is reached after the beginning of the first commitment period. In general, any new "since 1990" plantations that have not yet reached their equilibrium state by 2008 are eligible for carbon credits. The equilibrium level of carbon stocks is the greater, the longer the rotation length of the forest. Therefore, there may be an incentive, from a carbon-credit perspective, to delay harvesting, because harvest is associated with the opportunity cost of not being able to claim further carbon sequestration. However, new plantations that are encouraged by carbon deliberations will in any event provide an additional timber and possibly biofuel resource that would not have been available otherwise.

The trade-off between maximizing on-site carbon stocks and maximizing output will depend on the relative prices of biofuels/timber vs. the price of CO_2 credits, but also on the amount of carbon in fossil fuels that can be displaced with one ton of carbon harvested for bioenergy. The more carbon can be displaced that way, the more likely harvesting for biofuels will be favored. For further details on the trade-offs between on-site sequestration and fossil-fuel substitution see Marland and Schlamadinger (1997).

ARTICLE 3.4 ANALYSIS IN RELATION TO BIOMASS ENERGY PRODUCTION

Two broad groups of options have been proposed for LULUCF activities in Article 3.4: narrowly defined activities (such as improved forest thinning, longer rotation periods etc.) and broadly defined activities (forest management, cropland management, grazing land management) (IPCC, 2000). Recent negotiations have focussed mainly on the latter. The current negotiating text (UNFCCC, 2001) proposes to include forest management, discounted by 85%, up to a cap for each Party which would also limit agricultural activities (cropland and grazing land management and revegetation), afforstation and reforestion sinks in the CDM, and "Joint Implementation" sinks.

How does Article 3.4 crediting affect bioenergy?

For the sake of this discussion we distinguish between bioenergy uses that increase carbon stocks in forest management / cropland management / grazing land management, and those that decrease stocks.

A) Biomass energy increases carbon stocks

An example is cultivation of herbaceous energy crops on former cropland, such as miscanthus or switchgrass. This activity is likely to increase soil carbon stocks and/or carbon in vegetation. Adequate consideration of such bioenergy projects in terms of their sinks component seems to be ensured with draft decisions as proposed in (UNFCCC 2001). These draft decisions propose a net-net accounting approach for cropland and grazing land management ("net-net" means that the sink strength in the first commitment period is compared with that in 1990, and any increase of sink being credited and any decrease debited). Such an incentive through Article 3.4 crediting would be in addition to the reduction in carbon emissions from substituting fossil fuels with biofuels.

Biomass energy production leading to greater carbon stocks may also occur within the narrowly defined activity "revegetation", which has also been proposed as a separate activity under Article 3.4.

B) Biomass energy decreases carbon stocks

Carbon credits for sequestration in existing forests ("second Tier" in proposal for Article 3.4, UNFCCC 2001) may create disincentives for biomass harvest that decreases equilibrium carbon stocks. Examples are the increased removal of logging residues, enhanced thinning, or a shortened rotation length possibly combined with a change in tree species, for increased output of timber and biomass fuels. However, the disincentive will be small if only a small fraction of carbon uptake is credited using broadly-defined activities (such as in the 15% discount proposed for existing forests, UNFCCC, 2001). Moreover, so long as the discounted uptake (plus third Tier in Art 3.4, and relevant JI and CDM credits) exceeds the cap, any reduction in biomass because of energy uses would be compensated by crediting of uptake elsewhere in the forest and there would be no disincentive.

Due to the perceived disencentive some wood-based industries are concerned about carbon crediting under Article 3.4. They see a competitive use of forests emerging that may move the equilibrium towards less harvesting and that could increase wood prices. The same concerns apply to the bioenergy objectives in the EC White paper on Renewable Energy. Bioenergy, pulpwood and carbon credits are often competing for the same lands and for the same biomass. However the commercial value of the timber harvest is likely to be greater than its carbon value under Article 3.4 and so the effect may not be so significant in practice.

Furthermore, associated sink crediting in the first commitment period may allow to increase the resource for future bioenergy uses, and may therefore prove beneficial for bioenergy in the long term. The overall conclusion is again that the Art 3.4 proposals in the Consolidated Negotiating text (UNFCCC, 2001) are reasonably favourable to the development of forestry options which would increase the use of biomass fuels in the longer term, but that the short-term trade-offs should be kept in mind when selecting rules for national implementation of Article 3.4.

Additional observations on forest management in Article 3.4

The following discussion focuses on biomass fuels derived from the land-use category "forest management" (Second Tier in proposal for Article 3.4, UNFCCC 2001). If at some future stage parties wanted to address the trade-off between bioenergy (and other industrial wood uses) and sinks enhancement in the first commitment, and to provide better incentives for truly additional forest management projects for carbon sequestration, then some options would be:

1) allowing very limited credit (e.g., 10 or 15%) for existing sinks in managed forests. This is low enough not to compromise enhanced removals for bioenergy, low enough to minimize windfall credits, but still high enough to provide (politically important) carbon credits to some countries. In

addition, one could allow an increase in the discount factor to the degree that the use of bioenergy (possibly excluding residues from various wood-based industries, because they are not directly derived from the land) is increased since 1990 on the national level. This could be done with a simple conversion factor that relates the increase in the amount of bioenergy (or the increase in total harvest share that is used for bioenergy) with the additional carbon credits for sinks in Article 3.4 (Second Tier, "forest management").

This option could offset a disincentive for bioenergy that results form Article 3.4 crediting. However, an impediment may be the poor data availability on bioenergy use in many countries. And this option would not create a full incentive for new, and truly additional, carbon mitigation projects in managed forests.

Formula as a start for discussion:
Discount factor = 10% + Constant x [$B_{2010} - B_{1990}$] */ LULUCF sink in managed forests in 1990*

B_{2010}: Bioenergy use in 2010 (PJ)
B_{1990}: Bioenergy use in 1990 (PJ)

If bioenergy is measured in the form of end-use energy such as electricity, heat or liquid biofuels, then there would also be an incentive for improving the efficiency of biomass conversion, besides that for using more biomass. The constant in the above formula could be chosen such that an increase in the share of bioenergy by 1 PJ could yield an increase in the discount factor by 1 (5, 10, 15 ...) %. However, this would mean that a large, forest-rich country could get more credits for each PJ of increase in biomass use than a small country. Therefore, one could introduce the additional part *in Italics*, thereby ensuring that the bioenergy increase is considered in relative terms to the sink strength.

2) using narrowly defined activities, i.e. to allow full crediting for new land management projects which are truly "additional". Such projects would have to address concerns of leakage, and thereby address the negative effects for wood industries and bioenergy explained earlier. A LULUCF project would have to show that it can provide the same, or a greater amount, of goods and services (such as timber and biofuels) than the reference land use, before stock changes on the land can be credited. For lands not undergoing a "project" there is no disincentive for biomass energy because no carbon crediting occurs on such lands.

Very importantly, option 2 would provide a 100% incentive for Article 6 (Joint Implementation) sinks projects that are not afforestation or reforestation projects - whereas option 1 would not.

3) discounted crediting for activities between 1990 and 2000 combined with a full project-based crediting for new LULUCF activities since 2000 or a subsequent date, provided that these activities meet an additionality test and similar criteria as in the CDM. This would imply limited credit (e.g., 10 or 15%) for existing sinks in forests, which could be seen as a proxy for sink activities initiated between 1990 and 2000. In addition, any new sinks projects since 2000 would be credited according to option 2 (narrowly defined activities). In terms of calculation procedure, the (10 or 15%) credit for forest management would apply to (national balance minus credits for new projects since 2000).

Option 3 would create a full, undiscounted, incentive for new projects (including LULUCF projects under Article 6 Joint Implementation) while not compromising the bioenergy use on other lands.

4) individual countries could refrain from implementing Article 3.4 in the first commitment period, thereby removing any adverse impacts on forest industries and bioenergy.

5) individual countries could claim credits for Article 3.4 activities internationally, but refrain from national implementation, thus giving no price signals that would discourage forest management for timber and biofuels.

ARTICLE 6 AND POTENTIAL TREATMENT OF SINKS AND BIOMASS ENERGY UNDER JOINT IMPLEMENTATION

Projects under Article 6 ("Joint Implementation") could encompass activities covered by Articles 3.3, 3.4, or covered by neither of these two articles.

(1) Afforestation and reforestation projects
Such projects would be credited to the country where they occur, with credits being transferred to the investor country thus resulting in a neutral result for the host country.

(2) Projects under Article 3.4 that are subject to discounting.
The viability as joint implementation projects depends on the discount rate applied in national crediting.

In the Article 3.4 category "forest management" the carbon accumulation due to a project would be credited to the host country with a discount of about 85%. However, the transfer of credits to the investor country according to Articles 3.10 and 3.11 would likely encompass the entire amount of carbon accumulated. Thus the host country is likely to incur a deficit of carbon credits. In order to overcome this, the host country could use the pool of the 15% credits from national forest management accounting, and transfer part of these credits to the investor countries. But nevertheless, any new JI project will decrease the amount of emission credits that is available to the host country, and will take it further away from compliance.

(3) Projects under Article 3.4 that are not subject to discounting

In the categories "cropland and grazing land management", if a net-net approach is used, there does not seem to be a problem as in category (2) because genuinely new projects would fully enter the equation under Article 3.4.

(4) Projects that fall neither under Article 3.3 nor under Article 3.4

If a project is covered by neither of Articles 3.3 and 3.4, or if the project falls under Article 3.4 but the host country decides not to report Article 3.4 activites in the first commitment period, then the project will not create carbon credits to the host country, and therefore a transfer of credits to an investor country will create a negative outcome – in terms of compliance –to the host country.

ARTICLE 12 AND OPTIONS FOR LINKING SINKS CREDITING WITH BIOMASS ENERGY PROJECTS IN THE CDM

The consolidated negotiating text (UNFCCC, 2001) introduced in June proposes to include afforestation and reforestation as eligible for project crediting under the CDM. The effect of afforestation and reforestation on incentives for bioenergy would be similar in the CDM as it is under Article 3.3. In the CDM the incentive to establish biofuels plantations would be somewhat greater due to the banking of carbon credits starting in 2000.

An alternative option for the CDM could be to allow associated sink crediting of mainstream bioenergy projects only. For example: project activities under the CDM that use new biomass-derived fuels to displace the use of fossil fuel could include in the project boundary the stock change between 2000 and 2012 resultant from associated LULUCF activities (afforestation, reforestation, and revegetation) that produce the biomass fuels. To avoid tokenism it might be necessary to specify that the proportion of carbon credits from LULUCF may not exceed the fossil fuel carbon displaced by the biomass energy project by more than a factor of between, say, 1 to 4.[1]

[1] The "factor" [1, 2, 4] is put forward based on numerical simulations (see Appendix). For plantation establishment, there are two independent variables to be considered in the modeling: 1) start date of

The expansion of the project boundary to include a LULUCF component must be within the same country. Biofuel use in other countries could be considered based on future SBSTA methodological work, including decisions on accounting for harvested wood products.

This proposal might help address concerns of:

Market leakage. This is minimized through use of a significant part of harvested biomass in new local markets. Local bioenergy uses may also enhance the acceptance of the project by the local population. Leakage due to displacement of food and feed production may remain a concern, but that is also true for unrestricted afforestation and reforestation.
Permanence. LULUCF activities that are part of bioenergy projects may well produce more permanent emission credits than stand-alone LULUCF activities, because the usefulness of the product should help guarantee continuation. Remaining concerns about the permanence of the "land-use carbon" could still be addressed through an equivalent to the Colombian proposal. Also, a possible loss of C stocks in the land-use part of the project would reduce the opportunity for continued generation of emission credits from the bioenergy produced, so that there is an additional incentive to maintain these carbon stocks.
Technology transfer. Implicit in the bioenergy linkage is the need for conversion technology associated with the bioenergy component; given this, there is an intrinsic incentive for the investor to use efficient and reliable equipment to ensure continuing production of energy and CERs.
Scale. The problem of excessive potential scale of LULUCF activities leading to a price collapse is limited because, within all afforestation and reforestation projects, only those that are associated with new uses of biomass for energy would be eligible.

Of course a plantation system, once subject to harvesting, does not generate any further increases in C stocks, with the possible exception of soil carbon, and the crediting regime would need to ensure that carbon credits were only issued for real increases in the time-average carbon stocks.

Finally, the question arises how to handle cases where biofuels are a co-product with other outputs (such as pulpwood)? In such a case only the bioenergy fraction of the harvested wood enters the calculations. If the bioenergy component is very small, then the "factor" should limit crediting of LULUCF (see Footnote 1 and Appendix for a detailed discussion).

A connection between carbon sinks crediting and bioenergy, as proposed here, may be easier to implement in the CDM than in Article 3.3 because the CDM requires, on the international level, the existence of legally defined projects with an agreed duration and scope. Therefore the future use of biomass for energy could be fixed in such a contractual agreement.

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plantation establishment, and 2) harvest-cycle length. For any combination of these two, it is possible to calculate the carbon accumulated on the site, and the amount of carbon in biofuels produced, between 2000 and 2012. A third consideration is whether all harvested wood is used for biofuels or whether other co-products (e.g., pulpwood or timber) are produced from the plantation. The ratio of (carbon accumulated / carbon in biofuels produced) will be at high levels if a) harvesting starts very late (e.g. in 2010) and b) if a considerable fraction goes to uses other than biofuels. The numerical simulations have shown that in order to credit stock changes associated with most dedicated biofuels plantations that are operational before or in the first commitment period, the "factor" would have to be greater than 2 or even better greater than 4. On the other hand, in order to limit credits from most plantations where biofuels are a minor by-product, the "factor" would have to be less than 1. Whatever value is finally chosen, there will always be some errors on both sides. One option would be to select the "factor" at a higher level (about 4) for dedicated biofuels plantations, and at lower levels (1 or below) for plantations not mainly established for biofuels production. The use of a formula for deriving the threshold factor is recommended, such as:
Threshold factor = 4 x (share of biomass fuels produced, relative to total biomass harvested). With this the factor will usually be between 0.5 and 4. In cases where biomass for energy is produced along with other products like timber or pulpwood, only a portion of associated stock changes - corresponding to the share of bioenergy relative to total use of wood - is credited.

Some implications for the economics of biomass energy

The change in carbon stock due to afforestation and reforestation projects is roughly equal to the average carbon stock in the newly established tree crop. For a typical project in a developing country, this may be around 20 tones C/ha/yr, averaged over entire plantations.[2]. It should also be noted that forests established on previously cultivated lands are likely to enhance soil carbon stocks (the exact magnitude is more uncertain; including soil carbon could thus increase crediting but would be more costly to verify at given confidence levels).

Carbon credit prices in the range 10 – 100 $/tC would then imply that accumulated revenues from carbon credits of roughly 200-2000 USD/ha could be generated for the type of plantation discussed above. This can be compared to the costs of plantation establishment, which typically range between 200 and 900 USD/ha (Amatayakul and Azar, 2001,for Thailand; and Azar and Larson, 2000, for Brazil). Thus, crediting the carbon sinks component of plantations could potentially provide a significant push for biomass energy. It would also favor longer rotation periods and some types of crops over others, with annually harvested crops such as corn, sugar cane or grasses having less incentive than short rotation forests.

On the other hand the additional incentive for plantation establishment may increase concerns about intensified land-use conflicts in many developing countries (see e.g., Carrere & Lohman 1996). Thus, it remains important that adequate attention is paid to sustainable development criteria in the CDM when designing carbon abatement projects, including socio-economic and biodiversity criteria. These issues would apply with at least equal force to any LULUCF crediting. Creating a linkage to productive use of accumulated carbon, namely generation of energy to displace fossil fuels, would enhance the wider sustainable attributes in respect of both local employment and contribution to wider national goals of sustainable development – as well as addressing a number of other concerns surrounding the more general crediting of sinks in the CDM.

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[2] The carbon content in a plantation depends on the rotation period (Trot) and the yield (tons C/ha/yr) and is roughly equal to yield*Trot / 2. Typical yield levels on well managed plantations in Brazil, for example, are 10-20 tons dry matter/ha/yr, half of which is carbon, and the rotation period (for pulpwood or charcoal) is typically around six years (Azar & Larson 2001). Assuming the central value for the yield, we get a carbon stock of 22.5 tons C/ha.

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ACKNOWLEDGEMENTS

'This paper is derived from a broader project on possible linkages between biomass energy and carbon sinks, convened by Climate Strategies (www.climate-strategies.org). The authors and Climate Strategies are grateful to the project sponsors for their support. The views expressed are the sole responsibility of the authors.

APPENDIX

Example 1:
Reforestation of a "normal forest system" with annual growth rate of 7 tC/ha/yr, initiated in 2002 (1 parcel planted in 2002, 1 parcel in 2003, 1 parcel in 2004 etc.). Harvest cycle length 8 years. 70% of harvestable material is assumed to be used as biofuels. Each parcel is assumed to comprise 12.5 ha, so that the totals system size is 8 x 12.5 = 100 ha. Such a plantation system would produ ce 12.5 x 39.2 tC/ha harvested = 490 tC to biofuels in each year 2010, 2011 etc.

Figure 2 shows the C budget at the stand level (1 ha), Figure 3 at the landscape level (assumed size 100 ha). Further analyses below focus on the landscape level. Several examples are used to demonstrate how the ratio of carbon sequestered, and biomass harvested, can differ. Finally these results are discussed with relation to possible limits of carbon credits for afforestation and reforestation.

Figure 2: Stand level carbon balance of reforestation for biofuels: maximum C per ha is 56 tC, trot = 8 years. Initial stand establishment in 2002.

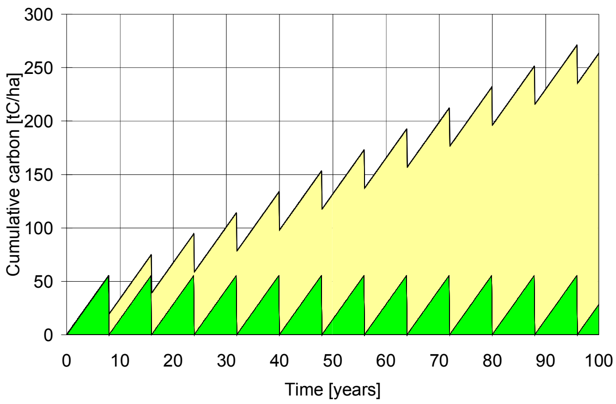
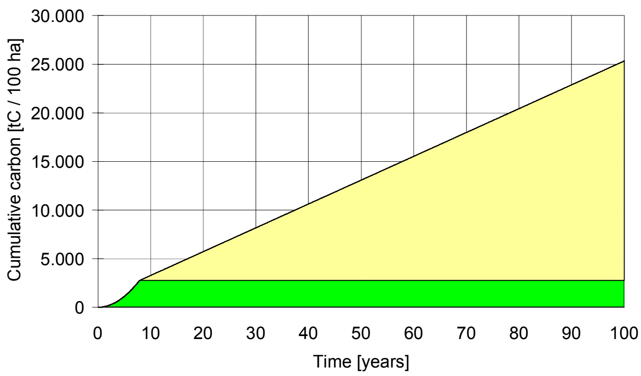


Figure 3: 100 ha of "normal forest" (8 stands comprising 12.5 ha each). The average C stock of the plantation is 56/2 tC/ha x 100 ha = 2800 tC. This is approached between 1 Jan 2002 and 1 Jan 2010. Due to "banking" in the CDM the full amount may be eligible for credits.



LULUCF stock change: 2800 tC (see caption of Figure 2). Biofuel produced by 2012 from this system: 3 years in which harvest occurs (2010, 2011, 2012) on 12.5 ha each.
Biofuels produced: 0.7 x 56 x 12.5 x 3 = 1470 tC

The ratio of stock change on the land, and biofuels produced (2800 / 1470 in this example) is independent of growth rate. The example excludes changes in soil carbon. If soil carbon were to increase due to the project, then the potential LULUCF credits would also increase.

Example 2:
Same plantation system, but established in 2004, and for the first time harvested in 2012:
LULUCF stock change: 2800 tC
Biofuels produced: 0.7 x 56 x 12.5 = 490 tC

Example 3: (extreme case):
Harvest cycle length is 12 years, plantation initiated in 2000, first harvested in 2012. Growth rate 7 tC/ha/yr, LULUCF stock change: stock accumulated on 100 ha: 7 x 12 = 84 / 2 = 42 x 100 = 4200 tC
Biofuel produced: 84 x 0.7 x 8.333 ha per stand = 490 tC

The difference to the previous example is that now the total accumulated stock is greater (whereas the amount of biofuels produced is the same as in example 2). This is an extreme case because the growth phase of the plantation covers the full time period for which credits are possible (13 years, 2000 – 2012).

Example 4:
As example 1, but stand establishment in 2000 (instead of 2002), and first harvest in 2008 (instead of 2010). This is a pulpwood plantation with only 20% of the harvestable biomass used for energy.
LULUCF stock change: 2800 tC
Biofuels produced: 0.2 x 56 x 12.5 x 5 = 700 tC

Example 5:
Plantation established in 2004, harvesting starts in 2008.
LULUCF stock change: 1400 tC
Biofuels produced: 0.7 x 28 x 25 x 5 = 2450 tC

Table 2: Summary of the five examples which have been chosen to include some extreme cases. A more thorough analysis of all possible cases can be found in the Figure 4.

All carbon numbers in this table are for the period 2000 - 2012	**LULUCF stock change (tC)**	**Biofuel Produced (tC)**	**Ratio (LULUCF stock change / biofuels produced)**
Example 1: Bioenergy starts in 2010 (t_rot = 8)	2 800	1 470	1.9
Example 2 Bioenergy starts in 2012 (t_rot = 8)	2 800	490	5.7
Example 3: Bioenergy starts in 2012 (t_rot = 12)	4 200	490	8.6
Example 4: Bioenergy starts in 2008 (t_rot = 8)	2 800	700	4.0
Example 5: Bioenergy starts in 2008 (t_rot = 4)	1400	2450	0.6

The ratio (LULUCF stock change / biofuels produced) is between 0.6 and 8.6 in the five examples. If one were to fully credit the stock changes in all five cases, then the threshold “factor” would need to be 8.6 or greater. On the other hand, if one were to begin limiting LULUCF credits from the pulpwood plantation (with biomass for energy as a by-product) in example 4, then the threshold "factor" would need to be below 4.

In more general terms, the "factor" needs to be large enough to allow credit for all projects that have a reasonable biofuels component. The main point of using the factor is to prevent projects that have a biofuels component just for the sake of qualifying afforestation/reforestation for crediting. I.e., the biofuels component should be significant in itself. On the other hand, the factor should be low enough to exclude projects where biofuels only constitute an insignificant project output.

It becomes clear that single cases are not sufficient to systematically analyze this problem. The two parameters that have been modified in the above examples are:

- The year in which plantation establishment begins, and
- The harvest-cycle length.

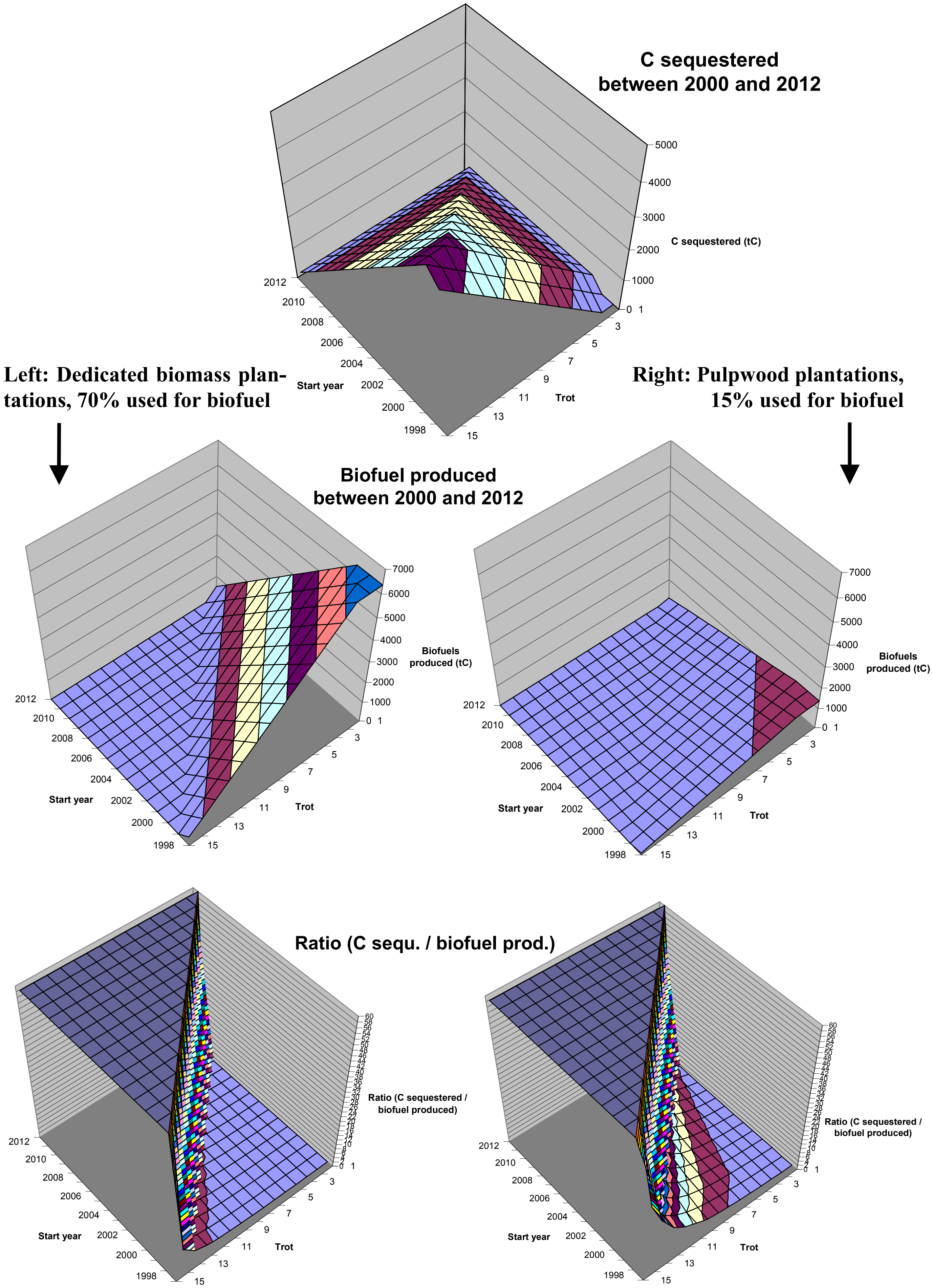
These two parameters have been modified simultaneously and all possible combinations have been calculated. The output can be shown in three-dimensional diagrams in Figure 4. The top diagram shows the carbon sequestered in an LULUCF project as a function of the two parameters. The two diagrams in the center show the amount of biofuels produced as a function of the same parameters (the left diagram is for a biomass plantation with 70% of the harvested material used for fuel, whereas the right one is for a pulpwood plantation with only 15% of the harvested material used for fuel). The two diagrams at the bottom are a combination of the top and middle diagrams and represent the ratio of (LULUCF carbon stock change between 2000 and 2012 / carbon in biofuels produced between 2000 and 2012). These diagrams provide a comprehensive overview of all possible cases that could occur in the proposed linking of carbon sinks and bioenergy.

In deriving recommendations about the threshold factors, the bottom diagrams will be most important. Taking the example of dedicated biomass plantations (bottom left), it can be seen that the uniformly shaded area in the lower part of the diagram corresponds to those cases where the ratio of (LULUCF stock change / carbon in biofuels produced) is below 2. I.e., if the threshold factor were chosen to be 2, then all these projects would be fully credited. If the factor were chosen to be 4, then also the projects in the dark purple area of the 3-dimensional surface would be fully credited. It appers that a threshold factor of 4 is sufficient to fully credit all projects (except those where the combination of plantation establishment year and harvest-cycle length results in an initial harvest only very late in the first commitment period, so that these projects would not likely be bioenergy projects in the first commitment period. These are the combinations shown on the left of the digram.

The bottom right diagram shows the same situation, but for a plulpwood plantation where only 15% of the harvested biomass is used for energy, 55% is used for pulpwood, and 30% remains on the site. For pulpwood plantations the are of the three-dimensional surface that is below "4" (two different shadings in the lower part of the diagram) is smaller. This means that not as many plantation cases would be fully credited at a threshold factor of 4. However, crediting does not appear sufficiently restricted. For example, a pulpwood plantation established in 2000 and first harvested in 2008 would still fully qualify. It seems more appropriate, in cases where bioenergy is a by-product, to award credit for only a portion of the carbon stock changes on the land. If one quarter of usable biomass is used for energy, and three quarters are used for pulpwood, then a quarter of the LULUCF stock changes could be allocated to the bioenergy project and thus credited – This would suggest an adjustment of the threshold factor depending on the relative share of bioenergy:

Threshold factor = 4 x (share of biomass fuels produced, relative to total biomass harvested).

Figure 4: Carbon sequestered in the plantation (top diagram), carbon in biofuels produced (two center diagrams) and the ratio of (carbon sequestered / carbon in biofuels produced) (two bottom diagrams), at differing harvest-cycle length and plantation establishment year.



Implications of Different COP Decisions for Bioenergy, Wood Market and Land Use Patterns in Italy

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PowerPoint presentation: www.joanneum.at/iea-bioenergy-task38/workshop/canberradata/ciccarese.ppt

ABSTRACT

The presentation, after providing some background information on the Italian forestry sector, includes a discussion of the recent trends in consumption of wood for energy in Italy.

The increased domestic consumption is mainly due to three factors: the high prices of fossil fuels, the availability of innovative conversion technology at household level (boilers, stoves), the new regulations that are favouring the recycling of final wood products through voluntary agreements between industrial producers of woody products, consumers and municipalities.

Official statistics are underestimating the current consumption wood products for energy and the production potentials, mainly for the dispersed structure of the supply and the large number of small-scale consumers. However, only a limited part of the domestic fuelwood consumption has clear substitution effects with fossil fuels or other non-renewable energy resources. Large quantities of wood products is currently used in fireplaces or in family cooking stoves with serious pollution effects.

In the conclusions 5 possible scenarios deriving from different COP decisions on articles 3, 4 and CDM: (a) the business as usual scenario, (b) a scenario based on a price premium for domestic production of wood for energy, (c) a carbon accounting in forest stocks scenario, (d) a carbon accounting in forest stocks and in wood products scenario, and (e) a scenario based on the development of flexible mechanisms connected with forest activities. Consequences of different decisions are analysed in relation to fossil fuel consumption, wood market development, land use patterns, externalites (i.e. non market services) provided by domestic forests. As a conclusion the paper is suggesting that non market effects connected with reduced abandonment of forestland (i.e: fires, uncontrolled grazing, soil degradation, etc.) are remarkably increasing the positive effects of fuelwood consumption as an instrument to reduce carbon emissions in the atmosphere.

Scenario	Fossil fuel consumption	Wood market development	Land use patterns	Externalities provision
business as usual	No trend changes: stabilisation	No trend changes: increased external dependence	No trend changes: forest abandonment, increased forest land, coppices conversion to highforests	No trend changes: reduced biodiversity
price premium for domestic production of wood for energy	Reduced consumption	Increased external dependence for industrial wood products	Reduced coppice abandonment	Reduced forest fires and of semi-natural forests
C accounting in forest stocks			Increased coppice conversion	
C accounting in forest stocks and in wood products scenario				
flexible mechanisms connected with forest activities.				

What Prospects for Soil C Sequestration in the CDM? COP-6 and Beyond

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ABSTRACT

Although generally supported by international experts and the United Nations Intergovernmental Panel on Climate Change, carbon (C) sequestration has long been a contentious and difficult issue in global climate negotiations. As the recent sixth Conference of the Parties (COP-6) held in The Hague in November 2000 demonstrated, the 'sinks' issue currently divides both the industrialized countries and the developing countries. To understand the background for the carbon sink controversy, and in order to assess the political acceptability of direct foreign investments in soil C sequestration in developing countries as an eligible climate policy measure, this paper briefly summarizes some of the main issues in the international policy debate on sinks. The paper also analyzes the informal outcomes of COP-6 and the coming COP-6 bis to be held in the summer of 2001.

THE TREATMENT OF SOIL C SINKS IN THE KYOTO PROTOCOL

The ultimate objective of the 1992 United Nations Framework Convention on Climate Change (FCCC) is to achieve 'stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'.[1] A Protocol to be attached to the FCCC establishes commitments for all the developed countries and former centrally planned economies–the so-called Annex B countries–to reduce their GHG emissions by the year 2010 with a total of about 5% compared to the 1990 level of emissions.[2] The Protocol, which was negotiated in December 1997 in Kyoto, Japan, does not establish commitments on the part of the developing countries (the non-Annex B countries) to mitigate GHG emissions. It has yet to be ratified by a sufficient number of countries before it can enter into force.

Article 12 of the Kyoto Protocol establishes the Clean Development Mechanism (CDM) as a mechanism for direct foreign investments in greenhouse gas (GHG) mitigation projects in developing countries.[3] The CDM is designed to give developed countries with high domestic mitigation costs access to low-cost mitigation projects in developing countries, and to benefit developing countries by supplying projects to investors in developed countries. Developed countries are able to count emission reductions achieved overseas in developing countries against their national climate commitments. The CDM offers an opportunity to increase financial resource flows from developed to developing countries.

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1 Article 2.

2 Australia, Austria, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, European Community, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, Great Britain, and the USA.

3 Formally, the objective of the CDM is 'to assist [developing countries] in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist [developed countries and former centrally planned economies] in achieving compliance with their quantified emission limitation and reduction commitments.'

Article 3.3 of the Kyoto Protocol explicitly mentions emissions from sources and removals by sinks as a direct consequence of human intervention affecting land-use change and forest-related activities −deforestation, reforestation and afforestation−undertaken since 1990. Article 3.4 identifies agricultural land as a possible carbon sink or source, and agricultural land should be included in the emission inventories that are prepared by the Annex I Parties. However, the Kyoto Protocol does not include provisions for national crediting for C sequestration in soils. And it is still unclear whether the CDM will provide credit for sink enhancement and permit broader sink activities

It is also unclear how carbon sink offsets are to be determined.[4] Essential issues still lack definitional precision:[5] How are afforestation, reforestation and deforestation defined?; Which carbon stock changes are verifiable?; Which additional activities for sources and sinks are meant under article 3.4?; How should carbon stock changes be measured during the commitment period in order to arrive at comparable and verifiable figures? And how can the impact of human-induced activities in land-use change and forestry be distinguished from natural impacts and from indirect human-induced activities (e.g. CO_2 fertilization)?

Perhaps C sequestration in soils in non-Annex B (and in Annex B) countries could become an eligible activity under the Kyoto Protocol, but several regulatory and technical issues remain unresolved. Moreover, as documented in the next section, a number of additional issues are influential in the international policy debate on C sinks under the CDM.

THE COMPLEXITY OF SINKS

The policy debate on C sinks dates back to the beginnings of international cooperation on climate protection in the late 1980s and early 1990s. Many issues have been raised since then. It is possible to divide the main issues and questions into three groups: issues that are primarily technical and scientific; issues that are more ‘deep’ and fundamental; and economic and distributional issues. The issues are listed and briefly summarized below. This non-exhaustive list is neither supposed to indicate their relative significance nor how frequently they have been raised.

Scientific and technical issues

Some reservations concern scientific-technical issues and generic issues in regard to sinks and sinks-related activities and projects. Among some of the oft-mentioned reservations are the following:

- High scientific uncertainty and even ignorance surrounds sinks, making C sequestration an uncertain and risky option. Viewed from a scientific viewpoint, it is problematic to utilize sinks because the scientific and technical basis for policy-making is too uncertain. Among other things, the hypothesis about CO_2 fertilization is not sufficiently scientifically sound and is insufficiently supported by empirical evidence.

- Under changed environmental conditions (e.g. due to a changing climate) soil (and forest) sinks may instead act as sources.

- There is a risk of bogus sinks because well-known biogeochemical processes (e.g. CO_2 fertilization), and probably some as yet unknown processes, could stimulate sink enhancement. The precautionary principle adopted in the FCCC should instead provide the

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4 Article 3.4 states that ‘the Parties to this Protocol shall, at its first session or as soon as practicable thereafter, decide upon modalities, rules and guidelines as to how, and which, additional human-induced activities related to changes in greenhouse gas emissions by sources and removals by sinks in the agricultural soils and the land use change’ shall be taken into account. But the global climate negotiations have not yet produced a solution to this issue.

5 See Nabuurs et al. (2000).

basis for policy-making and it is necessary to be conservative.[6] Promoting environmental integrity justifies erring on the side of safety and reducing environmental risks.

Comments

The IPCC has addressed, more or less directly, these issues in its recent special report on *Land Use, Land-Use Change, and Forestry*.[7] The International Geosphere-Biosphere Programme (IGBP) has also examined many of these issues.[8] However, it seems clear that these international scientific-advisory initiatives have not been sufficiently successful in demonstrating that these risks are either manageable or are relatively minor. But it is also evident that more research, experiments and demonstration projects are necessary.

Fundamental or basic issues

Some of the more fundamental issues raised in the context of C sequestration are the following:

- C sinks are a risky and intermediate step rather than a permanent solution to the global climate change problem. It is very problematic to rely on sinks because they could easily be reversed (e.g. by forest fires or by reverting to intensive tillage in agriculture). It is only too likely, because of their long lifetime, that they would be subject to negative human, or non-human, interference.

- It is a fundamentally misguided approach to continue emitting GHGs even though terrestrial aboveground and below-ground C sinks absorb CO_2 emissions. Sequestration does not lead to a net removal of CO_2 from the atmosphere because crediting sinks enables a parallel increase in fossil fuel CO_2 emissions.

- Sink opportunities would delay the necessary shift from a fossil fuel-based energy system to a system that is not based on fossil fuels. Sinks are a sidetrack and would simply slow down the necessary transition to non-fossil energy technologies and systems.

- Offset policies and programs allowing international trade in ‘pollution’ should be entirely prohibited under the global climate regime.

Comments

The first issue is concerned with permanency–which arises because sinks are potentially reversible–an issue that it clearly is more difficult to devise satisfactory solutions to.[9] The key rebuttal to the next two issues is that sequestration offsets are time-buying and cost-saving devices that would avoid premature retirement of the capital stock. Thus they could reduce the potentially massive economic costs of changing the energy system to become less fossil-fuel based and they would buy time for the development of cleaner energy technologies. Sinks projects would therefore be an attractive but limited complementary option to GHG emissions reductions options. The fourth issue is normative, thus it cannot be solved on scientific and technical grounds. Tradable pollution permits schemes are often criticized for being irresponsible and anti-environmental.[10]

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6 According to Article 3.3 of the FCCC: ‘The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures (…)’.

7 Watson, R. T., I. R. Noble, B. Bolin, N.H. Ravindranath, D.J. Verardo, and D.J. Dokken, (eds.), *Land Use, Land-Use Change, and Forestry*. Special Report of the Intergovernmental Panel on Climate Change (Cambridge, U.K.: Cambridge University Press, 2000).

8 See IGBP Terrestrial Carbon Working Group: 29 May 1998, ‘The Terrestrial Carbon Cycle: Implications for the Kyoto Protocol’, *Science* 280**,** 1393-1394; Falkowski et al., 2000.

9 See, e.g. Chomitz, 2000.

10 For an example from marine pollution prevention, see Lasse Ringius, Radioactive Waste Disposal at Sea

Economic and distributional issues

This group of issues is concerned with economic and equity aspects of C sequestration. An important, but not uncontested, underlying assumption is that a large amount of inexpensive C sequestration options exists in developing countries[11]:

- Annex B countries would primarily make investments in the inexpensive sequestration options that exist today in developing countries and developing countries would therefore be left with costly options when they later need to control GHG emissions. This argument about international fairness in a 'North-South' perspective suggests that Annex B countries would unfairly pick 'low-hanging fruits' or 'skim the cream' in developing countries.
- The present generation would pick up the cheap sequestration options in non-Annex B countries and it would therefore impose heavier burdens on future generations. This argument concerns intergenerational fairness and the responsibility of the present generation towards future generations.
- The rent generated by sink projects would be unevenly and unfairly distributed among the non-Annex B host countries and sellers. According to this argument, countries and sellers that offer attractively priced (i.e. low cost) sink projects would benefit, whereas countries and sellers that are unable to compete in the global GHG offset market would lose. This is unfair seen from an intragenerational and international perspective.
- Annex B country investments would be concentrated in the attractive low cost forestry, agriculture and land-use sectors. Thus the CDM would not lead to sustainable development in other sectors such as energy, industry, and transport. But attracting foreign investments in the latter sectors are high national priorities in developing countries.
- Sequestration projects would because of their low cost advantage be more competitive than energy, industry, waste, and transportation projects, and, since large amounts of these options would be available, they would flood the global GHG offset market.[12] As a result, developing countries' earnings from Annex B country investments in CDM project would be significantly reduced.
- It is not desirable or acceptable if (some) Annex B countries achieve their targets at little costs.[13] The supporting argument is seldom stated explicitly but could be that only a costly 'stick' would be able to stimulate society, the private sector, and governments to undertake the necessary changes. Perhaps it is perceived as simply unfair if protecting the climate system is inexpensive for 'polluters', especially the major ones.[14] But by excluding the high-cost options from the CDM, Annex B countries would have to utilize the medium and high-cost options available in Annex B countries.

(Cambridge, Mass: MIT Press, 2000), p. 65.

[11] The costs and local economic benefits are better documented for forest C options than for soil C options. For an overview over prices and potential, see Fanny Missfeldt and Erik Haites, 'The Potential Contribution of Sinks to Meeting the Kyoto Protocol'. Manuscript, 2001.

[12] It is estimated that 1,698 MtC/y from conservation projects would be available in developing countries by 2010. See I.R. Noble and R. J. Scholes, 'Review: Sinks and the Kyoto Protocol,' *Climate Policy* 1 (2001), pp. 5-25.

[13] According to a leading environmental non-governmental organization, 'it is also clear that a number of Annex I countries support the inclusion of sinks in the CDM, primarily in order to gain access to even 'cheaper tons' of carbon than would otherwise be available though a clean technology orientated CDM'. Greenpeace, August 2000, p. 4.

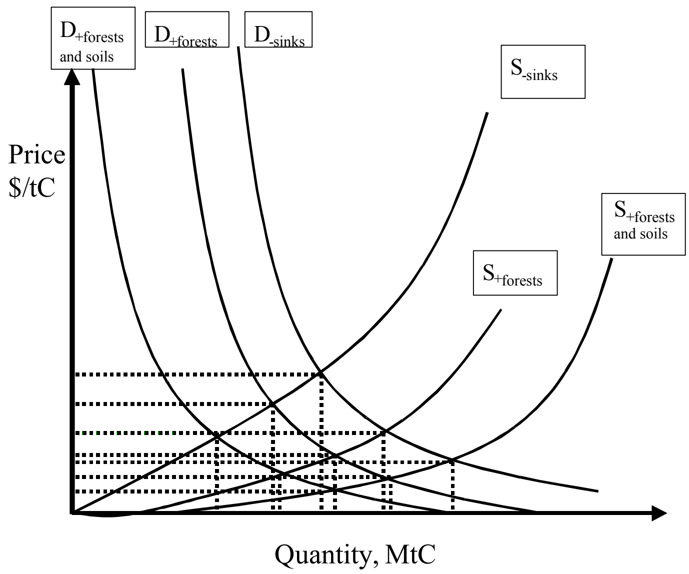
[14] For example, an analysis of the COP-6 actually claims that 'some European ministers made it clear that they wanted Americans to feel some economic pain more than they wanted a workable agreement'. *The Economist*, 'Oh No, Kyoto', 7 April 2001, p. 81.

The argument is illustrated diagrammatically by Figure 1. It shows three different supply curves (marginal costs), three demand curves (marginal costs), and nine different global offset prices and quantities of offset being traded globally. Demand and supply are measured in million t C, while the global offset price is expressed in US$/t C. Figure 1 shows that Annex B countries' demand for offsets and non-Annex B countries' supply of offsets would influence both the global C offset price and the quantity traded. It is assumed that the willingness of Annex B countries to buy international C offsets depends on the costs of domestic GHG mitigation options. Annex B countries' willingness to buy C offsets from non-Annex B increases when the costs of domestic GHG mitigation options in Annex B countries increase, and vice versa.

The curve labeled S-sinks shows the quantity of offsets supplied and at which costs when sink enhancement projects in non-Annex B countries are not eligible under the CDM. The S+forests cost curve shows the quantity of offsets supplied and their costs when forestry (i.e. afforestation, reforestation, and avoided deforestation) projects in non-Annex B countries are eligible under the CDM. The S+forests and soils cost curve shows the quantity of offsets supplied and their costs when both forest and soil C projects in non-Annex B countries are eligible under the CDM. Similarly, the D-sinks cost curve shows the global demand curve for offsets if sink enhancement projects in Annex B countries are not eligible under the Kyoto Protocol. The D+forests cost curve shows the demand curve for offsets if forestry projects in Annex B countries are eligible under article 3.3. The S+forests and soils cost curve shows the demand curve for offsets when forest and soil C projects in Annex B countries are eligible under article 3.3 and 3.4.

As Figure 1 shows, depending on the supply of sink enhancement projects by Annex B and by non-Annex B countries, the global carbon offset price could vary significantly, given changes in the supply of and demand for offsets. A number of GHG abatement opportunities available in non-Annex B countries (e.g. relatively more expensive solar PVs) would not be picked up by Annex B countries if sink enhancement projects are eligible under the Kyoto Protocol. Although the quantity of offsets that is traded is reduced if sink enhancement projects are not eligible, the energy options have significantly higher prices, resulting in more profit to the non-Annex B countries.

Figure 1: Impact on the Global C Offset Price and Trade of Including Forest and Soil C Sinks in Annex B and Non-Annex B Countries in A Global Trading Regime.



Comments

The assumption that underlies the first and second issue is that cheap mitigation options are scarce and will be exploited relatively quickly. But this is a static and rather pessimistic view of future technology development and of the opportunities for shaping fossil energy demand and social behavior more broadly. If it becomes clear (issue 3-5) that the CDM revenues are very unevenly distributed among developing countries, then the FCCC Parties may decide to influence the CDM investment patterns to become more equitable, e.g. though establishing co-financing programs to reduce the incremental costs of medium- and high-cost mitigation opportunities in developing countries. Some have proposed to set a minimum price for CDM options in order to level the playing field. As to the final point, the argument that it is desirable if climate targets are economically costly runs counter to the CDM's aim to achieve global cost-effectiveness and ignores basic principles of environmental economics. At the same time, it is important to develop mechanism and instruments under the FCCC that will increase investments in decarbonization of energy systems, including investments in research and development and market-integration of cleaner technologies and energy systems.

REGULATORY ISSUES UNDER THE KYOTO PROTOCOL

Although partly overlapping with the issues touched upon above, an additional group of issues concern the emerging regulatory framework in the Kyoto Protocol and the rules and modalities that are likely to be applied if CDM sinks projects would be eligible under the Kyoto Protocol. These issues are in many cases genuine to all project types—they are not concerned only with sinks projects but also other abatement and mitigation project types:

- Project eligibility, i.e. which project types are acceptable?

As mentioned initially, the eligible sink-related human activities are still undecided. There is need for definitions of the human-induced eligible activities in forestry, agriculture and other land-use sectors.

- Uptake should be real, measurable, and long-term.

The issue of the measurability of C stock changes has often been raised in the international policy debate. More recently the opportunities for cost-effective measurements have received more attention, e.g. combining satellite images and on-ground measurements, existing land-classification systems and statistical approaches in order to produce reliable, cost-effective measurement of changes in C stocks. The complex issue of permanency is, as mentioned, one that distinguishes sinks projects from fossil energy projects.

- Additionality, i.e. C uptakes must be additional to what would have otherwise occurred.

The baseline establishes the reference for the assessment and calculation of the project performance in terms of emissions reductions or amount of CO_2 sequestered compared with the 'without-project' situation. No internationally prescribed method or standardized guidelines exist for baseline-setting in the area of C sinks. It is likely that there will be put more emphasis on development of international sector guidelines in the context of the FCCC.

- Supplementarity, i.e. to what extent should targets be achieved though domestic measures? Should the regulatory emphasis be placed mainly on domestic measures?

The supplementarity issue evidently concerns all the three so-called flexibility mechanisms in the Kyoto Protocol, i.e. joint implementation (JI), the Clean Development Mechanism, and international emissions trading.

- Leakage, i.e. mitigation achieved in one place is outweighed by releases of emissions elsewhere.

Some argue that it will be possible to capture and measure leakage through application of sufficiently wide project or systems boundaries. Too narrow boundaries will ignore leakage effects. The issue is particularly important in the context of the CDM because the host country is under no obligation to reduce or limit GHG emissions. The issue may usefully be addressed in international project guidelines.

- Perverse incentives. For instance, it has been suggested that host countries would have incentives to clear primary forests so that they subsequently can produce credits from plantation projects established at the cleared sites.

Most project types are prone to some measure of free-riding, gaming and cheating. But standardized international guidelines may reduce some of these problems, especially at more aggregate levels.

COP-6 AND SINKS IN THE CDM

Similar to many other issues on the negotiating table, soil C sequestration in the CDM is negotiated as a part of a broader agreement or package deal. To a large degree, Parties' positions on other key issues determine their positions on the narrow, more specific question of soil C sinks in the CDM.

COP-6

C sequestration and human-induced changes in C fluxes from terrestrial C pools was a very complex and contentious issue at COP-6, and was an important reason for the lack of overall agreement.[15] According to Jan Pronk, the environment minister of the Netherlands who was appointed as the COP president, the question of whether to allow the CDM to include sinks activities was a 'difficult' and 'tough political issue'.[16] He addressed it in informal notes and in plenary presentations that, however, put forward a rather inconsistent solution.[17]

On the one hand, the conference president assigned a modest role to forests and sequestration projects in the CDM. It was suggested that the priority projects in the CDM should be in the areas of renewable energy (i.e. small-scale hydro) and energy efficiency. No mention was made of forests, agriculture, or sequestration projects. On the other hand, Mr. Pronk also proposed that afforestation and reforestation projects should be included in the CDM, and that these could generate credits. Projects targeting prevention of deforestation and land degradation, however, should be excluded from the CDM and would not create GHG credits.

Mr. Pronk stressed that issues concerning non-permanence, social and environmental effects, leakage, additionality, and uncertainty should be addressed, and that land-use, land-use change and forestry (LULUCF) projects should conform to the objectives of other multilateral environmental agreements. The conference president also identified a need for developing the 'modalities' for such projects, taking into account the methodological work by IPCC. But these proposals did not help to narrow the considerable gap that divided the key parties, i.e. the USA and the European Union, on this issue.

LOOKING TOWARDS COP-6 BIS

Several technical issues in the negotiations were addressed at talks in Ottawa in early December. With respect to the CDM, three different proposals were proposed (since there was no agreement on

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[15] See 'Critical Politics of Carbon Sinks', *Nature* (30 November 2000) vol. 408, no. 6812, p. 501. According to the International Institute for Sustainable Development (IISD), 'disagreement on sinks was a principal stumbling block' at COP-6. See IISD, 'Summary of the Sixth Conference of the Parties to the Framework Convention on Climate Change, 13-25 November 2000,' *Earth Negotiations Bulletin*, 12:163 (27 November, 2000). http://www.iisd.ca/vol12/enb12163e.html

[16] 'Informal Note by the President of COP 6', p. 4 and p. 6.

[17] For the 'Note by the President of COP-6. 23 November 2000', see: http://www.unfccc.int/resource/docs/cop6/dec1-cp6.pdf; Informal Note by the President of COP 6.

the proposals, all three were bracketed in the text). The first proposal was 'no sinks in the CDM'. The second was 'no decision on LULUCF in the CDM–SBSTA (i.e. the Subsidiary Body for Scientific and Technical Advice) will study issues of permanence, additionality, leakage with agreed deadline'. And the third proposal was 'no language on sinks in the CDM'. It was also suggested to follow a number of principles[18]:

- Decisions should be based on sound science,
- IPCC should developed good practice guidelines for estimation and reporting of LULUCF emissions and removals,
- Credits would be dependent on reliable national systems for estimation of GHG fluxes. Independent review teams should verify national inventories prior to issuance of credits,
- Necessary to separate out human effects on sinks
- Work on separating out natural effects and pre-1990 activities in the second and subsequent commitment periods, and
- Control for time consistency and double counting of LULUCF.

It was furthermore suggested to discuss the eligibility of forest management, cropland management, grazing land management, and revegetation.

After conducting a series of consultations with key countries and key regions, the COP-6 president recently suggested a set of new proposals for reaching agreement at COP-6 bis.[19] It is proposed that forest conservation, rehabilitation of degraded land and combating desertification are not eligible as CDM projects, but that such projects will be eligible under a new Adaptation Fund. The only eligible LULUCF project activities under the CDM during the first commitment period will be afforestation and reforestation. The proposed exclusion of forest conservation projects from the CDM is a response to the potential problem of a large amount of cheap sink options flooding the CDM. The decision on other LULUCF activities, including agricultural soils, will be postponed and it will instead be part of the negotiations on the second commitment period (2013-2017).

CONCLUSION

The issue of forest C overshadows the issue of soil C in the international policy debate on sinks as well as in the global climate negotiations. This paper has documented that a number of issues are being raised in the context of C sinks, and that several of these issues have influenced the treatment of soil and forest C sinks in the global climate negotiations. Unless a significant change in the negotiating dynamics takes place, it is very unlikely that COP-6 bis will include soil C sinks in the CDM.

More broadly, given the lack of progress on key political issues at the talks held prior to COP-6, and a feeling that the climate issue has lost some of its political prominence since Kyoto, it is perhaps unsurprising that COP-6 failed to reach an agreement on how to implement the Kyoto targets, including the role of C sinks. It is extremely difficult to predict if negotiators will finally succeed to reach an agreement at COP-6 bis. The attempts to salvage the COP-6 made immediately after the COP-6 failed, and since the Bush administration's position on climate change seems to be far from the EU's position, it appears increasingly unlikely that a meaningful global climate agreement can be reached at COP-6 bis.[20]

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[18] See 'Technical Talks on Climate Change' (12 December, 2000). Document prepared for a meeting of a group of officials from the Umbrella Group and the European Union held in Ottawa on December 6 and 7, 2000.

[19] 'New Proposals by the President of COP 6', 9 April 2001. See: http://www.unfccc.de/sessions/cop6_/unfccc_np.pdf

[20] For the Text of the Letter from the President to Senators Hagel, Helms, Craig, and Roberts on March 13, 2001, see http://www.globalclimate.org/BushLetter.htm.

Note. The views expressed in this paper are those of the author. They should not be attributed to the organization with which the author is affiliated.

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Ecologic Foundation Of New Zealand Proposes Linking Sinks With Domestic Action on Biofuel

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ABSTRACT

A paper circulated by the Ecologic Foundation at COP6a proposed a biofuel obligation to be attached to sinks in the KP. Additionally Ecologic has proposed a comprehensive positive lists of discounts for Art 4.3 activities. These proposals reflect a view that the key to avoiding another – and likely long term – breakdown at COP6b, is to package LULUCF in such a way that it is not primarily a 'loophole'. Acting as a lever for the take-up of biofuel technology, it actually makes an important contribution to energy sector transformation. Since emissions from imported oil are regarded as domestic emissions, sinks in the CDM can be seen as a form of 'domestic action' if linked to the prospect of importing biofuel-based transportation fuels in lieu of oil. The proposed positive list could allow the full amount to be claimed for activities which involve enhanced management since 1990 where overall sequestration and biofuels benefits are readily and accurately verifiable. An intermediate proportion could be claimed for activities that involve enhanced management, but with less certainly verifiable benefits. If necessary to achieve agreement with the Bush administration, a low proportion also to be claimed for those activities which are essentially in the business-as-usual category. Thus a comprehensive positive list of discounts can wrap up both measurement uncertainty and non-additionality

Keywords: COP6bis; negotiating balance; sinks-biofuel linkage; energy transformation; precautionary action.

INTRODUCTION

COP6 President Pronk intends an initial political compromise at COP6a, with officials then left to 'work it out'. But without new ideas – and with a Bush team maybe less committed to action – push and shove over the same ground may lead to another collapse, possibly long term. This article expounds new thinking, circulated at COP6 by New Zealand's Ecologic Foundation, and now before policy advisors, both in Europe and the umbrella group.

The Proposal

Ecologic's proposal is:

- Each 100 tonnes of CO2-equivalent credit, from both Art. 3.3 and Art. 3.4 related projects, should be linked to a proportionate biofuel-using project contemporary with credit measurement. This 'biofuels obligation' would be a few tonnes initially but increase as incremental costs of using biofuel decrease.
- All Art. 3.4 activities should be measured and monitored. Credit against Annex 1 Party commitments in 2008-12 should be up to a comprehensive positive list of discounts with the excess of credits, above the discounted amounts, usable after 2012

The intuition is that avoiding another collapse may require a LULUCF package where land use change is not just a 'sink,' but actually makes a real contribution to the domestic action sought by the EU, e.g. helping transform energy sector technology by producing gasoline substitutes. The use of biofuel liquids, wherever produced, is as much 'domestic action' as the importation and use of petroleum is domestic emissions.

Why specifically a biofuel obligation?

A real contribution to domestic action might come from linking sinks to any renewable energy technology. The *specific link with biofuel* is because biofuel intrinsically involves land use change, i.e. sinks, and because a particular problem of market co-ordination arises with biofuel. Biofuel raw material cannot be used unless it is grown previously: neither will it be grown unless landowners can foresee a market. There is no obvious market mechanism to co-ordinate the decisions of landowners and energy sector investors, two very different types of risk-averse decision taker, maybe in different countries.

Also, dispersed collectors of CO2 – sinks – are needed to collect dispersed emissions from transportation. Biofuel closes the cycle, yielding a sustainable system (with increased vehicle efficiency hopefully matching increased vehicle ownership worldwide). So low emissions scenarios – sponsored by industry, NGO's, governments, international organizations, etc – show a large and increasing role for modern biofuel in the new century, for which there is urgent need to begin growing raw material.

And the feature of sinks that makes them objectionable to those who 'want policy to hurt' – that they are a low cost way to get greenhouse levels down – is a precautionary bonus if a low threshold for catastrophic climate change is revealed. Large scale carbon storage in new forest sinks both enables an urgent response to start from a lower level of carbon in atmosphere, and provides a 'buffer stock' of potential biofuel that can quickly displace fossil fuel in the existing energy supply system, with the cleared land then available for intensive biofuel production.

Sinks in the CDM

Suitable land for growing biofuel raw material is mostly in developing countries, where risks and interest rates are high, deterring investment. So the exclusion of sinks from the CDM (under which carbon credit cash flows can sustain low income land-owners through the initial rotation, when there is no saleable product) is crucially damaging to the timely growth of a modern biofuel industry. Such growth prospectively yields sustainable development to some land-rich but otherwise impoverished G77 Parties.

Biofuel plantations use land on which people live, pointing to the importance of maintaining flexibility to design individual projects that are suited to the requirements of local participants. However, the biofuels-using project could be quite separate, possibly in another country. All that is implied for the CDM project is that a minor additional cost element (relative to the volume of sink credits) is incurred.

The negotiating balance

Ecologic's proposal for Art. 3.4 combines EU language about positive lists with US language about discounting. Delayed use of the balance of 3.4 credits, in excess of the discounted amounts used in the first commitment period, lends environmental integrity to Article 3.4 since it would enable greater certainty to develop regarding the magnitude of carbon reductions, including baseline issues. The corrected magnitude would be taken into account when negotiating allocated amounts beyond 2012. Such an approach would thus wrap up both measurement uncertainty and non-additionality.

This approach also allows the US to win an agreed proportion of 3.4 credits in the interim, reflecting the impact of the definitions of Art. 3.3 activities recommended by the IPCC relative to the less restrictive expectations of US negotiators at Kyoto. Without violating Kyoto's environmental integrity, the aim would be to encourage desirable activities that

A. were not taken into account when the first commitment period allocated amounts were negotiated
B. involve substantial uncertainty and may yield CO2-equivalent credits that are large in relation to allocated amounts in the first commitment period.

Owners of credit balances carried over to beyond 2012 may expect to benefit from higher CO2-equivalent prices under more ambitious commitments for the second and later commitment periods.

Summary

The broad trade-off proposed is that the umbrella group accepts a minor cost increment on sink projects and the EU accepts the US getting from Art 3.4 what it thought it was going to get from Art 3.3. A general benefit comes from resolving the co-ordination failure that hampers the development of biofuel, and from accelerated progress with a key technology for reducing transportation emissions. There is specific benefit to a number of developing countries.

IMPLEMENTATION ISSUES

If the Ecologic proposal is to be used it needs to be formulated in negotiable text capable of legal interpretation..

Familiar wording of 3.4 proposal

As regards the second part of the proposal, for a comprehensive positive list of discounts in relation to 3.4 activities, all of the words have been used by European or Umbrella group negotiators in the past. Presumably they have a well-defined meaning, at least in the minds of those that have used them, that can be formalised through negotiation. The process would appear to involve quantifying each of the activities listed in Chapter 4 of the IPCC's SR_LULUCF on a by-country basis [i.e. dividing-up the global totals established by the IPCC]. This would be to establish in the minds of negotiators an understanding of the extent to which each Party stands to win of lose from these activities under different levels of discounting. Discounts would then be agreed as an exercise in political horse trading, leaving the balance after discounting, that is banked for crediting after 2012, to become better defined, both as regards magnitude and additionality, in advance of negotiating allocated amounts for the second commitment period. Such negotiations would recognise that various individual Parties should benefit from banked credits in the determination of their allocated amounts after 2012, while enabling the overall total of allocated amounts to be adjusted [reduced] to reflect the aggregate quantity of banked credits arising from action outside the second commitment period.

Novel wording in 3.3 proposal

Each 100 tonnes of CO2-equivalent credit, from both Art. 3.3 and Art. 3.4 related projects, should be linked to a proportionate biofuel-using project contemporary with credit measurement. This 'biofuels obligation' would be a few tonnes initially but increase as incremental costs of using biofuel decrease.

The Ecologic proposal for linking sinks to biofuel projects involves novel language that needs to be clarified before the proposal can be introduced into negotiations. However, elements of the proposal involve language that is already in use and may thus be taken to be definable, with nothing new involved. These are "CO2-equivalent credit, from both Art. 3.3 and Art. 3.4 related projects" – i.e. all credits for removals from the atmosphere due to sink activities – and "biofuel-using project" – i.e. reductions in emissions due to a biofuel project. As with all projects there are additionality and baseline issues. These are crucial for environmental integrity in relation to projects credited under the CDM, but merely redistributive in relation to project based credit trading between entities within an Annex 1 Party, or JI related crediting involving entities under the jurisdiction of different Annex

1 Parties. But nothing new arises. The specifically new element arises from underlined words in the following extract "a proportionate biofuel-using project "contemporary with credit measurement".

The proportionate word can be made effective by defining a mechanism for determining the proportionality. A workable mechanism could be that "the proportionality is to be determined from time to time by the COP/MOP for a number of years ahead, in response to recommendations of the SBSTA, with previously determined values remaining in force in the absence of such recommendations, and with an initial default value of 100 per cent for all years ahead". The effect of this would be that, until the SBSTA had proposed otherwise, and the COP/MOP had accepted the proposal, all sink activities would be burdened by an equal biofuel-using project. It is anticipated this would substantially block the crediting of sink activities until time had elapsed to enable the SBSTA to negotiate agreed proportionalities for a number of years ahead. The purpose of this is to enable the Ecologic proposal to be agreed in principle at COP6b, if it is needed then in order to avoid an impasse, whilst leaving it to subsequent discussion what proportionality values are appropriate.

It is envisaged that negotiations in SBSTA would lead to agreement at COP7, or COP8 at the latest, on a set of proportionality values that might, for instance, increase from 5 per cent in 2003 with 5 per cent increments annually. This would lead to 30 per cent proportionality in 2008, 50 per cent in 2012, etc .

The meaning of "contemporary with credit measurement" then requires to be defined.

- Suppose sink project A, initiated in 2003 in a non-Annex 1 country, leads to removals from the atmosphere of 100 tons in 2004, 2005 and 2006, with the 300 tons of stored carbon then being permanently secured. (We abstract from the practical difficulties involved in ensuring permanence and from the transactions costs of permanent monitoring).
- Suppose also that project X, located in an Annex 1 country, incinerates garden waste in a district heating scheme, displacing natural gas, and results in a 5 tons emissions reduction annually for ten years, from 2004 onwards. Then project X could be linked to project A in the UNFCC registry of projects and would enable (5ton/5 per cent) = 100 tons of carbon to be credited in 2004, 2005 and 2006, i.e. 300 tons of carbon credits to be banked under the CDM until 2008-2012.
- Suppose further that sink project B, also in a non-Annex 1country, and initiated in 2006 when the proportionality is 20 per cent, results in emissions reductions for twenty years, beginning in 2007, of 25 tons annually. Then the remaining seven years of emissions reduction from project X of 5 tons annually could be linked to the first seven years of removals by project B. This would enable 25 tons (= 5tons/20 per cent) credits to be claimed annually from 2007 to 2013 (with the 2007 credit banked till 2008 or later).
- Additionally, project X would generate 5 tons of emissions reductions credits annually through the first commitment period which could be traded to an entity at the point of policy obligation in the same country or, through JI, to an entity in another Annex 1 country.
- In 2014, it would be open to the owners of project B, if they wished to continue to get carbon credits for their sink project, to seek a different biofuel using project, say project Y initiated in 2013, and to purchase linkage equivalent to (5 tons per year/ 55 per cent) for 13 years ahead from the owners of project Y.

By 'initiated' in the above example is intended the substantial commencement of the physical actions (and financial expenditures) that lead to the creation of the sink, e.g. the establishment (planting) of a new plantation, or the fencing off of a conservation area. Paper activity such as the planning or contractual commitment for a removal from the atmosphere would not count as initiation.

Markets for credits and for linkages

Clearly the one-for-one seeking out of trades by the owners of sink projects and owners of biofuel using projects, barter-style, involves high and unnecessary transactions costs. As with other trading activity, linkage, along with projects based credits, would come to be mediated through markets, including futures markets. These would establish through arbitrage, and over the relevant time horizon for projects:

1. the price of dated credits for absorption from the atmosphere by sinks
2. the price of dated credits for reductions in emissions through biofuel-using projects, and
3. the price of dated linkages between the first and the second.

Then an entity that starts a sink project would need to purchase linkage (3.) on the world market for linkages, before selling the credits created by its sink on the world market for project based credits at price (1.). And an entity that invests in a biofuel-using project would be able to sell both linkage at price (3.) and credits at price (2.) on the appropriate world markets. Prima facie 1. and 2. would be the same.

The prospective cost of sinks projects would thus be increased by a stream of cash outlays corresponding to the future prices of linkages (3.) multiplied by the proportionality applying at the time of initiation. This would effectively be a partial offset against by the benefit from credits for absorption by sinks priced according to (1.).

The prospective cost of biofuel using projects would be offset both by a stream of cash outlays corresponding to the future price of a linkages (3.) and, from 2008, by a stream corresponding to the future price of credits for emissions reductions through biofuel using projects (2.).

A consequence would be that biofuel using projects would receive the enhanced incentive that appears to be needed, relative to other emissions reducing projects (prima facie the same as (1.) and (2.)) in order to secure the evolution of biofuel technology in line with low emissions scenarios. The basis for such enhanced incentive would be

A the significant beneficial features of biofuel noted below
B the evidence of slow take-up of biofuel using technology, relative to, e.g. photo- voltaics, and
C the existence of specific barriers to entry facing biofuel systems, also noted below

Apart from – and more effective than – incentives, entities seeking to take advantage of sinks as a low cost option would also incur a physical obligation. This would ensure that physical experience is being gained of biofuel using technologies somewhere within the energy sector and consequentially that their costs reduce in line with the 'learning by doing' process.

It may be noted that, under proposals for 'allocating permits usefully', the prices for project related credits (which constitute incentives for mitigating innovations that yield a beneficial inter-temporal externality through learning by doing) would all be greater than the penalty on emissions reflected in the traded price of emissions permits. For more on such asymmetric measures see web-site http://econ.massey.ac.nz/apu . Allocating permits usefully has the effect that entities reluctant to risk taking a lead with renewables innovation, in order to be in a position to learn from the mistakes of pioneer innovators (a specific example of the general problem of under-investment in innovation) would pool this risk, innovating together.

Features of biofuel energy systems:

Energy relevant aspects

1 Precautionary: biofuel is one of two renewable technologies that are particularly relevant to the potential need for urgent measures – smokestack sequestration (so called 'clean coal' – not quite sustainable for ever, but good for a few centuries) and biofuel (possibly combined with smokestack sequestration)

2 Both are compatible with the existing fossil fuel based system and can therefore be deployed quickly subject to modest precautionary expenditures to achieve necessary land use changes and initiate learning with these technologies to secure cost reductions

3 Additionally, biofuels
- . sequester carbon during the growth of the first rotation of a biofuel plantation, reducing the GHG level and giving urgent policy a head-start
- can, under urgency, be directly substituted in fossil fuel boilers at minimal cost
- collect dispersed emissions from the transportation system

Non energy aspects – problems:

a) co-ordination failure between energy sector managers investing in plant to use biofuel, and landowners, investing in biofuel plantations several years earlier, maybe in other countries;
b) small-medium scale and variability of biofuel supplies;
c) need for on-going relation with land based producers in context of local environmental and socio-economic impacts, both beneficial and detrimental;
d) no 'one size fits all' solution and need for local community commitment, with good project design delivering continuing local benefits.
e) need for capacity building for country-driven projects

Non energy aspects – opportunities:

f) sustainable development for rural communities, rural electricity, enhanced life styles and slowed drift from the land;
g) redesigned farm support strategies with lower costs to taxpayers in the North but likely continued high farm product costs;
h) carbon credit initiated growth of least developed African and Latin American economies;
i) subsequently sustained by biofuel liquid exports and South-South trade with industrialising Asian economies;
j) increased capitalisation of land use activities, replacement of unsustainable traditional land use patterns, and protection of biodiversity and other values;
k) climate treaty driven carbon credits as the financial springboard for other multilateral environmental agreements objectives.

ACKNOWLEDGEMENTS

The research upon which this article is based is supported by the New Zealand Foundation for Research Science and Technology through Public Good Science Fund Contract PRC00X.