Biochar and the Carbon Market

A review of carbon market development perspectives and biochar offset projects GHG accounting aspects

A publication of the Interreg IVB project Biochar: climate saving soils

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Foreword

One of the objectives of the Interreg IVB project Biochar: Climate Saving Soils is promoting the use of biochar as a tool for carbon sequestration. The mechanisms and development of the international carbon market are a complex topic. Therefore the Biochar project has made an effort to inventarise the status quo of the carbon market and to summarise this in a concise publication. The experts of the Joint Implementation Network have produced this publication for the project Biochar: Climate Saving Soils. This publication can also be downloaded from our project website www.biochar-interreg4b.eu.

Frans Debets
Project leader for the Interreg IVB project Biochar: climate saving soils

1. Introduction

Since the mid-1990s carbon markets have internationally become accepted as a way to provide additional financial incentives to climate-friendly investment options. The main framework for carbon markets has been the UN Framework Convention on Climate Change (UNFCCC) and its 1997 Kyoto Protocol. This has been followed by, among other schemes, the EU emissions trading scheme (EU ETS, in 2005), the Regional Greenhouse Gas Initiative (RGGI, USA), the Western Climate Initiative (WCI, USA/Canada) and the New Zealand emissions trading scheme. In Australia, China, South Korea and Brazil national and sub-national emissions trading schemes are being planned. When adding up all such initiatives, it is estimated that by 2015 75% of global GDP is produced in regions where, in one form or another, greenhouse gas (GHG) emissions are priced (Promethium Carbon, 2013).

Carbon markets usually emerge when countries (such as under the Kyoto Protocol) or companies (such as in the EU ETS) become subject to GHG emission reduction or limitation commitments (mandatory or voluntary) in the form of maximised (annual) GHG emission allowances. In order to comply with these commitments, the market schemes allow countries/companies to invest in measures to reduce their own GHG emissions or purchase emission allowances from other countries/companies. In addition, if permitted by the carbon market scheme, carbon credits can be purchased from emission reduction projects taking place outside the scheme. These credits are then added to the country's/company's emission allowances within the scheme (see Figure 1 for an illustration). A reason for purchasing allowances from projects outside the scheme is that this could be cheaper than investing in extra emission reductions domestically or within the company's own installation. As such, a market results where emission reductions take place where the costs are lowest. The best known example of what such a market looks like is the Clean Development Mechanism (CDM) under the Kyoto Protocol.

The main objective of carbon markets is to put a price on GHG emissions and a clear benefit of using markets is that additional private sector funding can be mobilised and pressure on governmental budgets relieved. Typically, this funding goes to investments in low emission technologies which have not yet reached the stage of commercial feasibility (*i.e.* costs are higher than revenues) and which could become financially viable by adding the value of carbon credits to the revenues. At the same time, there is a challenge that the purchased carbon credits must represent real emission reductions so that GHG accounting processes need to be available with accompanying validation, monitoring and verification procedures.

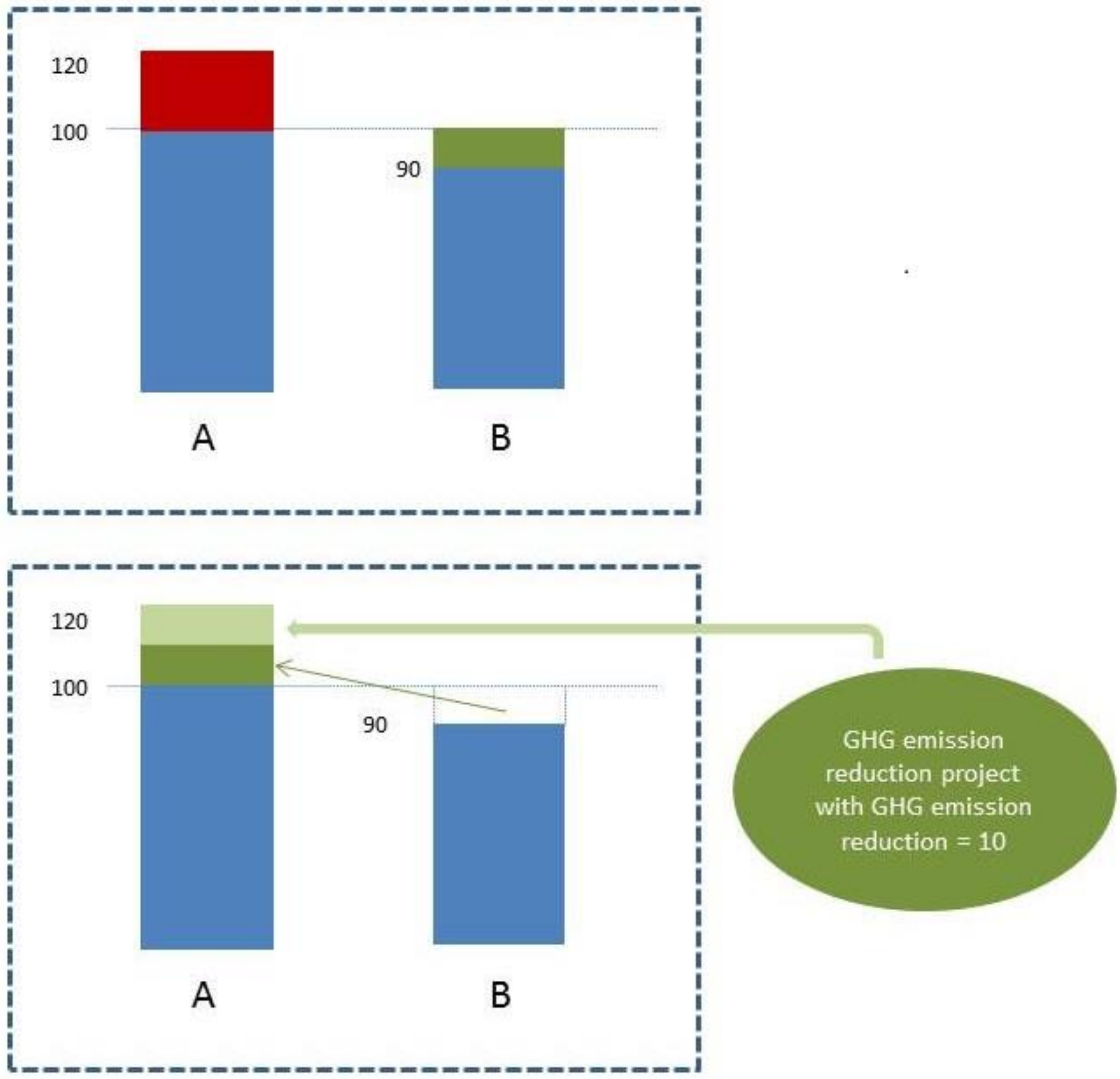

Figure 1. Illustration of cap-and-trade scheme with link to emission reduction projects

This diagram shows two installations (e.g. companies) within an emissions trading scheme which both receive 100 allowances to emit greenhouse gases during one year (1 allowance = 1 tGHG). Installation A, however, emits 120 tGHG during the year and therefore overshoots its allowance level by 20 tonne. Installation B manages to keep its emissions below its allowances level by emitting only 90 tGHG. For compliance, installation A can purchase B's surplus of 10 allowances and add these to its own allowances. In order to cover the remaining deficit, A could invest in an emission reduction project taking place outside the scheme to attract another 10 carbon credits. By doing so, A manages to surrender 120 allowances/carbon credits and comply with its commitments under the scheme.

Recently, international carbon markets have experienced strong declines in prices due to over-allocation of allowances under the EU ETS and reduced demand for carbon credits under the Kyoto Protocol (partly due to the US withdrawal from the protocol). Both effects have been enhanced by the global economic crisis since 2008 which led to decrease in industrial production and corresponding GHG emissions and therefore reduced demand for GHG emission allowances and carbon credits. The lower allowance/carbon credit prices have reduced the potential of carbon markets to promote commercially non-viable projects to financially feasible investments.

Biochar production with application to soils is a technology option which could potentially be applied in a project with its contribution to GHG emission reductions calculated as credits and sold on a GHG emission trading market. As such, additional funding could be generated for biochar project investments. At present, however, it is uncertain at what carbon credit price a biochar technology project would become financially feasible, as this requires detailed insight on the net emission reduction impact of producing biochar and applying it to soils, including the techniques used for that, and on the permanence of the biochar stored in soils.

In light of this uncertainty, this paper discusses:

1. The current status of international carbon markets (chapter 2).
2. Possible directions of international climate policy making towards a post-2020 climate policy regime and possible implications of these for international carbon market development (chapter 3).
3. How biochar-based technology options could contribute to GHG emission reductions and what accounting methodology/ies would be required for that (chapter 4).

2. Current Status of International Carbon Markets

The main objective of carbon markets is to internalise environmental impacts of GHG emissions as a cost in economic decision making and to create incentives for low emission investments. Ideally, the carbon market price reflects the environmental costs of GHG emissions.[1] Carbon trading was adopted internationally under the 1997 Kyoto Protocol, which contained quantified emission reduction/limitation commitments for industrialised countries (for the years 2008-2012).[2] Countries could comply with these commitments partly through the purchase of carbon credits through projects in developing countries (Clean Development Mechanism, CDM) or in other industrialised countries (Joint Implementation, JI) (UNFCCC, 1997). As a result, a global market for carbon credits emerged.

2.1. Overview of Carbon Markets

As per September 2013, 7890 Kyoto-based projects (JI and CDM) have entered the carbon market (individual projects registered by the JI and CDM authorities under the UNFCCC; in addition, the CDM pipeline contains 721 Programmes of Activities which group small-scale emission reduction activities into larger programmes).[3] Initially, during the early years of the Kyoto Protocol crediting period 2008-2012, credit prices were between € 15 and 20 (per tonne CO_2-equivalent), but they dropped after 2010 due to the economic recession and the

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[1] In reality, however, it has turned out difficult to realise this ideal situation. As will be explained below, at present there is a very large gap between international carbon market prices and science-based estimates of the costs of climate change.

[2] developing countries were exempted from such commitments.

[3] CDMpipeline.org: http://cdmpipeline.org/publications/CDMPipeline.xlsx and http://cdmpipeline.org/publications/JiPipeline.xlsx

international disagreements on an ambitious extension of the Kyoto Protocol beyond 2012. This has resulted in a weakening of carbon credit demand. As a result, carbon credit prices dropped to less than €2 in December 2012, shortly before the end of the first Kyoto Protocol commitment period. Consequently, the market perspective for Kyoto-based credits has become bleak: despite the agreed extension of the Kyoto Protocol at the Doha climate summit of 2012, it remains unclear whether this will stimulate carbon credit demand. At Doha, an agreement was reached on a second commitment period under the Kyoto Protocol from 2012 to 2020, although a number of key industrialised countries (among them the USA, Canada and Russian Federation) announced that they would not adopt emission reduction commitments during this period (UNFCCC, 2012). Eventually, 37 countries (mainly European countries and Australia, representing 14% of global emissions) pledged emission reductions (18% below 1990 levels) (CDCClimat, 2012).

As part of its Kyoto Protocol policy package, the EU launched an emissions trading scheme (ETS) in 2005. The scheme caps GHG emissions for over 10,000 energy-intensive installations (around 40% of the EU's total emissions) and allows trade between installations to remain below their caps. During 2005-2007, the EU ETS was operated as an initial, learning phase with emission allowances allocated for free to installations and without the possibility to carry over surplus allowances to future ETS phases. As a result, the ETS carbon market price could either increase to a level equal to the fine that installations had to pay if their annual emissions were higher than the allocated emission allowances (€ 100/tonne CO_2, in case allocated allowances would be structurally lower than emissions) or decrease to a value close to zero euro per tonne CO_2 (in case allocated allowances would be structurally higher than actual emissions) (Ellerman, 2008). In practice, the ETS market price dropped to around zero by the end of 2007 as the 3-year market faced considerable over-supply of allowances.

In 2008, the second phase of the EU ETS began which covered a five-year period of 2008-2012. This time, the allocation of emission allowances could be based on verified emissions of European installations under the scheme during 2005-2007. During the second phase, the Kyoto Protocol and EU carbon markets also became interlinked (although with limitations): European installations could buy Kyoto-credits (through JI and CDM) and add these to their allowances (so that they could be used, for instance, as a compensation if their annual emissions were higher than their allocated emission allowances). As a result, during 2008-2012, European installations developed the strongest demand for Kyoto-based carbon credits of any major trading block (World Bank, 2012). Moreover, surplus allowances during the second EU ETS phase could be carried over to the third phase of the EU ETS, covering the years 2013-2020.

In addition to the EU scheme, several other cap-and-trade schemes have been established such as the Regional Greenhouse Gas Initiative (USA) and Western Climate Initiative (Canada, USA) and New Zealand emissions trading schemes.[4] In Australia a domestic CO_2 taxation

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[4] For most cap-and-trade schemes, biochar credits can only be included with the help of linking offset mechanisms to the cap-and-trade mechanism. However, the New Zealand Emissions Trading Scheme also includes sink categories, and herewith biochar could also potentially be included directly under this scheme. In addition, the Kyoto protocol allows carbon credits to be generated through sinks.

scheme was agreed (as part of the Clean Energy Future Package legislation) in 2012 (Promethium Carbon, 2013) which taxes each tonne of GHG emitted by AUS$ 23. The Government of Australia has the objective to transform the carbon tax system into a trading scheme by 2015 and to link the scheme to the EU ETS from then on. As of 2018, EU ETS installations may also enter the Australian ETS and purchase Australian emission allowances. In China, South Korea and Brazil national and sub-national emissions trading schemes are being planned (JIN, 2013).

Next to these ‘compliance markets’ also markets have developed for crediting voluntary actions to offset emissions related to, e.g., travelling and conference organization. The voluntary carbon market has been diverse with, e.g., varying standards for accounting of carbon benefits. Nonetheless, voluntary carbon schemes have become a stable carbon market with improved standards. Examples of voluntary schemes are: Verified Carbon Standard, Climate Action Reserve, Gold Standard, American Carbon Registry and Plan Vivo (Ecosystem Market Place, 2013).

On the voluntary carbon markets, prices have remained relatively stable, as they are not immediately linked to the EU and Kyoto carbon markets.[5] In addition, improvements in GHG accounting and environmental integrity standards of voluntary market credits have generally enhanced the credibility of these markets.[6] As a result, prices are nowadays at levels around € 6 to € 8 per tonne CO_2 which is considerably higher than the current carbon credit and allowances prices on the ETS and under the Kyoto protocol. Demand on the voluntary markets (e.g. from organisations such as JetBlue, eBay, Google, Dell, Siemens initiatives as well as organisations that aim at greening supply chains or branding their products as green or sustainable) is expected to grow to 200 or even 500 million credits by 2020 (from 100 million voluntary credits in 2012 (Ecosystem Market Place, 2013)). The USA is the country that hosts most of the buyers of voluntary carbon credits (43%), followed by the UK (26%) and Germany (13%). Most of the buyers are from the energy and wholesale/retail sectors (50% jointly). Generally, voluntary market transaction volumes are much lower than, for instance, CDM-based credit transactions and usually have a short term focus, while CDM-transactions could have a focus of even 21 years.

2.2. Managing an Unbalanced EU ETS market

The price development on the EU ETS market has shown a similar downward trend from almost €30 per emission allowance around mid-2008 to € 2.81 in January 2013 (JIN, 2012). From this trend it has become clear that without any structural measures to bring supply and demand back in balance on the ETS market, prices will remain low and stay far below the €30 to €40 per allowance level that were expected for the third ETS phase to trigger a large-scale switch from CO_2-intensive to low emission technologies within Europe. For instance, in a

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[5] In principle, voluntary market buyers could also buy CDM credits, but procedures for that have been relatively complex, as it requires approval of the buying and selling governments. In the future, however, sale of CDM credits on non-compliance market may increase.

[6] Although there are examples of voluntary crediting schemes which collapsed due to poor understanding of the carbon accounting rules and consequences of sectoral policies for carbon credit potential.

report to the European Parliament and the Council, the European Commission explained that during the second phase of the ETS (2008-2012) supply of issued allowances and used credits from JI and CDM projects amounted to 8720 million whereas installations' cumulative emissions during this period (i.e. demand for emission allowances) amounted to 7765 million tonnes CO_2-eq. ((European Commission, 2012). In other words, the second ETS phase had an oversupply of 955 million allowances. Only in 2008, before the global economic crisis began, emissions were higher than allowance supply (24 million tons) ((JIN, 2012).

As a consequence, price development on the ETS market has shown a downward trend during 2008-2012 with an acceleration from almost €25/allowance around mid-2008 to less than €15/allowance in 2009 and to around € 5/allowance in January 2012 (which was related to the accelerated build-up of JI and CDM credits supply on the ETS market). During 2009-2011, prices remained relatively stable around €13/allowance (see Figure 2).

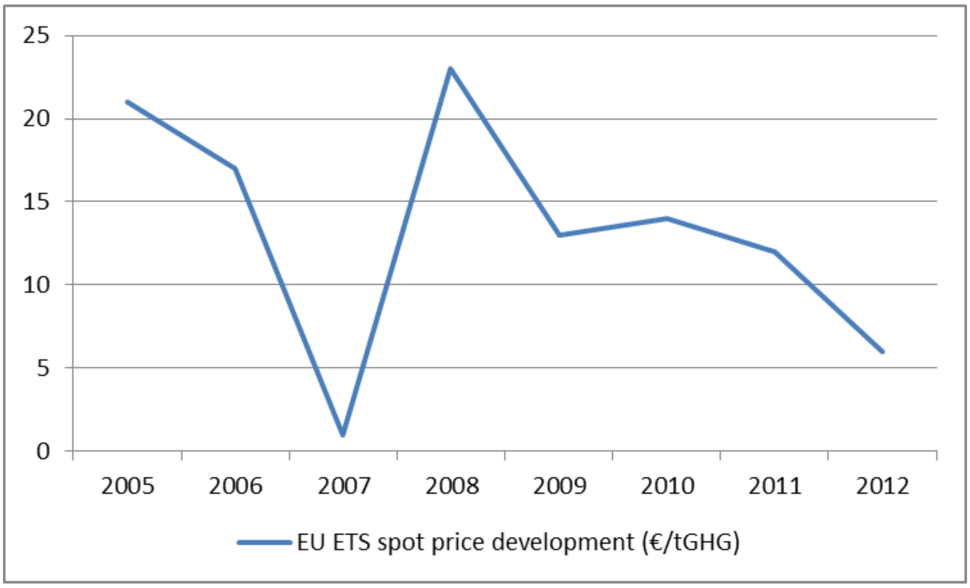

Figure 2. EU ETS spot price development (€/allowance) (Gloaguen, 2013)

The diagram shows how during 2005-2007 (the EU ETS first trading period) prices dropped to almost zero euro. In 2008, at the beginning of the second EU ETS trading period, prices increased again, but started to decline due to lower GHG emissions in Europe due to the economic crises and resulting oversupply of allowances.

In order to scale up the ambition level of the EU ETS in its third phase (2012-2020), a number of changes were agreed in 2009 for application in 2013 (European Parliament and the Council, 2009):

- Instead of national emission caps, as was the case during the second phase of the ETS, during the third ETS phase there will be an EU-wide cap on allowances. This cap is based on verified emissions during 2008-2012 and will be reduced by 1.74% per year.
- The majority of allowances will be distributed across installations through auctioning.
- In cases where allowances are allocated for free, this will be based on performance benchmarks.

- The use of credits from the Kyoto mechanisms JI and CDM is further restricted.
- There will be one single EU-wide registry for registering allowances and emissions.

With these changes, it is intended to make the scheme more harmonized across the Member States and to tighten the supply of allowances thereby creating upward pressure on the prices. However, as the European Commission has concluded (European Commission, 2012), these pre-economic crisis measures will not prevent that also during most of the third ETS phase there is likely to be a surplus of allowances. The latter is largely due to surpluses from the second ETS phase that are carried over to the third phase. The European Commission estimates that during 2013-2020 the cumulative surplus of allowances could amount to approximately 2 billion (European Commission, 2012),[7] although it is assumed that from 2014 onwards the annual increase of surpluses will slow down.

In order to support price development in the EU ETS market, the European Commission proposed to retire 900 million allowances from the ETS during 2013-2015 (400 million in 2013, 300 million in 2014 and 200 million in 2015) and bring these back to the market at the end of current third ETS phase ((European Commission, 2012). Through this ‘backloading’ idea it is hoped that EU ETS prices will recover as a result of short-term scarcity. On 3 July 2013, the European Parliament in a full plenary session considered the ‘backloading’ proposal again (after it had rejected the proposal on 16 April) (JIN, 2013). This time, the Parliament supported the proposal (by a vote of 344 for against 311 against), by deciding that ‘backloading’ can take place as proposed with postponing auctions of 900 million allowances and reintroducing these in the market by the end of the third ETS phase.

The passing of the ‘backloading’ proposal through the European Parliament means that it can now be considered by the European Council of Ministers. About half of the EU Ministers seem to be supportive of the proposal, but with expected opposition from Poland and governmental changes in Germany, the ‘backloading’ proposal is still surrounded by uncertainties.

In the meantime, the European Commission has also suggested other possible solutions to restore balance between greenhouse gas demand and supply on the EU ETS market (see Box 1). Each of these possible solutions would imply a significant impact on the current ETS legislation and would require support from policy (European Parliament and the Council) and through this from the market itself.

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[7] To compare: annually, the EU ETS allocates around 2 billion allowances to installations covered by the scheme. http://ec.europa.eu/clima/policies/ets/cap/index_en.htm

Box 1. Possible measure to restore balance between demand and supply on EU ETS market (European Commission, 2012)

- Increase of the EU GHG emission reduction target to 30% in 2020 as this would need a consequential amendment to the quantity of EU ETS allowances. This amendment could be in the form of a retirement of allowances from the scheme or a revision of the annual reduction of the cap. It is estimated that aligning the ETS cap with a 30% reduction target in 2020 would need a 1.4 billion reduction of allowances during the third phase.
- Permanently retiring a number of allowances during the third ETS phase. This would imply a reduction in the quantity of allowances available for auctioning. As a consequence, this option would result in a GHG emission reduction within the EU that goes beyond the -20% target in 2020.
- Early revision of the annual linear CO_2 emission reduction factor. As explained above, during 2013-2020 the emission cap for ETS installations will decrease by 1.74% per year. According to the ETS Directive, the reduction factor will be reviewed as from 2020, and this option would imply a revision already during the third phase. The European Commission note explains that such a revision would also bring GHG emission reduction trends in the EU in line with the longer term climate goals, such as the 80-95% emission reduction target in the EU Climate Roadmap for 2050. It is currently estimated that should the present annual reduction schedule of 1.74% be continued during the third phase and beyond, EU GHG emission would be 70% below 1990 emissions in 2020.
- Extension of the ETS to other sectors. According to the Commission, emission reductions in ETS sectors have been stronger than in non-ETS sectors (for instance, 11% vs. 4% in 2009). One option to extend the ETS scope to other sectors could be to include energy related CO_2 emission sources in non-ETS sectors within the scheme.
- Limit access to credits from international carbon markets. The Commission estimates that without access to JI and CDM credits, the surplus of allowances during the period 2008-2020 would have been only 25% of the presently expected surplus (see also above). In this option, access to international credits would be limited (or even excluded) whereby temporary demand increases could be softened by the present allowance surplus. More structural price increases could then lead to more flexible access to international credits again (or to non-ETS projects as described in Art. 24a of the ETS Directive).
- Discretionary price management mechanisms. Options for such mechanisms are: a price floor during the auctions and depositing of a certain amount of allowances in a reserve in case of a temporary demand-supply imbalance.

3. Possible Climate Policy Scenarios and Implications for Carbon Markets

3.1. Overview of International Climate Policy Developments

As the Kyoto Protocol’s first commitment period ended in 2012 (it started in 2008), negotiations were required on a post-2012 international climate policy regime under the UNFCCC. These negotiations started in 2005 (after the formal entry-into-force of the Kyoto Protocol earlier that year) but faced a set back at the UN Climate Conference in Copenhagen (2009) when Parties did not reach consensus on a new follow-up agreement. Instead, after ‘Copenhagen’ a shift took place from a top-down architecture where an overarching goal is translated in individual country targets (such as in the Kyoto Protocol) to one in which national GHG emission reduction pledges should add up to a joint international effort (Gaast, 2012). Other concepts introduced in the post-2012 negotiations were those of nationally appropriate mitigation actions (NAMA) and low emission development strategies (LEDS) which both aim at supporting developed and developing countries in identifying and embedding GHG emission reduction measures within their sustainable development contexts.

These measures, however, do not have the legally binding nature of the Kyoto Protocol emission reduction commitments for industrialised countries (UNFCCC, 2013).

Eventually, at the UN Climate Conferences of Durban (2011) and Doha (2012) it was agreed to extend the Kyoto Protocol with a second commitment period (Doha Amendment to the Kyoto Protocol to cover the period 2012-2020) (UNFCCC, 2012)[8] and to prepare a new climate regime for the period after 2020. The continuation of the Kyoto Protocol was generally considered a relatively weak step as the portfolio of GHG emission reduction pledges by countries represented only 14% of global GHG emissions[9] (without participation of, among other countries, USA, Canada, Japan and the Russian Federation) (CDCClimat, 2012). Consequently, carbon markets, which had initially flourished during the early stage of the first commitment period, were characterised by significant oversupply of credits. The extended Kyoto Protocol, with the absence of key industrialised countries, does not contain measures to repair this imbalance (Taminiau, 2012).

For the period after 2020, it has been agreed at ‘Durban’ to negotiate a global climate policy regime for the period beyond 2020 to be agreed upon by 2015 (Taminiau, 2012). Currently, it is therefore unclear what a future international climate policy regime will look like. ‘Simply’ continuing from the Kyoto Protocol has become unlikely. An important reason for that is that the group of countries with quantified, legally-binding commitments under the Kyoto Protocol is limited to industrialised countries only. Such a division of tasks will not be possible under a future regime as this would imply exemption (again) of rapidly industrialising countries, such as China, India, Mexico and Brazil, from emission reduction commitments (Gaast, 2012). While in 1997 (when the first commitment period of the Kyoto Protocol was agreed) such a division between industrialised and developing countries was still acceptable, nowadays exemption of rapidly industrialising developing countries from commitments has become unacceptable for industrialised countries.

Another aspect is whether a future climate policy regime will be fully centrally-governed or more decentralised. The UNFCCC and Kyoto Protocol are centralised top-down agreements aiming at global, long term GHG emission reduction targets and dividing these targets between individual countries (Gaast, 2012). However, recently, also a range of climate policy initiatives have been taken by countries or regions within countries which have no direct link to the UNFCCC or Kyoto Protocol. For example, Japan has initiated a Bilateral Offset Credit Mechanism (BOCM) within which it collaborates bilaterally with other countries in the form of technology transfer support with carbon credits in return. In China, the municipalities of Beijing, Tianjin, Chogqing and Shenzhen and the governments of the provinces Hubei and Guangdong have developed plans for regional emissions trading schemes.

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[8] <http://unfccc.int/files/kyoto_protocol/application/pdf/kp_doha_amendment_english.pdf>

[9] Of the industrialised countries in Annex B of the Kyoto Protocol (countries with quantified commitments during 2008-2012) only Australia, Belarus, Croatia, EU, Kazakhstan, Liechtenstein, Monaco, Norway, Sweden, Switzerland and Ukraine made pledges for GHG emission reductions by 2020 under the 2012 Doha Amendment to the Kyoto Protocol. Consequently, the group of countries in the amended Annex B of the Kyoto Protocol represent a much smaller share of global GHG emissions (14%) than in the initial Annex B of the protocol as agreed in 1997.

When adding up the Kyoto-related and decentralised initiatives being taken or planned, It is estimated that “by the first quarter of 2013, only 30% of global emissions came from jurisdictions that in one form or another, have failed to take steps towards carbon pricing” (Promethium Carbon, 2013). Figure 3 illustrates this. It is also estimated that by 2015 75% of global gross domestic product will be generated in countries and regions that place a price on GHG emissions. In most cases, this pricing will have the form of an emissions trading market (either Kyoto-based or based on national/regional initiatives), while in a few cases the pricing could take the form of an emissions tax (as explained above, in the case of Australia the carbon tax system is scheduled to be transferred into an emissions trading market by 2015).

Figure 3. GDP covered by carbon pricing at regional, national or sub-national levels (Promethium Carbon, 2013)

3.2. Implications for carbon markets and/or carbon pricing

3.2.1. UNFCCC and non-UNFCCC carbon pricing initiatives and their links

What would the above international climate policy developments imply for carbon markets? On the one hand, as explained above, price development on carbon markets have been disappointing and prospects for recovery of prices are weak, especially under the Kyoto Protocol and EU ETS. On the other hand, the fact that an increasing share of global GDP is now being covered by carbon pricing (market) mechanisms shows that pricing of GHG emissions will continue to exist.

An important aspect of the current patchwork of carbon pricing initiatives is that they generally aim at establishing interlinkages with each other. The above example of enabling Australian and EU installations to trade in each other’s markets is a clear illustration of that. In addition, existing markets and market plans envisage links with GHG emission reduction projects outside the carbon market schemes (offsets). The CDM is an example of that, but also the provision in the EU ETS Directive that ETS installations could, in principle, purchase credits from projects outside ETS sectors within Europe for their ETS compliance is an example of an offset link (Article 24a of the ETS Directive of 2009; thus far this offset option has not been used yet due to the low ETS prices) (European Parliament and the Council, 2009). Enhanced interlinkages between carbon trading/pricing schemes and possibilities for offsetting emissions with activities outside the schemes will require that rules for accounting of GHG emissions are harmonised, so that the quality of a tonne CO_2-equivalent traded in one market is similar to that of a tonne CO_2-equivalent traded elsewhere. Such rules could emerge from increased collaboration between carbon pricing schemes, but could be arranged by countries under the auspices of the UNFCCC. Figure 4 shows a possible process of how increased collaboration between international carbon pricing schemes could eventually lead to global emissions trading scheme (Promethium Carbon, 2013). It is noted that such a development is not officially scheduled, but just an illustration of what a process towards global carbon pricing could look like.

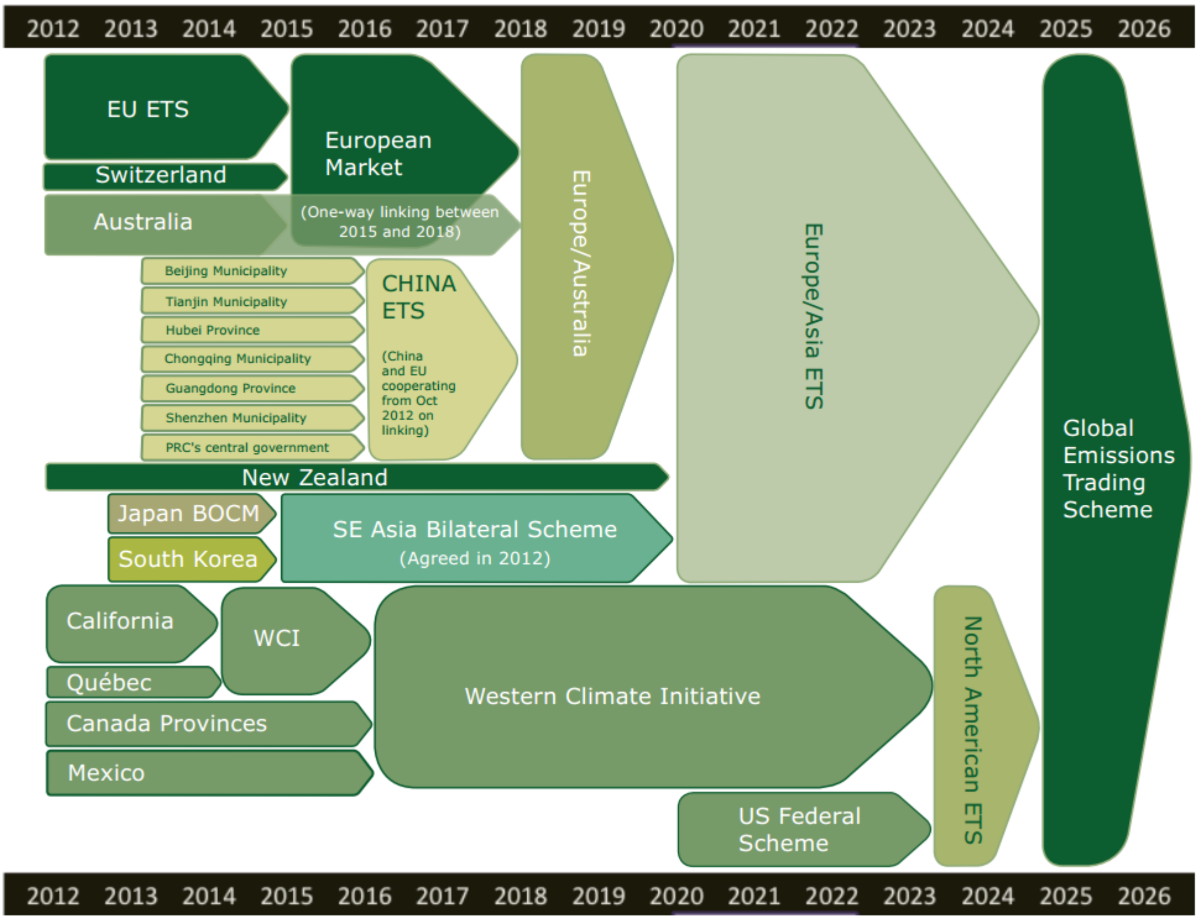

Figure 4. A potential process for establishing interlinkages between carbon market initiatives and how this could lead to a global market (Promethium Carbon, 2013).

The above description of global carbon pricing activities does not mask the fact that current carbon market price are relatively low and that in the short run there are no prospects of a strong recovery of carbon price development. In fact, when comparing supply and demand in the current compliance markets (such as Kyoto Protocol and EU ETS), then an oversupply of allowances and credits of 2 billion can be found which has had a downward pressure on carbon prices, at least in the short run (Michaelowa, 2013). In light of that reality, how could investors in low carbon technology projects sell their future carbon credits, what markets are most attractive and when to sell credits for maximising their value?

3.2.2. Short term carbon market perspectives

At a webinar on 3 July 2013 on “How to Sell you Carbon Credits in a Difficult Market?” (Korthuis, 2013), it was explained that in the short term the main carbon markets will be the so-called compliance markets (Kyoto Protocol, EU ETS, etc.), voluntary markets (e.g. Verified Carbon Standard, Plan Vivo, etc.) and carbon funds (such as, for instance, World Bank BioCarbon Fund, European Carbon Fund, KfW Entwicklungsbank carbon fund and NEFCO Carbon Fund).[10] As explained above, compliance markets and carbon funds currently face oversupply of credits with corresponding low prices, whereas demand and supply on the voluntary carbon market have remained more in balance, with generally higher credit prices than on the compliance markets.

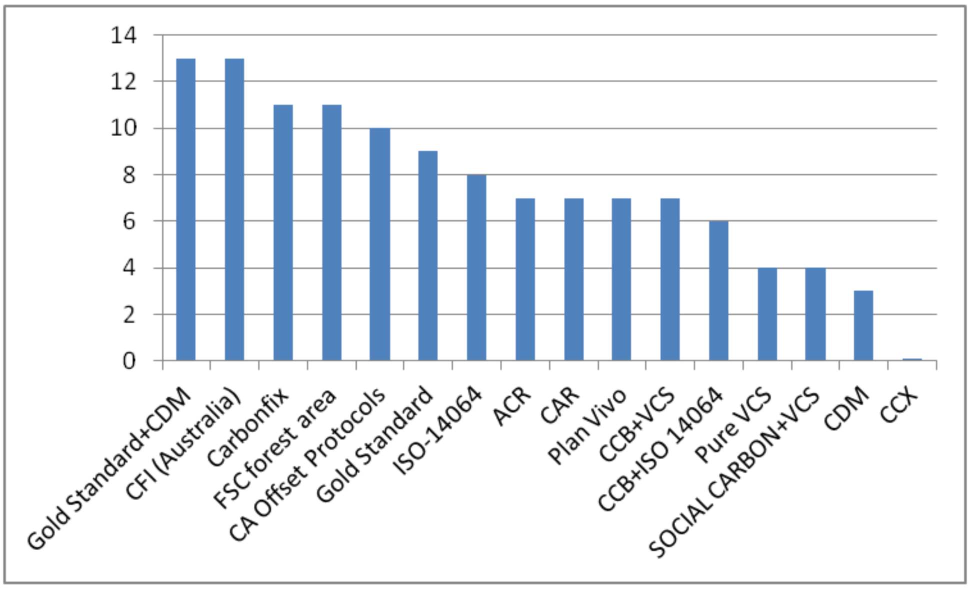

Figure 5. Average carbon credit price in 2012 for different voluntary carbon schemes (in USD/tGHG)[11]

In practice, both compliance and voluntary markets show a differentiation in credit prices depending on the region where the emission reduction takes place and the type of project (see Figure 5). For instance, the EU ETS has currently strongly limited links with the CDM under the Kyoto Protocol, but has made an exemption for projects generated in least developed countries. Credits originating from projects in these countries can still be traded within the EU

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[10] http://www.climatefocus.com/documents/how_to_sell_your_carbon_credits_in_a_diff

[11] In Figure 5 the following abbreviations have been used: CDM (Clean Development Mechanism; traded on both Kyoto Protocol and voluntary markets); CFI (Carbon Farming Initiative); Carbonfix (carbon credits from sequestering CO_2 through afforestation and reforestation projects); FSC (Forest Stewardship Council); CA (California Offset Protocols); ISO (International Organisation for Standardisation); ACR (American Carbon Registry); CAR (Climate Action Reserve); CCB (Cimate, Community & Biodiversity Standards); VCS (Verified Carbon Standard); CCX (Chicago Climate Exchange).

ETS, which results in higher prices for these credits. Another price differentiation can be observed in terms of project types, with a particular focus on projects' contribution to sustainable development. In the current market, it can, for instance, be observed that improved cook stove technology, forestry/afforestation, domestic biogas and other biomass-based projects receive higher prices than, for instance, landfill gas capture and hydropower and wind power projects (Korthuis, 2013). This sustainable development contribution impact is also reflected in the relative popularity of credits that have been accredited by the Gold Standard. This standard not only observes the credibility of emission reductions in terms of accounting rules used, but only how the project contributes to sustainable development. In the market, this has been reflected in a mark-up to the market price for credits (see Figure 5). CDM project developers would enhance the tradability of their credits if they added a Gold Standard label to their projects (Korthuis, 2013).

3.2.3. Medium term perspectives

In the medium term, finance for low carbon projects may be generated from processes under the UNFCCC such as nationally appropriate mitigation actions (NAMA). As explained above, NAMAs are actions that developing countries will undertake under the UNFCCC to reduce their GHG emissions. These actions are not mandatory in the sense that it is prescribed what they should look like. Instead, countries are encouraged to formulate GHG emission reduction (mitigation) actions within the context of their sustainable development goals. An overarching goal of NAMAs is that they aim at system changes towards low emission development and therefore identifying actions which are likely to go beyond countries' business-as-usual trends (Tilburg, 2011). However, NAMAs do not envisage carbon credit trading, rather could they be funding opportunities for low emission actions in developing countries.

Another medium-term carbon market opportunity could be reducing emissions from deforestation and forest degradation (REDD+). For instance, projects that reduce the consumption of non-renewable biomass, such as household cooking projects, or programmes that incentivize biomass projects could become eligible for carbon credit trading. Presently, funding for REDD+ has become available through, for instance, the UN-REDD programme and the World Bank's Forest Carbon Partnership Facility. Therefore, in the medium term, overarching, national REDD+ programmes could be partly funded through carbon markets (Korthuis, 2013).

In the medium term, also the development of domestic carbon credit markets, as described above, would represent increased carbon credit trading opportunities.

3.2.4. Longer term perspectives

With respect to the longer term, the NAMA and REDD+ funding opportunities could be enlarged, depending on what the post-2020 UNFCCC climate policy framework will look like. In addition, at the UNFCCC Climate Conference in Durban (South Africa, 2011) the Green Climate Fund (GCF) was established which is intended to collect USD 100 billion per year by 2020 to support developing countries in taking mitigation and adaptation actions (in the meantime, as per 2013, around USD 30 billion has been pledged by industrialized countries for short term climate funding) (UNFCCC, 2012). In general, the GCF funding shall be spent on enhanced action on mitigation, adaptation, technology development and transfer and capacity building. Although this money has therefore not been earmarked for carbon credit trading, the GCF will provide opportunities to financially support low emission technology projects in developing countries.

Finally, next to the existing Kyoto Protocol carbon credit mechanisms CDM and JI, a New Market Mechanism will be developed as per the decision of the UNFCCC Climate Conference at Durban (South Africa, 2011) (UNFCCC, 2012), “to enhance the cost-effectiveness of, and to promote, mitigation actions, bearing in mind different circumstances of developed and developing countries” (para. 83). An important aspect of New Market Mechanism proposals submitted by a range of countries is the tendency to consider GHG emission reduction activities at a larger scale than the CDM project level. For instance, proposals by the Alliance of Small Island States (AOSIS), Costa Rica, the Dominican Republic, Mexico, Panama and Peru explain how the new market mechanism should go beyond the project-based approach of the CDM and address countries’ sectoral emissions (De Sépibus, 2012).

The EU has proposed ‘sectoral crediting’ or ‘sectoral trading’ mechanism (De Sépibus, 2012). With sectoral crediting a country would agree on an absolute or relative target GHG emission level for a sector which it could achieve unilaterally or with international support. Emission reductions beyond this target level could then be traded as carbon credits. Sectoral trading refers to a cap-and-trade system whereby a country receives emission allowances upfront and can trade surpluses or deficits with other Parties. Such a system could possibly also be linked to CDM projects in sectors not covered by the cap-and-trade system.

4. Greenhouse Gas Accounting Aspects of Biochar Carbon Offsets

4.1. Introduction

The above sections have provided insights on the current status and future perspectives of international GHG emission reduction credit markets. Given its potential contribution to GHG emission reductions, biochar-to-soil projects could be eligible as carbon credit trading investments. The carbon credits could be generated from:

1. The gases and oil generated during the pyrolysis process can be used for energy purposes, which could replace the combustion of fossil fuels.
2. The long-term sequestration of carbon in biochar through pyrolysis prevents release of carbon back into the atmosphere in case of decomposition of biomass.
3. Avoidance of methane emissions as biomass used for biochar production is not left to decompose.
4. Emissions of nitrous oxides from soils may reduce through application of biochar to soils, while also methane uptake by soils may be enhanced.

5. Applying biochar to soils may reduce the need to use conventional fertilizers, which could contribute to carbon dioxide and nitrous oxide emission reductions.

The extent to which these five biochar-to-soil components or project stages could contribute to GHG emission reduction has been summarised in Table 1.

Table 1. Biochar-to-soil GHG emission reductions

GHG reduction	Description	GHG	% of Reductions
Carbon sequestration	Photosynthesis sequesters carbon in biomass as it grows. When this biomass decomposes, it releases the carbon back into the atmosphere. If the biomass is instead converted through pyrolysis into biochar, the carbon originally sequestered in the biomass will be stored for a much longer time – for hundreds or thousands of years depending on the characteristics of the biochar and the environment into which it is incorporated. This is because biochar is significantly more resistant to decomposition than the biomass used to produce it. Pyrolysing biomass therefore enhances carbon sequestration.	CO_2	50-65%
Renewable energy	The energy which can be produced from the gases and oils generated by pyrolysis can replace the combustion of fossil fuels. Pyrolysis could produce electricity (which would offset fossil-fuelled power plants) or heat (which could replace thermal demand at or near the pyrolysis plant previously supplied with fossil fuels).	CO_2	20-40%
Waste diversion	Many feedstocks, including rice residues, green waste sent to landfills and manure, are left to decompose without oxygen in rice paddies, landfills and lagoons. This anaerobic decomposition emits methane (CH_4). Collecting and pyrolysing feedstocks that would otherwise anaerobically decompose avoids CH_4 emissions.	CH_4	0-20%
Reduction in soil emissions	Applying biochar to soils may reduce soil emissions of nitrous oxide (N_2O) and increase the ability of soils to uptake CH_4. These reductions are highly variable and the precise mechanism through which they occur is not yet fully understood.	N_2O, CH_4	0-5%
Reduction in fertilizer manu-facturing	Applying biochar to fields may reduce the need to apply other conventional fertilizers. Many conventional fertilizers are energy intensive to manufacture. Reducing the demand for fertilizers reduces its manufacture, thereby reducing CO_2-emissions. When nitrogen fertilizers are applied to field, a small percentage of the nitrogen is emitted as N_2O. Reducing nitrogen fertilizer applications also reduces N_2O emissions	CO_2, N_2O	Not quantified

Source: Based on ranges reported in (Woolf, 2010) and (Roberts, 2010)[12]

Table 1 also estimates (in percentages) how each project component could contribute to the overall GHG emission reductions that a biochar-to-soil project could achieve. The table suggests that carbon sequestration by adding biochar to soils and renewable energy production based on controlled pyrolysis processes are expected to be the key contributors to the abatement impact of biochar projects. Both key impacts mainly concern the abatement of

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[12] Table taken from Report 'Carbon Market Investment Criteria for Biochar Projects', California Energy Commission September 2010.

CO_2-emissions (or fixation of carbon into soil), whereas the abatement potential for the 'other' three mitigation impacts mainly relates to avoidance of CH_4 and N_2O emissions. The next section discusses approaches for accounting the GHG emission reduction contributions by biochar-to-soil projects in further detail.

4.2. GHG accounting methodologies for biochar-to-soil projects

In order to calculate the GHG emission reductions from biochar-to-soil projects, it is necessary that for each of these five components robust accounting methodologies are prepared. In addition, these component methodologies need to be combined into one project methodology, which adequately reflects the project context. The main challenges of the GHG accounting methodology are to make a reasonable estimation of what would have happened in the absence of a biochar-to-soil project (baseline; e.g., if energy resulting from a pyrolysis process is used as energy source, what energy source does it replace?) and how one can reliably estimate and monitor the actual project performance.

To date there has been no biochar-to-soil offset carbon credit project, which has been mainly due to the lack of an approved baseline and monitoring methodology addressing the entire biochar-to-soil project chain. At the same, when looking at the list of approved baseline and monitoring accounting methodologies for CDM projects,[13] it can be concluded that for several of the individual biochar-to-soil project components draft or approved CDM methodologies have already been available.

However in 2013, an important step into the direction of an integrated approach for accounting GHG emission reductions, and eventually generating carbon credits, by biochar project has been made through the development of a comprehensive 'Biochar Carbon Offset methodology (Koper, 2013).[14] This methodology has been submitted to the American Carbon Registry (ACR) for public commenting (end of commenting period: 22 November 2013).

The developers of the 'biochar methodology' have put significant time and effort in integrating the latest best practices and science on biochar with the lessons learned and experiences gained from other carbon market regimes, such as the CDM. Especially experiences with the CDM were considered useful as they would provide the opportunity to build further upon existing (and already approved!) baseline and monitoring methodologies for GHG accounting as well as associated methodological tools.

The biochar methodology refers, for instance, to two approved small-scale CDM methodologies AMS-III.E (*on the avoidance of methane production from decay of biomass through controlled combustion, gasification or mechanical/thermal treatment*) and AMS-III.L (*on the avoidance of methane production from biomass decay through controlled pyrolysis*) which were found to be of interest with respect to the impact of avoidance of methane emissions. However, both methodologies seemed inadequate to tackle the baseline and monitoring issue of sequestration of biochar to soils. Despite this important methodological

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[13] http://cdm.unfccc.int/methodologies/index.html

[14] The methodology was prepared by a project team consisting of The Climate Trust, The Prasino Group, The International Biochar Initiative and Carbon Consulting. http://www.biochar-international.org/protocol.

gap, both approved CDM methodologies have already acknowledged the role of so-called stabilized biomass (SB)[15] which is quite similar to biochar. This recognition of the concept of SB might also prove to be useful in the methodology acceptance process. However, while both methodologies also recognize the need for monitoring the carbon content of SB, they do not consider admittance of SB to soils as an eligible end-use.

In addition to the two above-mentioned CDM methodologies, the ‘biochar methodology’ developers have also used certain methodological features of AM 0036 (on fuel switch from fossil fuels to biomass residues in heat generation equipment) regarding the GHG accounting aspects related to renewable energy production. This shows that existing CDM experience and practices not yet fully address the methodological needs of the biochar community.

The following sections discuss in more detail a set of five applicability conditions of the proposed biochar methodology. In order to perform this methodology review a broad subset of CDM methodologies and tools has been reviewed to see what additional lessons can be learned from this mechanism in relation to biochar carbon crediting.

For this an inventory overview of 26 CDM methodologies is presented in Annex I. Given the differing development and acceptance statuses of the methodologies and tools in Annex I, it is not possible to ‘simply’ pick methodology components from the shelf and combine them in one integrated biochar project methodology that covers all five relevant project components (see Table 1). For example, the soil-related impacts (e.g. carbon dioxide and nitrous oxide impacts) require additional science-based evidence and related methodological development for different soil types under different (climatic and hydrological) conditions.

4.3. Applicability conditions of the ‘biochar methodology’

The ‘biochar methodology’ attempts to formulate a integrated approach for accounting of GHG emission reductions (baselines and monitoring) through biochar-to-soil projects, nevertheless there are some limitations to its applicability. From the list of key conditions for methodology application that have been formulated by the methodology developers five have been selected that will be discussed in more detail.

1. The methodology is only applicable when secondary biomass (residues or waste streams) is used for biochar production (section 4.4);
2. Potential depletion (or changes) of soil organic carbon (SOC) stocks as a result of the project has to be accounted for (section 4.5);
3. Mixed origin feedstocks can be accounted for by the methodology, provided that the monitoring regime can differentiate between the various sources (and their expected GHG emission reduction impact) (section 4.6);
4. The biochar produced must be applied to land or be mixed with another soil, compost or amendment medium (section 4.7); and
5. Proof of the specific end-use is required (section 4.8),

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[15] Stabilized biomass (SB) is defined as biomass adequately treated to prevent further degradation in the environment. Examples of SB are: pellets, briquettes and torrified wood chips (Source: CDM methodologies AMS-III.E and AMS-III.L).

In the next sections, these five key conditions are discussed in further detail, so as to perform a review of the merits of the 'biochar methodology'.

4.4. Use of secondary biomass

Developing a methodology that only assumes the use of secondary biomass resources significantly reduces the monitoring costs relative to when primary biomass resources are used. In case of using primary resources some form of pre-project monitoring and reporting might be required to ensure that the assumed baseline agricultural (or forestry) practices – notably regarding pre-project use of land – are justified.[16] Using primary resources as input for biochar processes could thus significantly increase GHG accounting related transaction costs. Expanding the scope of the biochar methodology to also cover primary biomass resources eventually might be necessary if and when biochar production and use becomes a more mainstream and valued biomass application.

4.5. Accounting of soil organic carbon changes/losses

Any SOC stock loss can prove to be particularly harmful for any biochar project. SOC losses can occur in two ways, either by means of so-called 'priming' or in cases where the baseline application of the biomass resources is decay under aerobic conditions (e.g. when the feedstock will be left to decay under aerobic conditions).

"Priming can be defined as any change (positive or negative, persistent or ephemeral) in the turnover rate of soil organic matter caused by the addition of a new substrate (Woolf and Lehmann 2012). Increased or decreased turnover rates are defined as positive or negative priming, respectively."

Source: (Koper, 2013) excerpt from Appendix 3

The *first* type of SOC change/loss is general for all biochar projects that aim to administer the char to soil. In order to address this priming issue, the 'biochar methodology' developers applied a science-based approach in the Appendix 3 (Koper, 2013), where a default approach for determining 'priming of SOC mineralization by black carbon' is proposed. The manner in which this default is determined is in line with the most preferred justification method applied within the approved (CDM) 'Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities' (version 1).[17] This tool indicates a first order preference for "Peer-reviewed scientific publications relating to local conditions" to establish/calculate the key parameters for calculating SOC changes.

The *second* type of potential SOC change/loss (i.e. not being priming) could occur if the baseline application of the biomass feedstock would otherwise have been disposal on land, where despite the decomposition under aerobic conditions still some level of (SOC) carbon

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[16] AMS-III.A. on the 'Offsetting of synthetic nitrogen fertilizers by inoculant application in legumes-grass rotations on acidic soils on existing cropland --- Version 2.0' for instance requires *"Also the yield per crop per hectare during the last three complete rotations shall be established. It shall be verified that no inoculant was used for fertilization of legumes in the previous three complete rotations."*

[17] See: http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-16-v1.pdf

sequestration could take place. By using crop residues for biochar production, that normally would have been left to decompose on land (or which have been directly processed (e.g. chopping) and re-submitted to the soil[18]) also results in some level of carbon storage in the baseline scenario since not all biogenic carbon will be released into the atmosphere. Even though the 'avoided' carbon sequestration impact is likely to be fully offset by the incorporation of biochar to agricultural soils (especially if it is re-submitted to the same acreage), it nevertheless is a potential project-related impact that should be properly accounted for. The 'biochar methodology' tries to address this issue by proposing bio-energy production as the most conservative default baseline option, which would avoid this specific SOC issue. However, in many countries (un)controlled, (an)aerobic decomposition of secondary biomass still is the dominant baseline scenario and thus in some cases there also be a need to account for this type of SOC losses.

In terms of GHG accounting and crediting, this potential SOC issue might introduce some additional complexity. Soil carbon modelling has shown that only about 1% of carbon contained in non-pyrolyzed organic matter admitted to soil today will retain in the soil after 100 years. Based upon this evidence, this impact could be considered insignificant or could simply be discounted (e.g. 0.01 correction factor). However, GHG crediting periods generally cover much shorter time spans than 100 years. For non A/R projects this generally is 7 or 10 years (with 3 times 7 years = 21 years as maximum), while for A/R projects this normally is 20 or 30 years (with 60 years as maximum). The notion that for most secondary biomass resources the share of carbon retained in non-pyrolyzed biomass will not likely be at a level of 1% after 7, 10, 20 or 30 years (as it generally follows a pattern of exponential decrease) could thus result in a larger level of avoided SOC storage (in the baseline) during the crediting period as a result of the biochar project. From a methodological perspective this can simply be addressed by applying an appropriate correction factor (e.g. > 0.01), but the key question here is if this would be a fair discount factor knowing that a large part of the non-pyrolyzed carbon would still have been released into the atmosphere after the crediting period.

In addition to these two types of potential SOC losses, the application of biochar to soil as a carbon sequestration medium introduces a key monitoring challenge which requires a robust and standardized method for testing biochar carbon stability. A specific test method has been introduced and discussed in more detail in Appendix 2 of the 'biochar methodology' (Koper, 2013). In all circumstances the biochar-based carbon sequestration impact should be larger than the total of any potential (SO)C losses. The full recognition and acceptance of this standard test method within the various carbon market is crucial for the future potential of biochar projects to be able to generate revenues based on the sale of carbon credits. If the proposed standard test method (or any alternative method) would not become available; climate finance for pyrolysis-biochar projects can only become available based upon the non-

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[18] There is a CDM methodology (AMS-III.BE.: Avoidance of methane and nitrous oxide emissions from sugarcane pre-harvest open burning through mulching --- Version 1.0) that specifically refers to mulching as a means to avoid CH_4 and N_2O emissions, however mulching layers generally also contain a certain share of carbon, part of which (theoretically) could be considered permanently stored.

carbon sequestration related project activities (e.g. through renewable energy production and avoidance of methane emissions).

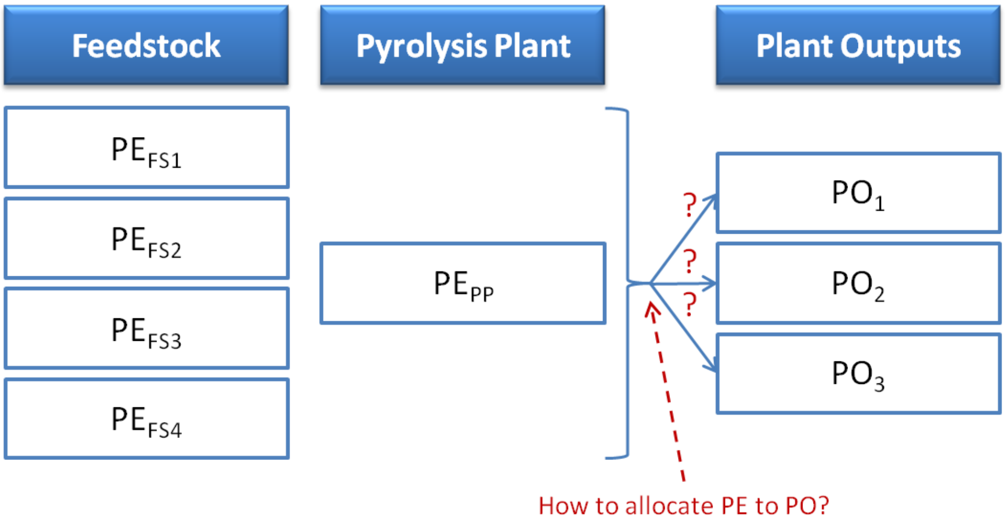
4.6. Allocation of GHG emission reduction impact across biochar project stages

The close monitoring of mixed origin feedstock inputs and its relative contribution to GHG abatement is likely to become an important methodological aspect for multi-input / multi-output processes - like controlled pyrolysis - in the near future. Some form of feedstock track-and-trace monitoring system therefore will be very useful for determining the specific abatement contribution of a given feedstock to the overall carbon sequestration performance. For example, assuming that the average biochar project is also likely to produce at least one or more co- or by-products (e.g. bio-oil and non-condensable gases) it could become particularly challenging to allocate the specific project emissions of a given feedstock input and the plant emissions to the specific output. Any form of allocation will have an impact of the net GHG abatement impact of the individual output (e.g. biochar, energy, etc.). This is graphically illustrated in Figure 6.

Even when a pyrolysis project operates on a single type of feedstock, more specific calculations, monitoring and reporting guidance might be needed when project proponents are aiming to allocate specific feedstock related project emissions to specific plant outputs. This will be particularly relevant when one wants to make sure that a fair net emission reduction claim for two or more outputs is being made.

The methodological issue of allocation is not specific for pyrolysis plants, but common for many biomass-use projects (often also bio-energy projects) that aim to claim GHG emission reductions for multiple outputs. In that regard, therefore, the biochar community can also learn from experiences in other segments/sectors of the carbon markets.

Figure 6. How to allocate feedstock related and plant related Project Emissions (PE) to specific Plant Outputs (PO)?



As a reference guide for project developers, an approved methodological (CDM) tool[19] available on apportioning (allocating) emissions from production processes between the main product, co-products, by-products and waste streams is available. However, to date there only have been a few existing CDM methodologies that explicitly take into account the issue of apportioning/allocation. A good example of this is AMS-III.AK. (Biodiesel production and use for transport applications --- Version 1.0), which applies the 'market value' (or economic) allocation principle where:

"The allocation factor is calculated using the amount of fuels, co-products and by-products obtained from the oilseed type k and respective market prices."

Another example could be AM0057 (Avoided emissions from biomass wastes through use as feed stock in pulp and paper, cardboard, fibreboard or bio-oil production --- Version 3.0.1). This methodology acknowledges that organic waste feedstocks can be used for the manufacturing and supply of different main-, co- and by-products. Although the methodology's primary goal is to claim credits for avoiding CH_4 emissions, it also applies a basic or minimal compliance condition related to the end-use impact of the expected outputs:

"The pulp and paper, cardboard, fibreboard or bio-oil produced with the agricultural wastes is of similar characteristics and quality to existing high quality products in the market and does not require special use or disposal methods."

The above condition is not an obvious example of allocation, but it is a methodological safeguard to minimize or avoid any carbon leakage[20], where for instance the downstream use of the outputs could result in an increase of project-related emissions. This could for instance occur when certain resources normally used for recycled paper would now be landfilled as a result of the project activity which uses other feedstocks. In such a leakage scenario the methane emissions from landfills can increase as a result of the project activity.

In order to remain conservative in their estimations the developers of methodology AM0057 only seem to have opted to focus on calculating and monitoring any project related 'negative leakage' effects, while for some project outputs (e.g. pulp, paper, cardboard, fibre-board, bio-oil) the reverse ('positive leakage') could be true as the baseline process for producing and supplying the conventional (baseline) output/product could just as well be more GHG intensive. In such circumstances the allocation of project related emissions will become an important methodological feature.

A similar methodological approach to address negative leakage is used in:

AMS-III.AQ.: Introduction of Bio-CNG in transportation applications --- Version 1.0,

Where:

> *"the digested residue waste leaving the reactor shall be handled aerobically and submitted to soil application, the proper procedures and conditions not resulting in*

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[19] See: http://cdm.unfccc.int/Reference/Guidclarif/meth/meth_guid37.pdf

[20] See: http://cdmrulebook.org/330

> *the methane emissions shall be ensured; otherwise the emissions shall be taken into account as per relevant procedures of AMS-III.AO."*

And:

> AMS-III.F.: Avoidance of methane emissions through composting --- Version 11.0

Where:

> *"soil application of the compost in agriculture or related activities will be monitored. This includes documenting the sales or delivery of the compost final product. It shall also include an in situ verification of the proper soil application of the compost to ensure aerobic conditions for further decay. Such verification shall be done at representative sample of user sites. The conditions for proper soil application ensuring aerobic conditions can be established by a local expert taking into account the soil conditions, crop types grown and weather conditions."*

Which:

> In both cases the methodology does not allow the project proponent to claim emission credits for any possible increases in SOC stocks, but only has to account for (or take appropriate measures to reduce) any potential negative leakage, in these examples being any potential SOC losses.

The above shows that the existing (methodological) experience of the carbon markets with allocation (or apportioning) is rather limited. Nevertheless allocating project related emissions to specific project outputs is likely to become more important in time[21]. This will especially be true for those pyrolysis plants that have the technical capability and flexibility to optimize their operational process according to market conditions. In more general terms, the allocation issue underlines the importance and methodological impacts of:

- The determination of the project boundary of a pyrolysis project
- The baseline selection process (i.e. considering the various baseline scenario(s))

When considering apportioning (e.g. as a result of an expansion of the project boundary), the consequence is that the GHG impact of the co-, by- and waste product(s) also needs to be accounted for (and monitored). This is likely to result in an increase in transaction costs given that the CDM apportioning (allocation) tool guideline stipulates that: *"for each by-product or co-product, the alternative production process(es) is/are identified as part of the procedure to identify how the byproduct or co-product would have been produced."*

The proposed biochar methodology does not consider the issue of allocation in great detail and therefore might be improved in this particular area in order to provide project developers with more guidance and flexibility to develop their project and claim emission reductions for the most significant project components.

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[21] General LCA literature refers to three different allocation principles; 1) Economic allocation – based on market value of primary-, co-, and/or by-product as well as 2) physical (e.g. energy content) and 3) mass-share allocation, but other allocation methods exist as well.

4.7. Selecting baseline and monitoring method

The ‘Biochar Carbon Offset Methodology’ includes comprehensive guidance with respect to the selection of the appropriate baseline for pyrolysis projects. The methodology developers also propose a conservative default baseline, being the controlled combustion of the biomass with energy capture (in the absence of the pyrolysis project). Although this approach might be considered conservative from the perspective of any potential unwarranted claims of avoidance of CH_4 and/or N_2O emissions; under specific circumstances the proposed default baseline might not be the most appropriate and be sufficiently conservative when - for example - considering any (non-priming related) potential SOC losses or leakage (see discussion in §4.5).

The proposed default baseline (bioenergy production) also takes into account the specific leakage impacts related to the avoided production and use of renewable energy as a result of the biochar project activities. The assumed impact of this would be that the production and use of other (generally fossil) energies will increase to fill this ‘gap’. In most circumstances this leakage impact is likely to be negative, which will result in a higher discount factor and with that a lower net claim of GHG emission reductions for biochar projects. From a methodological perspective this approach to baseline setting and leakage correction is rational, conservative and justifiable. However, here one could also argue that in some circumstances this is at odds with some generally accepted principles on biomass cascading. The core principle of cascading is that biomass resources should always be put to their ‘best’ or ‘most sustainable’ use. This can be explained by hypothesising that the advantageous impact of biochar on soil quality is a better use of a given biomass resource relative to energy application. The implication of this for any incentive scheme would be to provide a stronger incentive to biomass-to-biochar application relative to biomass-to-energy applications.

The baseline selection in biochar methodology has exactly the opposite impact (even though it is applied correctly). This can be explained by *first* assuming bioenergy as the project scenario with a fossil energy baseline and *second*, by assuming bioenergy as the baseline scenario of the biochar project. The left-hand side of Figure 7 illustrates this situation, whereas the right-hand side shows the incremental GHG performance of the project scenario relative to its baseline.

Figure 7. Setting baselines in a cascading situation

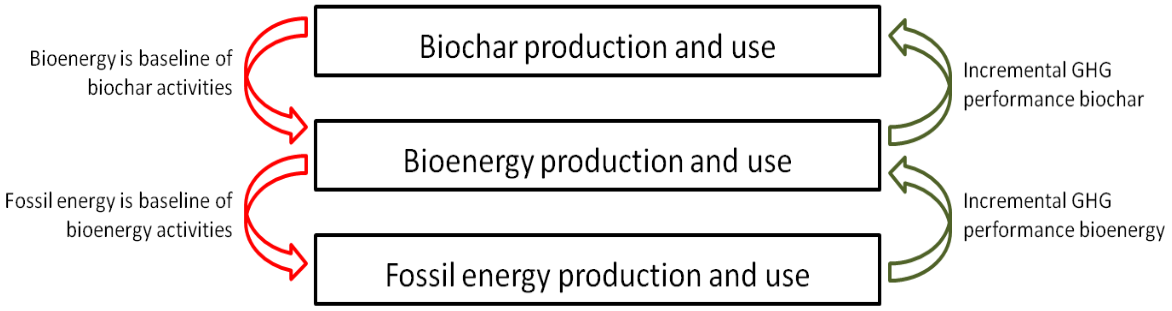

Figure 7 tries to show that the incremental GHG performance of the biochar project is not necessarily equal or the incremental GHG performance of the bioenergy project simply because different baselines were used.

1) In case incremental $GHG_{biochar}$ > incremental $GHG_{bioenergy}$, there is an incentive for project proponents to use the biomass for biochar purposes from a emission reduction perspective.
2) Alternatively in case incremental $GHG_{biochar}$ < incremental $GHG_{bioenergy}$, it is more favourable to consider bioenergy production with the aim to optimize GHG emission reductions.

Without any further quantification, and based upon current baseline practices in the carbon markets regarding bioenergy and the proposed baseline approach for biochar, it seems to be that scenario 2 prevails. As such project developers that are planning to use biomass resources might be inclined to stick to those practices with the highest GHG-returns (i.c. bioenergy application instead of biochar).

In more general terms this means when applying cascading principles one could argue that food, feed, material and soil nutrient applications rank higher (on the cascade ladder) relative to biomass-to-energy applications. However this ‘hierarchy of best use’ is not always promoted by the carbon market. This claim can be verified by comparing the incremental GHG performances of the various cascading options relative to its specific baseline.

It has yet to be determined if, how and to what extent further methodological guidance on biomass cascading is needed in relation to carbon markets, but it is clear that the carbon market might not always provide the right incentive when putting more emphasis on cascading. (Domburg, 2005) also raised this issue highlighting that:

“A wide variety of biomass material applications and possible cascading chains exist, and it is unclear yet, which biomass chain is optimal with regard to costs, CO_2 emission reduction and land demand.”[22]

In addition to the above, (Domburg, 2005) also acknowledged the importance of the ‘time dimension’ (comparable to the issue raised in §4.5) when calculating GHG emissions reductions in relation to biomass cascading systems, where:

“The use of biomass, when derived from well-managed plantations, is considered to be close to having no net impacts on the carbon in the atmosphere, because all carbon sequestered during plant growth is released during energy conversion and vice versa. However, if cascading systems of biomass are considered, the release of sequestered carbon can take place significantly later in time than the moment biomass is harvested. Depending on the applications in the cascading chains this period can vary from several weeks (e.g. paper) to a century or more (e.g. construction wood). Furthermore, CO_2 is emitted at different moments in time in the biomass as well as in the reference system.”

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[22] *“Preliminary analyses have shown that CO_2 emission reduction per hectare of biomass production and the CO_2 mitigation costs differ significantly for different biomass cascading systems (Domburg and Faaij, 2001a).”* (Quote taken from (Domburg 2005), on Chapter 3 dissertation, page 55).

The above discussion on biomass cascading is socially and politically relevant given the increasing notion of global biomass resource scarcity for various end-use applications. These considerations illustrate that future revisions of GHG baseline and monitoring protocols for any type of biomass-use systems (including those for pyrolysis systems) also might have to take cascading-related issues into account.

4.8. On end-use and avoidance of fossil fertilizer use

One of the key challenges of claiming carbon sequestration based on biochar applications to agricultural soils is to ensure and monitor the actual end-use of the marketed biochar (to be sure that the carbon is actually stored). The easiest and most secure way to deal with this monitoring issue is to apply the biochar to 'captive land' only, where the biochar end-use can be closely monitored[23]. There are several alternative monitoring approaches introduced in the 'biochar methodology' to ensure the desired end-use of the biochar resulting in carbon sequestration. One interesting alternative approach introduced in the biochar methodology is the mixing or blending of biochar *"with other soil amendments, microbial inoculants, fertilizers and other nutrient products."* Such an approach would avoid a (time and resource consuming) coordinated monitoring effort for all 'captive land' to which biochar is applied.

By introducing biochar into existing marketing and distribution channels, one can accurately determine if and to what extent the marketed biochar has been used for soil enhancement purposes only. This approach is similar to that applied in the CDM transport methodology AMS-III.AQ (Introduction of Bio-CNG in transportation applications --- Version 1.0), where the specific end-use of the final product can be determined by checking the sales volumes of dedicated Bio-CNG fuelling stations.

From a monitoring perspective the mixing/blending of biochar with other components to serve as soil fertilizer seems rather effective and efficient.

In addition to that, when considering biochar end-use as a fertilizer substitute as the preferred application; the biochar methodology seems to omit the potential claim on GHG emission reductions that would occur as a result of the avoidance (or increased efficiency) of the use of fossil fertilizers. This should be true for all biochar projects where the char is or will be applied to soils where otherwise fossil fertilizers would have been admitted.

In order to make such potential emission reduction claims one can draw from two approved CDM methodologies that provide relevant guidance[24] for biochar project proponents. These two methodologies would especially be useful for calculating the baseline emissions related to the production of fossil fuel based fertilizers.

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[23] This is similar to the monitoring approach taken in a number of CDM transport methodologies (e.g. AMS-III.AK.: Biodiesel production and use for transport applications --- Version 1.0; AMS-III.AQ.: Introduction of Bio-CNG in transportation applications --- Version 1.0; AMS-III.T.: Plant oil production and use for transport applications --- Version 2.0) where the renewable fuel consumption of a so-called 'captive fleet' shall be monitored by the project proponents.

[24] Although this concerns two approved CDM methodologies, there currently is not one project in the CDM pipeline at any given development stage.

- AMS-III.A.: Offsetting of synthetic nitrogen fertilizers by inoculant application in legumes-grass rotations on acidic soils on existing cropland --- Version 2.0
- AMS-III.BF.: Reduction of N_2O emissions from use of Nitrogen Use Efficient (NUE) seeds that require less fertilizer application --- Version 1.0

This biochar-related abatement opportunity, however, does also introduce a number of additional monitoring requirements, whereby the project proponent has to prove that the use of fossil fertilizer has actually been reduced during the crediting period. The above-mentioned 'fertilizer methodologies' apply similar baseline calculation and monitoring procedures.

The emission factor for nitrogen fertilizer (EF_{NF}) comprises the CO_2-emissions (from fertilizer production) as well as the N_2O emissions (from application to soil). The methodologies indicate that:

Project proponents may claim CO_2 emission reductions for the production of synthetic fertilizers ($EF_{CO2,P}$) for the share of synthetic fertilizer to the total nitrogen fertilizers shown to have historically been used on the participant farms.

Emission factor for N_2O comprises of emission factor due to direct N_2O emissions at the baseline and/or project crop cultivation areas and indirect N_2O emissions due to nitrogen fertilizer application.

For calculating and monitoring the CO_2-emission reductions appropriate (default) guidance is provided, which would also imply some form of pre-project monitoring regarding historic use of nitrogen fertilizers. This might cause some difficulties because in some circumstances pre-project monitoring could increase the transaction costs, especially if historic, farm-level fertilizer use administrations are non-homogeneous or incomplete. In order to calculate and monitor the N_2O-emissions, project proponents can either apply the IPCC default approach to determine the emission factor, or use the so-called DNDC model.

DNDC (i.e., DeNitrification-DeComposition) is a computer simulation model of carbon and nitrogen biogeochemistry in agro-ecosystems. The model can be used for predicting crop growth, soil temperature and moisture regimes, soil carbon dynamics, nitrogen leaching, and emissions of trace gases including nitrous oxide (N_2O), nitric oxide (NO), dinitrogen (N_2), ammonia (NH_3), methane (CH_4) and carbon dioxide (CO_2).

5. Concluding remarks

The analysis of the current status of carbon markets (Section 2) shows that supply of carbon credits has become considerably higher than demand. This holds in particular for so-called compliance markets, such as the Kyoto Protocol and the EU ETS. The prospective of market recovery is rather bleak as the EU ETS is expected to have an allowance surplus until at least 2020 and recent attempts to temporarily reduce supply of allowance have not been very successful. Also the outlook overview for the carbon markets of tomorrow (Section 3) shows a rather complex picture. Negotiations about the successor of the Kyoto Protocol under the

UNFCCC for the period beyond 2020 have neither resulted in indications that at the short term demand for carbon credits will strongly increase.

Nevertheless, despite this grim outlook, at the same time, and partly separate to the UNFCCC negotiation process, a range of country and sub-national initiatives have begun to put a price on GHG emissions (mainly in the form of carbon markets). In addition, most of these carbon pricing initiatives aim at interlinkages with each other which could eventually lead to global consistency in terms of accounting rules for calculating GHG emissions and emission reductions. This shows a strong commitment of many regions to the carbon trading instrument even though this does not guarantee stable and high carbon price-levels.

In the short term, the main carbon market opportunities are in the existing compliance markets and voluntary carbon trading markets. In the medium to longer term, new processes under the UNFCCC, such as NAMAs, REDD+ and the New Market Mechanism may provide additional funding opportunities for low emission technology investments.

As far as the GHG accounting related to biochar offset activities is concerned the recently published Biochar Carbon Offset Methodology (Koper, 2013) is an important advancement for the biochar community in terms of its (future) capabilities of getting access to climate finance. Should this methodology formally be accepted by the carbon trading community, the main hurdle for biochar to become active in the offsetting market will be removed.

Even though the presented biochar methodology is very robust, for addressing today’s and tomorrow’s methodological and guidance needs for biochar there are a number of areas that might require some additional emphasis or could be explored in more detail. The review and analysis of the ‘biochar-relevant’ CDM methodologies and methodological tools and the review of the Biochar Carbon Offset Methodology presented in Chapter 4 (including Annex I) has resulted in five comments on the biochar methodology:

1. Should biochar activities become more mainstream, the scope of the biochar methodology might need to be broadened to also allow for the use of *primary biomass resources* for biochar production.
2. Project-related (non-priming) SOC losses (avoided carbon sequestration) *during the crediting period* could be significant in cases where the baseline scenario is uncontrolled aerobic decomposition of the feedstock. This impact even holds given the fact that the SOC stored in the baseline (during crediting period) would also have declined to about 1% of initial SOC in feedstock in a time frame of about 100 years.
3. Further methodological *guidance on allocation* is needed should project developers desire to be able to properly allocate or apportion project emissions (PE) to specific project outputs (PO), such as biochar and energy.
4. The prevailing practices and notions regarding baseline setting might not always be in line with commonly accepted notions of *biomass cascading* where the ‘better’ or more ‘sustainable’ use of a given biomass resource should prevail. In this regard the carbon market might not always provide the strongest incentive to the ‘best’ use.
5. The biochar methodology might also benefit from including methodological guidance on the potential emission reduction claims that can be made as a result of the *avoidance of the use of fossil fertilizers* due to biochar admission to soils.

Given the non-fundamental nature of the above five concluding remarks it can be concluded that the existing biochar methodology should be sufficiently robust to meet the carbon community's GHG accounting and monitoring expectations.

In sum,

Considering that the carbon markets of today and tomorrow do not provide a very promising outlook in terms of high levels of climate finance for biochar-based carbon offset activities.

Nevertheless, many regions in the world seem committed to carbon trading and offsetting schemes therefore are likely to persist.

Therefore, the biochar community should keep a close eye on carbon market developments in order to be able to step in at the right moment.

However, for that, development and adoption of a sufficiently robust and integrated GHG accounting methodology is required, with, when necessary, regular updates to meet the biochar communities' expectations regarding their offsetting activities.

Moreover, in order to be well prepared for developing biochar carbon market projects, it is recommended to perform a financial analysis of potential biochar project costs (incl. GHG accounting costs) and revenues and explore the (range of) carbon market prices at which biochar projects could become financially viable.

References

CDCClimat. (2012). *"International climate negotiations - COP 18: the art of the Doha-ble", Climate Brief.*

De Sépibus, J. W. (2012). *Top-down, Bottom-up or In-between: How Can a UNFCCC Framework for Market-Based Approaches Ensure Environmental Integrity and Market Coherence?* NCCR Trade Regulation Working Paper No. 2012/31.

Domburg, V. (2005). *Cost and CO2-Emission Reduction of Biomass Cascading: Methodological Aspects and Case Study of SRF Poplar.* Chapter 3 dissertation.

Ecosystem Market Place. (2013). Maneuvering the Mosaic - State of the Voluntary Carbon Markets 2013. Ecosystem Market Place.

Ecosystem Market Place. (2013). *State of the Voluntary Carbon Markets 2012 Report Assessment.*

Ellerman, A. D. (2008). The EU Emission Trading Scheme: A Prototype Global System? *Discussion Paper 08-02* (p. 34). Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School,.

European Commission. (2012). *Report from the Commission to the European Parliament and the Council.*

European Parliament and the Council. (2009). Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community. *Official Journal of the European Union.* Brussels: European Parliament and the European Council.

Gaast, W. v. (2012). *Challenges and Solutions for Climate Change.* London: Springer.

Gloaguen, O. a. (2013). *Assessing the factors behind CO2 emission changes over the phases 1 and 2 of the EU ETS: an econometric analysis.* Paris: CDC Climat Research.

JIN. (2012). Uncertain Times for the EU ETS – Can the Market Imbalance be Repaired? *JIQ - Magazine on Climate and Sustainability* (pp. 2-3). Groningen: JIN.

JIN. (2013). ETS Backloading Proposal Takes Important Hurdle. *JIQ - Magazine on climate and sustainability* (pp. 2-3). Groningen: JIN.

JIN. (2013). State and Perspectives of International Carbon Markets. *JiQ - Magazine on climate and sustainability* (pp. 1-2). Groningen : JIN.

Koper, T. (2013). *Methodology for Biochar Projects.* Submitted to American Carbon Registry (ACR).

Korthuis, A. (2013). How to Sell your Carbon Credits in a Difficult Market? Climate Focus.

Michaelowa, A. (2013). Challenges on the carbon markets. *Austrian Cimate Change Workshop.* Vienna.

Promethium Carbon. (2013). *Carbon Pricing Scenarios.*

Roberts, K. (2010). *Life Cycle Assessment of Biochar Systems: Estimating Energetic, Economic and Climate Change Potential.* In Environmental Science Technology, 44, 827-833.

Taminiau, J. (2012, December). The Durban Agreement: A Deal to Negotiate a Deal. *Joint Implementation Quarterly*, pp. 2-4.

Tilburg, X. v. (2011). *Paving the Way for Low Carbon Development Strategies.* Amsterdam: Energy Research Centre of the Netherlands (ECN).

UNFCCC. (1997). Kyoto Protocol. *1998.* Bonn: UNFCCC.

UNFCCC. (2012). Report of the Conference of the Parties on its seventeenth session, held in Durban from 28 November to 11 December 2011 - Part Two: Action taken by the Conference of the Parties at its seventeenth session. Bonn: UNFCCC.

UNFCCC. (2012). Report of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol on its eigth session. *FCCC/KP/CMP/2012/13/Add.1.* Bonn: UNFCCC.

UNFCCC. (2013). *Interlinkages between Technology Needs Assessments and National and International Climate Policy Making Processes.* Bonn: Technology Executive Committee .

Woolf, D. (2010). *Sustainable biochar to mitigate global climate change.* In Nature Communications, 1:56.

World Bank. (2012). State and Trends of the Carbon Market 2012. *2013.* Washington, DC: The World Bank.

Annex I – Inventory overview of CDM methodologies and tools

Biochar potential GHG reduction impacts	Most relevant project categories for biochar	Rationale for baseline and monitoring for biochar impacts	Sample of relevant approved (CDM) methodologies (small and large scale)	Relevant methodological/guidance tools (hyperlinks included)
Carbon sequestration & Reduction in soil emissions	Afforestation	Includes guidance on how to calculate changes (losses) in soil organic carbon as a result of the project activity	AR-AMS0007: Simplified baseline and monitoring methodology for small scale CDM afforestation and reforestation project activities implemented on lands other than wetlands --- Version 2.0	Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity
	Reforestation			Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities
				Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity
Renewable energy	Biomass energy	Can be used as a reference to calculate and monitor baseline emissions related to stationary energy applications (e.g. electricity and heat)	AM0036: Fuel switch from fossil fuels to biomass residues in heat generation equipment --- Version 4.0.0	Tool for the demonstration and assessment of additionality
				Tool to calculate project or leakage CO2 emissions from fossil fuel combustion
				Emissions from solid waste disposal sites
				Tool to calculate the emission factor for an electricity system
				Tool to determine the baseline efficiency of thermal or electric energy generation systems
				Tool to determine the remaining lifetime of equipment
				Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period
				Project and leakage emissions from transportation of freight
			AMS-I.D.: Grid connected renewable electricity generation --- Version 17.0	Tool to calculate project or leakage CO2 emissions from fossil fuel combustion
				Tool to calculate the emission factor for an electricity system
			AM0042: Grid-connected electricity generation using biomass from newly developed dedicated plantations --- Version 2.1	Tool to calculate the emission factor for an electricity system
				Tool for the demonstration and assessment of additionality
			AM0053: Biogenic methane injection to a natural gas distribution grid --- Version 4.0.0	Combined tool to identify the baseline scenario and demonstrate additionality
				Tool to calculate project or leakage CO2 emissions from fossil fuel combustion
				Tool to calculate baseline,

				project and/or leakage emissions from electricity consumption
				Project emissions from flaring
				Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period
			AM0075: Methodology for collection, processing and supply of biogas to end-users for production of heat --- Version 1.0	Project emissions from flaring
				Tool to calculate project or leakage CO2 emissions from fossil fuel combustion
				Tool to calculate baseline, project and/or leakage emissions from electricity consumption
				Tool for the demonstration and assessment of additionality
			AMS-I.G.: Plant oil production and use for energy generation in stationary applications --- Version 1.0	Tool to calculate project or leakage CO2 emissions from fossil fuel combustion
				Tool to calculate baseline, project and/or leakage emissions from electricity consumption
			AMS-I.H.: Biodiesel production and use for energy generation in stationary applications --- Version 1.0	Tool to calculate project or leakage CO2 emissions from fossil fuel combustion
				Tool to calculate baseline, project and/or leakage emissions from electricity consumption
				Tool for the identification of degraded or degrading lands for consideration in implementing CDM A/R project activities
			ACM0017: Production of biodiesel for use as fuel --- Version 2.1.0	Tool for the demonstration and assessment of additionality
				Tool to calculate project or leakage CO2 emissions from fossil fuel combustion
				Tool to calculate baseline, project and/or leakage emissions from electricity consumption
				Project emissions from flaring
			ACM0018: Consolidated methodology for electricity generation from biomass residues in power-only plants --- Version 2.0.0	Tool to calculate project or leakage CO2 emissions from fossil fuel combustion
				Emissions from solid waste disposal sites
				Tool to calculate baseline, project and/or leakage emissions from electricity consumption
				Tool to calculate the emission

				factor for an electricity system
				Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period
				Project and leakage emissions from transportation of freight
			ACM0022: Alternative waste treatment processes --- Version 1.0.0	Combined tool to identify the baseline scenario and demonstrate additionality
				Tool to calculate project or leakage CO2 emissions from fossil fuel combustion
				Emissions from solid waste disposal sites
				Tool to calculate baseline, project and/or leakage emissions from electricity consumption
				Project emissions from flaring
				Tool to determine the mass flow of a greenhouse gas in a gaseous stream
				Tool to determine the baseline efficiency of thermal or electric energy generation systems
				Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period
				Project and leakage emissions from composting
				Project and leakage emissions from anaerobic digesters
	Transport	Can be used as a reference to calculate and monitor baseline emissions related to non-stationary energy applications (e.g. transport fuel)	AMS-III.AK.: Biodiesel production and use for transport applications --- Version 1.0	Tool to calculate project or leakage CO2 emissions from fossil fuel combustion
				Tool to calculate baseline, project and/or leakage emissions from electricity consumption
				Tool for the identification of degraded or degrading lands for consideration in implementing CDM A/R project activities
			AMS-III.AQ.: Introduction of Bio-CNG in transportation applications --- Version 1.0	Tool to calculate project or leakage CO2 emissions from fossil fuel combustion
				Tool to calculate baseline, project and/or leakage emissions from electricity consumption
				Tool for the identification of degraded or degrading lands for consideration in implementing CDM A/R project

				activities
			AMS-III.T.: Plant oil production and use for transport applications --- Version 2.0	Tool to calculate project or leakage CO2 emissions from fossil fuel combustion
				Tool to calculate baseline, project and/or leakage emissions from electricity consumption
Waste diversion	Landfill gas	Can be used as a reference to calculate and monitor baseline emissions related CH4/N2O emissions from organic waste stream and/or biomass residues	ACM0001: Flaring or use of landfill gas --- Version 13.0.0	Combined tool to identify the baseline scenario and demonstrate additionality
				Tool to calculate project or leakage CO2 emissions from fossil fuel combustion
				Emissions from solid waste disposal sites
				Tool to calculate baseline, project and/or leakage emissions from electricity consumption
				Project emissions from flaring
				Tool to determine the mass flow of a greenhouse gas in a gaseous stream
				Tool to determine the baseline efficiency of thermal or electric energy generation systems
				Tool to determine the remaining lifetime of equipment
	Methane avoidance		AM0057: Avoided emissions from biomass wastes through use as feed stock in pulp and paper, cardboard, fibreboard or bio-oil production --- Version 3.0.1	Tool for the demonstration and assessment of additionality
				Tool to calculate project or leakage CO2 emissions from fossil fuel combustion
				Emissions from solid waste disposal sites
				Tool to calculate baseline, project and/or leakage emissions from electricity consumption
				Project emissions from flaring
				Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period
			AMS-III.AO. Methane recovery through controlled anaerobic digestion	Tool to calculate project or leakage CO2 emissions from fossil fuel combustion
				Emissions from solid waste disposal sites
				Project emissions from flaring
				Tool to calculate the emission factor for an electricity system
			AMS-III.BE.: Avoidance of methane and nitrous oxide	Tool to calculate project or leakage CO2 emissions from

			emissions from sugarcane pre-harvest open burning through mulching --- Version 1.0	fossil fuel combustion
				Tool to calculate baseline, project and/or leakage emissions from electricity consumption
			AMS-III.E.: Avoidance of methane production from decay of biomass through controlled combustion, gasification or mechanical/thermal treatment --- Version 16.0	Emissions from solid waste disposal sites
			AMS-III.F.: Avoidance of methane emissions through composting --- Version 11.0	Tool to calculate project or leakage CO2 emissions from fossil fuel combustion
				Emissions from solid waste disposal sites
				Tool to calculate baseline, project and/or leakage emissions from electricity consumption
				Project and leakage emissions from composting
			AMS-III.L.: Avoidance of methane production from biomass decay through controlled pyrolysis --- Version 2.	Emissions from solid waste disposal sites
			ACM0022: Alternative waste treatment processes --- Version 1.0.0	Combined tool to identify the baseline scenario and demonstrate additionality
				Tool to calculate project or leakage CO2 emissions from fossil fuel combustion
				Emissions from solid waste disposal sites
				Tool to calculate baseline, project and/or leakage emissions from electricity consumption
				Project emissions from flaring
				Tool to determine the mass flow of a greenhouse gas in a gaseous stream
				Tool to determine the baseline efficiency of thermal or electric energy generation systems
				Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period
				Project and leakage emissions from composting
				Project and leakage emissions from anaerobic digesters

Reduction in fertilizer manufacturing	Agriculture	Can be used as a reference to calculate and monitor baseline emissions related to avoidance of use of fossil fertilizers as a result of the project activity	AMS-III.A.: Offsetting of synthetic nitrogen fertilizers by inoculant application in legumes-grass rotations on acidic soils on existing cropland --- Version 2.0	Combined tool to identify the baseline scenario and demonstrate additionality
			AMS-III.BF.: Reduction of N2O emissions from use of Nitrogen Use Efficient (NUE) seeds that require less fertilizer application --- Version 1.0	
	N2O	Can be used as a reference to calculate and monitor baseline emissions related to avoidance of use of fossil fertilizers as a result of the project activity	AM0051: Secondary catalytic N2O destruction in nitric acid plants --- Version 2.0	Tool for the demonstration and assessment of additionality
			ACM0019: N2O abatement from nitric acid production --- Version 2.0.0	Tool to determine the mass flow of a greenhouse gas in a gaseous stream
				Tool to calculate project or leakage CO2 emissions from fossil fuel combustion

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The Joint Implementation Network (JIN, Groningen, the Netherlands) is a research and consultancy unit on issues related to climate change and sustainable development. JIN has been a regular advisor to UN bodies, European Commission, (sub)national governments and private entities on technology transfer for low emission and climate resilient development, incentive schemes for climate change mitigation such as carbon markets, and working towards competitive and sustainable biomass to energy pathways (http://jiqweb.org).

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System analysis and energy markets; he has performed extensive research in a number of different EU-funded projects in the field of market system analysis (i.e. system mapping) on various energy-related market systems (e.g. build environment, bio-energy, electricity system, natural gas system, etc.).

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