Gold Standard

Quantification of climate related emission reductions of Black Carbon and Co-emitted Species due to the replacement of less efficient cookstoves with improved efficiency cookstoves

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Table of Contents

Glossary 3

Section I: Source and Applicability 4

Section II: Baseline Methodology 4

1. Project Boundary 4

2. Emissions sources included in the project boundary 4

3. Baseline Scenario 5

4. Project Scenario 5

5. Baseline Studies 5

6. Project Studies 6

7. Calculation of Emission Reductions for BC and Co-emitted Species 6

8. Data and Parameters Not Monitored over the Crediting Period 7

Section III: Monitoring Methodology 8

1. Monitoring Procedure 8

2. Data and Parameters monitored over the crediting period 8

3. Determining Emission Factors for BC and OC 10

# Glossary

|  |  |
| --- | --- |
| SLCFs/ SLCPs | Short-lived climate forcers (SLCFs)/Short-lived climate pollutants (SLCPs) include compounds such as black carbon (BC), methane (CH4), tropospheric ozone (O3), and many hydrofluorocarbons (HFCs). These compounds have short lifetimes in the atmosphere compared to long-lived GHGs (LL-GHGs). Although their concentrations/loadings can be elevated by human-related activities and emissions, these compounds do not accumulate in the atmosphere over multi-decadal to centennial time scales and longer, and so their effects on climate are shorter lived, predominantly in days to decades following their emissions.  Cookstoves fueled by solid fuels are one of the key contributors to SLCPs such as BC, CH4 and ozone (O3) precursors like carbon monoxide (CO) and volatile organic compounds (VOCs). These are compounds that exert positive radiative forcing on the lower atmosphere and surface. |
| Other Co-emitted Species | The incomplete combustion of solid fuels also releases other pollutants such as organic carbon (OC), nitrogen oxides (NOx) and sulfate – creating sulfur dioxide (SO2) primarily from combustion of coal. The OC and sulfate species exert cooling while NOx leads to a net cooling effect on the lower atmosphere and climate. Note that in this methodology only BC and co-emitted species - which includes OC, CO, VOCs, NOx and sulfur species - are accounted for and quantified. |
| Black carbon (BC) | Black carbon is a solid form of mostly pure carbon that absorbs solar radiation (light) at all wavelengths. BC is one of the most effective aerosols, by mass, at absorbing solar energy. It is sometimes referred to as soot. |
| Organic Carbon (OC) | Organic carbon generally refers to the mix of compounds containing carbon bound with another element such as hydrogen or oxygen. OC is a product of incomplete combustion, or formed through the oxidation of VOCs in the atmosphere. Primarily OC contributes to global cooling because it is composed of aerosol particles that reflect sunlight back into space. |
| Brown Carbon | Brown carbon (BrC) refers to a class of OC compounds that absorb ultraviolet (UV) and visible solar radiation. Like BC, BrC leads to global warming. Note that BrC is not accounted for in this methodology. |
| Volatile Organic Compounds (VOCs) and Non-methane volatile organic compounds (NMVOCs) | Volatile organic compounds (VOCs) - which include non-methane hydrocarbons (NMHC) and oxygenated NMHC (e.g., alcohols, aldehydes and organic acids) - have short atmospheric lifetimes (fractions of a day to months) and limited direct impact on radiative forcing. The Non-methane volatile organic compounds (NMVOCs) describe this group excluding the particular case of methane. VOCs influence climate through their production of organic aerosols and their involvement in photochemistry, i.e. production of O3 in the presence of NOx and light. |

# Section I: Source and Applicability

This methodology is applicable to project activities that introduce efficient cookstove technologies and/or practices or switch from non-renewable to renewable biomass for meeting thermal energy requirements for cooking regimes. This document describes the quantification approach to be used in the calculation of emissions reductions from black carbon (BC) and other co-emitted species (including organic carbon (OC), carbon monoxide (CO), nitrous oxide (NOX), non-methane volatile organic carbons (NMVOCs) and sulfates). The methodology is applicable for project activities that will result in emissions reductions of BC and co-emitted species, primarily from lower levels of fuel consumption and/or changes in emission factors (g/kg\_fuel) that can be achieved through use of a more efficient project technology as compared to baseline technology. The methodology described is to be used in conjunction with the Gold Standard methodology, [**Technologies and Practices to Displace Decentralized Thermal Energy Consumption (TPDDTEC**)](http://www.goldstandard.org/wp-content/uploads/2011/10/GS_110411_TPDDTEC_Methodology.pdf). Therefore the quantification approach and monitoring requirements for BC and co–emitted species are aligned, wherever possible, with the approach used in the TPDDTEC methodology.

Project developers seeking to quantify the emissions reductions of BC and co-emitted species are required to use this methodology in conjunction with TPDDTEC methodology. The project activities using this methodology must conform to demonstrate the project eligibility criteria as defined in the TPDDTEC methodology, which outlines the minimum criteria for baseline and project technology as summarised below:

* Minimum 20% thermal efficiency
* Useful thermal output capacity of project technology (i.e. maximum 150 kW per project technology)
* Defined project boundary
* Incentive mechanism(s) to discourage the parallel use of baseline technology
* Clear communications about ownership rights of carbon credits generated from project technology
* Evaluation criteria to avoid double counting of same project technology in other CDM/voluntary activities
* Specific requirements for fuel switching activities

Please refer to TPDDTEC methodology for further details of these applicability conditions.

# Section II: Baseline Methodology

## Project Boundary

The project developer must provide clear definitions of the project boundary, target area, and the fuel production and collection area[[1]](#footnote-1).

## Emissions sources included in the project boundary

Emissions of BC and co-emitted species can occur during fuel production, transport and consumption. In this methodology only the emissions of BC and co-emitted species from fuel consumption are accounted for. Upstream emissions, which include emissions from fuel processing and transportation, may become relevant where there is a change in fuel type from the baseline to project scenario. However, these emissions can be ignored in a fuel switch scenario if they are demonstrated and justified to be the same or less in a project scenario (compared to the baseline scenario).

Baseline emissions of any gases/pollutants outlined below could be omitted for purposes of simplification if they are:

* Justified to cause warming; OR
* Arguably negligible; OR
* Not applicable to the identified baseline scenario.

All project emissions from the gases/pollutants outlined below must be accounted for, unless:

* Arguably negligible; OR
* Not applicable to identified project scenario; OR
* They are also omitted in the calculation of baseline emissions; OR
* Justified to cause cooling.

Emissions must be well documented and based on publicly available and verifiable data:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Source | Gas/Pollutant\* | Included? | Justification / Explanation |
| Baseline | Thermal energy | BC | Yes | Important source of emissions |
| OC | Yes | Important source of emissions |
| CO | Yes | Maybe an important source of emissions |
| NOX | Yes | Maybe an important source of emissions |
| NMVOCs | Yes | Maybe an important source of emissions |
| Sulfates | Yes | Can be significant for some type of fuels |
| Project | Thermal energy | BC | Yes | Important source of emissions |
| OC | Yes | Important source of emissions |
| CO | Yes | Maybe an important source of emissions |
| NOX | Yes | Maybe an important source of emissions |
| NMVOCs | Yes | Maybe an important source of emissions |
| Sulfates | Yes | Can be significant for some types of fuels |

\* Methane is also a short-lived climate pollutant (SLCP); however, methane is already considered under the Kyoto Gases category, where it contributes to the estimation of tCO2eq and is eligible forGHGs offsetting purpose. For the purposes of this quantification methodology methane is therefore not included.

## Baseline Scenario

A baseline scenario is defined by the typical baseline fuel consumption pattern and technology use in the population that is targeted to adopt the new project technology. Hence, this “target population” is used to calculate the representative baselines for the project activity.

## Project Scenario

A project scenario is defined by the fuel consumption and technology usage of end-users within a target population that have adopted and are using the new project technology. Climate-related emission reductions are accounted for by comparing fuel consumption in a project scenario to the applicable baseline scenario. For project activities that use different technologies or target populations that consume significantly different fuels, project developers must have clear and distinct baseline and project scenarios.

## Baseline Studies

As outlined above, a baseline scenario is defined by the typical fuel consumption patterns and technology use among the target population prior to adopting the project technology. However, a project activity may have more than one applicable baseline scenario for end users with different fuel consumption characteristics.

The project developer must conduct the following baseline studies for each baseline scenario:

1. Baseline survey of target population characteristics. This survey needs to provide critical information on the target population, baseline technology use, fuel consumption, leakage and sustainable development indicators.
2. Baseline Performance Field Test (BFT) of fuel consumption (e.g. Kitchen Performance Test (KPT) in the case of cookstoves)

## Project Studies

A project scenario is defined by the adoption of project technologies by end users within a target population within the project area. The project developer must conduct a project survey of the target populations characteristics and project performance field test (PFT) of fuel consumption for each project scenario. This must be done in accordance with the schedule set out in Annex 5 of TPDDTEC methodology. These project studies have the same requirements as the baseline studies, but the project survey and PFT are conducted with end users representative of the project scenario target population and currently using the project technology.

## Calculation of Emission Reductions for BC and Co-emitted Species

The emission reductions of BC and co-emitted species are quantified by comparing the fuel quantity and emissions factor for a given project scenario to those for the applicable baseline scenario. The overall reductions achieved by the project activity in year y are calculated as follows:

**(1)**

where,

ERBR&CSs,y Emissions reduction of BC and co-emitted species (tonBCeq)

∑b,p Sum over all relevant (baseline b/project p) couples

Np,y Cumulative number of project technology-days included in the project database for project scenario p against baseline scenario b in year y

Up,y Cumulative usage rate for technologies in project scenario p in year y, based on cumulative adoption rate and drop off rate (fraction)

ERBCeq,y, BCand co-emitted speciesemission reduction for an individual technology of project p against an individual technology of baseline b in year y (tonBCeq)

The other species, primarily OC, CO, NOX , NMVOCs and sulfates, are accounted for under categories for co-emitted species. The following equation is applied to quantify the emissions reductions of BC and co-emitted species per cookstove unit.

**(2)**

where,

Pb,y Quantity of fuel consumed in baseline scenario b during year y, in kg per unit per day

Pp,y Quantity of fuel consumed in project scenario p during year y, in kg per unit per day

feq,x BC equivalent conversion factor for species x

EFb\_x Emission factor for species x for baseline technology b in year y, in g/kg fuel consumed

EFp\_x Emission factor for species x for project technology p in year y, in g/kg fuel consumed

AFb,x Adjustment factor to account for any bias in laboratory vs. field testing to determine species x emission factor for baseline technology. If determined by carrying out laboratory testing, apply ….. otherwise apply 1.0 if field tests are done

AFp,x Adjustment factor to account for any bias in laboratory vs. field testing to determine species x emission factor for project technology. If determined by carrying out laboratory testing, apply ……; otherwise apply 1.0 if field tests are done

[The Adjustment Factor (AFb,x / AFp,x) to account for any bias in laboratory vs field emission factor and fuel variability (moisture content/mix) remains under development/review by Expert Panel and Technical Advisory Committee].

The methodology allows BC and co-emitted species emission factors to be determined through laboratory or field-testing. The laboratory based emission factors may vary significantly as compared to those determined through field measurements. Therefore the lab based emission factors should be adjusted for any bias in laboratory vs. field-testing by applying adjustment factors.

**BC equivalent conversion factor:**

The BC equivalent conversion factor for species x is a ratio of the GWP of co-emitted species to the GWP of BC for the 20-year time horizon as calculated by the IPCC on a global basis. The global IPCC values are provided in the next section. The project developer can apply the regional GWP values or sector specific GWP values for BC and co-emitted species. The regional (country or group of countries) GWP values must be derived from published literature or other evaluated information. The regional values will be subject to further review and approval from Gold Standard. The approved regional values can be applied for subsequent projects developed in the same region and for the same sector.

## Data and Parameters Not Monitored over the Crediting Period

The parameters that are fixed ex-ante (not required to be monitored over the crediting period) are listed in the table below.

|  |  |
| --- | --- |
| **Data / Parameter:** | feq,x |
| Data unit: | Fraction |
| Description: | Ratio of GWP- 20 of co-emitted species to the GWP-20 of BC   |  |  |  | | --- | --- | --- | | Species | GWP\_20 (IPCC, 2013)[[2]](#footnote-2) | feq,x (i.e., GWPspecies,x/GWPBC) | | BC | 2421 | 1.000 | | OC | -244 | -0.100 | | CO | 5.9 | 0.002 | | NOx | 16.7 | 0.007 | | VOCs | 14 | 0.006 | | SO4-2 | -141 | -0.058 |   “-“ A negative sign indicates that emission of the species leads to cooling of the surface- troposphere system. |
| Source of data: | IPCC global average defaults or regional values based on credible published literature |
| Any comment: |  |

|  |  |
| --- | --- |
| **Data / Parameter:** | **AFb,BC** |
| Data unit: | - |
| Description: | Adjustment factor to account for any bias in laboratory vs. field -testing for BC emission factor for baseline technology.  - If determined by carrying out laboratory testing, apply ….. otherwise apply 1.0 if field tests are done. |
| Source of data: |  |
| Any comment: |  |

|  |  |
| --- | --- |
| **Data / Parameter:** | **AFp,BC** |
| Data unit: | - |
| Description: | Adjustment factor to account for any bias in laboratory and field testing to determine the BC emission factor for project technology.  - If determined by carrying out laboratory testing, apply ….; otherwise apply 1.0 if field tests are done. |
| Source of data: |  |
| Any comment: |  |

# Section III: Monitoring Methodology

## Monitoring Procedure

A total sales record and project database must be continuously maintained. For each project scenario a monitoring survey and usage survey must be conducted annually to update monitoring parameters over the crediting period of the project. For each baseline and project scenario the BFT and PFT must be updated every two years, respectively, except in cases of a fixed baseline where there is no need for a BFT. Further guidelines for monitoring, performance tests and other studies are provided in the TPDDTEC methodology.

If fuelwood is identified as the baseline fuel, the project developer may choose to monitor PM2.5 as the proxy monitoring parameter[[3]](#footnote-3) for OC. In such cases, the OC emissions shall be determined using the following equation.

**(3)**

where,

EFOC Emission factor for OC for project technology p in year y in g/kg fuel consumed

EFPM2.5 Emission factor for PM2.5 for project technology p in year y in g/kg fuel consumed

EFBC Emission factor for BC for project technology p in year y in g/kg fuel consumed

## Data and Parameters monitored over the crediting period

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Details** | **Unit** | **Reference/Source** |
| **As per TPDDTEC methodology** | | | |
| Pb,y (only applicable if baseline is not fixed) | Quantity of fuel that is consumed in baseline scenario b during year y | kg/unit-day, kg/person-meal, etc. | Baseline field tests (FT), baseline FT updates, and any applicable adjustment factors |
| Pp,y | Quantity of fuel that is consumed in project scenario p during year y | kg/unit-day, kg/person-meal, etc. | Project FT, project FT updates, and any applicable adjustment factors |
| Up,y | Usage rate in project scenario p during year y | % | Monitoring surveys |
| Np,y | Project technologies credited (units) | Technologies in the project database for project scenario p through year y | Total sales record |

|  |  |
| --- | --- |
| Data / Parameter: | EFb,BC |
| Data unit: | g/kg\_fuel |
| Description: | BC emission factor arising from the fuel consumption in the baseline scenario |
| Source of data: | Laboratory or field test |
| Monitoring frequency: | Ex-ante fixed for a given crediting period |
| QA/QC procedures: | Transparent data analysis and reporting |
| Any comment: | A representative emission factor for each baseline technology type that is being compared for project crediting |

|  |  |
| --- | --- |
| Data / Parameter: | EFp,BC |
| Data unit: | g/kg\_fuel |
| Description: | BC emission factor arising from the fuel consumption in the project scenario |
| Source of data: | 1st test: Laboratory test to measure emission factor (g/kg of fuel) with field measurements of BC concentration (g/m3) OR total field test to measure emission factor (g/kg of fuel).  2nd test and subsequent field tests: Field measurements of BC concentration (g/m3) OR field tests to measure emission factor (g/kg of fuel) |
| Monitoring frequency: | Updated every two years, or more frequently |
| QA/QC procedures: | Transparent data analysis and reporting |
| Any comment: | A representative emission factor for each project technology type that is being compared for project crediting |

|  |  |
| --- | --- |
| Data / Parameter: | EFb,OC |
| Data unit: | g/kg\_fuel |
| Description: | OC emission factor arising from the fuel consumption in the baseline scenario |
| Source of data: | Laboratory or field test |
| Monitoring frequency: | Ex-ante fixed for a given crediting period |
| QA/QC procedures: | Transparent data analysis and reporting |
| Any comment: | OC emission factor for baseline technology can be derived following the options below.   1. Direct measurement: The OC emission factor can be determined by testing a representative sample of the baseline technology for OC in the laboratory or field following the established test methods. 2. Indirect measurement (for fuelwood only): The OC emission factor can established by testing a representative sample of project technology for PM2.5 (g/kg\_fuel) in laboratory or in field following the established test methods. The OC emission factor can be derived following the eq 3 mentioned above in section 3.1. |

|  |  |
| --- | --- |
| Data / Parameter: | EFp,OC |
| Data unit: | g/kg\_fuel |
| Description: | OC emission factor arising from the fuel consumption in project scenario |
| Source of data: | Direct or indirect measurement for OC emission factor  First laboratory test to measure emission factor (g/kg of fuel) with field measurements of concentration (g/m3) OR field tests to measure emission factor (g/kg of fuel).  Second test and subsequent tests: Field measurements of concentration (g/m3) OR field tests to measure emission factor (g/kg of fuel) |
| Monitoring frequency: | Updated every two years, or more frequently |
| QA/QC procedures: | Transparent data analysis and reporting |
| Any comment: | OC emission factor for project technology can be derived following the options below.   1. Direct measurement: The OC emission factor can be determined by testing a representative sample of project technology for OC in the laboratory or field following the established test methods. 2. Indirect measurement (for fuelwood only): The OC emission factor can be determined by testing a representative sample of project technology for PM2.5 (g/kg\_fuel) in the laboratory or field following the established test methods. The OC emission factor can be derived following the eq 3 mentioned above in section 3.1 |

|  |  |
| --- | --- |
| Data / Parameter: | EFb,CO,NOx, NMVOCs, SO4-2 |
| Data unit: | g/kg\_fuel |
| Description: | Co-emitted species (CO, NOx, NMVOCs, SO4-2) emission factor arising from the fuel consumption in baseline scenario |
| Source of data: | Laboratory test or field test |
| Monitoring frequency: | Ex-ante fixed for a given crediting period |
| QA/QC procedures: | Transparent data analysis and reporting |
| Any comment: | A representative emission factor for each baseline technology type that is being compared for project crediting |

|  |  |
| --- | --- |
| Data / Parameter: | EFp, CO,NOx, NMVOCs, SO4-2 |
| Data unit: | g/kg\_fuel |
| Description: | Co-emitted species (CO, NOx, NMVOCs, SO4-2) emission factor arising from the fuel consumption in project scenario |
| Source of data: | 1st test: Laboratory test to measure emission factor (g/kg of fuel) with field measurements of concentration (g/m3) OR field tests to measure emission factor (g/kg of fuel).  2nd test and subsequent tests: Field measurements of concentration (g/m3) OR field tests to measure emission factor (g/kg of fuel) |
| Monitoring frequency: | Updated every two years, or more frequently |
| QA/QC procedures: | Transparent data analysis and reporting |
| Any comment: | A representative emission factor for each project technology type that is being compared for project crediting |

## Determining Emission Factors for BC and OC

The BC and co-emitted species emission factors for baseline and project technology are to be determined by carrying out a field test or a combination of laboratory and field based measurements as depicted in the figure on the next page. The emissions factor for co-emitted species can be estimated using the approach defined for measuring BC. To estimate the emission factor for the year y, multiply the ratio of concentration of species “x” (g/m3) for year y and first field test, by the emissions factor for species “x” (g/kg\_fuel) as determined in the first field test. It should be noted that the approach selected at the time of the first field test must then be used throughout the crediting period.

As depicted in the diagram below, monitoring requires either laboratory or field measurements of the emission factors (g/kg\_fuel) and field-based measurements of concentrations (g/m3) for BC, PM2.5  and other species. If a lab-based measurement is used, then the emission factor shall be derived based on at-least five tests each for individual baseline and project stove technologies. If the results from the five tests do not meet the 90/30 precision level, the sample size must be increased. The project developer should follow the sample size selection guidelines for required precision level as provided in Annex 5 of the TPDDTEC methodology.

To carry out the field tests for BC, PM2.5 and other species concentrations/emission factors, the recommended minimum sample size is 30. Preferably, the concentration test needs to be carried out in parallel to Kitchen Performance Tests (KPTs) in a representative manner. The project developer needs to demonstrate that the 90/30 precision level is met so the mean value can be applied; otherwise errors should be applied conservatively. For further guidelines, refer to Annex-5 of the TPDDTEC methodology.

Note that the project technology must not lead to higher emissions of PM2.5 and BC as compared to the baseline situation. It must be demonstrated that D(PM) < D(BC) <0, where D(PM) and D(BC) denote changes in PM and BC mass, respectively. If a project activity fails to meet this condition, the project activity would not be eligible for claiming BC and co-emitted species emission reduction benefits.



Generic guidelines are provided in Annex 1 and need to be followed for the field/lab measurements.

Annex – 1: Guidelines for baseline and field measurement [Under Review / To follow]

1. The project boundary is to be the physical, geographical site of the baseline, and the proposed cookstoves project and fuel collection area. The target area can be a single country or across multiple adjacent countries in a single sub-region where usage of the considered baseline cookstove is found to be prevalent and uniform across the political boundary. The target area is defined as the outer limit to the project boundary in which the project has a target population. [↑](#footnote-ref-1)
2. IPCC, 2013, Table 8.SM.16, Metric to support Figures, Chapter 8 Anthropogenic and Natural Radiative Forcing, *Climate Change 2013: The Physical Science Basis* [↑](#footnote-ref-2)
3. The PM emission factor agrees well with the sum of organic matter (OM) and Black Carbon (BC) emission factors, where organic matter represents organic carbon and associated elements. For fuelwood typical OM to OC ratio varies between 1.5 and 2.1. An average value i.e., 1.8 of this range is applied here. For details please refer to

   Roden CA, Bond TC, Conway S, Benjamin A, Pinel O (2006) Emission factors and real-time optical properties of particles emitted from traditional wood burning cookstoves. Environmental Science & Technology 40: 6750-675

   MacCarty N, Ogle D, Still D, Bond T, Roden C (2008) A laboratory comparison of the global warming impact of five major types of biomass cooking stoves. Energy for Sustainable Development 12: 56-65

   Johnson M, Bond TC, Lam N, Weyant C, Chen W, Ellis J, Modi V, Joshi Sandeep, Yagnaraman M, Pennise D (2011); In-Home Assessment of Greenhouse Gas and Aerosol Emissions from Biomass Cookstoves in Developing Countries. USAID, 2011 [↑](#footnote-ref-3)