Introductory Framework for Measurement, Reporting, and Verification

Clean Cooking MRV in the Paris Context

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Introduction

Document Purpose

This document introduces measurement, reporting, and verification (MRV) approaches and recommendations as they apply to cooking energy interventions. The document builds on existing MRV experience and highlights how these approaches may evolve in the context of the Paris Agreement.

MRV is a key component of any cooking energy transition program designed to reduce the emission of harmful climate pollutants. An MRV framework can be applied to clean cooking programs designed to:

- Meet targets in a country's nationally determined contribution (NDC).
- Create tradable assets under the Article 6 framework or in the voluntary carbon market.
- Fulfill the requirements of donor programs or results-based financing (RBF) programs.

In the lead-up to the 2021 United Nations Climate Change Conference, commonly called COP26,* 67 nations included the cooking sector in their NDCs, either with distinct aims and targets or as part of broader renewable energy, energy efficiency, and/or forestry goals. This is not surprising, because clean cooking interventions have been shown to be among the most cost-effective emission reduction approaches,[1] while also offering benefits for health and livelihoods. Improved biomass cookstove programs have been a staple of voluntary carbon markets for more than a decade, because their contributions to sustainable development have made them an appealing investment for private-sector corporate responsibility initiatives. More recently, this included clean cooking RBF investments.

When assets are traded or activities are donor-financed, MRV is the engine that generates value. If emission

reductions are not properly estimated and documented, their value as a source of climate funding may not be fully realized.

The MRV frameworks for improved cookstove projects and other approaches to reduce harmful emissions from cooking energy differ from those of other sectors, due to the distributed nature of the interventions. The purpose of this guide is to offer an introductory overview of these MRV frameworks.

A companion document, entitled "Clean Cooking for Climate Action: Roadmap for National Clean Cooking Programs to Achieve Emission Reduction Targets," is also available.

Intended Audience

This guide is intended for any professional involved in the planning, execution, or funding of clean cooking energy programs and projects that aim to reduce climate-harming emissions, within the context of the Paris Agreement goals.

* COP26 was the 2021 annual United Nations climate change conference. COP stands for Conference of the Parties, and the summit was attended by all countries that signed the United Nations Framework Convention on Climate Change, a treaty that came into force in 1994. This was the 26th COP and was hosted in partnership between Britain and Italy. The conference was held in Glasgow Nov. 1 to 12 of 2021, a year later than planned due to delays caused by the COVID-19 pandemic.

Acronyms

4C	Clean Cooking and Climate Consortium
AMS	Approved Methodology for Small-scale CDM project activities
BAU	Business as Usual
CCA	Clean Cooking Alliance
CCAC	Climate and Clean Air Coalition
CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
COP	Conference of the Parties
COV	Coefficient of Variance
FAO	Food and Agriculture Organization
fNRB	Fraction of Non-Renewable Biomass
GCF	Green Climate Fund
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
IRENA	International Renewable Energy Agency
ISO	International Organization for Standardization
ITMO	Internationally Transferrable Mitigation Outcomes
KPIs	Key Performance Indicators
LPG	Liquified Petroleum Gas
LULUCF	Land Use, Land-Use Change and Forestry
MRV	Measurement (or Monitoring), Reporting, and Verification
N_2O	Nitrous Oxide
NDC	Nationally Determined Contribution
NGO	Non-Governmental Organization
RBF	Results-Based Financing
RVO	Netherlands Enterprise Agency
TPDDTEC	Technologies and Practices to Displace Decentralized Thermal Energy Consumption
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

About the Authors

This report was jointly developed by the Clean Cooking Alliance (CCA) and Berkeley Air Monitoring Group, with contributions from Independent Climate Consultant Matthew Spannagle. CCA is the convener of the Clean Cooking and Climate Consortium (4C), whose mandate is to provide practical guidance to countries intending to include clean cooking programs in their NDCs. Berkeley Air is a member of 4C, which is also supported by the United Nations Framework Convention on Climate Change (UNFCCC) secretariat, the Climate and Clean Air Coalition (CCAC), the U.S. Environmental Protection Agency (US EPA), and Stockholm Environmental Institute. The Consortium aims to operate in harmony with actors in the broader community supporting the implementation of NDCs, including the NDC Partnership; the United Nations Development Programme (UNDP); the Gold Standard Foundation; the Africa NDC Hub; Energising Development (EnDev), managed by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and the Netherlands Enterprise Agency (RVO), and the International Renewable Energy Agency (IRENA).

Background on the Paris Agreement's Carbon Market Mechanisms

The landmark Paris Agreement was signed in 2015, with an overall goal (Article 2.1(a)):

> "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change."

The Paris Agreement provides flexibility to nations regarding the goals they set in their NDCs. The primary requirements for all ratifying countries are to:

1. Report their national greenhouse gas (GHG) inventories using standardized approaches.[2]
2. Demonstrate progress towards their specific national targets, in this case those related to cooking energy transitions.

Initially, key performance indicators (KPIs) may be tracked to demonstrate the magnitude and type of progress being made in the cooking sector. Over time, however, more detailed approaches may be required or become desirable to demonstrate more conclusively that cooking emissions are declining and that co-benefits are being achieved.

Article 6 of the Paris Agreement provides guidance on collaborative approaches; Article 6.2 covers agreements between governments that are parties to the Paris Agreement, such as between high-income and low-and-middle-income countries; Article 6.4 outlines a centralized mitigation mechanism for multilateral transactions supervised by a body created by the parties; and Article 6.8 guides non-market approaches. At the COP26 meeting, the parties adopted several decisions to operationalize carbon markets under Article 6:

- **6.2:** guidance for bilateral or multilateral agreements to create Internationally Transferrable Mitigation Outcomes (ITMOs), including a crediting mechanism and links to emission trading systems.
- **6.4:** rules, modalities, and procedures for a multilateral crediting mechanism (to be known as "A6.4M"), which will be a successor to the Clean Development Mechanism (CDM) created under the Kyoto Protocol.
- **6.8:** agreement to create a work program.

The A6.4M rules, including MRV requirements, are under development. While they are likely to build from the existing CDM and voluntary market methodologies and will probably include elements of the International Organization of Standardization (ISO) Technical Committee 285 on Clean Cookstoves and Clean Cooking Solutions,[3] there is not yet consensus around the requirements and best practices for MRV under the Paris Agreement. Projects that were started using either CDM or voluntary market methodologies will face some adjustments as the new A6.4M rules are created and operationalized. A6.4M is mandated to manage the transition of existing CDM projects to the new mechanism, and the Supervisory Body is due to meet twice in 2022 to give guidance on the implementation of the new rules. CDM activities can transition to the A6.4M with adjustments to comply with the new rules and upon approval by the host country (request by 2023 and approval by 2025). Projects registered after Jan. 1 of 2013 are grandfathered, and the credits generated from these projects can be counted toward the country's first NDC. In addition to the direction expected from the A6.4M Supervisory Body, the Gold Standard Foundation has also issued preliminary guidance, entitled Practitioners' Guide: Aligning the Voluntary Carbon Market with the Paris Agreement,[4] for voluntary market projects to adapt to the A6.4 requirements.

Activities that fall under Articles 6.2 and 6.4 will require robust measurement, reporting and verification approaches, as host countries are required to make corresponding adjustments to their national inventories for ITMOs transferred abroad. This requirement fundamentally alters the risk calculation for host countries: any overestimation of ITMOs will result in a deficit in the national inventory that the host country will have to compensate for by finding emissions reductions in other sectors of their economy in order to meet their own national targets. Thus, host countries now have strong incentives to ensure that MRV approaches are fully aligned with national inventory reporting, and that any default values used are conservative.

General MRV Principles

Overview

All MRV frameworks and approaches applied should be consistent with the Paris Agreement's transparency, accuracy, completeness, comparability, and consistency principles, which govern the preparation of national GHG inventories. While this document does not provide specific monitoring methodologies, these principles are inherent in the general approaches described. Adhering to these principles is fundamental to providing reasonable estimates, which will ensure the credibility of the assets generated and reduce the risk to the host country of overestimation, and potentially overshooting national targets.

Under Article 6, project implementers should also expect to face more stringent additionality tests to ensure that their activities are truly supplemental to existing efforts, representing new carbon reductions. Rather than focusing solely on financial additionality, as was required in the past, project implementers will also need to ensure that their proposed activities are not already mandated by existing or expected future regulation and that they go beyond the host country's unconditional NDC targets.[5] In the past, many cookstove projects qualified fairly easily as additional, often appearing on government "positive lists" of activities that were automatically considered additional. Now, however, as more nations have included some cooking energy targets in their NDCs – whether explicitly or as part of broader commitments to energy efficiency and/or forest conservation – project implementers may need to show more evidence to demonstrate the additionality of cookstove programs for Article 6.2 and 6.4 activities.

MRV systems for cooking energy interventions require a different approach than for other sectors, as the emissions result from many distributed point sources in homes (e.g., from three-stone wood fires, charcoal stoves, wood-burning stoves with chimneys and even kerosene lamps or cookers.) Furthermore, the fuel and stove use patterns in homes can vary substantially across regions, user characteristics, and time. While these complexities require unique considerations, efficient and smart approaches for the measurements and assumptions needed to calculate carbon dioxide-equivalent[6] (CO_2e) reductions are available. This section provides an overview of those approaches to indicate what is required to create a robust cooking energy monitoring system.

Cooking energy programs have been successfully integrated into carbon markets for at least 15 years, and the methodologies used to quantify their carbon reductions are available to inform MRV frameworks. The approaches presented in this document are largely informed by two methodologies that have been widely used to quantify the impacts on emissions of cooking energy interventions:

- "AMS-II.G.: Energy efficiency measures in thermal applications of non-renewable biomass" (AMS-II.G)[7] was developed by the CDM under the Kyoto Protocol and is currently in its 13th version, published September, 2022.
- "Technologies and Practices to Displace Decentralized Thermal Energy Consumption" (TPDDTEC) is a methodology currently available in its fourth version (revised July 10, 2021) from the Gold Standard Foundation. Gold Standard is a standard-setting body founded by the World Wildlife Fund and other nongovernmental organizations (NGOs) to set standards for climate and development interventions.

Other relevant resources consulted in the development of these MRV recommendations include the testing guidance developed by ISO Technical Committee 285 on Clean Cookstoves and Clean Cooking Solutions as well as the CDM methodologies AMS-I.I.: Biogas/biomass thermal applications for households/small users and AMS-I.E.: Switch from non-renewable biomass for thermal applications by the user, which covers electric cooking appliances under certain scenarios.

In the transition of CDM activities to A6.4M set in motion by COP26, it is likely that existing CDM methodologies will be revised for use under A6.4M in order to manage the cost and accelerate the timeline for ramping up Article 6 operations.[8] However, the transition from CDM methodologies to A6.4M guidance is widely expected to bring more stringent requirements and more conservative default values, in an effort to reduce overestimation of emission reductions. In preparation, the CDM published a new Methodological Tool that provides more conservative default values for the key

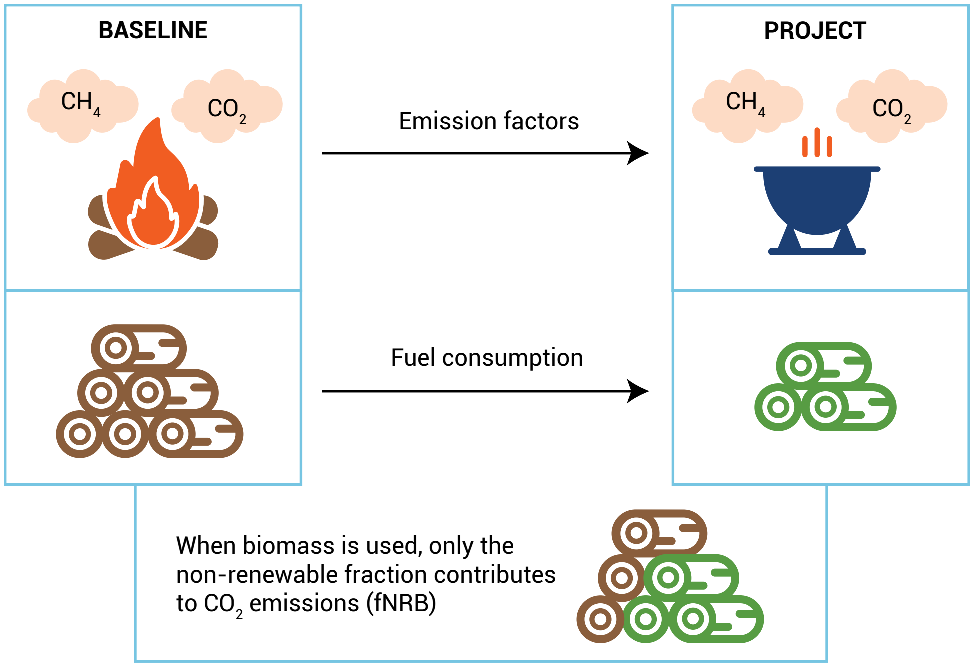

Figure 1: Main inputs for estimating emissions reductions

parameters, including fraction of non-renewable biomass (fNRB), per-capita baseline wood fuel consumption and wood-to-charcoal conversion factor.[9] The revisions were based on a review comparing the prior default values with those used in CDM cookstove projects to date and those published in peer-reviewed literature.[10]

This section is organized to:

- Outline how emission reductions are calculated;
- Describe how the key inputs for those calculations can be estimated;
- Provide guidance on considerations for upstream emissions from processed fuels; and
- Suggest how to account for changes in emissions reductions over time

Information on sampling approaches is provided in the subsequent section so titled.

Estimating Emissions Reductions

Emissions estimation calculations follow the general principle of determining the differences in emissions generated by a baseline scenario versus emissions generated or avoided from a project scenario.

Approaches for characterizing the baseline scenario are described in more detail later in this section; however, the overarching concept as applied to cooking energy programs is to measure the amount of fuel commonly used prior to the implementation of a clean cooking program. To ensure this estimate is conservative, and that the emissions reductions measured against it are real and additional, the baseline must be adjusted to anticipate the impacts of other relevant external factors. These might include changes to national policies and updates to national targets or commitments, as well as rising standards of living, and/or expanding markets.

The project scenario measures the fuel use after the start of the implementation of the cooking energy transition activity. This estimate is adjusted to account for leakage,[11] for frequency of usage of various technologies within a home, for changes in performance over time, and for the energy density of the fuels.

Fundamentally, the emissions estimates for each scenario (baseline and project) involve multiplying estimates of the GHG emission factor[12] for the fuel-technology combination, by fuel consumption estimates. Where the fuel is biomass, the result must also be multiplied by the fraction of the biomass used that is not renewable. There are multiple valid strategies for estimating the inputs that are used to generate the scenario emission estimates. For fuel consumption there are two general approaches: 1) measuring the fuel consumption in the baseline and project scenarios; and 2) measure the baseline fuel consumption and then estimate the project scenario fuel consumption by comparing relative cooking technology efficiencies[13] and extrapolating.

Fuel Consumption

Fuel consumption can generally be estimated using surveys (participant estimates); by directly weighing fuel; or through the use of sensors that track fuel consumption. Literature sources and national databases can also be used for baseline fuel consumption estimates and/or used as a check on estimates directly monitored by a project. Fuel savings can be estimated using different tests, including the laboratory Water Boiling Test, Controlled Cooking Test, and Kitchen Performance Test. There are new ISO protocols that provide updates to these laboratory and field tests.[14] Many countries are currently in the process of adopting and adapting these new ISO protocols, and they are well-positioned to be incorporated into emission reduction methodologies for monitoring baseline and project fuel consumption estimates. Fuels that are regularly purchased or metered may also be estimated via transaction records or sensors that track the quantity of fuel used.

To date, baseline fuel consumption and/or fuel savings may have been overestimated in cookstove projects,[15] potentially leading to over-issuance of emissions reduction credits. Under Article 6, to ensure alignment with the national inventory and achievement of NDC targets, it will be imperative for projects to use more conservative default values or conduct a more accurate and nuanced assessment of fuel consumption. While household surveys are typically a less expensive option for measuring fuel consumption, self-reported estimates of fuel use can be inaccurate and unreliable. Direct measures of fuel consumption, such as weighing fuel in homes over time with the kitchen performance test or monitoring fuel use with meters, provide more accurate estimates. Direct measures of stove or fuel use may involve more technical skill and cost; however, there are promising new approaches to electric devices,[16] and corresponding methodologies that may provide more user-friendly and efficient data collection.

Examples to estimate household fuel consumption can be found at:

- https://cleancooking.org/research-evidence-learning/standards-testing/protocols/
- https://www.iso.org/standard/66521.html
- https://www.climatecare.org/resources/news/press-release-new-methodology-approved-gold-standard/

Emission Factors

It is common to use default emission factors for carbon dioxide (CO_2e), nitrous oxide (N_2O), and methane (CH_4) for the residential use of various fuels. These defaults are typically from the Intergovernmental Panel on Climate Change Guidelines for National Greenhouse Gas Inventories,[17] which provides default emission factors for various sectors and activities, including residential fuel combustion. While sector-specific, these defaults are not technology-specific (e.g., there are not separate emission factors for a three-stone-fire compared to an advanced, forced-draft wood stove), and thus may not be sufficiently accurate to reflect the impacts seen in the national inventory. Technology or region-specific emission factors can also be applied, if sufficient evidence for the choice exists in the literature or if a local emissions study is conducted. Importantly, emission factors for electricity generation also exist (default and grid-specific)[18] and can be applied when electric cooking is a program component.

Importantly, due to restrictions imposed by the Kyoto Protocol, the current CDM methodology (AMS-II.G v12.0) applies default fossil-fuel-based emission factors to biomass (wood or wood equivalent in the case of charcoal). These default emission factors range from 63.9 to 85.7 t CO_2e/TJ, while an average of field-based studies involving traditional wood cookstove emissions indicates that 103 t CO_2e/TJ is a much more realistic estimate.[19] Applying this emission factor to traditional wood cookstoves would provide a more accurate emissions estimate.

Renewability of Biomass

Renewable biomass consumption is considered to have no net CO_2 release into the atmosphere, because the CO_2 is taken up by new growth. Biomass that is burned, but not harvested in a renewable manner, results in a net increase of CO_2 in the atmosphere. This biomass is referred to as fNRB.

The fNRB can be estimated by simple calculations or more complex modeling. Under existing methodologies, default estimates could be used from the literature, or studies can be conducted to establish the value for a country or program area. However, the application of these methodologies has typically resulted in substantially overestimated estimates (often above 90%).[20] More reasonable estimates (typically

in the range of 5%-30%), based on granular modeling within project areas, are currently available and would provide a more justifiable and accurate set of default values.[21] The UNFCCC has also published a tool that provides guidance and a step-by-step method for calculating fNRB values.[22]

Under the Paris Agreement, project values will need to be consistent with national inventory reports on the land use, land-use change and forestry (LULUCF) sector. For example, if the host country's inventory shows that forests are stable (or increasing), then the national fNRB is 0%. Therefore, national rates will increasingly be framed by the national inventory's assessments of LULUCF, and in most circumstances, a proposed project will not be able to use a significantly different rate. In some cases, local or regional forest conditions may justify a higher value, but these cases will likely be the exception rather than the rule as Article 6 implementation ramps up.

It is also important to note that CH_4 and N_2O emissions are not impacted by the renewability of the biomass, because plants do not convert these gases into stored carbon during photosynthesis, and thus can be counted even if the estimate is 0%. Black carbon also falls in this category, although it is not currently allowed to be included in CO_2e estimates, despite its large warming contributions.

Additional Factors for Monitoring Emission Reductions

Stove Use

Transitioning to new cooking technologies and fuels rarely occurs exclusively, as households tend to retain their old stoves to help fulfill cooking and/or heating tasks.[23] Continued use of multiple stoves, or "stove stacking", has important implications for fuel consumption estimates. For example, if the project fuel consumption is being estimated by how much more thermally efficient a project technology is compared to the baseline technology, the savings can only be applied to the fraction of the baseline technology displacement occurring in households. The extent of stove stacking can be estimated via survey or directly with sensor-based monitors. Household surveys are generally not as accurate or reliable but can be easier and less expensive to deploy. As mentioned in the fuel consumption section, however, there are advances in sensing technologies and approaches that can make them more user-friendly.

Investing in more reliable and accurate stove use estimates is another important strategy for governments to increase the confidence in the emission reductions being estimated. Many cookstove projects to date have estimated use of the project cooking technology at 90% or more, even though the literature suggests that this level of adoption is rare for many biomass-improved cookstoves and that ranges of 10% to 75% are more likely. (Levels of adoption of 90% or more have been more typically observed in households adopting ethanol, biogas, or LPG). Governments should scrutinize usage rates carefully and consider reducing the resulting emission reductions estimates if the usage values used are not conservative.

Estimating Upstream Emissions

In addition to the emissions arising at the point of use, some fuels also have substantive emissions associated with their feedstock production, transportation, processing, and distribution. These upstream emissions need to be included to accurately account for the overall mitigation being attributed to a given program. In the case of cooking energy programs, the main fuels of interest for their upstream emissions are charcoal, ethanol, liquified petroleum gas (LPG), biogas, and electricity. Fuel wood does not generally have meaningful upstream emissions, unless there is substantial processing and transport involved, which can be the case with pellets or other highly processed wood-based fuels.

Generally, the approaches used to estimate upstream emissions rely on default emission scaling and/or emission factors. For example, the CDM methodology for cooking energy devices (AMS–II.G.) has stipulated that a default assumption may be made that 1 kg of charcoal requires approximately 4 kg of wood to produce. (This value was recently reduced from the prior value of 5.3 kg, reflecting the typical efficiencies of newer kiln technologies.) In such cases, the charcoal mass is converted into a wood equivalent, and then the wood emission factors are applied. Similar scenarios arise for other fuels, and there are resources available[24] to provide reasonable assumptions for their upstream emissions. For any Article 6 crediting, the wood-to-charcoal conversion factor should reflect a robust assessment of the specific charcoal production processes relevant to the project.

Leakage

It is also important to account for how a project could potentially increase emissions outside of the project area. Accounting for the lifecycle emissions of a fuel, as described above, is important, but further considerations may be needed if a project, for example, causes the increase of non-renewable woody biomass use in non-project households (e.g., a tree plantation is no longer accessible to non-project households due to project activities). In such cases, those increased emissions in non-project households must be monitored and subtracted from the overall emission reductions. Assessment of leakage can be difficult and can add to the monitoring burden. Therefore, making conservative assumptions, such as a 5% default adjustment factor, is a common approach and allowable under the AMS-II.G methodology.

Estimating Reductions over Time over Lifetime

As noted previously, cookstove emissions measurements are conducted by determining a baseline scenario and then comparing that to the project scenario over time.

Measurement of the Baseline

Existing methodologies offer multiple ways to determine baseline emission scenarios, which typically seek to establish the "business as usual" (BAU) scenario—the most likely scenario if the project is not undertaken. These baselines are usually fixed over the crediting period of the project[25], and have generally not accounted for changes or improvements in the business-as-usual scenario. With the increased resources and attention paid to addressing climate change, and the higher ambition of the Paris Agreement, stricter assessment of baseline scenarios is necessary to avoid divergence between project-based emissions reductions calculations and the national inventory. These include that baselines must be ambitious; that they must be improvements over the business-as-usual scenario; and that they should be re-determined once an emissions reduction strategy gains widespread adoption, creating a new business-as-usual state. A range of factors can impact the baseline case and require it to be restated, including growth in the market as a result of carbon- or climate-financed programs or new government policies, as well as shifts in fuel availability due to environmental or demographic factors.

Under Article 6.4, three general approaches have been approved to estimate the baseline scenario for future projects under the A6.4M crediting program, which are in line with the aforementioned principles: assume the best available (and economically feasible) technologies are being used, use higher-performing technologies as benchmarks, or adjust historical emissions estimates conservatively. The A6.4 Supervisory Body has been tasked with issuing additional guidance on how these baseline approaches can be implemented, and the UNFCCC will provide further capacity building tools to assist governments and other parties to implement them effectively.

Most cookstove projects in the past have assumed a three-stone fire baseline, with an efficiency of 10%. With improved cookstoves gaining market penetration, the baseline may need to be adjusted to include, for example, 10% LPG, 20% improved cookstoves, and 70% three-stone fires, with the efficiency of each estimated. The UNFCCC recently published more conservative default values of 15% for three-stone fires or conventional stoves, with no improved-combustion air supply or flue gas ventilation (that is, without a grate or a chimney) and 25% for other types of baseline stoves.[26] The implication of these changes is that project stove efficiency must be greater than 15% when replacing three-stone fires, and greater than 25% when replacing existing stoves, to generate emissions reductions.

Stove Aging

Consideration should be given to changes in emissions reductions over time for a given stove due to component decay or failure, transition to other stoves, or other reasons. The Gold Standard's TPDDTEC and AMS.II-G for both provide guidelines on incorporating stove aging into the emissions reduction calculations. The TPDDTEC methodology requires Water Boiling Tests[27] be conducted by independent entities every year the cookstove project is under analysis. Each annual batch must comply with rules about how precise the stove's efficiency estimates must be (see the section on Sampling Approaches for more information on precision rules). AMS.II-G also requires adherence to precision rules, but it offers the option for changes in efficiency over time to be estimated from a single batch of stoves, then extrapolated linearly over time for all project stoves.

Both field and laboratory Water Boiling Tests, and new ISO protocols, are acceptable methodologies, though any sample of tested stoves must be representative of typical usage. The flexibility given under the methodologies is appropriate, and designers of MRV plans should consider the logistics involved in conducting sampling campaigns. If stoves are mobile, they may be brought to laboratories for analysis by experienced lab technicians using calibrated instrumentation. If the stoves are built-in or transport is challenging, trained lab technicians may go into the field to conduct tests. Analysis of the thermal efficiency data from the testing provides changes in efficiency over time, which can then be incorporated into emissions reduction calculations. AMS.II-G requires testing by batches of stoves, rather than by year installed, thus providing more flexibility and lower sampling requirements.

In the context of Article 6 transactions and national targets, countries will also need to consider the overall longevity of programs in the context of 5-year NDC renewals. In addition to adjusting for any degradation in performance with the 5-year period, programs will need to understand (and reassess) technology replacement rates and factors such as developments in cooking energy options and/or changes in the standard of living.

Sampling Approaches

Given the distributed nature and variability in emissions from cooking technologies, tracking and measuring each is not practical. Therefore, strategies to sample target populations are critical for providing representative and/or conservative inputs for calculating emission reductions. A CDM guidance note, including a sample size calculator, is available for further details.[28]

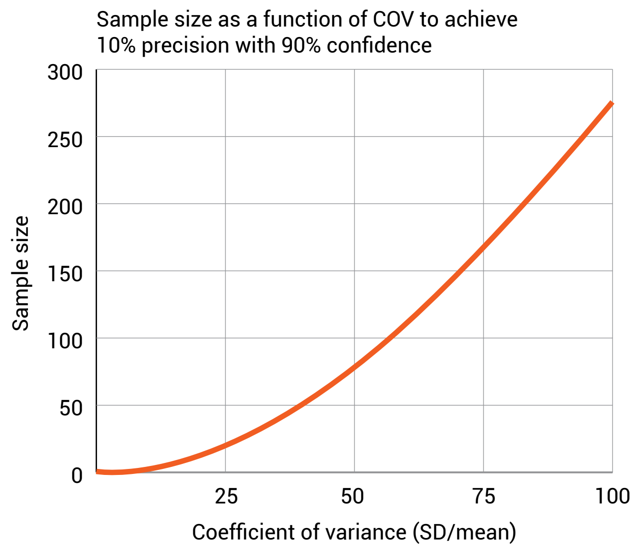

Figure 2. As variability increases, so does the number of samples required to achieve the same level of precision.

Sample Selection

The testing concepts and methodologies described in previous sections must be applied thoughtfully to ensure that the data translate to useful and accurate results. For example, homes selected for sampling should be representative of the target population over key descriptors such as regional location, types of fuels and stoves used, fuel use patterns, seasonality, population density (urban/peri-urban/rural), and activities in the region, such as occupations and transportation. Extrapolation of results to different regions or fuel/stove combinations with other baseline scenarios should be either avoided, or justified rigorously.

Sample Size

Sample sizes should be determined considering the project goals, existing data that can be used, and new data that can be incorporated for precision rule calculation as it is collected for the MRV.

Precision rules are guidelines to ensure that the data are sufficiently representative of the sample population and that there is a common understanding of data quality expectations across a variety of projects in different settings. For example, 90/10 precision rules are used in various methodologies. In order to adhere to the rule, a data set (e.g., kilograms of fuel used per household per day) must have its 90 percent confidence interval within +/- 10% of the average set forth in the Gold Standard's TPDDTEC methodology. Figure 1 below illustrates the relationship between variability and sample size that must be considered to meet precision rules. When the data are widely spread, the confidence interval is larger than if they are narrowly spread, so more samples would be needed to adhere to the rule, even for data with the same mean. This variability, or spread of the data, is often presented as a coefficient of variance (COV, defined as the variance of the data divided by the mean of the data). The COV may then be used to estimate sample sizes to adhere to a given precision rule calculation. For example, a homogenous population with very similar fuel consumption patterns may have a COV of 40%, meaning that ~50 samples would be needed to meet the precision guideline, whereas more than 200 samples would be required when variability in fuel consumption estimates have COVs of ~80% or more. When collecting data related to cooking energy in homes, it is common to find substantial variability from household to household due to many differences in cooking practices, preferences, and behavior.[29]

It is also important to note that the sampling and measurement approaches are designed to provide estimates on a per-home or per-capita basis. When scaling these fuel consumption or emissions estimates to the project or program's full target audience, a reliable estimate of this population's size must be derived from reliable sources, such as sales databases or household surveys.

Case Studies

Nepal Case Study: Electric Cooking

Background

Nepal's long-term low GHG development strategy, completed in 2021, aims to reach net-zero GHG emissions by 2050. Nepal's 2019 National Climate Policy calls for the production and use of renewable energy, including hydroelectricity and energy efficient technologies. Nepal's enhanced NDC targets in the cooking sector include the bold electric cooking goal to "use primarily electric cooking in 25% of households by 2030."

Implementation

Two separate initiatives are underway to support rapid and widespread increases in the availability and use of electricity for cooking, along with the promotion of electric cooking technologies and user behavior with the goal of generating emissions reductions that can be counted towards Nepal's national targets. These programs aim to build on Nepal's existing electricity infrastructure, which is primarily generated from hydropower, making it a clean and renewable energy resource. Further, as much as 90% of the population already have access to electricity[30] (although many connections require upgrading to accommodate electric cooking devices safely).

The most active project is currently being implemented with funding from the Green Climate Fund (GCF) in Nepal's Terai region, where connection rates are higher than in other areas. This initiative, entitled "Mitigating GHG emission through modern, efficient and climate-friendly clean cooking solutions," focuses on creating awareness of and expanding access to electricity for cooking, using both household and policy approaches. The project targets installing 500,000 electric stoves, as well as other clean or transitional cooking technologies, using a mix of market mechanisms, RBF for lowering risk and scaling up investments, and increasing institutional capacity at local government authorities. Clean cooking solutions in this program could reduce or avoid 3.54 million tCO_2e from buildings, cities, industries and appliances.

Another initiative supporting Nepal's electric cooking target is the Nepal Electric Cooking Initiative. The initiative has four primary objectives: support effective utilization of

surplus, renewably-sourced electricity; reduce reliance on imported LPG and unsustainably harvested firewood for cooking; achieve sales of induction stoves, infrared stoves, and electric pressure cookers resulting in 500,000 households adopting electric cooking within five years; and establish a sustainable market for electric cooking devices across the country, beyond the lifetime of the program. Through the promotion of electric cooking solutions, the initiative aims to reduce 3.04 million tCO_2e (direct) and 6.46 million tCO_2e (indirect). The co-benefits to health from the project are expected to result in a reduction of 8,400 disability-adjusted life years during the project lifetime.

Measurement, Reporting and Verification

The GCF-funded initiative intends to follow some elements of the CDM AMS.II-G methodology for quantifying progress toward their tCO_2e target, to the extent applicable. Because the programs in Nepal are not aiming to generate ITMOs to be traded under Article 6, they have more discretion in the design of their MRV practices, as long as these meet Nepal's own guidelines. The AMS.II-G methodology, however, does not cover grid-connected electric stoves, unless the grid is fully powered from renewable sources, which is not the case in all seasons in Nepal. The most recent updates to the Gold

Standard's TPDDTEC methodology (version 4.0), however, offers an MRV approach for electric grid-connected stoves that accounts for the percentage of the electricity generated from renewable sources, which may prove valuable to electric cooking programs such as those initiated in Nepal.

Installation of electric cooking devices will be tracked using management information systems set up with local government entities that receive capacity building support through the project. Data will be sex-disaggregated to provide data on the gender co-benefits of the program. The Nepal Living Standard Survey and other data collection activities regularly conducted by the government of Nepal will be used to track the portion of the population adopting clean cooking solutions. The initiative will also conduct multiple evaluations to inform many of the initiative's goals. Finally, new and existing cookstove performance testing capacity will be developed to ensure that all promoted technologies meet the targeted ISO standards.

Progress toward and achievement of CO_2e mitigation in the Nepal Electric Cooking Initiative will be monitored via baseline (year 1), midline (year 3), and end-line (year 5) evaluations. The monitoring will consist of household surveys, which will include direct measurements of wood and electricity, as well as logs of LPG consumption via receipts or sales records. Smart sensing devices will be employed to measure usage where feasible. The sampling strategies will be designed to capture the variability across major user groups and geographies. Sample sizes will be guided by 90/10 precision rules as presented in the CDM methodology AMS-II.G. Customer and sales records from enterprises participating in the Nepal Electric Cooking Initiative will be used to scale the CO_2e savings per home for the project-wide mitigation estimate. In addition, program activities will be continuously monitored to ensure adherence to the best business practices and initiative guidelines.

Case Study: Ghana-Switzerland Bilateral Agreement

Background

Expanding the adoption of market-based cleaner cooking solutions is one of Ghana's climate goals, included in their NDC as scaling-up access and the adoption of 2 million efficient cook stoves by 2030. Co-benefits are expected to include saving 39,500 hectares of woodland, as well as reduced household air pollution and smoke-related respiratory and eye diseases. Economic co-benefits include lower household cooking fuel expenditures and job creation through the manufacture and sale of efficient stoves.

A pioneering agreement facilitated by the United Nations Development Programme and signed in 2020 between Ghana and Switzerland aims to support these goals.[31] The agreement outlines their cooperative approach under the Paris Agreement and intent to design a framework for projects in Ghana using the Paris Article 6.2 mechanism to generate ITMOs. Under the agreement, Switzerland will agree to buy a certain volume of emission reductions from Ghana. This commitment in advance from Switzerland, conditional upon independent verification of results, acts as an incentive for project developers in Ghana to finance projects that deliver mitigation outcomes, such as implementing cleaner cooking programs.

Implementation: National Clean Energy Programme

The ITMO agreement supports Ghana's National Clean Energy Program, which is the primary implementation mechanism. Expanding the adoption of market-based cleaner cooking solutions is one of three strategies prioritized to achieve a targeted 30% reduction in CO_2e, in addition to a 15% unconditional commitment to be achieved by developing natural gas for electricity generation and prioritizing reforestation of degraded lands. Under the agreement, Switzerland will buy credits for 5 years but the benefits of the supported Ghana activities are expected to continue well beyond that, creating an investment in Ghana's energy sector that will facilitate future expansion. The Ghana program is also designed to produce many co-benefits, including improvements to livelihoods, health, and communities.

Measurement, Reporting and Verification

The Ghana-Switzerland collaboration will use bespoke MRV methodologies that follow the MRV rules established in each country's national framework and are mutually agreeable to both parties. To ensure alignment with national inventories, the MRV system will need to address the key points outlined above. In addition, all cookstoves that are disseminated under this agreement must undergo standardized laboratory and field testing, overseen by the government of Ghana. Only cookstoves fueled by processed biofuels, such as pellets or biogas, are eligible for the program, and these must prevent negative health effects by demonstrating top-tier performance for emissions.

Role of Key Performance Indicators

The second main requirement of the Paris Agreement (after inventory reporting) is for each ratifying country to demonstrate progress toward their NDCs. KPIs are relatively simple measures that demonstrate progress toward national targets. When clean cooking programs make up a portion of a country's unconditional commitment under the Paris Agreement, they may be tracked in terms of programmatic indicators (such as 'number of households with improved cookstoves') rather than in emissions reductions. This approach is credible because the resulting emission reductions will be captured in the national inventory, though the inventory cannot (and does not) attribute a particular amount of emission reduction achieved to the improved cookstoves installed. Monitoring KPI progress in the short term allows countries to build the infrastructure to formally estimate CO_2e reductions in the longer term.

KPIs may be used nationally to demonstrate progress on a national goal and potentially as the basis for Article 6 transactions. However, if a host government proposes to use them under Article 6—and therefore to transfer the corresponding ITMOs out of its national inventory—the host government must have a robust understanding of the relationship between the KPIs and emissions reductions, in order to predict the impact on the national inventory and plan the projected future emissions pathway to 2030. A host government and partner purchasing government may agree to transfer a set number of mitigation outcomes per KPI or for reaching certain KPI milestones. For example, $0.5tCO_2e$ per installed high efficiency cookstove, with a goal of 25% of the population using modern cooking services. These proxies must be conservatively set to avoid excess transfer from the host country or overshooting the national target. Such approaches are new to host and buyer governments and have not yet been explored in depth. Nonetheless, they offer an alternative approach to the higher transaction cost approaches outlined above.

KPIs may be informed by data that are already collected in existing national surveys or inventories, such as the national census, or Demographic and Health Surveys. These existing data collection tools may also be updated to include KPI metrics. The World Health Organization offers "Harmonized survey questions for monitoring household energy use and SDG indicators 7.1.1 and 7.1.2,"[32] developed in conjunction with the Energy Sector Management Assistance Program and the World Bank. The World Bank's Multi-Tier Framework survey[33] may also prove useful in this context.

Examples of common KPIs for cooking energy programs include:

- Percent of population with access to modern cooking energy services.
- Percent or number of households using clean fuels (e.g., electricity, ethanol, solar, biogas, etc.).
- Percent or number of households using high-performance biomass stoves (defined with international testing standards).

For any program seeking to also demonstrate health impacts, it is important to integrate a measure of the displacement of baseline biomass technologies that expose households to health-damaging emissions into the KPIs. The dose-response relationships between exposure to particulates from biomass burning and many of the diseases commonly associated with chronic exposure to biomass smoke are not linear. Instead, the greatest benefits are estimated to be achieved by near-complete displacement of traditional stoves with clean technologies.[34]

Data Sources

Readily available data sources may include:

- Demographic and health surveys
- World Health Organization harmonized questions for monitoring energy use
- Multi-Tier Framework Survey (World Bank)
- Guidelines for the Incorporation of a Woodfuel Supplementary Module into Existing Household Surveys in Developing Countries (FAO)
- Living Standards Measurement Study

Table 1: Considerations for Developing Key Performance Indicators for Clean Cooking Initiatives

Considerations	Example	Implications
What data sources already exist for collecting information about cooking?	Demographic and health surveys, the Multi-Tier Framework surveys, other national or subnational surveys	A high-level snapshot of clean cooking progress may be obtainable from existing data
What data are tracked?	Primary fuel type is commonly reported, along with cooking technology and/or location. The Multi-Tier Framework also measures fuel quantity.	Fuel quantity is a highly relevant KPI. Survey questions may be added to inform on this parameter, or it can be tested in a population subsample.
What significant clean cooking activities are not well tracked through existing sources?	Electrical appliances that perform some but not all cooking tasks may be undercounted in surveys that focus on primary cooking devices and fuels.	Could appliance manufacturers or importers be asked to participate in voluntary, industry-level reporting?
What other clean cooking data might be possible to measure or collect?	Some programs may target commercial or school cooking.	Can clean cooking assessments be added to school or restaurant accreditations or inspections?
Can community health workers be mobilized to collect information on clean cooking?	Community social workers visit families with new babies to support infant care and provide immunizations.	Could data on cooking appliances and fuels be collected during new baby visits?

Conclusions and Next Steps

Global climate goals cannot be achieved without reductions in emissions from cooking, and climate mitigation efforts are a key pathway to expand clean cooking opportunities to millions of families. MRV is a key component of any emissions reduction program: if emissions reductions are not properly estimated and documented, their value as a source of climate funding may not be fully realized.

Designing and implementing an MRV system that addresses the uniquely challenging aspects of tracking cooking energy interventions into a national monitoring framework requires building and maintaining capacities and infrastructure. Countries opting to undertake this activity may be aided by capacity building and technical support resources.

This introductory MRV framework document, and the companion guidance document on planning and implementing clean cooking programs,[35] are the initial offerings from 4C. 4C provides targeted practical and technical support to countries that expect cooking energy interventions to play a key role in meeting their obligations under the Paris Agreement, whether as part of their unconditional targets or through Article 6 mechanisms. Please contact climate@cleancooking.org for further information.

Additional MRV Resources for Cooking Energy Interventions

Note: this section will continue to be expanded over time—contributions welcome![36]

Current Methodologies and Protocols

Resource	Purpose
"AMS-II.G.: Energy efficiency measures in thermal applications of non-renewable biomass" (AMS-IIG)	A cookstove methodology developed by the CDM under the Kyoto Protocol and currently in its 13th version, published September 8, 2022.
Methodological Tool: Default values for common parameters Version 2.0	Tool 33 provides default values for common parameters found in methodologies relevant to household energy.
"Concept Note: Review of default baseline assumptions applied in AMS-I.E, AMS-II.G and TOOL30"	A review compared existing default values with those used in CDM cookstove projects to date and those published in peer-reviewed literature for the following parameters: fNRB, per capita baseline wood fuel consumption and wood-to-charcoal conversion factor. Considered by the Methodology Panel at MP88 for recommendation to the CDM Executive Board, resulting in Tool 33.
"Technologies and Practices to Displace Decentralized Thermal Energy Consumption" (TPDDTEC)	A methodology currently available in its fourth version (revised July 10, 2021) from the Gold Standard for Global Goals. The Gold Standard is a standard-setting body founded by the World Wildlife Fund and other NGOs to set standards for climate and development interventions.
AMS-I.I.: Biogas/biomass thermal applications for households/small users	A methodology for activities that generate renewable thermal energy using biomass or biogas for use in residential, commercial, and institutional applications. Examples of these technologies that displace or avoid fossil fuel use include, but are not limited to, biogas cook stoves, biomass briquette cook stoves, small-scale baking and drying systems, water heating, or space heating systems. Currently in its 6th version, published in March 2022.

Resource	Purpose
AMS-I.E.: Switch from non-renewable biomass for thermal applications by the user, which covers electric cooking appliances under certain scenarios	A methodology for generating thermal energy by introducing renewable energy technologies for end-users that displace the use of non-renewable biomass. Examples of these technologies include, but are not limited to, cookstoves using renewable biomass, biogas stoves, bioethanol stoves, and electric cookstoves powered by renewable energy. Currently in its 12th version, published in May 2021.
ISO Technical Committee 285 on Clean Cookstoves and Clean Cooking Solutions	Protocols for laboratory and field assessment of cookstove efficiency, emissions, durability and safety.

Article 6 of the Paris Agreement

Resource	Purpose
"COP26 Outcomes: Market mechanisms and non-market approaches (Article 6)"	This FAQ from the United Nations Framework Convention on Climate Change provides answers to common questions about A6.
"What You Need to Know About Article 6 of the Paris Agreement"	This post from the World Resources Institute provides background on A6.
Developing an Article 6 tool to set a robust crediting baseline.	This short study from Perspectives Climate Research examines how the A6 decisions can be integrated into existing methodologies and reviews several on-going initiatives to create baseline-setting guidance.
"COP26 DIGEST: THE SIGNIFICANCE OF ARTICLE 6 AND CDM TRANSITION OUTCOMES FOR AFRICA"	This policy brief from Perspectives Climate Research reflects on the significance of COP26 outcomes for global carbon markets, with a focus on African priorities. This includes carbon market cooperation under Article 6 of the Paris Agreement, as well as the transition of the CDM in the Kyoto Protocol to the A6.4 mechanism.
"A PRACTITIONERS' GUIDE: Aligning the Voluntary Carbon Market with the Paris Agreement"	
Blueprint for Article 6 Readiness in member countries of the West African Alliance	A guidance document published by the West Africa Climate Alliance offering suggestions to countries with an interest in authorizing and transferring mitigation outcomes on how to build sufficient technical capacities to engage in A6 cooperation and comply with related international rules.

Determining fNRB

Resource	Purpose
Bailis, Robert, Rudi Drigo, Adrian Ghilardi, and Omar Masera. "The Carbon Footprint of Traditional Woodfuels." *Nature Climate Change* 5, no. 3 (March 2015): 266–72.	Provides sources and methodological guidance for calculating the fNRB.
Modeling Fuelwood Savings Scenarios (MoFuSS)	MoFuSS is an open-source GIS-based freeware model developed to evaluate the potential impacts of firewood harvest and charcoal production over the landscape.
CDM, and UNFCCC. "Methodological Tool: Calculation of the Fraction of Non-Renewable Biomass." UNFCCC, December 2020.	This tool provides guidance and a step-by-step procedure/ method to calculate values of non-renewable biomass. The tool may be applied when calculating baseline emissions in applicable methodologies (e.g., AMS-I.E, AMS-II.G, AMS-III.Z, AMS-III.AV, AMS-III.BG) for a project activity or a program of activities that displaces the use of non-renewable biomass.
World Bank Group, and Carbon Initiative for Development (Ci-Dev). "Fraction of Non-Renewable Biomass in Emission Crediting in Clean and Efficient Cooking Projects A Review of Concepts, Rules, and Challenges," September 2020.	An introduction to non-renewable biomass measurement approaches and challenges.

Survey Tools

Resource	Purpose
Borlizzi, Andrea. "Guidelines for the Incorporation of a Woodfuel Supplementary Module into Existing Household Surveys in Developing Countries," FAO, August 2018.	Survey tool for estimating household wood use.
CDM and UNFCCC. "Guideline: Sampling and Surveys for CDM Project Activities and Programmes of Activities." UNFCCC, October 2015. Sample size calculator	This document includes generic approaches for sampling and surveys applied to CDM projects and programs of activities. This document describes common types of sampling approaches and includes a recommended outline for a sampling plan; recommended practices for unbiased estimates of sampled parameters and recommended evaluation criteria for designated operational entity validation, in addition to several best-practice examples covering large and small-scale project activities. It also provides examples for checking the reliability of data collected through sample surveys.

Co-benefit Methodologies

Resource	Purpose
"Methodology to Estimate and Verify ADALY s from Cleaner Household Air" (Gold Standard)	Gold Standard methodology for measuring health impacts from cooking energy interventions.
"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" (Gold Standard)	Gold Standard methodology for measuring impact on short-lived climate pollutants from cooking energy interventions.
Quantifying and Measuring Climate, Health and Gender Co-Benefits from Clean Cooking Interventions: Methodologies Review (English). Washington, D.C.: World Bank Group.	World Bank approaches to measure health, gender, and expanded climate (black carbon) benefits for RBF.

Case Studies

Resource	Purpose
"The Kenyan cooking sector – Opportunities for climate action and sustainable development. GHG mitigation potential, health benefits and wider sustainable development impacts."	This study provides new and additional insights on the specific link between residential cooking solutions, climate change, health impacts and associated sustainable development objectives in Kenya. It builds on the 2019 National Cooking Sector Study and uses scenario modelling to present different possible development pathways for the Kenyan residential cooking sector, estimating their respective impact on GHG emissions and human health, and additional analysis on fuel use, energy demand and fuel expenditure as well as deforestation.
2020 Annual Performance Report for FP103: Promotion of Climate-Friendly Cooking: Kenya and Senegal	Showcases MRV methodology for a program funded by the GCF, aiming to accelerate the growth of improved cookstove markets in Kenya and Senegal and significantly increase the level and quality of improved cookstove production and sales

Notes

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6. CO_2 equivalent is a metric that normalizes the warming potential of different greenhouse pollutants to that of an equivalent amount of carbon dioxide, and thus allows for combining multiple emission types (e.g., CO_2, CH_4, N_2O) into one metric.
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36. Please send any recommended additions to climate@cleancooking.org.

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