Towards a more standardised approach to baselines and additionality under the CDM

Determining nationally appropriate performance standards and default factors

Case study II: Charcoal production

Zurich, May 2010

Prepared by:

Perspectives GmbH
Authors: Daisuke Hayashi, Nicolas Müller, Sven Feige, Axel Michaelowa*

Commissioned by the UK Department for International Development.

* Corresponding author: Klosbachstrasse 2, 8032 Zurich, Switzerland; email: hayashi@perspectives.cc

The contents of the report reflect the views of the authors and not necessarily the views of the UK government.

Contents

List of figures

List of tables

1. Case study II: Charcoal production

– Summary –

Improvements in the conversion of biomass to charcoal in Sub-Saharan Africa show a substantial potential for reductions in the associated GHG emissions. **The mitigation potential could be around 100 Mt CO_2e per year in this region alone.** It consists in both avoided consumption of non sustainable biomass and mitigation of CH_4 emissions during the production process. In Africa, over 20 Mt of charcoal are consumed per year. The strong and growing demand for charcoal fuel is an important cause of deforestation. More efficient charcoal production processes could decrease the wood consumption to 2.5 kg per tonne of charcoal**.** The identified ancillary benefits from more efficient charcoal production and reduced deforestation are huge and well understood.

CDM methodologies already exist for the mitigation of CH_4 emissions in charcoal production but have not lead to a significant number of projects, mainly due to the complex requirements of project specific data. **Standardised approaches can overcome the problem of high transaction costs incurred by the plant-specific data collection.** As a result, standardised approaches will likely enable the implementation of emission reduction projects which have previously been prevented. Ideally, the burden of baseline determination would largely be shifted away from project developers by establishing standardised factors.

Further data collection efforts are needed in order to derive the factors used in the standardised approach. These include among others the average CH_4 emission rate as well as the conversion efficiency of the kiln found to represent the most attractive course of action for the region. Additionally, a survey of technical and economical data collection should provide a clear answer on which technology can be considered as the baseline case with regard to the affordability to producers. **Most importantly, data collections on the share of non renewable biomass should be improved.** Due to the limited financial resources in host countries, international support with the right institutional framework is essential. An early start for financial support and additional surveys are needed in order to reduce the lead time.

Our recommendations on the key technicalities of the standardised approaches to charcoal production projects are summarised in Table 1. The proposed **standardised approach would lead to significant ease of the data collection burden on project developers**. The environmental effectiveness of the standardised approach is expected to be high because an appropriate stringency level for additionality determination can readily be set, and the proposed approach is conservative enough to avoid over-crediting of CERs. As **detailed disaggregation is not considered necessary** and **the replicability of this project type is high**, the standardised approach is likely to prove cost effective. The geographical distribution would be very positive as it can trigger projects in Sub-Saharan Africa, currently the most underrepresented region under the CDM. As further data collection efforts are needed, institutional capacity building and funding are essential.

Table 1: Summary of standardised approach to charcoal production projects

	Description
System boundary	Charcoal production site.
KPI	tCO_2e per TJ of charcoal produced.
Aggregation level	(1) Process: Not differentiated. (2) Product: TJ of charcoal – need to disaggregate inputs according to their sustainability (renewable biomass vs. non-renewable biomass). (3) Time: No need for differentiation between old and new as retrofit projects are highly unlikely – frequent update is not seen as critical. (4) Space: Similar socio economic conditions – mostly for LDCs in Sub-Saharan Africa.
Data requirements	Standardised baseline for specific greenhouse gas emissions per unit of charcoal: • Average efficiency of each charcoal kiln type. • Cost of various kiln types. • Sampling of financial resources of charcoal producers. • CH_4 emissions of kiln types. • Sampling of kiln types as share of the production. • Share of non renewable biomass used for the production of charcoal in the relevant region. Output of the project plant • Amount of charcoal produced (in volume or weight). • Specific heat content of the produced charcoal (per weight or per volume).
Stringency level	Baseline: • CO_2 emissions: Determined based on the "weighted average" of producers and the level of charcoal kiln efficiency they can operate. • CH_4 emissions: Weighted average for the region as there is no "most economically attractive course of action" for CH_4 emissions from pyrolysis gases – as there is no economic incentive for charcoal producers to reduce CH_4 emissions. These emissions are the result of both the technology and operating conditions. Additionality: • For CO_2 emissions: efficient technology which encounters an investment barrier. • For CH_4 emissions: any reduction below the average is seen as additional as there is no significant incentive for users to mitigate such emissions.
Updating frequency	Pluriannual update.

1.1 Relevance of the sector for standardised approaches

Charcoal is a widely used fuel in Sub-Saharan Africa, where most LDCs are located. Changes in the fuel mix have been observed in Sub-Saharan Africa (Seidel 2008). A significant share of households has shifted from unprocessed biomass such as fuelwood to more convenient fuels. Growing urbanisation along with changes in habits explains this shift to fuels which require less handling and gathering (Girard 2002). The shift to petroleum products such as kerosene and LPG has however been limited and an overwhelming majority of the energy supply in Africa still comes from wood[1]. This is mostly due to the limited affordability of petroleum based fuels for low-income households. Instead, charcoal has become one of the preferred fuels due to both its convenience and affordability (Girard 2002). Studies have confirmed this success of charcoal as the cheapest fuel per unit of energy[2] in Africa. In many parts of Sub-Saharan Africa, Charcoal has become the main domestic fuel, especially in urban areas (Kammen and Lew 2005).

The increased use of charcoal has raised major environmental concerns. Although charcoal can be combusted in a more efficient manner than wood, its production is inefficient. While 1 kg of charcoal has an energy content equivalent to 2 kg of wood, the production of 1 kg of charcoal commonly requires 6 kg of wood (Triffelner 2009). This means in turn that the increased use of charcoal has lead directly to a large increase in wood consumption (Kammen and Lew 2005) as roughly three times more wood is required per unit of biomass energy consumed. Along with agriculture, the production of charcoal is thought to be among the leading causes of deforestation in Africa (Greenresources 2010)[3]. The contribution of charcoal to deforestation is more obvious in places with scarce wood supply and strong demand for charcoal (Girard 2002). This is the case for example with forests surrounding centres of charcoal consumption such as cities. In Tanzania for example, out of the 420,000 ha of forest lost each year, around 100,000 ha of annual deforestation have been attributed to the production of charcoal (Mongabay 2005).

Producing charcoal more efficiently could significantly reduce GHG emissions related to its production:

(1) State of the art charcoal production processes can achieve primary biomass consumptions as low as 2.2 to 3.0 kg per kg of produced charcoal (Pronatura 2009). Switching from outdated production processes to efficient charcoal production processes could in turn save 5.5 kg of dry wood per kg of

---

[1] Pronatura suggests in its document that 89% of the energy supply in Africa still comes from wood (Pronatura 2009).

[2] The cost per household for shifting from charcoal to kerosene has been estimated to be an increase from $50 initially to $200 fuel cost per year (Triffelner 2008).

[3] In Africa, the leading driver for clear cutting of forests is still for livestock and agricultural purposes (Kammen and Lew 2005). In some cases charcoal is produced as a by-product of these forest clearing.

charcoal. With a conservative estimate[4] of a 50% carbon content in wood, the CO_2 savings from avoiding the use of non renewable biomass amounts to 8.25 kg CO_2 per kg charcoal.

(2) Optimised charcoal production can entirely avoid the emissions of CH_4 from pyrolytic gases resulting from traditional processes. Avoiding CH_4 emissions represents an emission reduction of roughly 3.5 tCO_2e tonne of charcoal (Pronatura 2009).

Considering a total charcoal consumption in Sub-Saharan Africa of 20 Mt annually (de Gouvello et al 2008) in 2003 and roughly 11.5 tCO_2e savings per tonne of charcoal (Pronatura 2009), the potential for emission reductions in the Sub-Saharan charcoal sector is between 50 and 200 Mt CO_2e per year[5], depending on the share of wood used for charcoal which is not sustainable[6].

It should be noted that while the relevance of charcoal as a domestic fuel and driving force for deforestation is high in Africa, it is of lower importance in other regions of the world. Efficient charcoal production in Africa is of key importance as there are many negative consequences of deforestation. These include, among others, the loss of biodiversity, land degradation, lower precipitations and water retention as well as a huge loss of economic potential. There is a stark contrast between the efficient supply of charcoal which can contribute to economic development by freeing time for fuel gathering and use and regions in which an unsustainable charcoal production has led to a shortage of fuel and construction material which hinders local development.

Existing CDM methodologies have so far not been able to incentivise the more efficient production of charcoal. The key constraint is the complexity in calculating emission reductions in charcoal production, through both (1) the reduction in CH_4-related emissions, and (2) the improved conversion (kg of charcoal produced per kg of wood) of non renewable biomass.

(1) CH_4 emission reductions: Complex procedures are required in AM0041 or AMS-III.K in order to determine the CH_4 emission factor in the baseline. These procedures require a rather high level of expertise. The use of simple procedures with default factors could greatly improve the usability of the methodologies.

(2) Energy efficiency improvement: No suitable methodology exists for the more efficient use of non renewable biomass by replacing inefficient installations with new, more efficient ones (other than for cookstoves). No procedure exists for establishment of the baseline level of efficiency of such installations.

---

4 As a large share of carbon forests is stored not only in trunks and thick branches but also for example below ground, accounting only for the wood in deforestation represents a conservative approach.

5 Previous estimates from the Food and Agriculture Organization (FAO) put the number of tonnes of wood annually cut at 100 million (Kammen and Lew 2005) – equivalent to 50 millions of tonnes of CO_2 annually (excluding pyrolysis CH_4 related emissions). As explained in the source used, the fuel wood cut for charcoal is likely to be larger than estimated.

6 It is estimated that most of the charcoal used is unsustainably harvested.

A standardised approach could greatly simplify the baseline calculation in particular.

Details of existing applicable methodologies and their limitations are provided in the table below. Overall, **the complex procedures for baseline emissions calculation are the prime obstacle for charcoal projects.** It is thus essential to simplify these methodologies allowing the use of standard baseline factors.

Table 2: CDM biomass methodologies related to energy efficiency and/or CH_4 avoidance in biomass pyrolysis

Methodology	**Specificities and limitations**
<u>AM0041</u> Mitigation of CH_4 emissions in the wood carbonisation activity for charcoal production.	<u>Applicability:</u> Only for reduced CH_4 emissions at existing charcoal kilns (no greenfield projects allowed – the methodology is not applicable to gains in energy efficiency. <u>Data collection:</u> Characterisation of the relation between yield and CH_4 emissions at the charcoal kiln in order to characterise the baseline function at the kiln before the project activity is implemented.
<u>AMS-III.K.</u> Avoidance of CH_4 release from charcoal production by shifting from traditional open-ended methods to mechanised charcoaling process	<u>Applicability:</u> New facilities (greenfield or replacement) to replace a specific plant or displace any outdated production capacity in the region - only for reduced CH_4 emissions at existing charcoal kilns (no gains in energy efficiency can be accounted for) – no switch in biomass type allowed. <u>Data collection:</u> Procedures to estimate the CH_4 emissions from charcoal production in "*open pit charcoal manufacturing process*" and "*brick based charcoal making processes*".
<u>AMS-I.E.</u> Switch from non-renewable biomass for thermal applications by the user	<u>Applicability:</u> Only for end users of small appliances using non-renewable biomass *(non applicable).* Stringent requirement that non-renewable biomass has been used since 31 December 1989. <u>Data collection:</u> Only vague procedure to determine the nature (renewable vs. non renewable) of the biomass.
<u>AMS-I.C.</u> Thermal energy production with or without electricity	<u>Applicability:</u> Only for "*supplying users with energy that displaces fossil fuel*" (thus non applicable to non renewable biomass in the baseline). *"Charcoal based biomass energy generation project activities are eligible to apply the methodology only if the charcoal is produced from renewable biomass sources* *(a) Charcoal is produced in kilns equipped with CH_4 recovery and destruction facility; or* *(b) If charcoal is produced in kilns not equipped with a CH_4*

	recovery and destruction facility, CH_4 emissions from the production of charcoal shall be considered. These emissions shall be calculated as per the procedures defined in the approved methodology AMS-III.K. Alternatively, conservative emission factor values from peer reviewed literature or from a registered CDM project activity can be used, provided that it can be demonstrated that the parameters from these are comparable e.g., source of biomass, characteristics of biomass such as moisture, carbon content, type of kiln, operating conditions such as ambient temperature." In turn the methodology is not suitable for the displacement of inefficient and carbon-intensive charcoal production. It could solely be applied in countries with a sufficient supply of biomass in new charcoal kilns whose production replaces fossil fuels. Data collection: n.a.
AMS-II.G. Energy efficiency measures in thermal applications of non-renewable biomass	Applicability: Mostly for appliances, especially cooking stoves (for which default factors are provided). The methodology is not applicable to CH_4-related emissions reductions. Data collection: n.a.

As of February 2010 an analysis of charcoal related CDM projects has identified a total of 16 projects at various stages. Of these projects only 10 are for applications other than power generation or the supply of industries. Out of these 10 projects, 7 have been found solely to target emissions from the pyrolysis gases (mostly CH_4) related to the production process of charcoal. These projects use either the approved large scale methodology AM0041 (Mitigation of CH_4 emissions in the wood carbonisation activity for charcoal production) or the approved small scale methodology AMS-III.K. (Avoidance of CH_4 release from charcoal production by shifting from traditional open-ended methods to mechanised charcoaling process). None of these 7 projects have been implemented in Sub-Saharan Africa. In total, 3 of these 7 projects targeting pyrolysis gases in the production of charcoal have so far been registered. The sole project found in Sub-Saharan Africa is the "Lusaka Project" in Zambia. This project is however not aimed at the transformation of biomass but at end-use substitution and energy efficiency. It applies the approved methodology AMS-I.E. and aims at replacing sustainably harvested small sticks in energy efficient cook stoves. This project has already been registered (Point Carbon 2010).

Standardised approaches could overcome the limitations observed in the existing methodologies, such as AM0041 and AMS-III.K, by providing standardised factors for the determination of the baseline. For project developers, the use of standardised factors will substantially reduce the complexity in the determination of baseline emissions. In order to maintain the environmental integrity of the approach, standardised baseline factors need to be stringent enough. The design of the approach and the decision on the stringency level will require expert judgement.
The following sections explain how performance standards can be established for charcoal production projects. The following key aspects of performance standards are discussed:

- System boundary: A physical boundary for accounting for GHG emissions..
- KPI: An indicator used for comparison of emission performance of the project against peers.
- Aggregation level: Criteria for identification of peers for the emission performance comparison. Four key dimensions are process, product, time, and space.
- Data requirements: Data required for the development of a performance standard, and availability of such data.
- Stringency level: The level of a performance standard for baseline emissions and/or additionality demonstration.
- Updating frequency: Required frequency for updating of a performance standard over time.

1.2 System boundary

As explained in the previous section, the system boundary for a standardised approach for low emitting charcoal production should include the whole production site. The approach specifically targets the efficient transformation of wood and possibly other types of biomass into charcoal.

For the sake of simplification, a standardised approach should not include end-users of the charcoal as the application of the charcoal is beyond the control of the project proponent. Charcoal is sometimes used in Africa for the cottage industry. Dedicated charcoal production for large scale industries should specifically be excluded from the standardised approach as it is not comparable to the small scale production of charcoal for domestic use[7]. Additional and separate energy efficiency measures at the end-user stage would still be possible in separate projects using adequate methodologies. This is the case for example with the distribution of efficient cook stoves. Such projects are not expected to conflict with the switch to a more efficient charcoal production.

Emission sources should at least include both CO_2 emissions and pyrolysis related emissions as their shares in the overall emission reductions are around 60-70% and 30-40%. Emissions related to the production of charcoal in the project should include (1) the emissions from sources of non renewable biomass, (2) additional energy use at the charcoal kiln such as auxiliary fossil fuels and electricity, and (3) emissions related to pyrolysis gases. Emissions from sources of non renewable biomass are the main emissions, and thus should be included. Emissions related to sustainable biomass should not be included. Emissions from auxiliary energy consumption are easy to monitor and should be included in the project for the sake of conservativeness.

[7] An identified risk for the inclusion of industries in the methodology is turning new users to charcoal as a result of the additional financial incentive, while its production is often not sustainable. Any approach should refrain from turning new users to charcoal in areas where it can potentially lead to deforestation.

As biomass related emissions include only non-renewable biomass, possibilities exist for switching from non renewable biomass to renewable biomass[8]. This is similar to other methodologies. This would for example include among other things (1) the switch to bio-residues which have not previously been used, (2) the switch to other types of biomass for which there is a sufficient availability for a sustainable supply, or (3) the sourcing of biomass from areas where it can be harvested sustainably[9].

One major question concerns the inclusion of Land Use Change and Forestry (LUCF) in the approach. A clear distinction can be made between LUCF activities and activities to reduce emissions occurring as a result of the transformation of the biomass. Thus it is recommended that the distinction between the two activities be maintained. Generally, it is thought that such projects can still be implemented in conjunction with the approach accounting for emission reductions at the charcoal kiln using the appropriate set of UNFCCC methodologies and tools. This allows the approach to be kept simple while making use of already approved procedures. Positive changes in carbon stocks from LUCF might occur if dedicated forest or dedicated plantation is established in order to supply primary biomass to charcoal production sites.

Finally, transportation might also play a role. Various reports have found that the supply of charcoal generally originates within a 50-200 km radius around consumption centres (Kammen and Lew 2005), with some exceptions in which charcoal is brought from over 300 km[10]. With a rough estimate of 100 g CO_2e per tonne-kilometre[11], emissions from transporting one tonne of charcoal are estimated at 0.01 tCO_2e per tonne for 100 kilometres. In comparison, savings from a reduced consumption of non sustainable wood are much larger. In turn, emissions related to the transportation of charcoal are only a minor source of emissions[12]. Therefore, they can be ignored in most cases.

In summary, **only a limited number of elements should be included in the standardised approach.** These are:

- The main emissions related to the production of the charcoal at the charcoal production site (including CO_2 emissions from energy use in the transformation as well as pyrolysis gas).
- Auxiliary fuel consumptions from the production of charcoal (electricity and auxiliary fuels).

---

[8] Such cases are thought to be rare - upon local depletion of one type of biomass, other types of local biomass would be used unless there is availability and affordability of fossil fuels instead.
[9] In this case, increased emissions from transportation should be accounted for.
[10] In some cases, charcoal has been transported to large cities from sites 350 to 1200 km away (Seidel 2008).
[11] For example a federal statistic in Canada indicated a trucking CO_2 intensity of 114 tCO_2 /t-km (CN 2010).
[12] Minor sources of emissions for CDM methodologies are defined as emissions accounting for less than 1% of the gross total.

Monitoring the consumption of auxiliary fuels is seen as uncomplicated as it can either be metered (electricity), measured or estimated from billing. The CO_2 emissions from the biomass conversion can be calculated based on the ratio of mass of charcoal produced and mass of biomass utilised. CH_4 emissions do not need to be monitored if the charcoal production unit is designed to avoid such emissions. New production units resulting in CH_4 emissions might not be desirable at all. For this reason, the use of the standardised approach could simply be limited to charcoal production units free of CH_4 emissions. As an alternative option, CH_4 emissions could be calculated in a conservative manner according to the prescribed formula in AM0041 or AMS-III.K. For larger units, they can be calculated on the basis of continuous monitoring using appropriate equipment.

1.3 Key performance indicator

Key performance indicators are typically expressed in emissions per unit of product. The product considered is charcoal. As both CO_2 and other GHGs are emitted in the process, emissions should be expressed in tonnes of CO_2 equivalent (tCO_2e).

The denominator used in the KPI should refer to the charcoal produced, expressed in an appropriate unit. It should be noted that the quality of charcoal can vary based on many parameters (e.g. temperature of operation, type of charcoal kiln, type of biomass used, etc.). For charcoal used as fuel the quality can be defined by its heating value. This heating value largely depends on the carbon content of the charcoal. Charcoals generally present carbon content of around 85%[13]. Comparing charcoals of different types would in turn require adjusting them to "standardised charcoal" by correcting for their heating value. For this reason it is more appropriate to express the product in unit of heat (TJ).

The resulting KPI should therefore be expressed as the sum of all emissions associated with the production of one terajoule (TJ) of charcoal per unit of charcoal:

$$\mathrm{KPI}: \ \frac{[\mathrm{tCO_2e}]}{[\mathrm{TJ}]}$$

Under a simplified approach, the project emissions could be calculated as:

$$PE = EF_{elec,y} \times EC_{elec,y} + \sum_{n} (EF_j \times Q_j) + \sum_{i} \left(B_{i,y} \times f_{NRB,i,y} \times CC_i \times \frac{44}{12} \right)$$

Where:

[13] Typically charcoal processes operated at 500°C yield a carbon content of charcoal of 86% (FAO, 1987).

PE	=	Project emissions (tCO_2e/year)
$EF_{grid, y}$	=	Electricity emission factor in year y (tCO_2) *NB: A default value of 1.4 tCO_2/MWh can be used*
$EC_{elec,y}$	=	Electricity consumed by the charcoal plant in year y (MWh)
$EF_{,j}$	=	Emission factor of the auxiliary fuel j used (tCO_2/tonne)
Q_j	=	Quantity of auxiliary fuel *j* used in year y (tonnes)
$B_{i,y}$	=	Quantity of biomass from type *i* used in year y (tonnes)
$f_{NRB,i,y}$	=	Fraction of biomass of type i used in the absence of the project activity in year y that can be established as non renewable biomass using survey methods
CC_i	=	Carbon content of the biomass used. NB: For dry wood, the default value of 50% can be applied[14]

The baseline emissions could be calculated as:

$$BE = Q_{charcoal,y} \times NCV_{charcoal} \times EF_{BL,fuel,y}$$

Where:

BE	=	Baseline emissions (tCO_2e/year)
$Q_{charcoal,y}$	=	Quantity of charcoal produced at the site in year y
$NCV_{charcoal,y}$	=	Net calorific value of the charcoal produced (a default factor can be used if it can be ensured that the system properly yields a sufficient carbon content)
$EF_{BL,fuel}$	=	Emission factor for the baseline fuel (tCO_2/tonne)

This emission factor for the baseline fuel would be calculated as:

- For charcoal production sites supplying an area in which deforestation is occurring:

$$EF_{BL,fuel,y} = f_{NRB,i,y} \times SEF_{charcoal,CO2} + SEF_{charcoal,CH4}$$

Where:

$f_{NRB,y}$	=	Fraction of biomass used in the absence of the project activity in year y that can be established as non renewable biomass using survey methods
$SEF_{charcoal,CO2}$	=	Standard emission factor for the production of charcoal for CO_2 emissions (tCO_2/TJ)
$SEF_{charcoal,CH4}$	=	Standard emission factor for the production of charcoal emissions from pyrolysis gases (tCO_2e/TJ) *NB: This factor includes all emissions other than CO_2 (e.g. CO, N_2O and CH_4) which would have occurred in the baseline*

- For charcoal production sites at which an excess of biomass fuel is available and the use of domestic fossil fuel is observed:

[14] The number of 50% carbon content in wood is found in several sources (Pronatura 2009; Nabuurs et al. 2003).

$$EF_{BL,fuel,y} = SEF_{fossil fuel}$$

Where:

$SEF_{fossil\ fuel}$ = Standard emission factor for the baseline fossil fuel (tCO_2e/TJ)
NB: Without additional information the standard value of 63.0 tCO_2/TJ corresponding to the use of LPG can be used[15].

1.4 Aggregation level

The processing of biomass is done throughout the African continent. In order to derive a standardised approach for baseline and additionality in Sub-Saharan Africa, it is essential to identify which level of disaggregation is needed. The following section discusses how the appropriate aggregation level should be determined for the four dimensions of aggregation.

1.4.1 Process aggregation

Many different technologies with different levels of efficiency have been observed for the small scale production of charcoal as found in Africa. Generally small scale processes should be considered, as they are the ones supplying most of the charcoal to be used as domestic fuel. Our literature survey did not find very large scale charcoal production lines in Africa for large scale users such as large industries or the power sector (other than in the CDM). Generally there is no reason to exclude large scale units provided that they sell charcoal to households and thus displace the small inefficient producers, and provided that their production does not specifically lead to additional deforestation by locally increasing the demand for charcoal (this would be the case if they supplied a large scale user).

No differentiation in the performance standard should be made based on the technology used as the final product is comparable and can be substituted. The objective is the substitution of small and inefficient/emitting production processes. Outputs can be comparable based on the heat content of the produced charcoal, expressed in TJ. The total heat content in the produced charcoal can be derived from the amount of charcoal produced as well as the specific heat content of this produced charcoal.

1.4.2 Product aggregation

[15] In AMS-I.E. LPG and Kerosene emission factors as baseline domestic fuels are suggested. The use of 63.0 tCO_2/TJ from Kerosene in the baseline, instead of 71.5tCO_2/TJ for LPG, is more conservative.

Charcoal is not a homogeneous product as the heat content per tonne of charcoal may differ. The specific heat content of charcoal depends not only on the type of biomass used but also on the process, with its parameters such as temperature and residence time. A standard unit of weight or volume of charcoal does not provide a good basis for an accurate comparison. Instead, **the comparison should be based on unit of heat.**

The key product differentiation should be by the inputs used for the production. Biomass inputs can not only be different in type but also in their moisture content and their sustainability. Wood is considered the reference input for the production of charcoal in the baseline. Any approach should however allow and be able to credit the switch to other types of biomass (1) which do not lead directly to deforestation, and (2) for which there is an observed surplus which ensures that their use will not lead to an increase in emissions outside the project activity. This is done by using the factor $f_{NRB,i}$ in the project, which accounts for the share of non renewable biomass in the supply of the biomass of type *i* to the market. For each type of biomass *i* which is not from renewable sources, it is important to know the carbon content CC_i as this value is proportional to the carbon emitted from its use. As types of wood show only minor differences in carbon content, however, a standard factor for wood could be used[16].

1.4.3 Temporal aggregation

As already mentioned it has not been observed that new plants have been built much more efficiently than existing ones without additional financing of some sort, mostly from environmental programmes and NGOs. As the goal is mostly to replace the existing production with a more efficient one, **the current level of performance including the least efficient plants should form the baseline.** The main change over time is expected to be in the renewable/non renewable nature of the biomass used (see Ch. 1.7).

1.4.4 Spatial aggregation

There are three possible reasons for spatial disaggregation when establishing a standardised approach for charcoal production:

(1) The geographical location of the charcoal production plant might influence its efficiency.
(2) The sustainability of the biomass used as input for charcoal production might be linked with the location delivering this biomass.
(3) The location in which the project plant charcoal is sold could determine which other sources of charcoal the project would displace.

[16] Derived from several sources, including (Sampson 2002).

It must be determined whether the above reasons are justified in the specific geographical area of concern.

(1) Geographical location and charcoal production efficiency

Our review of the literature found similar charcoal production technologies across Sub-Saharan Africa. If the average regional performance levels were to be slightly different, the same performance standards could still be used. Indeed no incentive for gaming has been found in this precise case, even with the same emission factors used in a larger region[17]. Therefore, **broadly applicable performance standards valid for many African countries could be used for both charcoal conversion efficiency and CH_4 emissions from the pyrolysis process.**

(2) & (3) Geographical location and sustainability of biomass and/or type of charcoal currently in use

The origin and destination of each type of biomass processed into charcoal are thought to be key parameters for the level of emission reductions from a more efficient production of charcoal.

Indeed, the share of non sustainable wood sources in the supply of biomass for the production of charcoal can show some strong regional differences. This means that the same increase in the efficiency of the charcoal production process will not lead to the same amount of avoided consumption of non-sustainable biomass. As found in the literature, essentially two cases can be distinguished regarding the situation of the biomass produced (Kammen and Lew 2005): (1) the biomass supply is in excess and the more efficient production of biomass can replace fossil fuels (mostly LPG and kerosene), or (2) the biomass is harvested too intensively with deforestation as a consequence.

Spatial disaggregation might also be required according to the area in which the charcoal is sold. Charcoal produced from renewable wood in region A and sent in the form of charcoal to users in region B can still lead to substantial emission reductions if the baseline case would have been the use of non sustainable biomass from region B for charcoal production. In turn, such a project should also be able to apply the same baseline as found for charcoal from biomass sourced in region B. Such a project would lead to emission reductions from the replacement of non renewable biomass by renewable biomass.

It has indeed been observed that, as the fuelwood supply becomes scarce, charcoal transportation distances increase. While the usual supply of charcoal is found in the range of 30 to 250 km from urban centres, transportation over 1000 km has also been observed (Kammen and Lew 2005). In turn it makes sense for a standardised

[17] It is reasonable to think that new charcoal kilns would avoid areas where they would be exposed to the competition of more modern and lower emitting kilns while the baseline emission factor is standard – this would lead to a conservative adjustment.

approach to take into account the possibility of switching the region from which the biomass input is sourced.

To conclude, **the basis of spatial aggregation for the baseline should be the availability of biomass in the area of consumption.** Different cases are summarised in the following table.

Table 3: Implications of an efficient production of charcoal – fuels displaced by saved biomass

Availability of biomass wood	**Production of charcoal from generic wood supply**	**Production of charcoal from dedicated forest plantation**
Limited and decreasing – fuelwood crisis	Emission reductions from reduced CH_4 emissions (pyrolysis). Emission reductions from saved non renewable biomass.	Emission reductions from reduced CH_4 emissions (pyrolysis). Emission reductions from saved non renewable biomass. *NB: It has to be ensured that the dedicated plantation does not displace agricultural and pastoral activities.*
Close to balanced	Unknown.	Unknown.
Oversupply well established	Emission reductions from the replacement of fossil fuels (probably kerosene or LPG) by renewable biomass[18]. No emission reduction from CH_4 should be credited as the baseline is the use of fossil fuels.	Emission reductions from the replacement of fossil fuels (probably kerosene or LPG**Error! Bookmark not defined.**) by renewable biomass. No emission reduction from CH_4 should be credited as the baseline is the use of fossil fuels. Additional emission reductions could be claimed from A/R activities.

[18] As found in AMS-I.E.

1.5 Data requirements

Monitoring parameters

Aggregated data would be required for the baseline while plant specific data would be required in the project. Data required for the project can be represented in the following diagram also summarising the point of monitoring.

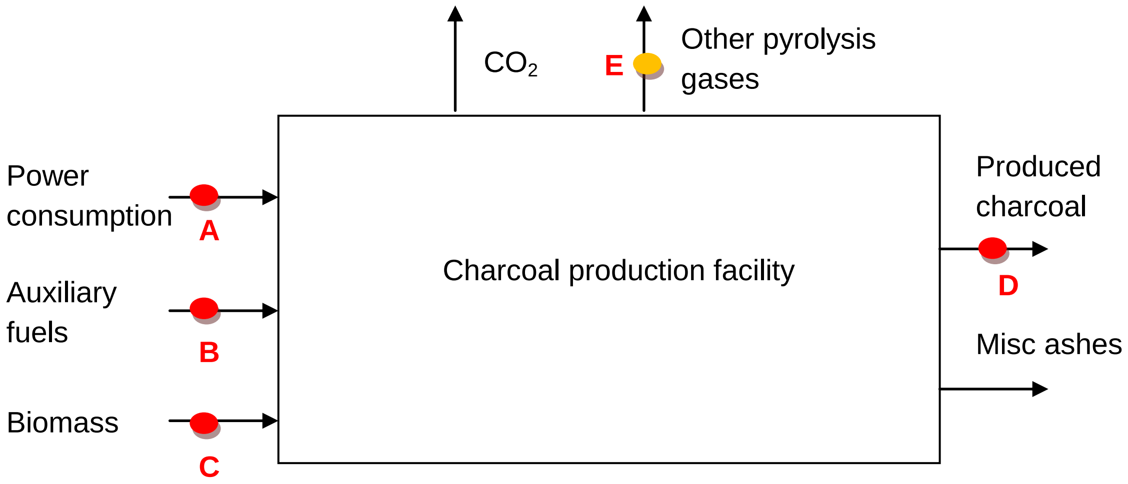

Figure 1: System boundary and monitoring points for charcoal projects

Table 4: List of key monitoring parameters and respective points of monitoring

Monitoring point	**Data to monitor**	**Type of monitoring**
A	Power consumption Emission factor *(not monitored)*	Direct and continuous metering of power consumption (MWh). For the project electricity emission factor, a conservative assumption can be used (e.g. 1.4 tCO_2/MWh).
B	Quantity of auxiliary fuel consumption Emission factor of auxiliary fuels used *(not monitored)*	The quantity of auxiliary fuels consumed can be taken from stock inventory and checked against billing. The emission factors can be taken from standardised emission factors.

C	Quantity of biomass *i* Fraction of non renewable biomass for biomass type *i* $f_{NRB,i,y}$ Carbon content of biomass *i*	The quantity of biomass *i* used in the production of charcoal is monitored by gravimetry. The fraction of non renewable biomass for the type of biomass *i* will be determined either top down by a study or by the project proponent. The carbon content for each type of biomass *i* can be taken directly from available sources of literature (IPCC or others). A conservative value should be available for non listed types of biomass as a fallback option.
D	Quantity of produced charcoal fuel $Q_{charcoal,y}$ Net calorific value of the produced charcoal $NCV_{charcoal,y}$	Monitoring per gravimetry of the amount of charcoal produced (tonnes). Monitoring of the specific heating value of the charcoal produced can be done by either (1) direct sampling and analysis, or (2) calculation as a function of the pyrolysis parameters, such as time and temperature, applied for specific biomass types.
E	Emissions of other pyrolysis gases, especially CH_4 emissions	None if the system can prove by its design that it does not lead to significant emissions from pyrolysis gases (less than 1% of the total GHG emissions). Continuous monitoring is possible but more expensive. A monitoring of parameters for which a clear correlation with CH4 emissions can be established can be used instead, as with approved methodologies AM0041 or AMS-III.G. (e.g. CH_4 specific emission factor as a function of the pyrolysis temperature).

Data availability

Data on the CH_4 emissions from pyrolysis gases are quite difficult to derive as the specific CH_4 emissions per produced tonne of charcoal depend on the technology used and operation characteristics. However, a fair amount of data already exists and could be used. Values for emissions of pyrolysis gases are already available from the following:

- PDDs developed under the two dedicated methodologies AM0041 and AMS-III.K.
- Miscellaneous sources of literature.
- As a back-calculation applying methodologies found in the literature, where it is for example a function of the yield (tonnes of charcoal yield per tonne of biomass used).

It must be ensured that meaningful and representative data are used to derive an adequate standardised baseline emission factor for Sub-Saharan Africa. Values are found mostly in a range from 0.6 to 1.0 tCO_2e per tonne of charcoal produced. Further work is needed in order to determine the exact performance standard to be used in the baseline.

Data required for the choice of a baseline emission rate of CO_2 from produced charcoal include three key parameters: (1) the efficiency of the conversion of biomass to charcoal, (2) the carbon content of various types of biomass used, and (3) the share of non renewable biomass.

- There already exist appropriate standard carbon contents for various common types of biomass.
- Data on the efficiency of the conversion of biomass to charcoal is partly available in the existing literature. It is probably not realistic to perform an in-depth survey to monitor the performance of each small kiln available in the region. Instead, a conservative enough standardised factor can be used per technology.
- The share of non renewable biomass for each type of biomass *i* should be determined for the main types of biomass throughout target countries in Africa. The most obvious type of biomass to be surveyed is wood, especially types which are traditionally used in the production of charcoal. Publications of national forest inventories and deforestation rates could be useful for the calculation of the share of non-renewable biomass used. A top-down survey would largely eliminate the risk for gaming. Project proponents would still be able to use other types of surplus biomass in the geographic area using an approach similar to that of ACM0006.

So far, only a limited amount of data is available for assessing the additionality of new charcoal kilns. Therefore, **further efforts would be required in data collection on the cost of various charcoal kilns as well as the financial resources available for charcoal producers.**

1.6 Stringency level

Stringency level for baselines

Greenfield plant vs. retrofit: There is a need to avoid crediting efficient charcoal kilns for their continued BAU operation. For this reason any approach should select for the baseline the lowest emission factor of either (1) the standardised baseline performance (not differentiated between greenfield plants and retrofit) or (2) the current plant performance based on the continued operation of the plant. Crediting of non-additional charcoal production can be excluded using one of the following approaches:

(1) Use the lowest of the standardised common baseline emission factor or the technology specific baseline factor in case a technology more efficient than

the average is already used. This would only require the characterisation of the baseline technology at the site.

(2) Mandate a substantial investment for the project which should materialise in a switch toward a new technology with the scrapping of the original installation.

(3) Simply exclude any retrofits from the approach and only allow for the construction of new plants.

Generally, mitigation potential through retrofit of existing plants is very limited in Sub-Saharan Africa. Most of the charcoal plants in Sub-Saharan Africa are micro- to small-scale ones. Thus, only a limited number of the existing plants can be retrofitted in a technically and economically rational manner. As there is no large potential for retrofits to be implemented, there no major interest in creating an incentive for such retrofits. Therefore, **differentiation between new and existing plants is necessary.**

Differentiation based on biomass sustainability: The key requirement for differentiation is the availability of biomass according to which the efficient production of charcoal will either reduce the demand for unsustainable biomass or replace fossil fuels which would otherwise have been used. Where charcoal replaces a fossil fuel, the approach is generally very straightforward as the fuel replaced will in all likelihood be the fossil fuel most affordable to end users. This is justified by the fact that the literature shows that the single largest factor hindering the switch to fossil fuels for domestic use is their affordability.

Specific levels for pyrolysis related emissions: The stringency level to be selected in the baseline for the standard emission factor for the charcoal consists in two elements: firstly the efficiency of the conversion of non renewable biomass, and secondly the associated CH_4 emissions from the pyrolysis. For new plants the most economically attractive course of action will determine the level of performance expected from the baseline for both the emission of pyrolysis gases and the efficiency of the conversion from biomass to charcoal. There is however generally no economic incentive to reduce the pyrolysis gases other than climate protection[19]. As the incentive to abate CH_4 emissions from pyrolysis emissions is negligible, even newer and more modern plants such as the Plantar project in Brazil show a CH_4 emission baseline in line with those of the studied earth mound kiln in Kenya, which is among the least efficient types worldwide (Table 5). Thus the most economically attractive course of action regarding CH_4 emissions is a continued level of emissions for new plants. In the absence of the CDM present levels are generally expected to continue.

For this reason, a number as close as possible to the weighted average of specific CH_4 emissions of production might be suitable. From our review of the literature many technologies and operating practices can be found in Africa. However, these

[19] It should be noted that the emissions of such gases for many kilns types is a function of the efficiency with lower CH_4 emissions for higher efficiencies

technologies are the same throughout the whole continent, perhaps only with different levels of diffusion.

Several options exist for a standardised baseline for CH_4 emissions:

(1) Perform measuring campaigns at all sites: This option is not realistic due to the workload it represents. Additionally, for kilns for which CH_4 depends upon operating conditions, a continuous monitoring of operating parameters would be required for all kilns.

(2) Perform a sampling monitoring for different technologies and use the average: This procedure could be acceptable for small scale methodologies but can be inaccurate, as production capacity is not evenly spread among technologies. Thus, knowledge of the share of each technology would be needed.

(3) Perform a sample monitoring for different technologies – perform a second sampling to determine the share of each technology in the weighted production capacity – and multiply the performance by the weighted production capacity of each type of technology: This approach is considered more complicated but feasible, justifiable and quite accurate. The weighted average of the performance will determine the baseline for pyrolysis related emissions.

(4) Derive numbers from the existing literature and apply them: Without an accurate knowledge of the distribution of the production capacity per type of technology, this approach might be seen as too arbitrary. Reviewing the literature, a certain spread in numbers used as a baseline for CH_4 emissions from charcoal consumption can generally be observed (Table 5).

Table 5: CH_4 emission factors for charcoal production

CH_4 emissions per tonne of charcoal	**Source**
3.5 tCO_2/t charcoal (average value between the least efficient carbonisation methods in Sahelian regions (which constitute the common practice in the baseline) and the value used in the Plantar project, where improved charcoal kilns are used)	(Pronatura 2009)
0.997 tCO2e/t charcoal (based on regression analysis for the baseline Plantar production of an emission factor of EF=140-(314*yield) expressed in kg CH_4 per t charcoal – equivalent to 47.5 kg CH_4 per t charcoal for a yield of 29.2% or 0.292 tonnes of charcoal per tonne of dry wood)	Plantar project (PDD under AM0041)
0.777 tCO_2e/t charcoal (equivalent to 0.037 tCH_4/t charcoal).	(Amous 1999) 6.1.1 “Conversion and Emission Factors”
0.63 tCO_2e/t charcoal (based on 1000 kg CH4 per TJ of charcoal produced and 30 GJ/t charcoal)	(Reumerman and Frederiks 2002)
0.67 to 1.30 tCO_2e/t charcoal (based on 32 to 62 kg of CH_4 emitted by various	(Pennise et al. 2001)

kilns in Kenya and Brazil)	Note that this study is of high relevance as the tested technology, the earth mound kiln, is widely used in Sub-Saharan Africa. For example in Kenya, over 90% of producers use this technology (Seidel 2008)

Generally, option 3 is considered the most likely and robust option from which to derive numbers. The data collection should exclude any kiln equipped with CH_4 recovery or flaring as the purpose of such a measure can be regarded as almost solely climate protection, and thus is not representative of the baseline.

Specific levels for emissions related to the conversion of non renewable biomass: For new plants, the level of stringency of standardised baselines should reflect the most economically attractive course of action, taking into account barriers which prevent the implementation of various scenarios. A lack of capital is one of the main barriers, especially in countries where monthly income per capita is less than €50. Even low cost charcoal kilns such as basic steel kilns with a capital requirement of €700[20] are too expensive for most producers (Seidel 2008). As such it should be taken into account that a certain share of producers will not be able to shift to more efficient kilns. In turn the baseline representing the most attractive course of action might be valid only for a number of producers with access to some capital.

Overall, **we conclude that deriving figures will require surveying the economic activity and possibly the capital availability of producers on the ground.** Another survey or review of the literature would need to explore the cost of different kiln types. In turn, a stringent and reasonable assumption for the baseline would be the use of the most efficient kiln available for the level of potential capital availability. For each technology, the average level of operational efficiency can be used[21]. The resulting global performance standard would be a weighted average of the performance available for the weighted average of capital availability of producers.

In reality, not all producers operate the best kiln they could reasonably operate given their access to capital. Other parameters should therefore also be taken into account. For example, charcoal kilns built with additional financing (e.g., NGO, ODA, carbon finance, etc.) should be excluded from the sample. Additionally, technologies not having reached a meaningful penetration rate for their affordability class should not be taken into account[22]. An example of this diffusion rate could be 10% of the production tool added or replaced over the last 5 years in the relevant market, as found in US offset programmes.

[20] Converted from $1,000.

[21] A further differentiation taking into account measured operation parameters of local plants would complicate the approach to the point that most elements of standardisation would be lost.

[22] This is the case for example with the Adam-retort kiln which despite a low cost of only $300 to $400 and efficiency as high as 40% is only at a pilot phase (Seidel 2008) – its diffusion is uncertain due to the skills required for its operation.

Overall, the approach proposed is conservative for several reasons:

- The CO_2 savings associated with the avoided deforestation are larger than those of the approach in which only non renewable wood is used for calculating the savings.
- Producers with the lowest efficiency and thus the highest emissions per tonne of charcoal are the ones likely to be replaced first by the most efficient production capacity.

It must be noted that the approach taken can in theory be set either specifically for an area or as a standardised factor for a larger region which can even include several countries. Due to the need for an in-depth study with a subsequent treatment of the data to adjust for the most efficient technology which can be found in the class of capital availability, a baseline factor valid for a broader region would greatly reduce the survey cost.

The goal of the survey, and the subsequent data processing based on the capacity to afford specific technologies, is to derive the average yield for the baseline kiln. Once this value has been calculated, the standard emission factors for the production of charcoal $SEF_{charcoal}$ can in turn be calculated. It is expressed in CO_2 emitted from the charcoal production process per TJ of charcoal heating fuel produced from non renewable wood. As charcoal quality varies, the carbon content or heating value of charcoal differs. The survey of charcoal production needs to take into account the difference in charcoal quality in order to enable a fair comparison.

Stringency level for additionality testing

Establishing additionality would require consideration of two key elements. First, a certain performance threshold needs to be established to prove that the project clearly deviates from what is seen as BAU. If the CDM is to play a meaningful role in incentivising the establishment of new efficient charcoal kilns, the performance has to be notably higher than the baseline. A stringent additionality level is considered appropriate, as very efficient technologies have been developed recently. Such technologies are almost free of any CH_4 emissions and show a yield between 0.35 to 0.45 tonnes of charcoal per tonne of fuelwood (Pronatura 2009).

Second, a survey is necessary to show that there are indeed inefficient plants supplying the local market. It has to be proven that there is a possible gain in the efficiency of conversion from wood to charcoal which can contribute to the decrease of deforestation. This could be established solely on the basis of the observed production capacity in the region without specific numbers.

The level of additionality would typically be based on kilns which are already found in Africa, such as the Casamance kiln and the Steel kiln, which have a higher efficiency but have not been more widely used due to their lack of affordability. The yield[23] for

[23] The yield of a charcoal kiln is defined as the mass ratio between the charcoal produced and the wood used for its production.

those kilns is in the range of 27 to 35% (Seidel 2008) for various steel kilns and 25 to 30% for the Casamance kiln (Kammen et al. 2005). With a carbon content of 50% in wood and 85% in charcoal, this is equivalent to an emission factor of 6.1 tCO_2 per tonne of charcoal.

Due to the lack of economic incentive, CH_4 abatements for charcoal kilns are additional, an average CH_4 emission factor could be used. Based on Table 5, the value applied could be the average of the range of emission factors observed, i.e. 0.6-1.0 tCO_2e per tonne of charcoal produced. Additional steps would need to narrow down this range and provide a simple procedure to derive a precise and conservative enough value for baseline CH4 emissions from pyrolytic gases.

1.7 Updating frequency

$SEF_{charcoal}$ (Standard emission factor for the production of charcoal): There is generally no large need for updating the specific emission factor for charcoal production. It has been observed in the literature that the charcoal industry in Africa is overwhelmingly artisanal[24] and answers the needs for subsistence (Seidel 2008). So far, no large scale investment in new equipment has been observed other than for environmental purposes (either against deforestation or against related emissions or both). These investments have mostly been supported by public actors, whether national or international. No large scale investment in more modern charcoal production can be expected on a "for profit" basis without the CDM as producers lack the required capital (Kituyi 2004). In turn this parameter is expected not to change or to change only in a minor way and could safely be fixed ex-ante based at the point of time of the decision to implement the CDM. The stringency level of $SEF_{charcoal}$ could be revised after a long period of 3 to 5 years based on a new field survey to estimate the performance of units used for the determination of the baseline.

$f_{RNB,I,y}$ (Fraction of biomass used in the absence of the project activity in year y): Generally, types of biomass which are renewable do not change suddenly. The most likely change is from a sustainable supply of biomass to an unsustainable supply of the biomass type due to its depletion. The chances of having an unsustainable biomass supply turn sustainable without external support are very low. Thus, a low frequency of updating is more conservative. It could be sufficient to conduct a survey once for the whole crediting period of the project. New studies would only have to be undertaken, ideally on a top-down basis, once the new modern production capacity installed under the CDM (as well as other environmental programmes) has reached a level at which most of the inefficient production processes in the specific region are considered to have been replaced.

[24] The observed scale for most producers is of batches of 1 to 5 tonnes (Kammen and Lew 2005) in earth, brick or steel drum kilns.

1.8 Implications of the standardised approach

Environmental effectiveness

The environmental effectiveness of the standardised approach hinges on whether a performance standard can be set at the right level of stringency. It has been observed that the deployment of more efficient technologies to produce charcoal in Sub-Saharan Africa has almost always been done as a result of national or international support. Without external support, only artisanal types of production processes have been implemented. This is especially the case in the poorest countries with extremely limited financial resources[25]. A standardised additionality level does not need to be much more stringent than the present average performance in order to exclude projects which would have been implemented anyway. Production processes more efficient than the market average are not implemented autonomously. Thus, the most economically attractive option would very likely be a charcoal production process with a low efficiency and with no abatement of CH_4 emissions.

Legal requirements have sometimes been put in order to stop inefficient charcoal production. However, such laws have never been successfully enforced and have just led to an illegal continued charcoal production. According to a CDM rule, national laws in place do not need to be taken into account in the determination of project additionality if the enforcement rate does not exceed 50% in the region[26]. This means that the regulations in Sub-Saharan Africa "currently" do not need to be taken into account[27].

The above concludes that **a stringency level set at the current common practice level would be a reasonable threshold for baseline emissions and additionality demonstration.** Due to the fact that deforestation reduces the carbon stock not only in the trunk and branches of trees but also below the ground level, the project is expected to result in substantial emission reductions that are not credited at all. This conservativeness helps ensure the environmental integrity of the standardised approach.

Cost effectiveness

The standardised baseline could be further differentiated by type of biomass used, country, amount of moisture in the biomass, local composition of the production process, etc. This would however increase the cost for setting up the approach

[25] Despite its huge negative impact on their economic potential, potential host countries have not been able to halt this deforestation, highlighting the additionality even taking into account the case where the project is undertaken by a public entity (which would be able to reap ancillary benefits from halted deforestation).
[26] The 50% compliance rate ruling refers to what has been accepted in the methodology of AM0012 and since then in several other methodologies.
[27] This may change in the future. Hence an enforcement rate of relevant regulations needs to be monitored over time.

without increasing the overall environmental integrity. **A single standardised baseline per country or even valid for a group of countries can be envisioned.** More importantly, clear definitions of areas which are suffering from deforestation tied to the use of charcoal should be established. As the product is roughly the same, no technology specific performance standards should be set. Only technologies having demonstrated that they guarantee a very low CH_4 operation should be eligible, unless the project proponent accepts the complex characterisation and additional monitoring of its production[28].

The overall cost of developing a standardised approach is low compared to the market value of the emission reductions it could achieve under the CDM. Taken as a whole, setting up a standardised approach for emission reductions could require considerable upfront financing. This upfront financing could however lead to substantial emission reductions. For example, an upfront cost of €1 to 10 million for the approach represents only €0.01 to 0.10 per CER generated if only 10 million CERs[29] per year were to be issued. Thus the cost of developing a standardised approach to charcoal production has to be compared with the direct benefit of tapping the mitigation potential.

Additionally, co-benefits for the host countries should be taken into account. Significant co-benefits can be expected in economic development, environmental protection, energy and food security, etc. For example, the following co-benefits from an efficient production of charcoal have been identified:

- Potential for further economic use of forests with a stopped depletion (e.g., selective logging or agro forestry).
- Increased predictability of income generated from charcoal production activity in Sub-Saharan Africa[30].
- Reduced desertification and increased biodiversity from reduced deforestation.
- Improved energy access, as charcoal is the cheapest of all commercial fuels in Africa.
- Improved gender equality, as most of the cooking is performed by women and wood cooking requires much more time than charcoal cooking.
- Reduction of indoor air pollution, as the combustion of charcoal produces less fumes by far than fuelwood.

Distributional considerations

This project type is aimed at Sub-Saharan Africa where most LDCs are located[31]. Charcoal does not play a major role as a domestic fuel in other parts of the world

[28] For example in production where CH4 emissions are a function of temperature, an initial characterization of the CH4 emissions as a function of the temperature, and monitoring of the temperature, are necessary.
[29] This is a onservative assumption, as the potential for emission reduction from a more efficient charcoal production in Africa has been estimated between 50 and 200 million tCO_2e.
[30] The charcoal sector in Africa might represent as much as $350 million per year (Seidel 2008).

except in Latin America, where it is also used for large scale industrial applications and the energy sector. The approach is expected to be able to improve the distribution of CDM projects. If no differentiation is made for biomass moisture content in the baseline, the distribution might slightly favour more arid areas. Also, more charcoal might be produced locally in areas with greater availability of biomass and transported to places with a strong demand for and a lasting deficit of available domestic biofuel. This means that **the geographical distribution of CDM projects is likely to favour rural areas with forestry resources within a certain radius from the consumption centre.** This is similar to the present situation. A notable exception could be the transportation of charcoal from regions with a sufficient supply of biomass to Sahel regions which have already exhausted their biomass. **On project size distribution, a shift towards slightly larger charcoal production units may be observed.** Highly efficient units can already be built for a scale of just 3 to 4 tonnes of charcoal production per day.

Institutional capacity

Institutional capacity is considered high even if the appropriate expertise does not always exist in host countries. Institutions such as the FAO have sufficient expertise in identifying areas of deforestation and/or verifying the standardised approach. There is moreover a strong willingness from Annex I countries to develop the CDM in Sub-Saharan Africa, fight deforestation and poverty and contribute to local economic development by lowering energy poverty. Consequently, initial funding could easily be gathered from individual countries, international institutions or multilateral fund.

1.9 Recommendations for further work

The next steps for further development are summarised in Figure 2. In particular, the following steps would require major efforts. First, **evaluate the biomass sustainability** on a regional or national level starting with areas which have been identified as being the most exposed to deforestation. For example, national forest inventory and deforestation baselines can be used for the approach if such data is publicly available.

Second, perform a literature review to **collect and validate figures on the carbon content of the most common types of biomass** used in Africa for the production of charcoal.

[31] In order to be relevant to other countries and bring the same benefits, charcoal would need to be a key fuel for a large share of the population, and this would need to be combined with high deforestation in which charcoal plays a key role due to the low conversion efficiency of biomass into charcoal. While this situation is encountered in Africa, it is unknown at this point whether other countries are also suitable for the approach. Nepal, which has both need for cooking/heating fuel and substantial deforestation, could be one possible candidate for the standardised approach outside Africa.

Third, carry out a survey to **collect data on the level of CH_4 emissions from the pyrolytic gases** from the conversion of biomass into charcoal. This encompasses the following two main tasks:

- Collect information on CH_4 emissions for each type of kiln used with a sufficient number of samples to characterise each technology, e.g., 5 to 10 kilns of each technology should be sampled. Figures already available in the literature can be combined with the sampling study.
- In order to calculate the weighted average for these emissions in the existing production capacity, a sample of the respective technologies should provide data on the share of the cumulative amount of charcoal produced by each technology in the region. In the absence of observed large differences, all of Sub-Saharan Africa could be used as the relevant region.

Fourth, conduct a survey to **determine the level of efficiency of the conversion of biomass into charcoal for each technology.** A procedure should be established that ensures a fair and comparable assessment of every technology.

Last, **perform a technical and economical study in order to determine the technology which represents the baseline.** Such a study would need not only to assess the cost of different charcoal production technologies but also to provide information on their affordability. Such a survey would need in particular to record financial information from charcoal producers and assess the barriers which have prevented the switch to more efficient technologies, if this switch is economically affordable to the producer. This study on the cost of kilns and the affordability of kilns to charcoal producers should be backed by a meaningful collection of qualitative and quantitative data representative of the geographical region concerned.

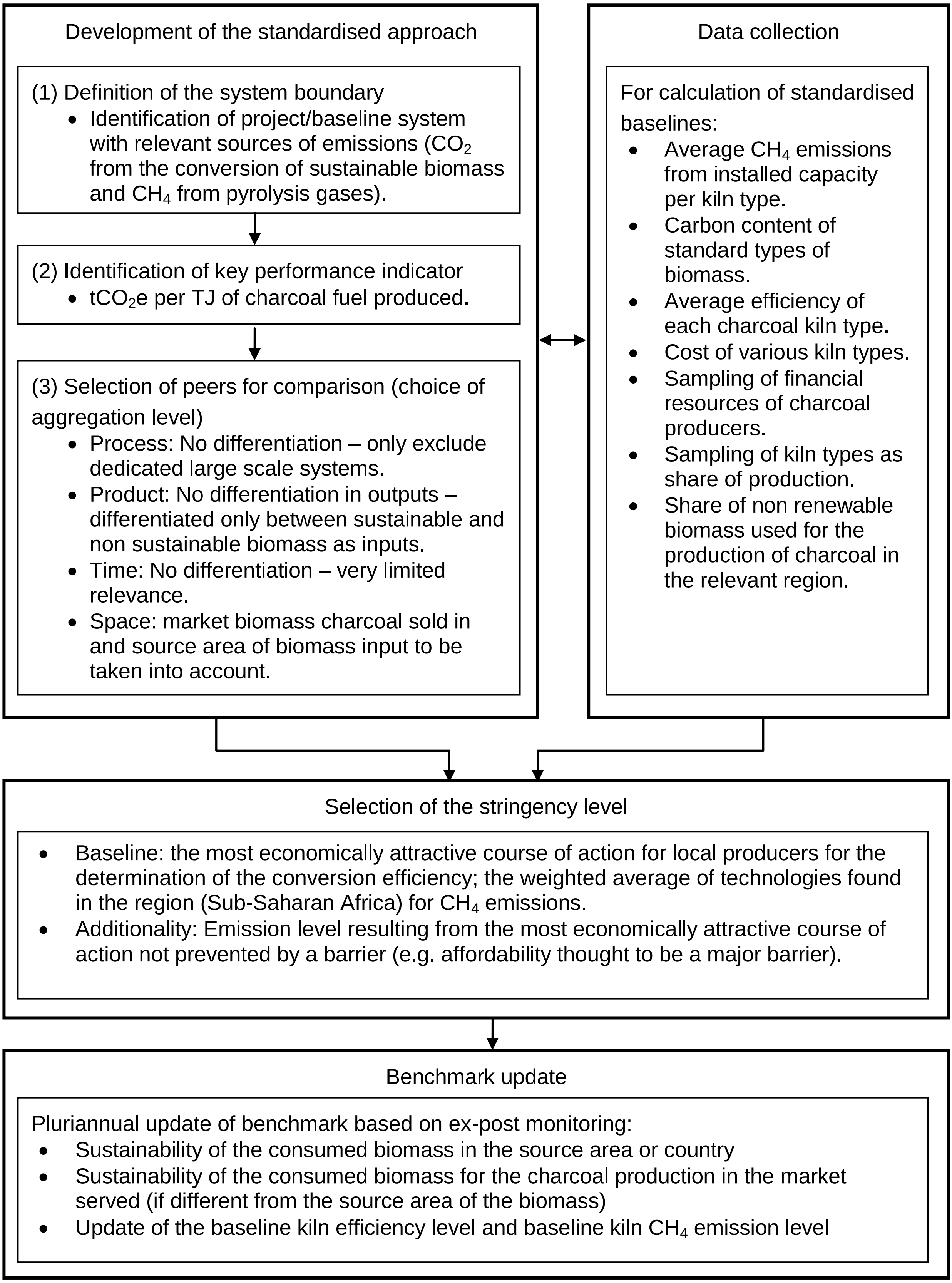

Figure 2: Flow chart of development of standard approaches to charcoal production projects

References

Amous, S. (1999): The role of wood energy in Africa. Food and Agriculture Organisation of the United Nations. Reference X2740/E. Available at: http://www.fao.org/docrep/x2740E/x2740e60.pdf.

CN (2009): Greenhouse Gas Calculator Emission Factors. Available at: http://www.cn.ca/en/greenhouse-gas-calculator-emission-factors.htm.

De Gouvello, C.; Dayo, F.B. ; Thioye, M. (2008): Low-carbon Energy Projects for Development in Sub-Saharan Africa: Unveiling the Potential, Addressing the Barriers. World Bank. Washington D.C.. Available at: http://www.riaed.net/IMG/pdf/Main_Report_-_Low_Carbon_Energy_projects_for_Development_of_Sub_Saharan_Africa_8-18-08.pdf.

[FAO] Food and Agriculture Organisation (1987): Simple technologies for charcoal making. FAO Forestry Paper – 41. Reference X5328/E. Available at: http://www.fao.org/docrep/X5328E/x5328e05.htm.

Girard, P., (2002): Charcoal and use in Africa: what future, Unasylva N°211, FAO Forestry department, CIRAD-Forêt, Montpellier, France.

Greenresources (2010): A forestry CDM/VCS case study from Tanzania. Available at: http://www.natureandpoverty.net/uploads/media/carbon_forestry_in_tanzania.pdf

Nabuurs, G.J.; Ravindranath, N.H.; Paustian, K.; Freibauer, A.; Hohenstein, W.; Makundi, W. (2003): Good practice guidance for land use, land-use change and forestry, Chapter 3: LUCF sector good practice guidance. IGES, Hayama.

Kammen, D.; Lew, D. (2005): Review of technologies for the production and use of charcoal. Energy and resources group & Goldman School of Public Policy, University of California Berkeley; National Renewable Energy Laboratory. Available at: http://rael.berkeley.edu/sites/default/files/old-site-files/2005/Kammen-Lew-Charcoal-2005.pdf.

Kituyi, E. (2004): Toward sustainable production and use of charcoal in Kenya. African Center for Technology Studies. Nairobi. Kenya. Available at: http://www.populationenvironmentresearch.org/papers/Kituyi_Paper.pdf.

Mongabay (2005): Statistics: Tanzania. Available at: http://rainforests.mongabay.com/deforestation/2000/Tanzania.htm.

Pennise, D.; Smith, K.; Kithinji, J.; Rezende, M.E.; Raad, T.J.; Zhang, J.; Fan, C. (2001): Emissions of greenhouse gases and airborne pollutants from charcoal making in Kenya and Brazil. Journal of Geophysical Research, Vol106, No D20.

October 27, 2001. Available at: http://ehs.sph.berkeley.edu/krsmith/publications/JGRPennise.pdf.

Point Carbon (2010): Carbon Project Manager, Databases. Available at: http://www.pointcarbon.com/trading/cpm.

Pronatura international (2009): Innovations toward sustainable development: Green charcoal, Paris, France. Available at http://www.pronatura.org/projects/green_charcoal.pdf.

Reumerman, B.; Frederiks, B. (2002): Charcoal production with reduced emissions. 12th European Conference on Biomass for Energy, Industry and Climate Protection, Amsterdam, 2002. Available at: http://www.cleanfuels.nl/Projects%20&%20publications/Charcoal%20Production%20with%20Reduced%20Emissions%20(paper).pdf.

Sampsons, N. (2002): Monitoring and measuring wood carbon. Available at: http://www.sampsongroup.com/Papers/Monitoring%20and%20Measuring%20Wood%20Carbon.pdf.

Seidel, A., (2008): Charcoal in Africa: Importance, Problems and Possible Solution Strategies. GTZ, Eschborn, Germany.

Triffelner, K. (2009): CDM Lusaka sustainable energy project and CDM cook stove project Kupang 1, Cologne, Germany Available at: http://www.jiko-bmu.de/files/inc/application/pdf/carbonexpo08_triffelner.pdf.