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Application of the Oeko-Institut/WWF-US/EDF methodology for assessing the quality of carbon credits

This document presents results from the application of version 3.0 of a methodology, developed by Oeko-Institut, World Wildlife Fund (WWF-US) and Environmental Defense Fund (EDF), for assessing the quality of carbon credits. The methodology is applied by Oeko-Institut with support by Carbon Limits, Greenhouse Gas Management Institute (GHGMI), INFRAS, Stockholm Environment Institute, and individual carbon market experts. This document evaluates one specific criterion or sub-criterion with respect to a specific carbon crediting program, project type, quantification methodology and/or host country, as specified in the below table. Please note that the CCQI website Site terms and Privacy Policy apply with respect to any use of the information provided in this document. Further information on the project and the methodology can be found here: www.carboncreditquality.org

Sub-criterion:	1.3.2 Robustness of the quantification methodologies applied to determine emission reductions or removals
Quantification methodology:	Gold Standard: Technologies and Practices to Displace Decentralized Thermal Energy Consumption (GS TPDDTEC) Version 3.1 (August 2017)[1]
Assessment based on carbon crediting program documents valid as of:	30 June 2021
Date of final assessment:	20 May 2022
Score:	1

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[1] Also noting rule clarification (July 2020) and update (October 2020).

Assessment

Relevant scoring methodology provisions

The methodology assesses the robustness of the quantification methodologies applied by the carbon crediting program to determine emission reductions or removals. The assessment of the quantification methodologies considers the degree of conservativeness in the light of the uncertainty of the emission reductions or removals. The assessment is based on the likelihood that the emission reductions or removals are under-estimated, estimated accurately, or over-estimated, as follows (see further details in the methodology):

Assessment outcome	**Score**
It is very likely (i.e., a probability of more than 90%) that the emission reductions or removals are underestimated, taking into account the uncertainty in quantifying the emission reductions or removals	5
It is likely (i.e., a probability of more than 66%) that the emission reductions or removals are underestimated, taking into account the uncertainty in quantifying the emission reductions or removals OR The emission reductions or removals are likely to be estimated accurately (i.e., there is about the same probability that they are underestimated or overestimated) and uncertainty in the estimates of the emission reductions or removals is low (i.e., up to ±10%)	4
The emission reductions or removals are likely to be estimated accurately (i.e., there is about the same probability that they are underestimated or overestimated) but there is medium to high uncertainty (i.e., ±10-50%) in the estimates of the emission reductions or removals OR It is likely (i.e., a probability of more than 66%) or very likely (i.e., a probability of more than 90%) that the emission reductions or removals are overestimated, taking into account the uncertainty in quantifying the emission reductions or removals, but the degree of overestimation is likely to be low (i.e., up to ±10%)	3
The emission reductions or removals are likely to be estimated accurately (i.e., there is about the same probability that they are underestimated or overestimated) but there is very high uncertainty (i.e., larger than ±50%) in the estimates of the emission reductions or removals OR It is likely (i.e., a probability of more than 66%) or very likely (i.e., a probability of more than 90%) that the emission reductions or removals are overestimated, taking into account the uncertainty in quantifying the emission reductions or removals, and the degree of overestimation is likely to be medium (±10-30%)	2
It is likely (i.e., a probability of more than 66%) or very likely (i.e., a probability of more than 90%) that the emission reductions or removals are overestimated, taking into account the uncertainty in quantifying the emission reductions or removals, and the degree of overestimation is likely to be large (i.e., larger than ±30%)	1

Information sources considered

Gold Standard methodologies:

1 Gold Standard Methodology “Technologies and Practices to Displace Decentralized Thermal Energy Consumption (TPDDTEC)”, Version 3.1; Published August 2017.

https://globalgoals.goldstandard.org/407-ee-ics-technologies-and-practices-to-displace-decentrilized-thermal-energy-tpddtec-consumption/

2 Gold Standard Methodology Rule Clarification “Clarification on application of requirement and guidelines for usage rate assessment (Annex 10: TPDDTEC & usage rate guidance).”, Published July 2020

3 “Methodology for Metered Energy Cooking Devices”, V1. Published 7 October 2021

Further literature:

4 Gold Standard (2016) “Guidebook to Gold Standard and CDM Methodologies for Improved Cookstove Projects”, Version 1.0

5 Cames et al. (2016), Öko-Institut “How additional is the Clean Development Mechanism?”

6 Shishlov, Bellassen (2015) “Review of the experience with monitoring uncertainty requirements in the Clean Development Mechanism.”, Climate Policy, published online: 04 June 2015

7 Bailis et al. (2015) “The carbon footprint of traditional wood fuels.”, Nature Climate Change, published online: 19 January 2015

8 Bailis et al. (2020), Climate Initiative for Development (Ci-Dev) “Fraction of the non-renewable biomass in emission crediting in clean and efficient cooking projects.”, Word Bank Group, published online: September 2020.

9 IPCC Guidelines (2006) “Emission factors for the combustion of fuels for energy generation in the residential sector.”

Original references for issues raised on f_{NRB} in the above documents:

10 Statistics Balances, International Energy Agency, 2012; http://www.iea.org/stats/index.asp

11 Rogner et al. (2007) “Mitigation of Climate Change” (eds Metz, B. et al.) 95–116 (IPCC, Cambridge Univ. Press, 2007).

12 de Miranda et al. (2013), de Miranda Carneiro, R.; Bailis, R. & de Oliveira Vilela, A. (2013). “Cogenerating electricity from charcoaling: A promising new advanced technology. Energy for Sustainable Development”, 17 (2), pp. 171-176.

Original references for issues raised on accuracy and uncertainty in Source (6), pages 135-136:

13 Abeliotis & Pakula (2013) “Reducing health impacts of biomass burning for cooking”.

14 Lee et al. (2013), Lee, C. M.; Chandler, C.; Lazarus, M. & Johnson Francis X. (2013). “Assessing the Climate Impacts of Cookstove Projects: Issues in Emissions Accounting.”, Available at https://www.sei-international.org/mediamanager/documents/Publications/Climate/sei-wp-2013-01-cookstoves-carbon-markets.pdf

15 Johnson et al. (2010), Johnson, M.; Edwards, R. & Masera, O. (2010). “Improved stove programs need robust methods to estimate carbon offsets.”

16 Berrueta et al (2008), Berrueta, V., Edwards, R. & Masera, O. (2008). “Energy performance of wood-burning cookstoves in Michoacan, Mexico.”, Renewable Energy, 33(5), pp. 859–870.

References for issues raised on behavioral patterns:

17 Hanna et al (2016), Hanna, R., E. Duflo, and M. Greenstone, 2016 “Up in Smoke: The Influence of Household Behavior on the Long-Run Impact of Improved Cooking Stoves.”, Am. Econ. J. Econ. Policy, 8, 80–114, https://doi.org/10.1257/pol.20140008.

18 Wathore et al. (2017), Wathore, R., K. Mortimer, and A. P. Grieshop, 2017 “In-Use Emissions and Estimated Impacts of Traditional, Natural- and Forced-Draft Cookstoves in Rural Malawi.”, Environ. Sci. Technol., 51, 1929–1938, https://doi.org/10.1021/acs.est.6b05557.

19 Patange et al. (2015), Patange, O. S., and Coauthors, 2015 “Reductions in Indoor Black Carbon Concentrations from Improved Biomass Stoves in Rural India.”, Environ. Sci. Technol., 49, 4749–4756, https://doi.org/10.1021/es506208x.

20 Aung et al. (2016), Aung, T. W., G. Jain, K. Sethuraman, J. Baumgartner, C. Reynolds, A. P. Grieshop, J. D. Marshall, and M. Brauer, 2016 “Health and Climate-Relevant Pollutant Concentrations from a Carbon-Finance Approved Cookstove Intervention in Rural India.”, Environ. Sci. Technol., 50, 7228–7238, https://doi.org/10.1021/acs.est.5b06208.

21 Schilmann et al. (2019) : Schilmann, A., and Coauthors, 2019 “A follow-up study after an improved cookstove intervention in 17 rural Mexico: Estimation of household energy use and chronic PM2.5 exposure.”, Environ. Int., 18 131, 105013, https://doi.org/10.1016/j.envint.2019.105013.

22 Shankar et al. (2014), Shankar, A., and Coauthors, 2014 “Maximizing the benefits of improved cookstoves: moving from acquisition to correct and consistent use.”, Glob. Heal. Sci. Pract., 2, 268–274, https://doi.org/10.9745/GHSP-D-14-00060.

Other methodologies:

23 CDM AMS-II.G, Version 12.0. Small-scale methodology for energy efficiency measures in thermal applications of non-renewable biomass

24 CDM TOOL30, Version 03.0. Methodological tool for the calculation of the fraction of non-renewable biomass.

References for issues raised on the other default factors:

25 Revised IPCC Guidelines for National Greenhouse Gas Inventories Reference Manual (1996): Energy Chapter, page I.46, https://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch1ref3.pdf .

26 CDM Information Note (CDM-SSCWG42-A05). Rationale for default factors used in AMS-I.E and AMS II.G Version 1.0. Available at https://cdm.unfccc.int/Panels/ssc_wg/meetings/ssc_2013.html#42

27 CDM Concept Note CDM-MP85-A07. Analysis and options regarding caps used in AMS-I.E, AMS-II.G and TOOL30 Version 01.0

Assessment outcome

The quantification method of “Technologies and Practices to Displace Decentralized Thermal Energy Consumption”, Version 3.1 (GS TPDDTEC V3.1), is assigned a score of 1. This assessment also applies to earlier versions of the methodology.

Justification of assessment

Project Type

This assessment refers to the following project type:

“Distribution of energy efficient fuel wood or charcoal cookstoves to households or institutions (e.g., schools), thereby replacing the use of less energy efficient fuel wood or charcoal cookstoves.”

This is within the scope of the quantification methodology, which is applicable to “reductions in thermal energy consumption patterns for the purpose of both heating and cooking based on energy efficiency improvement projects in both household and commercial settings” (Source 1).

The assessment in this document does not address the rest of the project types covered by the TPDDTEC methodology, which may include a variety of technologies, such as solar thermal energy, bio-digesters, water supply and treatment technologies displacing water boiling, building retrofit thermal insulation, and projects based on shifting habits which do not involve introducing improved devices (Source 1).

Projects involving wood cookstoves are likely to occur in mainly rural areas, in households that cannot afford to buy any other type of solid fuel (e.g., charcoal, which is easier to handle) and thus rely on the collection of wood from the surrounding areas. In some cases, however, rural households might also use charcoal, but this is less common.

The baseline scenario under this methodology, however, is characterized by the type of fuel and technology displaced and is determined based on the practices observed within the project boundaries, which may contain multiple scenarios with multiple displaced fuels and avoided greenhouse gases (GHGs), both CO_2 and non-CO_2.

In the case of urban households that use LPG, switching from this fuel to non-renewable biomass could increase emissions and this type of switch is unlikely to happen. The methodology considers this type of user as a source of leakage, which must be subtracted from the project benefits. This highlights the importance or rigorous assessment of methodology applicability.

Also, another important consideration is the local context in which the project is implemented – and particularly the level of exposure to indoor air pollutants and the resulting burden on public health. While this is very high in some geographic locations, the methodology does not differentiate among countries. The countries that experience the highest levels of exposure to household air pollutants, and that are thus in the greatest need for projects that will alleviate the current burden on public health, such as efficient cookstove projects that effectively reduce the volume of indoor emissions from cooking, are identified by Bailis et al. (Source 7) to be:

- Africa: Chad, DR Congo, Cote d´Ivoire, Guinea, Guinea-Bissau, Liberia, Mozambique, Sierra Leone, Tanzania, Zambia, Zimbabwe, Cameroon, Central African Republic, Malawi, Mali, Niger, Timor-Leste, Kenya, Uganda, Ethiopia, Lesotho, Somalia, Togo, Burkina Faso, Burundi, Gambia, Eritrea, Rwanda, Sudan, Madagascar, and Benin.

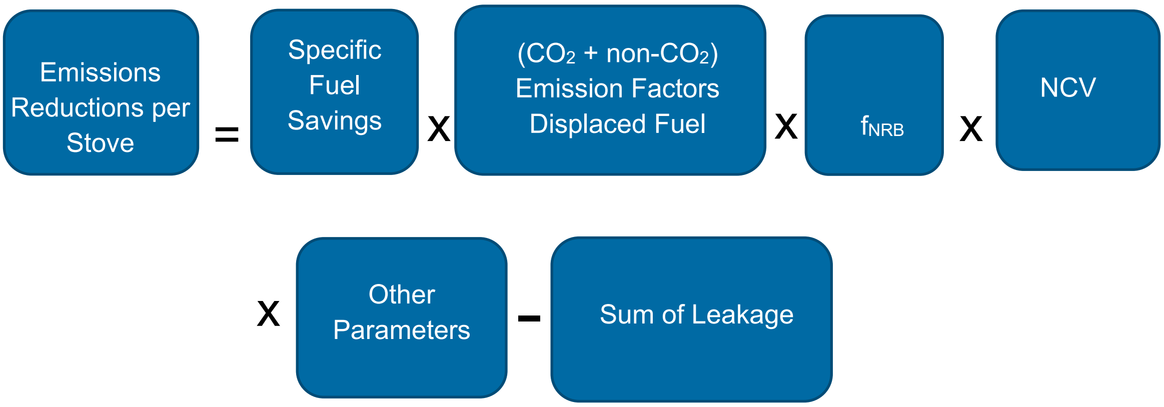
- Asia: Pakistan, Bangladesh, Bhutan, Nepal, Indonesia, Laos, Myanmar, and Cambodia.
- Americas: Haiti.

The health benefits from indoor emission reductions resulting from the adoption of efficient cookstoves are therefore more significant in countries with the highest global burden of disease from exposure to household air pollutants (HAP), although the emission reductions of the project are based on the same parameters in any location.

Focus of assessment

The focus of this assessment is the emission reduction determination in the equations of the TPDDTEC, and in particular, the specific elements that potentially introduce uncertainty. Figure 1 and Figure 2, below, show the main elements of the quantification of emission reductions when the baseline and project fuels and/or emission factors are the same and when these components differ, respectively. Some of these elements play a key role in the potential for the methodology to result in an under- or overestimation of emissions reductions.

Figure 1 **Emission reductions, as calculated in TPDDTEC for projects where the fuels and emission factors in the baseline and project are the same**

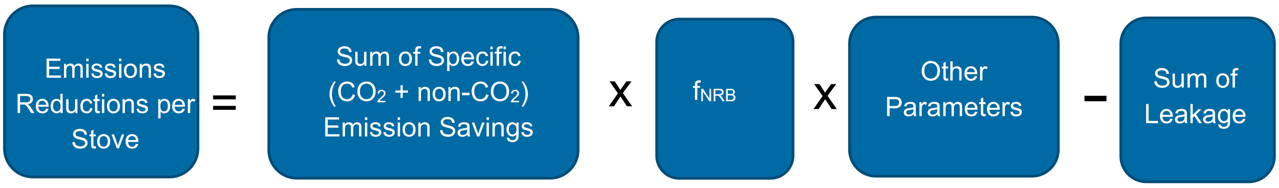


Where:

- **Specific fuel savings** are quantified by one of the two approaches described in allowed under the methodology (i.e., Water Boiling Test (WBT) and Kitchen Performance Test (KPT)) or a combination of these two approaches.
- **Emission factors (EF) for displaced fuels** (i.e., biomass or fossil fuels, depending on the actual baseline fuel mix) may be project-specific. Emission factors for both CO2 and non-CO2 emissions are accounted for.

- **The fraction of non-renewable biomass (f_{NRB})** may be calculated using area-specific data through qualitative or quantitative assessments or taken from a list of default values for 5 Latin American countries[2].
- **The net calorific value (NCV)** of the non-renewable wood substituted is taken from the IPCC default values for the combustion of wood in the residential sector (0.0156 TJ/t).
- **Other project parameters** included in Figure 1 are the cumulative number of project technology-days and the fraction for the cumulative usage rate for the technology, based on cumulative adoption rate and drop off rate revealed by usage surveys.
- **Sum of Leakage**, which quantifies an increase in fuel consumption by the non-project household/users attributable to project activity, further described on page 15.

Figure 2 Emission reductions, as calculated in TPDDTEC for projects where the baseline fuel and the project fuel are different, and/or the baseline and project emission factors are different



Where:

- **The specific CO2 and non-CO2 emission savings** are derived from the statistical analysis of the data collected from field tests.
- **The f_{NRB}, other parameters, and leakage** are the same as those described above for **Figure 1**.

Elements potentially overestimating emission reductions

OE1 Non-renewable biomass (NRB) assessment and fraction of non-renewable biomass (f_{NRB})

The fraction of non-renewable biomass (f_{NRB}) is the extent to which the CO_2 emissions of the woody biomass are not offset by re-growth in the fuel collection area, based on the NRB assessment contained in **Annex 1** of the methodology. Maximizing the value of the f_{NRB} maximizes carbon revenues, given the linear relation of the f_{NRB} and total emission reductions, as shown in Figure 1 and Figure 2.

This fraction has been estimated at different spatial levels. For example, at a global level, the f_{NRB} is estimated by the 4th assessment of the Intergovernmental Panel on Climate Change (IPCC) to be 10% (Sources 9 and 11), while Bailis et al. (Source 7) estimated country specific values between 27% and 34%, and Miranda et al. (Source 12) between 20% to 30%. By contrast, the f_{NRB} used by 70 carbon market projects, as surveyed by Bailis et al. (2020), ranged from 50% to nearly 100% (Source 8). This is because the calculation approaches that are allowed in the methodology can lead

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[2] These default values appear in a Gold Standard Technical Advisory Committee (TAC) decision 4 October 2016 posted here https://www.goldstandard.org/articles/tac-rule-updates

to much higher values than the more detailed spatial analysis approaches used in the literature to more accurately assess f_{NRB}. In fact, Bailis et al. (2020), in the Carbon Initiative for Development (Ci-Dev) review of the f_{NRB} in efficient cooking projects, also noted that calculated values are much higher than (the more detailed spatial modelling using) WISDOM-derived values, ranging from 82 percent to 97 percent in the case of cookstove projects registered under the Clean Development Mechanism´s (CDM) AMS II.G methodology (Source 10), which uses a quantitative assessment approach very similar to the quantitative assessment A1.1 approach used under the GS TPDDTEC.

Project developers are given the option to determine country-specific, or even locality-specific, f_{NRB} values based on qualitative and quantitative assessments, through one of three assessment options, which the methodology presents under two approaches, listed in Annex 1 on page 36 of the methodology.

The first approach includes the following two assessment options:

- **A quantitative NRB assessment described in section A1.1**, on pages 36 through 38 of the methodology, which includes Equation 8 on the estimation of the amount of non-renewable biomass (NRB) drawn from the collection area and Equation 9 on the estimation of the f_{NRB} as the result of dividing NRB between the annual consumption of wood (H), or
- **A qualitative NRB assessment described in section A1.2**, on page 38 of the methodology, which the methodology says would lead to an "acceptable conservative estimate of the f_{NRB}", based on insight gathered from sources such as expert consultations, interviews, field evidence, literature, and satellite imagery.

The second approach is to consider:

- **An assessment approach similar to the CDM AMS II.G,** based on DRB, in which project proponents can determine the share of renewable and non-renewable woody biomass using data from "reliable and credible sources", including surveys, reports, published literature, and government records to determine NRB and DRB, both of which are then used to estimate the f_{NRB} using Equation 10, by dividing the amount of NRB by the sum of the NRB and the DRB.

All three assessment options presented under the two approaches introduce a significant degree of uncertainty and are likely to lead to an overestimation of the f_{NRB}, as discussed below.

While it is possible that cookstove projects registered under carbon crediting programs could be implemented in geographical areas with higher f_{NRB} values, it appears unlikely that the true (unknown) values for f_{NRB} are significantly higher in these projects than the values from the literature. Projects registered under carbon crediting programs have been implemented in many different regions, including deforestation hotspots but also areas where the literature suggests that the values f_{NRB} are much lower than the values used by registered projects.

Overestimation Likelihood

Quantitative NRB assessment A1.1

The quantitative NRB assessment A1.1approach involves input parameters of high uncertainty that may be estimated using less reliable options and data sources than the more detailed spatial modelling approaches used in literature (9). One of these key parameters is the sum of the mean annual increment (MAI) of the wood species, or “re-growth” in area A (1), which is used to estimate the non-renewable biomass (NRB) in Equation 8. The concepts of annual increment and sustainable yield, which are the key concepts underlying f_{NRB}, are taken from silviculture, where forest stands are well-bounded, planted with a single species, and not subject to other high-impact or simultaneous uses (9). In contrast, the landscapes exploited for wood fuel are often forest mosaics with irregular stands of trees inter-mixed with crops and grazing lands, and they include many types of land cover other than forests, such as gardens, roadsides, live fences, agricultural lands, with undefined boundaries, which are also subject to multiple activities and periodic fires (9). Therefore, although the GS TPDDTEC considers the existence of multiple wood species in the collection area, there is still large uncertainty in this parameter, and project developers are faced with the challenging task of estimating MAI to represent the quantity of renewable biomass. This may have led to much higher values of f_{NRB} used in the GS projects, compared to values based on more detailed spatial modelling.

Given that the peer-reviewed literature uses much more accurate and reliable approaches to estimate values for f_{NRB}, it is highly likely that the values used by project developers significantly over-estimate the f_{NRB}. Since NRB is determined by the quantity of renewable biomass, represented by the sum of the MAI of the wood species in the collection area, subtracted from the total annual harvest of wood biomass (H) -which includes forest clearance, timber extraction, and consumption of wood fuels- and an underestimation of the total annual harvest would lead to an underestimation of the f_{NRB}, it is highly likely that the overestimation of the f_{NRB} lies in the underestimation of the MAI.

On the other hand, another element of uncertainty that impacts the estimation of the f_{NRB}, but in the opposite direction, leading to an underestimation of the f_{NRB}, is not accounting for illegal logging in the estimation of annual forest clearance, which is one of the elements of the total annual harvest (H). Because of the illegal nature of this element, forest clearance statistics are likely to be underestimated in official data sources. Illegal logging is not specifically addressed in the methodology. Therefore, whether it is considered in the estimation of H, as well as the magnitude of the impact of this element on H, is subject to the criteria of the project developer.

On the other hand, any changes in the use of land through-out the project lifetime, along with any variations derived from climate change, such as additional heat stress or freezing temperatures, water shortage, pests, and forest fires, will further impact the capacity of the land to re-generate wood supply, represented or characterized by the MAI value. TPDDTEC currently does not accounting for climate change or illegal logging, both of which lead to an overestimation of the sum of the MAI, underestimation of the non-renewable biomass resulting from Equation 8, and, in turn, to an underestimation of the f_{NRB}.

However, as previously discussed, the values for the f_{NRB} used in projects that have been applied by registered projects under the GS are highly likely to be significantly overestimated, not underestimated, which suggests that ignoring these other elements that underestimate the f_{NRB} is likely to have a smaller overall impact than that of the elements that are likely to lead to an overestimation of the f_{NRB}.

To summarize, given the high uncertainty involved with the calculation of MAI and non-renewable biomass, and given that the calculated f_{NRB} values for projects in practice are much higher than the country-specific f_{NRB} estimated by peer-reviewed studies to range between 20% to 34%, it is highly likely that project proponents overestimate the f_{NRB}, which leads to overestimation of the emission reductions.

Qualitative NRB assessment A1.2

As for the **qualitative assessment A1.2**, project developers may estimate the f_{NRB} using satellite imagery, field surveys, pertinent literature reviews, expert consultations, interviews, and field evidence to determine an “acceptable conservative estimate” and to show that “over recent years, collection distance is increasing and that the harvest of fuel wood is exceeding the sustainable supply” (Source 1). This assessment approach introduces even higher uncertainty in the estimation of the f_{NRB} and resulting emission reductions, as well as variation among projects.

Assessment based on AMS II.G A1.3

The second approach is to consider **an assessment for NRB** similar to the CDM AMS-II.G (described in section A1.3) based on DRB, in which project proponents can determine the share of renewable and non-renewable woody biomass using data from “reliable and credible sources”, including surveys, reports, published literature, and government records to determine NRB and DRB, both of which are then used to estimate the f_{NRB}.

Concerns on the use of this approach have been raised in the past, since it was shown to be leading to unrealistically high values for the f_{NRB}, as high as 90% (Source 10), and, consequently, of the total emission reductions. The CDM suspended the use of the DRB approach for the calculation of the f_{NRB} under the AMS II.G and substituted it in 2017 with the CDM Tool 30 (Source 25).

Alternatively, project developers may choose f_{NRB} from a list of country-specific **default values** for 5 Latin American countries. Gold Standard estimated these values using a DRB approach, with results from 48% to 82%. However, Bailis et al. (2020) show that the GS default values for Latin America are higher than the values derived for those countries with more accurate modelling tools, such as Wood Fuel Integrated Supply/Demand Overview Mapping (WISDOM) (Source 8). Project using the default values for these countries in Latin America may therefore have significantly overestimated the f_{NRB} and emission reductions.

Degree of Overestimation

As noted above, the f_{NRB} employed by 70 GS projects ranged from 50% to nearly 100% according to Bailis et al. (2020) (Source 8), while projects which applied the DRB approach used an f_{NRB} ranging from 82% to 97%. Meanwhile, GS approved default values for Peru, Bolivia, Colombia, Honduras, and Guatemala (GS 2016) range from 48% to 82% (Source 4). These values are unrealistic not only because they do not reflect the spatial context of biomass depletion but also because these very high rates (near 100%) would imply that all forests would be entirely lost in a relatively short period. This does not match the observations in these countries, which may have significant deforestation challenges but still have forest cover almost 20 years after the first carbon crediting project started. Compared to the range between 27% and 34% suggested by Bailis et al (Source 8) study in tropical countries, which were used to adjust default values to 30% under other standards (Source 25), this leads to an over-estimation that may range from **147%** to **360%** (i.e., 50%/34% to 97%/27%).

OE2. Wood to charcoal conversion factor

For projects using charcoal, the wood to charcoal production ratio may be estimated from project specific monitoring or alternatively by researching a conservative production ratio from IPCC, credible published literature, project-relevant measurement reports, or project-specific monitoring, and multiplying this value by the pertinent EF for wood. No default values are provided in the methodology itself, as in the CDM methodology AMS II.G. Analysis by the UNFCCC Secretariat of CDM improved cookstove projects (Source 27) found that the conversion factors used are typically 6 to 12, while revised 1996 IPCC Guidelines for National GHG Inventories state that the typical wood to charcoal conversion factors in many developing countries range from 2.5 to 3.5, and rarely beyond this (Source 25). A similar analysis is not available for GS projects.

The methodology does not specify under what criteria, threshold, or indicator would a local conversion study be considered “credible”. More research would be required, to verify the actual parameters used for registered projects. It is likely, however, the many GS projects are using higher conversion factors, since there is limited guidance on this and the practice among CDM projects has been to use the higher values. This would therefore lead to an overestimation of emission reductions.

Elements with uncertain impact

U1 Specific fuel savings

The **specific fuel savings** are quantified by one of the following two methodologies, both of which involve uncertainty, or a combination of these two approaches:

- The Kitchen Performance Test (KPT) described in Annex 4 of the methodology, which is a field-based method which represents cooking behavior, but yields high uncertainty in the measurements, since sources of error are difficult to control (Source 5).
- Water Boiling Test (WBT), which is a laboratory-based method, standardized and replicable, with the additional advantages of simplicity and reduced costs, but with a lower accuracy level due to under-representation of cooking habits (Source 11) as well as reliance on default values for baseline cookstove biomass consumption (Source 5).

As for the WBT, the accuracy of this method has been called into question by Abeliotis & Pakula (2013), who found that stove performance does not necessarily translate to cooking actual meals in households (Source 13), and by Berrueta et al. (2008), who evaluated the performance of a stove designed primarily for tortilla-making by using all three tests and found that the WBT “gave little indication of the overall performance of the stove in rural communities” (Source 16). Furthermore, Cames et al. (2016) indicate that evidence suggests the Water Boiling Test (WBT) is not an appropriate tool and should be not be used (Source 5). Whether the different approaches other than KPT consistently over- or under-estimate biomass savings and emission reductions is not clear.

U2. Baseline fuel consumption

When the baseline fuel is fuelwood, the baseline fuelwood consumption can be determined through one of the following options: using the default minimum service level figure of 0.5 tons per capita per year of fuelwood consumption, through a “singe sample test”, for which guidelines are provided in section 7 of the methodology, or by a project-specific baseline fuel test (BFT), with minimum sample sizes according to section 4.B of the methodology (Source 1). The default value of 0.5 tons/capita/year was derived in 2013 by the Small-Scale Working Group of the CDM, based on an analysis of projects, the literature, and the minimum energy demand for cooking (Source 26). Both data from projects and the literature confirmed that this value is a typical value to be expected for these types of projects. Since the higher the rate of wood consumption, the higher the resulting biomass saved, and the more carbon credits generated by the project, the use of lower values is more conservative than the use of higher values. An analysis of CDM projects shows that the large majority of projects used higher values than 0.5 tons per capita, but this analysis is not available for Gold Standard projects. More research would be needed to determine whether this factor leads to an overestimate of emission reductions.

U3. Behavioral patterns - Stove stacking

Efficient cookstove projects are meant to displace pre-existing cookstoves. However, the pre-existing stoves may also be kept and used for different purposes, a phenomenon called "stove stacking". In these cases, the efficient cookstoves have not fully replaced the previous consumption of biomass in a traditional stove. Thus, some of the fuel savings estimated, which assumed 100% of the cooking would take place with a single, new, device, provided by the project, will not take place in reality, leading to an overestimation of emission reductions. This behavioral pattern is addressed to some extent by the GS TPDDTEC as one of the potential sources of leakage on page 15 and also may do so through the guidance for project performance tests.[3] The degree to which the leakage provisions fully capture this effect is not clear, and so there is still the potential for overestimate of emission reductions, even if the likelihood is unknown.

U4 Cumulative adoption rate and drop off rate

Other project parameters are the **cumulative number of project technology-days**, and the **fraction for the cumulative usage rate** for the technology, based on **cumulative adoption rate and drop off rate** revealed by usage surveys. While these parameters could impact accuracy, the direction and magnitude of the uncertainty of these variables is not known. Some authors (Source 18 to 21) found that, in many cases, households use improved stoves irregularly, inappropriately, and fail to maintain them. They have also found that the usage of the cookstoves declines over time. Not considering these behaviour & maintenance patterns could overestimate the emission reductions of the project, since the actual GHGs displaced from the saved fuel would be less than the amount estimated. The TPDDTEC methodology accounts for these elements by incorporating insights from the usage survey. Determining whether this survey leads to over or underestimations would require a more detailed analysis of the external usage survey guidance referenced in Annex 10.[4]

U5 Efficiency losses from inappropriate maintenance, repair, and replacements

As mentioned above, some authors have found that households using improved cookstoves fail in providing adequate maintenance (Source 18 to 21). In addition, Schilmann et al. 2019 (Source 21); Shankar et al. 2014 (Source 22) have also found that cookstoves will lose efficiency over time resulting from lack of appropriate long-term maintenance. Lack of proper accounting for a drop in efficiency would lead to an overestimation of emission reductions. Whether or not this element is well addressed in the survey guidance provided for the estimation of the fraction for the cumulative

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[3] The guidance notes that "Baseline and project performance field tests would subsume this potential for leakage, but the later would not be addressed in case of a single sample performance test and efficiency ratio multiplier."

[4] Annex 10 notes that detailed usage monitoring requirement and guideline are available https://globalgoals.goldstandard.org/sdg_13/401-13-cookstove-usage-rate-guidelines

usage rate or captured by the Kitchen Performance Test procedure detailed in Annex 4 would require further research.

U6 Other elements introducing uncertainty

Other elements addressed by the GS TPDDTEC that may introduce uncertainty are:

- Single or multiple technologies and/or practices
- Baseline emission factors based on the typical fuel patterns among target population.
- Baseline efficiency calculations including those from the most efficient technologies
- Emission sources related to the transportation and distribution of fuel.
- Suppressed demand
- Overlapping project scenarios with different baselines for the same project boundaries.

Summary and conclusion

Table 1 summarizes the results of the assessment and, where possible, presents the potential impact on the quantification of emission reductions for each of the previously discussed elements.

Table 1 Relevant elements of assessment and qualitative ratings

Element	Fraction of projects affected by this element[5]	Average degree of under- or overestimation where element	Variability among projects where element materializes [6]
Elements potentially overestimating emission reductions			
OE1 Fraction of non-renewable biomass (f_{NRB})	High	High (on the order of 300%).	Low **
OE2 Charcoal conversion factor	High	Unknown	Unknown, but likely to be high
Elements with unknown impact			

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[5] This parameter refers to the likely fraction of individual projects (applying the same methodology) that are affected by this element, considering the potential portfolio of projects. “Low” indicates that the element is estimated to be relevant for less than one third of the projects, “Medium” for one to two thirds of the projects, “High” for more than two third of the projects, and “All” for all of the projects. “Unknown” indicates that no information on the likely fraction of projects affected is available.

[6] This refers to the variability with respect to the element among those projects for which the element materializes. “Low” means that the variability of the relevant element among the projects is at most ±10% based on a 95% confidence interval. For example, an emission factor may be estimated to vary between values from 18 and 22 among projects, with 20 being the mean value. “Medium” refers to a variability of at most ±30%, and “High” of more than ±30%.

U1 Specific fuel savings	Unknown	Unknown	Unknown
U2 Baseline fuel consumption	Unknown	Unknown	Unknown
U3 Stove stacking	Unknown	Unknown	Unknown
U4 Adoption and drop off rate	Unknown	Unknown	Unknown
U5 efficiency losses	Unknown	Unknown	Unknown

Overall, the very likely overestimation of f_{NRB} has the largest impact on emission reduction quantification for cookstove projects. The magnitude of over-estimation exceeds by far the known magnitude of underestimation (i.e., due to the choice of baseline emission factors based on fossil fuels rather than wood or charcoal). Other factors also contribute to uncertainty, either with an unknown direction or with a tendency to over-estimate emission reductions. In conclusion, it is very likely that the overall emission reductions are significantly overestimated, taking into account the uncertainty in quantifying the emissions reductions, and the degree of overestimation is very likely to be significantly greater than 30%.

The findings by Bailis et al. (2015) support this conclusion, indicating that project developers are very likely overstating the emission reduction potential of improved stoves (Source 7). So do the findings by Bailis et al. (2020), which indicate that the f_{NRB} values of the registered GS projects are systematically high when comparing them with the outputs from modelling tools, leading to systematic overestimating of emission reductions (Source 8).

Furthermore, Lee et al. (Source 14) also conclude that there is uncertainty in the approaches to estimating wood biomass saved and the fraction of non-renewable biomass, which are some of the parameters addressed in this assessment. A study by Johnson et al. (Source 15) assessed the relative contributions of these elements to the overall uncertainty in carbon offset estimation for an improved cookstove project in Mexico, and also found that they contributed significantly to uncertainty. The fraction of non-renewable biomass (f_{NRB}) contributed to 47% of the uncertainty, while fuel consumption contributed to 28% of the uncertainty (Source 10).

Therefore, according to the relevant scoring methodology provisions described in page 2 of this document, which assess the robustness of the quantification methodologies applied by the carbon crediting program to determine emission reductions or removals, the overall assigned score of the GS TPDDTEC is 1.