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MECS
Modern Energy Cooking Services

Loughborough University

ESMAP
Energy Sector Management Assistance Program

A COMPREHENSIVE EVALUATION OF THE MMECD FRAMEWORK

Identifying areas of improvement for effective project implementation

2024

AGS Carbon Advisory

About AGS Carbon Advisory

AGS Carbon Advisory (AGS) is a prominent carbon project advisory and consulting firm headquartered in New Delhi, India. Renowned as a market leader in carbon markets consulting and trading services, AGS boasts a team led by individuals with a cumulative experience of over 45 years in the field. AGS specializes in community-based initiatives such as clean cooking, safe drinking water, and solar lighting, alongside energy-efficient solutions like LED lighting and solar irrigation systems such as solar pumps. The founders bring extensive expertise, having been pivotal figures in carbon markets since their inception, serving in roles ranging from third-party auditors to consultants and certifiers for esteemed international standards like the Gold Standard.

About Modern Energy Cooking Services

Modern Energy Cooking Services (MECS) is an eight-year research programme funded by UK Aid (FCDO) which is a partnership between Loughborough University and Energy Sector Management Assistance Program (ESMAP). MECS has a geographically diverse, multicultural, and transdisciplinary team working in close partnership with NGOs, governments, private sector, academia and research institutes, policy representatives and communities in 16 countries of interest to accelerate a transition from biomass to genuinely 'clean' cooking.

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Abbreviations

CCP	Core Carbon Principles
CCT	Controlled Cooking Test
CLEAR	Comprehensive Lowered Emissions Assessment and Reporting Methodology
CP	Crediting Period
dMRV	Digital Monitoring, Reporting, and Verification
EF	Emission Factor
EPC	Electric Pressure Cooker
ER	Emission Reduction
ICVCM	Integrity Council for the Voluntary Carbon Markets
IDC	Induction Cookstove
KPT	Kitchen Performance Test
LPG	Liquified Petroleum Gas
MECS	Modern Energy Cooking Services
MMECD	Methodology for Metered and Measured Energy Cooking Devices
NCV	Net Calorific value
SC	Specific Energy Consumption
SFC	Specific Fuel Consumption
SUM	Stove Use Monitor
TCS	Traditional Charcoal Stove
TPDDTEC	Technologies and Practices to Displace Decentralized Thermal Energy Consumption
TSF	Traditional Firewood Stove
WBT	Water Boiling Test

Executive Summary

This report examines the Methodology for Metered & Measured Energy Cooking Devices (MMECD) version 1.2 approved by the Gold Standard in 2022, designed to generate Emission Reduction (ER) calculations for electric cooking devices. While many market stakeholders[1] recognize this methodology as most aligned with the requirements set out by Core Carbon Principles (CCP) by Integrity Council for the Voluntary Carbon Markets (ICVCM), there may be opportunities to refine and clarify the uncertainties in the interpretation for the users on how best to apply the methodological framework. This would further enhance the methodology's environmental integrity, precision, accuracy, and quality of the resulting emission reductions.

The primary objective of this study is to improve the understanding and application of the MMECD methodology to identify whether and how it can be further improved. Through a comparative analysis of MMECD with other methodologies such as Technologies and Practices to Displace Decentralized Thermal Energy Consumption (TPDDTEC) v4.0 and draft Comprehensive Lowered Emissions Assessment and Reporting Methodology (CLEAR), the study identifies and interprets key differences in carbon credit generation for Induction Cookstoves (IDC) and Electric Pressure Cookers (EPC) under various scenarios. The review of the Controlled Cooking Test (CCT) and Kitchen Performance Test (KPT) data from project developers provided useful insights into one example real-world scenario. The data provided was statistically significant and followed the CCT and KPT protocol. While converting the data into usable format to input into ER calculation model, it was found that there was no uniformity in how different projects might interpret and apply this methodology framework. This study deep-dived into the nitty gritty of the methodology starting from understanding the input parameters to how the parameter could be calculated using the data collected from field tests and qualitative surveys. The study highlights areas where the methodology could be strengthened. These refinements will enhance the methodology's rigour, accuracy and environmental integrity, further increasing the quality of the credits generated.

Key findings indicate that the current MMECD methodology indeed provides a robust yet conservative framework that yields high quality ERs with strong environmental integrity, especially in comparison to other methodologies available to the cooking sector. However, improvements could still be made to enhance this sector-best methodology, including refining the sampling requirements and incentivising complete metering/measurement and clarifying how key procedures and inputs can be applied consistently across different projects and project developers (particularly as it relates to electric cooking). To capture these opportunities, the report recommends potential updates to the MMECD methodology, including but not limited to:

- wider applicability of Case 2 of the methodology;
- standardization of CCT data analysis;
- clarification on key input parameters for ER calculation;
- allowing use of default specific energy consumption (SC) values for larger scale projects;
- updating and upward revision of the default charcoal emission factor;
- improvement to the sampling approach;
- incentivizing high metering/measurement rates.

By implementing these recommendations, an updated MMECD methodology can provide an even more robust and credible framework for emission reduction than it already does.

[1] https://abatable.com/blog/which-methodologies-will-help-cookstoves-thrive/

Introduction

In 2022, the Gold Standard approved a new methodology titled "Methodology for Metered & Measured Energy Cooking Devices" (MMECD) version 1.2[2], designed to enhance the framework for ER calculations related to clean cooking devices (including electric cooking technologies). This first-of-its-kind methodology aims to address the displacement of traditional biomass fuel consumption in cooking scenarios. Notably, it introduces an innovative method for improved and clean cookstoves by incorporating specific provisions for Digital Monitoring, Reporting, and Verification (dMRV), which are intended to enhance the robustness and credibility of how ERs from improved and clean cooking have historically been quantified in the cooking sector.

Despite the immediate advantages presented by the MMECD methodology and because of its innovative and frontier nature, project developers have encountered questions in interpreting its provisions and realizing full GHG reduction potential. How these questions are resolved could slow or accelerate the swift deployment of new modern energy cookstove projects.

The study was undertaken to answer a few of those critical questions encountered by project developers and to provide actionable steps to further improve the MMECD methodology, that may ultimately result in more effective deployment of the projects.

Objective of the Study

The primary aim of this study is to improve the understanding and application of the MMECD methodology by ensuring consistent and the most effective implementation in real-world contexts. The study performed a comparative analysis between various crediting methodologies available for the cooking sector to evaluate the performance of MMECD against the other existing methods. The report also suggests practical recommendations aimed at improving/refining the MMECD methodology that may be raised through Technical Clarification Requests or other processes used to revise GS-approved methodologies. Additionally, the study has proposed interventions to minimize risks of under- or over-crediting within the current methodology without necessitating modifications.

The main activities conducted to achieve the abovementioned objectives are listed below:

[2] https://globalgoals.goldstandard.org/431_ee_ics_methodology-for-metered-measured-energy-cooking-devices/

Activity 1

Conduct a comparative and robust assessment of cookstove carbon crediting methodologies

- Comparative assessments of carbon credit generation of inducation cookstove (IDC) and electric pressure cooker (EPC) under MMECD (Case 1 & Case 2), TPDDTEC V.4 and CLEAR Methodology
- Review CCT and KPT data provided by MECS and project developers to assist in the comparison of Emission Reductions generated by methodology type, and in particular to review MMECD Case 2
- Identification of differences in the emission reduction generation under the methodologies and provide a detailed assessment of the variances in crediting scenarios against the MMECD methodology

Activity 2

Review key MMECD methodology default values and cross check the reference values provided.

- Examine the default specific energy consumption (SC) ratios in the MMECD methodology for microscale using the CCT data provided by project developers to check the applicability of default values for small and large-scale projects
- Review the emissions factors provided as default, with specific reference to the CO_2 & Non-CO_2 emissions for charcoal production and combustion – providing clarity on which of the default options provided are applicable to project developers who have charcoal baseline fuels

Activity 3

Compile recommendations for methodology improvements based on feedback from project developers.

- Review of sampling approach and requirement for ground truthing data
- Detailed report with recommendations from the above study

Methodology

A mixed-method approach was utilized to thoroughly evaluate the MMECD v1.2[3], TPDDTEC v4.0[4] and CLEAR (draft version)[5] methodologies. By combining qualitative and quantitative analyses, this approach provided a comprehensive understanding of the opportunities for improvement within the existing framework.

To gain practical insights, a case study of electric cooking projects in Ghana was examined to identify how the current MMECD methodology would be applied in a real project scenario. Controlled Cooking Test (CCT) and Kitchen Performance Test (KPT) results were analysed. Based on the pathways outlined in the three methodologies, final ER calculation models were created.

The study included the following approaches which have been discussed in detail below:

Literature Review

Review of existing literature in scientific journals on the analysis of CCT data, energy use by different cooking devices, sampling best practices, ER methodologies, and electric cooking technologies, was conducted. The search strategy thoroughly examined energy use by different cooking devices and their impacts on emissions and baseline fuel displacement. This included review of relevant peer-reviewed research articles. The review also scrutinized guidance on sampling approaches used in evaluating cooking technologies to ensure that the data collected was representative and reliable. Key sources included recent studies and seminal works that have shaped current understanding in this field.

Data Collection and Analysis

Analysis of cooking diary, CCT and KPT data which included dish type and cooking frequencies, stove type, energy & fuel consumption, cooking performance under controlled conditions, and real-world kitchen scenarios and performance metrics, was undertaken to evaluate the back-calculation approach in the MMECD methodology in real-world scenarios.

- Controlled Cooking Test and cooking diary

The controlled cooking test (CCT) is designed to assess the performance of an improved or clean stove relative to the common or traditional stove(s) that the improved/clean model is meant to replace. Stoves are compared as they perform a standard cooking task that is closer to the actual cooking that local people do every day.

The CCT template (figure 1 below) was designed as per the CCT protocol version 2.0[6] by Clean Cooking Alliance (CCA). The equations had to be updated based on latest updates and feedback from project developers. The parameters considered and modified are listed below:

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3 Methodology for metered & measured energy cooking devices
4 Reduced emissions from cooking and heating –TPDDTEC
5 https://cleancooking.org/wp-content/uploads/2024/07/CLEAR-methodology-public-review.pdf
6 https://cleancooking.org/binary-data/DOCUMENT/file/000/000/80-1.pdf

I. For baseline stove/fuel – firewood, charcoal, and LPG

Specific fuel consumption (SFC) – This is the principal indicator of stove performance for the CCT. It tells the tester the quantity of fuel required to cook a given amount of food for the "standard cooking task." It is calculated as a simple ratio of fuel to food:

$$SFC = \frac{f_d}{W_f} X\ 1000 \qquad \text{Eq.1}$$

Where,

f_d	=	Equivalent dry fuel consumed in grams
W_f	=	Total weight of food cooked

Equivalent dry fuel consumed (f_d) – This is defined as per the Water Boiling Test (WBT), adjusting for fuel that was burned to account for two factors: (1) the wood that must be burned to vaporize moisture in the wood and (2) the amount of char remaining unburned after the cooking task is complete. The calculation is done in the following way:

For firewood - $f_d = (f_f - f_i) * (1 - (1.12*m)) - 1.5*\Delta C_c$ Eq.2

For charcoal - $f_d = (f_f - f_i) * (1 - (1.08*m)$[7]

For LPG - $f_d = (f_f - f_i)$

Where,

f_f	=	Initial weight of fuelwood (wet basis) in grams
f_i	=	Final weight of fuelwood (wet basis) in grams
ΔC_c	=	Weight of char remaining
1.5	=	losses and inefficiencies inherent in the process of converting wood to charcoal.
1.12	=	Conversion factor for wet to dry basis wood weight
1.08	=	Due to differences in the energy content between charcoal and wood, the coefficient of 1.12 is replaced with 1.08
m	=	Moisture content of wood

However, the above equation was updated for firewood and charcoal in line with the latest Water Boiling Test (WBT) protocol version 4.2.3[8] by CCA.

$$f_d = \frac{f_{cm}\ X\ \left(LHV(1-MC) - MC(4.186(T_b - T_a) + 2{,}257)\right) - \Delta C_C\ X\ LHV_{char}}{LHV} \qquad \text{Eq.3}$$

Where,

f_d	=	Equivalent dry fuel consumed (grams)
f_{cm}	=	Fuel consumed, moist (grams)
LHV	=	Net calorific value of fuel (kJ/Kg)
LHV_{char}		Net calorific value of char (kJ/Kg)

[7] https://www.osti.gov/servlets/purl/1050448
[8] https://cleancooking.org/research-evidence-learning/standards-testing/protocols/

ΔC_c	=	Change in char during test (grams)
T_b - T_a	=	Temperature difference between initial and boiling point of water (°C)
2,257	=	Latent Heat of Vaporization for water
4.186	=	Specific heating capacity of water
MC	=	Moisture content of fuel

Variables specific to the water component were removed from the equation:

$$f_d = \frac{f_{cm} X(LHV(1-MC)) - \Delta C_C\ X\ LHV_{char}}{LHV} \quad \text{Eq.4}$$

Total weight of food cooked (W_f) – This is the final weight of all food cooked; it is simply calculated by subtracting the weight of the empty pots from the pots and food after the cooking task is complete:

$$W_f = \sum_{j=1}^{4}(Pj_f - Pj) \quad \text{Eq.5}$$

Where j is an index for each pot (up to four)

Specific Energy consumption (SC): This is calculated by multiplying the specific fuel consumption (SFC) and net calorific value (NCV) of the fuel.

The value of NCV for different fuel were sourced from IPCC[9]:

Net Calorific Value (NCV)	Value (TJ/tonne)	Value (KJ/Kg)
Wood	0.0156	15600
Charcoal	0.0295	29500
LPG	0.0473	47300

Table 1: Net Calorific Value of different fuels

MANDATORY PARAMETERS											NON MANDATORY PARAMETERS (Only if you use the same pots and							
Stove type 1 (name)		Fuelwood			Weight of char remaining			$f_{cd} = \frac{f_{cm}(LHV(1-MC) - MC(4.186(T_b - T_a) + 2.257)) - \Delta c_c \cdot LHV_{char}}{LHV}$			Weight of food cooked			Cooking duration			Specific Fuel Consumption (gm/kg of cooked food)	Specific Energy consumption (SC) in MJ/Kg of food cooked
											Pot 1		Total weight of food cooked					
Ambient temp: Wind condition:		Initial Wt of wood_wet basis (gms)	Final wt of wood_wet basis (gms)	MC of wood	Char container weight (gms)	Char container + char weight (gms)	Weight of char remaining			WBT formula modified latent heat value 4.186, temp and enthalpy of water removed	Empty weight of pot (gms)	Weight of pot + cooked food (gms)		Start time (mins)	End time (mins)	Total cooking time		
Standard meal	No of Test	f_i	f_f	(m)	k	C_c	Δ Cc = Cc – k	Δ Cc*15600	fcm = ff - fi	fcd = fcm (LHV(1-MC)-Δ Cc*LHV char/ LHV	P1	$P1_f$	$W_f = \sum_{j=1}^{4}(Pj_f - Pj)$	t_i	t_f	$\Delta t = t_f - t_i$	SC = fcd/Wf *1000	Ec=((SC/1000)*LHV)/1000
Milo	Test 1	0	355	0.1			0	0	355	313.7	0	1485	1485		7	7	211.23	3.30
	Test 2	0	419	0.1			0	0	419	370.2	0	1447	1447		10	10	255.86	3.99
	Test 3	0	468	0.1			0	0	468	413.5	0	1438	1438		13	13	287.57	4.49
Porridge	Test 1	0	913	0.1			0	0	913	806.7	0	2004	2004		26	26	402.56	6.28
	Test 2	0	1028	0.1			0	0	1028	908.4	0	1697	1697		36	36	535.27	8.35
	Test 3	0	637	0.1			0	0	637	562.9	0	1844	1844		20	20	305.24	4.76
Banku	Test 1	0	1224	0.1			0	0	1224	1081.5	0	1682	1682		18	18	643.01	10.03
	Test 2	0	1066	0.1			0	0	1066	941.9	0	1497	1497		18	18	629.21	9.82
	Test 3	0	1062	0.1			0	0	1062	938.4	0	1634	1634		27	27	574.29	8.96
Ampesi	Test 1	0	1558	0.1			0	0	1558	1376.7	0	2186	2186		39	39	629.76	9.82
	Test 2	0	1514	0.1			0	0	1514	1337.8	0	2090	2090		30	30	640.09	9.99
	Test 3	0	1481	0.1			0	0	1481	1308.6	0	1772	1772		28	28	738.50	11.52

Figure 1: CCT data template for baseline fuel

[9] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_1_Ch1_Introduction.pdf

II. For project stove/fuel – Electricity

Considering the project fuel directly measures the quantity of energy use in kWh, the above equations were modified as below:

$$SC = \frac{E_c}{W_f} X\ 1000 \qquad \text{Eq.6}$$

Where,

E_c	=	Amount of energy consumed in MJ
W_f	=	Total weight of food cooked

Amount of energy consumed (E_c) – This is defined as amount of energy consumed by the cooking devices to undertake the cooking task. The calculation is done in the following way:

$$E_c = E_{total}\ x\ 3.6 \qquad \text{Eq.7}$$

Where,

E_{total}	=	Amount of energy consumed in kWh
3.6	=	Conversion factor (kWh to MJ)

	MANDATORY PARAMETERS					NON MANDATORY PARAMETERS (Only if you use the same pots and same quantity of ingredients for a given dish for a given test across all stove types)												
Stove type 2 (name)		Induction Cookstoves		Energy Consumed (kWh)	Energy Consumed (MJ)	Weight of food cooked									Cooking duration			Specific Energy consumption (SC) in MJ/Kg of food cooked
						Pot 1		Pot 2		Pot 3		Pot 4		Total weight of food cooked				
Ambient temp: Wind condition:		Initial Meter Reading (kWh)	Final Meter Reading (kWh)			Empty weight of pot (gms)	Weight of pot + cooked food (gms)	Empty weight of pot (gms)	Weight of pot + cooked food (gms)	Empty weight of pot (gms)	Weight of pot + cooked food (gms)	Empty weight of pot (gms)	Weight of pot + cooked food (gms)		Start time (mins)	End time (mins)	Total cooking time	
Meal/ day	No of Test	E_i	E_f	E_{total}	$Ec=E_{total}$*Converstion Contant	P1	$P1_f$	P2	$P2_f$	P3	$P3_f$	P4	$P4_f$	$W_f = \sum_{j=1}^{4}(Pj_f - Pj)$	t_i	t_f	$\Delta t = t_f - t_i$	$SC = E_c/W_f$ *1000
Milo	Test 1	0	0.179	0.179	0.6444	0	1472							1472		6	6	0.4378
	Test 2	0	0.166	0.166	0.5976	0	1479							1479		8	8	0.4041
	Test 3	0	0.164	0.164	0.5904	0	1492							1492		7	7	0.3957
Porridge	Test 1	0	0.288	0.288	1.0368	0	1911							1911		18	18	0.5425
	Test 2	0	0.251	0.251	0.9036	0	1826							1826		16	16	0.4949
	Test 3	0	0.268	0.268	0.9648	0	1616							1616		17	17	0.5970
Banku	Test 1	0	0.275	0.275	0.99	0	1521							1521		22	22	0.6509
	Test 2	0	0.285	0.285	1.026	0	1702							1702		23	23	0.6028
	Test 3	0	0.286	0.286	1.0296	0	1681							1681		20	20	0.6125
Ampesi	Test 1	0	0.303	0.303	1.0908	0	2383							2383		19	19	0.4577

Figure 2: CCT data for project fuel

The process of data collection for CCT and cooking diary has been explained below:

- A qualitative survey was conducted across 69 randomly selected households across all 16 regions of Ghana - Northern, Bono, Upper West, Ashanti, Greater Accra, Ahafo, Western, Bono East, Western North, Oti, North East, Upper East, Central, Volta, Eastern, Savannah. The objective of the survey was to understand the cooking characteristics of the population and create a cooking diary. The survey was conducted in the Q2 of calendar year 2024. The sample size was calculated using the CDM Sampling and Survey for project activity and programme of activity.

- The qualitative survey captured the cooking behaviour of the 69 households over a 2-week period. This helped in identifying the most common dishes being cooked across the country. Total of 34 dishes were found to be cooked by the households across the 2-week period. As per parameter table MECD7 and 8 of MMECD, CCT shall be designed so that it captures a cooking pattern representative of a whole year using a reasonable number of dishes expected to be most cooked in the project device. Hence, 13 dishes were picked for IDC and 4 dishes for EPC.

- In line with CCT protocol, each of the dishes was cooked at least 3 times per stove type.

	Traditional Firewood Stove	Traditional Charcoal Stove	LPG Single Burner	Induction cookstove	Electric Pressure Cooker	Total
Porridges (oat, rice, corn)	3	3	3	3		12
Tomato Stew	3	3	3	3		12
Beverages (Tea, Chocolate/milo, coffee)	3	3	3	3		12
Banku	3	3	3	3		12
Ampesi (plantain, Yam, cassava)	3	3	3	3	3	15
Plain Rice	3	3	3	3	3	15
Groundnut Soup	3	3	3	3		12
Touzaffi	3	3	3	3		12
Okra soup	3	3	3	3		12
Light soup	3	3	3	3	3	15
Jollof rice	3	3	3	3		12
Garden egg stew	3	3	3	3		12
Rice & Beans	3	3	3	3	3	15
Total	**39**	**39**	**39**	**39**	**12**	**168**

Table 2: CCT conducted on each stove/fuel combination

The qualitative data and the CCT data were used in combination to arrive at various input parameters required for ER calculation such as specific energy consumption used in baseline and project scenario, amount of baseline fuel used in baseline device and proportion of cooking of baseline device required to complete the ER calculations across the methodologies.

To derive the above-mentioned parameter values for each stove/fuel combination using CCT data and cooking diary, a step wise approach was devised:

Step 1: From the cooking diary, the daily probability of cooking a dish was calculated using the total number of times a particular dish was cooked divided by total number of times all the dishes were cooked over a 2-week period. Same approach was used to calculate the percentage of cooking device type used to cook a dish in the baseline.

Step 2: The CCT results were used to derive the average specific energy consumption for each dish across stove/fuel combinations.

Step 3: The fuel consumption values were derived from the CCT data sheet using the equivalent dry fuel weight.

After extracting the above values from the cooking diary and CCT data, the parameter values were calculated as follows:

Parameter	Calculation approach
Specific Energy Consumption – baseline and project	The specific energy consumption for each stove type (TCS, TSF, LPG) was weighted by the daily average probability of a dish being cooked by each stove/fuel combination. For e.g. as per figure 3 below, to calculate SC for TSF, row 7 was weighted by row 3.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1			Rank-1	Rank-2	Rank-3	Rank-4	Rank-5	Rank-6	Rank-7	Rank-8	Rank-9	Rank-10	Rank-11	Rank-12	Rank-13
2			**Porridges (oat, rice, corn)**	**Tomato Stew**	**Beverages (Tea, Chocolate/milo,coffee)**	**Banku**	**Ampesi (plantain, Yam, cassava)**	**Plain Rice**	**Groundnut Soup**	**Touzaffi**	**Okra soup**	**Light soup**	**Jollof rice**	**Garden egg stew**	**Rice & Beans**
3		Daily Average Probability	12.64%	11.83%	12.45%	9.75%	9.32%	8.52%	7.38%	6.58%	6.44%	5.87%	4.54%	2.37%	2.32%
4	Step 1	Traditional Firewood Stove (TFS)	1%	1%	0%	2%	1%	1%	1%	2%	1%	1%	0%	0%	1%
5		Traditional Charcoal Stove (TCS)	9%	9%	9%	7%	7%	7%	6%	5%	5%	5%	4%	2%	1%
6		LPG Single Burner (LPG)	2%	2%	3%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%
7	Step 2	$SC_{b,TFS}$ (MJ/Kg)	6.46	24.98	3.92	9.60	10.44	9.54	21.43	10.49	23.07	14.50	12.04	22.32	13.46
8		$SC_{b,TCS}$ (MJ/Kg)	8.46	19.71	5.70	7.52	7.08	5.39	12.46	6.52	8.83	11.02	9.75	31.89	8.74
9		$SC_{b,LPG}$ (MJ/Kg)	1.08	5.11	0.79	1.64	1.96	1.70	9.15	2.21	6.45	3.80	4.93	4.91	4.74
10		$SC_{p,induction}$ (MJ/Kg)	0.545	0.965	0.413	0.622	0.468	0.604	1.549	0.500	0.641	0.780	0.913	1.337	0.829
11	Step 3	Firewood consumption (tons)	0.0182	0.0303	0.0033	0.0484	0.0295	0.0246	0.0416	0.0517	0.0619	0.0223	0.0056	0.0000	0.0323
12		Charcoal consumption (tons)	0.0816	0.0939	0.0511	0.0582	0.0707	0.0679	0.0801	0.0468	0.0522	0.0512	0.0475	0.0208	0.0223
13		LPG consumption (tons)	0.0018	0.0029	0.0018	0.0009	0.0019	0.0008	0.0023	0.0001	0.0008	0.0010	0.0013	0.0001	0.0004

Figure 3: Calculation approach for SC

Parameter	Calculation approach
Proportion of cooking conducted on baseline device	The parameter value was calculated using the data from step 1. For e.g. as per figure 4 below, proportion of cooking conducted on TSF is calculated as sum of row 4.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1			Rank-1	Rank-2	Rank-3	Rank-4	Rank-5	Rank-6	Rank-7	Rank-8	Rank-9	Rank-10	Rank-11	Rank-12	Rank-13
2			**Porridges (oat, rice, corn)**	**Tomato Stew**	**Beverages (Tea, Chocolate/milo,coffee)**	**Banku**	**Ampesi (plantain, Yam, cassava)**	**Plain Rice**	**Groundnut Soup**	**Touzaffi**	**Okra soup**	**Light soup**	**Jollof rice**	**Garden egg stew**	**Rice & Beans**
3		Daily Average Probability	12.64%	11.83%	12.45%	9.75%	9.32%	8.52%	7.38%	6.58%	6.44%	5.87%	4.54%	2.37%	2.32%
4	Step 1	Traditional Firewood Stove (TFS)	1%	1%	0%	2%	1%	1%	1%	2%	1%	1%	0%	0%	1%
5		Traditional Charcoal Stove (TCS)	9%	9%	9%	7%	7%	7%	6%	5%	5%	5%	4%	2%	1%
6		LPG Single Burner (LPG)	2%	2%	3%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%
7	Step 2	$SC_{b,TFS}$ (MJ/Kg)	6.46	24.98	3.92	9.60	10.44	9.54	21.43	10.49	23.07	14.50	12.04	22.32	13.46
8		$SC_{b,TCS}$ (MJ/Kg)	8.46	19.71	5.70	7.52	7.08	5.39	12.46	6.52	8.83	11.02	9.75	31.89	8.74
9		$SC_{b,LPG}$ (MJ/Kg)	1.08	5.11	0.79	1.64	1.96	1.70	9.15	2.21	6.45	3.80	4.93	4.91	4.74
10		$SC_{p,induction}$ (MJ/Kg)	0.545	0.965	0.413	0.622	0.468	0.604	1.549	0.500	0.641	0.780	0.913	1.337	0.829
11	Step 3	Firewood consumption (tons)	0.0182	0.0303	0.0033	0.0484	0.0295	0.0246	0.0416	0.0517	0.0619	0.0223	0.0056	0.0000	0.0323
12		Charcoal consumption (tons)	0.0816	0.0939	0.0511	0.0582	0.0707	0.0679	0.0801	0.0468	0.0522	0.0512	0.0475	0.0208	0.0223
13		LPG consumption (tons)	0.0018	0.0029	0.0018	0.0009	0.0019	0.0008	0.0023	0.0001	0.0008	0.0010	0.0013	0.0001	0.0004

Figure 4: Calculation approach for proportion of cooking on baseline device

Parameter	Calculation approach
Amount of baseline fuel used in baseline device	The amount of baseline fuel used in baseline device was calculated by using the data from step 3. For e.g. as per figure 5 below, amount of firewood consumption is calculated as sum of row 11.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1			Rank-1	Rank-2	Rank-3	Rank-4	Rank-5	Rank-6	Rank-7	Rank-8	Rank-9	Rank-10	Rank-11	Rank-12	Rank-13
2			**Porridges (oat, rice, corn)**	**Tomato Stew**	**Beverages (Tea, Chocolate/milo,coffee)**	**Banku**	**Ampesi (plantain, Yam, cassava)**	**Plain Rice**	**Groundnut Soup**	**Touzaffi**	**Okra soup**	**Light soup**	**Jollof rice**	**Garden egg stew**	**Rice & Beans**
3		Daily Average Probability	12.64%	11.83%	12.45%	9.75%	9.32%	8.52%	7.38%	6.58%	6.44%	5.87%	4.54%	2.37%	2.32%
4	Step 1	Traditional Firewood Stove (TFS)	1%	1%	0%	2%	1%	1%	1%	2%	1%	1%	0%	0%	1%
5		Traditional Charcoal Stove (TCS)	9%	9%	9%	7%	7%	7%	6%	5%	5%	5%	4%	2%	1%
6		LPG Single Burner (LPG)	2%	2%	3%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%
7	Step 2	$SC_{b,TFS}$ (MJ/Kg)	6.46	24.98	3.92	9.60	10.44	9.54	21.43	10.49	23.07	14.50	12.04	22.32	13.46
8		$SC_{b,TCS}$ (MJ/Kg)	8.46	19.71	5.70	7.52	7.08	5.39	12.46	6.52	8.83	11.02	9.75	31.89	8.74
9		$SC_{b,LPG}$ (MJ/Kg)	1.08	5.11	0.79	1.64	1.96	1.70	9.15	2.21	6.45	3.80	4.93	4.91	4.74
10		$SC_{p,induction}$ (MJ/Kg)	0.545	0.965	0.413	0.622	0.468	0.604	1.549	0.500	0.641	0.780	0.913	1.337	0.829
11	Step 3	Firewood consumption (tons)	0.0182	0.0303	0.0033	0.0484	0.0295	0.0246	0.0416	0.0517	0.0619	0.0223	0.0056	0.0000	0.0323
12		Charcoal consumption (tons)	0.0816	0.0939	0.0511	0.0582	0.0707	0.0679	0.0801	0.0468	0.0522	0.0512	0.0475	0.0208	0.0223
13		LPG consumption (tons)	0.0018	0.0029	0.0018	0.0009	0.0019	0.0008	0.0023	0.0001	0.0008	0.0010	0.0013	0.0001	0.0004

Figure 5: Calculation approach for amount of baseline fuel consumption

The final parameter values have been listed in tables below[10]:

Specific Energy Consumption (MJ/Kg of food)	IDC	EPC
$SC_{b,TSF}$	12.98	11.33
$SC_{b,TCS}$	9.93	7.56
$SC_{b,LPG}$	3.24	2.54
SC_p	0.72	0.47

Table 3: SC_b and SC_p input values

Proportion of baseline fuel (%)	IDC	EPC
u_{TSF}/fC_{TSF}	13%	13%
u_{TCS}/fC_{TCF}	75%	79%
u_{LPG}/fC_{LPG}	12%	9%

Table 4: Proportion of baseline fuel

Baseline fuel consumption (tonne)	IDC	EPC
$P_{b,wood,TSF}$	0.3697	0.1087
$P_{b,charcoal,TCS}$	0.7442	0.2121
$P_{b,LPG}$	0.0162	0.0042

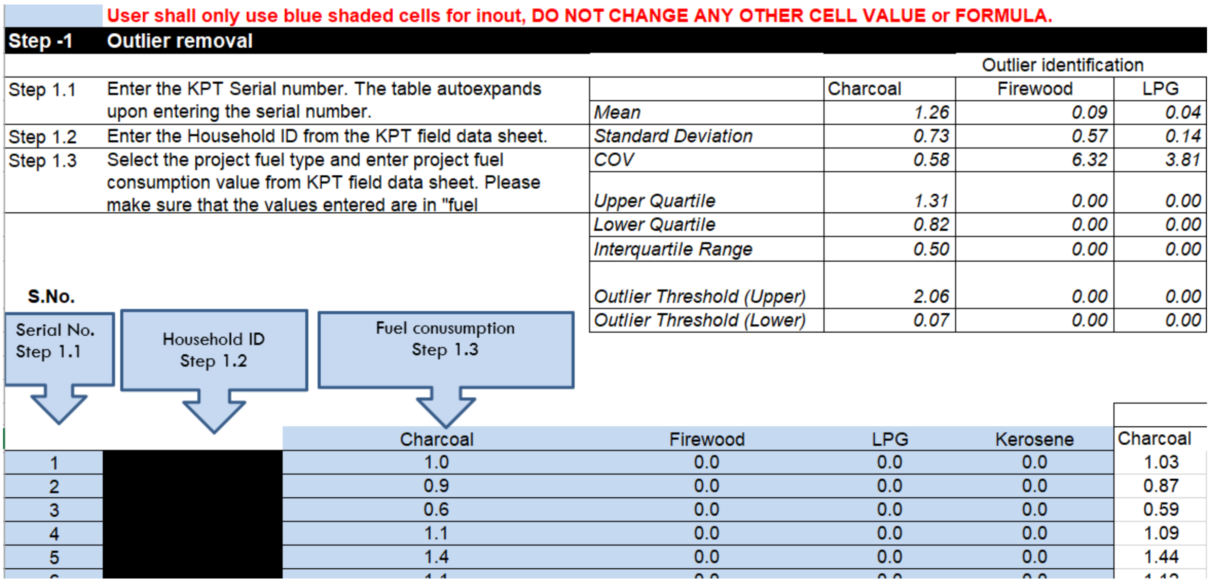
Table 5: Amount of baseline fuel from CCT

- Kitchen Performance Test (KPT)

The KPT is the principal field–based procedure to demonstrate the effect of stove interventions on household fuel consumption. There are two main goals of the KPT: (1) to assess qualitative aspects of stove performance through household surveys and (2) to compare the impact of project stove(s) on fuel consumption in the kitchens of real households. To meet these aims, the KPT includes quantitative surveys of fuel consumption and qualitative surveys of stove performance and acceptability.

The KPT data was available for 9 countries which were conducted in Q3 of calendar year 2023. However, for parity, only data from Ghana was used for this study. The KPT was conducted across 128 households across all the regions of Ghana. The sample size was calculated in line with the KPT protocol[11]. As per the protocol, the fuel measurement was done for 4 consecutive days (avoiding weekends, festivities, and public holidays). The baseline fuel consumption (tonnes/capita/day) on dry basis (adjusted for moisture) was derived from the KPT sheet after removing the outliers. This value was then used for the calculation and comparison of ERs. For the project fuel consumption especially to capture stove stacking, estimated values were used for the purpose of the study based on available project KPT data and local experience of the developer.

[10] The parameter notation may vary based on the methodology.
[11] https://cleancooking.org/binary-data/DOCUMENT/file/000/000/604-1.pdf



User shall only use blue shaded cells for inout, DO NOT CHANGE ANY OTHER CELL VALUE or FORMULA.

Step -1 Outlier removal

Step 1.1	Enter the KPT Serial number. The table autoexpands upon entering the serial number.
Step 1.2	Enter the Household ID from the KPT field data sheet.
Step 1.3	Select the project fuel type and enter project fuel consumption value from KPT field data sheet. Please make sure that the values entered are in "fuel

Outlier identification

	Charcoal	Firewood	LPG
Mean	*1.26*	*0.09*	*0.04*
Standard Deviation	*0.73*	*0.57*	*0.14*
COV	*0.58*	*6.32*	*3.81*
Upper Quartile	*1.31*	*0.00*	*0.00*
Lower Quartile	*0.82*	*0.00*	*0.00*
Interquartile Range	*0.50*	*0.00*	*0.00*
Outlier Threshold (Upper)	*2.06*	*0.00*	*0.00*
Outlier Threshold (Lower)	*0.07*	*0.00*	*0.00*

S.No.

Serial No. Step 1.1 | Household ID Step 1.2 | Fuel consumption Step 1.3

S.No.	Household ID	Charcoal	Firewood	LPG	Kerosene	Charcoal
1	[redacted]	1.0	0.0	0.0	0.0	1.03
2		0.9	0.0	0.0	0.0	0.87
3		0.6	0.0	0.0	0.0	0.59
4		1.1	0.0	0.0	0.0	1.09
5		1.4	0.0	0.0	0.0	1.44

Figure 6: KPT data template

The baseline fuel consumption value derived from the KPT sheet for Ghana:

Baseline fuel consumption (tonne)	**Values**
$P_{b,wood}$	-
$P_{b,charcoal}$	0.9416
$P_{b,LPG}$	0.0502

Table 6: Amount of baseline fuel from KPT

Peer Feedback

In the current study, data was systematically collected and analyzed. Preliminary findings were presented to a broader group of project developers, and the feedback received were integrated to enhance the robustness of the study. This iterative process ensured that the findings are reflective of expert insights, thereby strengthening the overall quality and credibility of the research.

Limitations of the study

As part of the current study, CCT and KPT data for only one country was used, which may not be representative of the diverse cooking patterns and practices across the continent. However, the data from one country provides sufficient evidence to recommend potential updates to MMECD. Additionally, the KPT data for the baseline fuel consumption was available only for charcoal and LPG. However, as per the cooking diary, 13% of the households were using firewood. Therefore, to ensure parity in calculation, the ER calculation was also done using CCT data. Lastly, there were certain assumptions made for the other project fuel consumption specifically for pathways using KPT data to capture stove stacking. The assumptions were made based on the project KPT data and local experience of the project developer.

Results and Analysis

Activity 1

The aim of the first activity was to:

- evaluate the difference between MMECD Case 1 and Case 2 for IDC;
- identify the differences in the emissions reduction generation under MMECD, TPDDTEC and CLEAR and provide a detailed assessment of the variances in crediting scenarios against the MMECD methodology

The goal was to identify strengths and opportunities for improvement, ensuring that the MMECD methodology continues to provide an accurate, credible, and efficient framework for ER crediting.

Difference between MMECD Case 1 & Case 2 for IDC:

A detailed comparative assessment of ER calculations for Induction Cookstove (IDC) using MMECD Case 1 and Case 2 was performed. This assessment included a review of baseline scenarios, analysis of CCT and KPT data, and calculation of input parameters required for the ER calculation.

Under the current version of the MMECD methodology, baseline emissions shall be determined based on the characteristics of the technology to be implemented:

Case 1 shall be used for project devices where it is possible to determine the thermal efficiency and to know the useful energy that is being replaced.

Case 2 shall be used for project devices with additional characteristics that affect the cooking energy consumption, e.g. pressure, and it is not possible to determine thermal efficiency or useful energy by methods such as the Water Boiling Test (WBT). One example cited under Case 2 is EPC.

The example provided in Case 2 has introduced ambiguity among project developers regarding its applicability to other cooking devices. The analysis of using Case 2 for IDC was undertaken to demonstrate that a single thermal efficiency value, as required for Case 1 from a WBT, may not accurately reflect the device's high performance. This is because IDC is highly controllable and less susceptible to losses due to user behaviour.

As part of the study, emission reduction for IDC was calculated using both Case 1 and Case 2 to understand if there are any differences in result. The objective of the analysis was to identify the main reasons for differences (if any) in the ER under the two pathways.

Case 1 used KPT data to determine the baseline fuel consumption values for each baseline device/fuel. The current version of the methodology allows multiple options to determine the baseline fuel consumption values – KPT, credible published literature for project region, studies by academia/NGOs/multilateral institutions and official government publications. **Case 2** used CCT data in combination with qualitative data from cooking diary in line with methodology requirement. For the study, ERs were also computed using CCT's fuel consumption data for Case 1 to evaluate their efficacy relative to KPT.

ERs calculated for Induction stove using Case 1 and 2 are summarised below.

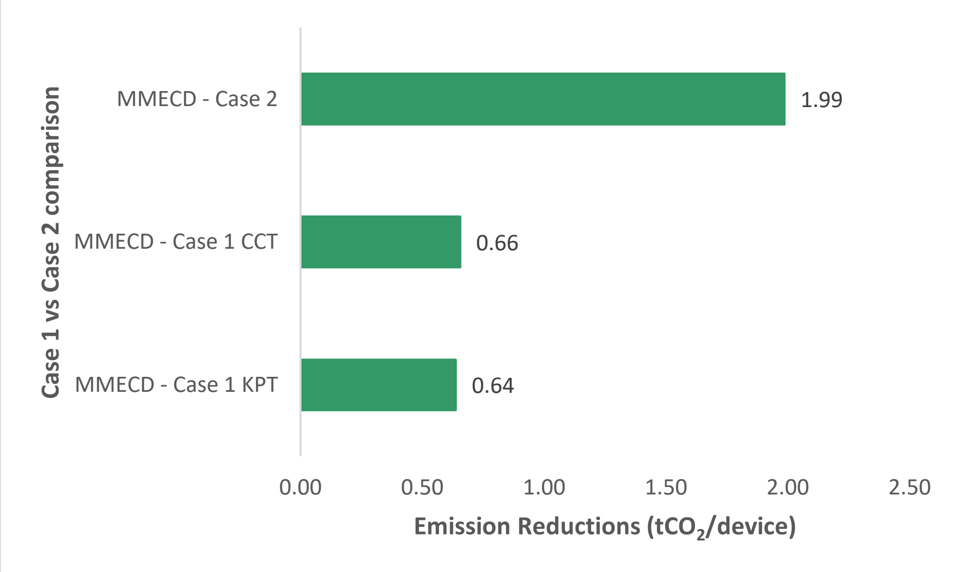


Figure 7: ER for IDC using Case 1 and Case 2

There is a stark difference between emission reductions calculated using Case 1 and Case 2 for induction stoves. This led to a deeper analysis to understand the reasons for such a huge difference. Firstly, it is critical to understand the difference in the calculation approach between Case 1 and Case 2 as per the MMECD methodology.

As stated above, equation for Case 1 uses the concept of useful energy for determination of baseline emissions. Useful energy is calculated using the total energy output multiplied by efficiency of the stove. The premise of the MMECD methodology is the back calculation approach which calculates baseline emissions avoided by determining the amount of useful energy required for the baseline technology(ies) to provide the same level of useful energy as the project technology according to its metered energy consumption. Hence, Case 1 effectively uses the ratio of stove efficiencies between project and baseline to determine baseline emissions. However, Case 2 uses the total energy output instead of useful energy to determine the baseline emissions. This estimation is done using specific energy consumption. Specific energy consumption (SC) refers to the amount of energy a stove consumes to perform a specific cooking task. Hence case 2 effectively uses the ratio of SC between project and baseline to determine baseline emissions.

For project devices where cooking energy is influenced by factors such as temperature control, fast heat transfer between stove and utensil, even heat distribution across pans and/or cooking at pressure, the approach used in Case 1 does not accurately represent the performance of the stove. Using a single thermal efficiency value derived from simmering water for such high performing devices disincentivizes projects by not providing correct emission reduction estimation. The graph in figure 7 precisely establishes the fact, based on detailed example KPT and CCT data. The study was carried out by using induction stove as an example however, similar arguments for the appropriateness of case 2 are applicable to all project devices that have additional characteristics mentioned above which influence the cooking energy.

Comparison of MMECD with TPDDTEC and CLEAR:

The pathways included in the study have been explained below:

- MMECD Case 1 – back-calculation using fuel consumption value derived from KPT (MMECD-Case 1 KPT). For parity in comparison, fuel consumption derived from CCT (MMECD-Case 1 CCT) was also used which is explained in the limitation of the study.

- MMECD Case 2 – back-calculation using specific energy consumption derived from CCT (MMECD-Case 2)

- TPDDTEC v4.0 method 3 which is used when baseline and project fuels are different and emission reductions are from fuel switch and efficiency gains. For this, analysis was done using fuel consumption data from KPT, and for IDC with CCT data too (TPDDTEC-KPT and TPDDTEC-CCT)

- CLEAR
  - Metered pathway – using baseline KPT (bKPT), direct measurement for project stove and project KPT (pKPT) for other stoves used in project scenario (CLEAR – M).
  - Metered pathway – back-calculation using specific energy consumption ratio calculated by CCT and direct measurement for project stove (CLEAR – CCT)
  - Non-metered – using bKPT and pKPT for both baseline, project stove and other stoves used in project scenario (CLEAR – nM).

For the analysis, the value of f_{NRB}, amount of electricity consumed by project device, usage/uptake (wherever used) and grid emission factor were kept constant across the different pathways.

Graphical representation of emission reductions for IDC and EPC using different pathways mentioned above is given below:

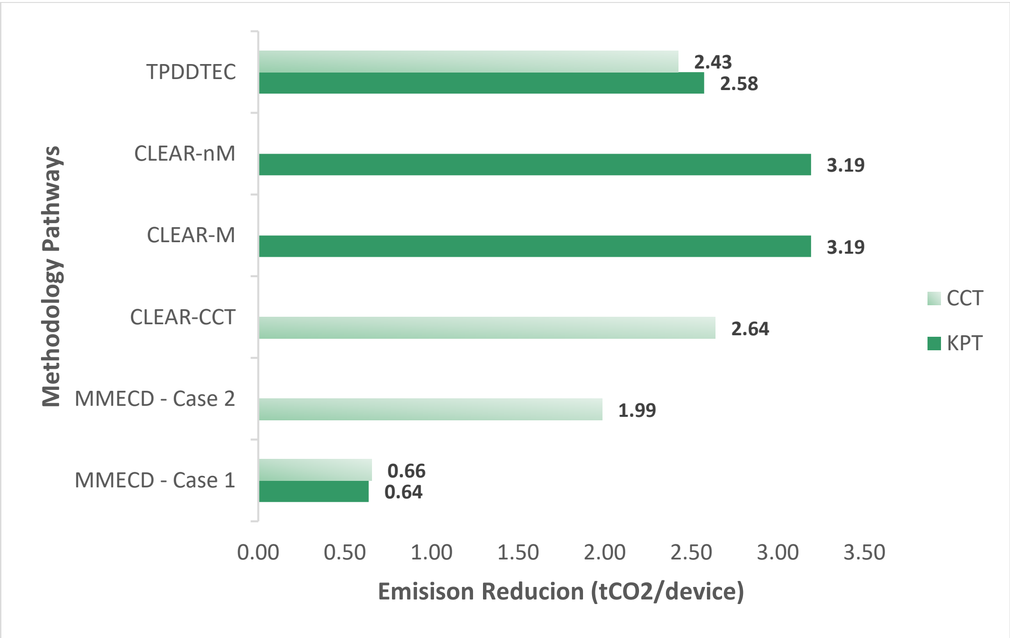


Figure 8: Emission reduction using different pathways for IDC

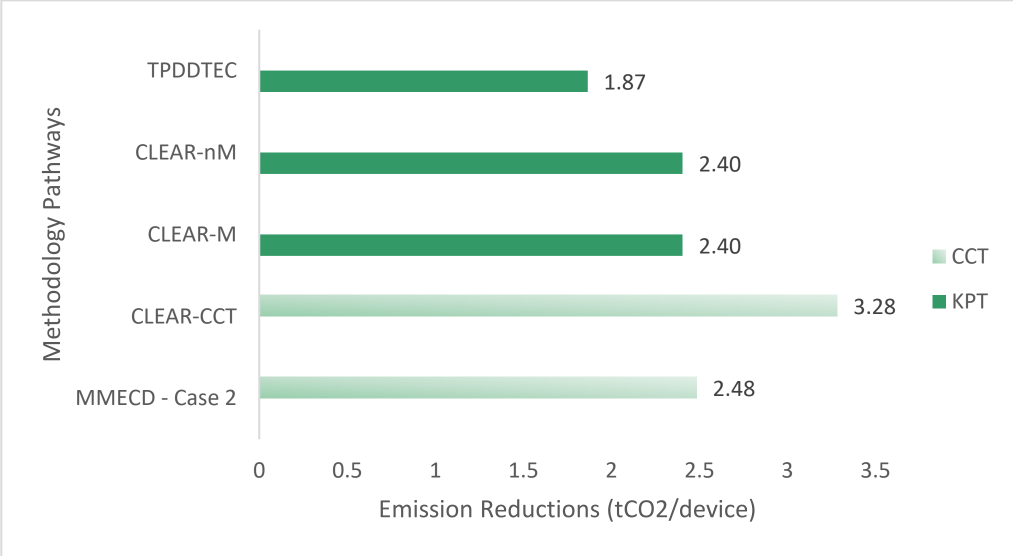


Figure 9: Emission reduction using different pathways for EPC

A systematic comparison of MMECD with each pathway is provided below:

I. MMECD Case 2 versus CLEAR CCT

Both these pathways use back-calculation approach with SC values for ER calculation. All the input parameter values such as baseline fuel consumption, proportion of cooking on baseline stove, f_{NRB}, amount of electricity consumed by project device, usage/uptake and grid emission factor were kept same for both the pathways. However, the ERs from CLEAR CCT was higher than MMECD Case 2 for both IDC and EPC. This is mainly attributed to the higher default charcoal emission factor (CO_2 and non-CO_2) for CLEAR. The MMECD default charcoal CO_2 and non-CO_2 emission factor is 165.22 tCO_2/TJ (including upstream emissions) and 44.84 tCO_2/TJ (including upstream emissions) respectively. However, the CLEAR methodology default charcoal CO_2 and non-CO_2 emission factor is ~193.5 tCO_2/TJ (including upstream emissions) and ~82.96 tCO_2/TJ (including upstream emissions) respectively. Comparison between ERs for MMECD and CLEAR when using cap rather than default values for emission factors in MMECD are discussed under Activity 2 below.

In the draft version of the CLEAR methodology, charcoal upstream emission factor (CO_2 + non-CO_2) is considered as 190 tCO_2/TJ however, the breakdown of CO_2 vs non-CO_2 is not clear. Hence, approximate values have been considered. Nevertheless, the overall emission factor including upstream emissions is higher under CLEAR. Another interesting observation on the CLEAR CCT, the upstream emissions contribute more than 50% of the total baseline emissions and ERs. The methodology is still under development and hence it would be noteworthy to see what the final version looks like.

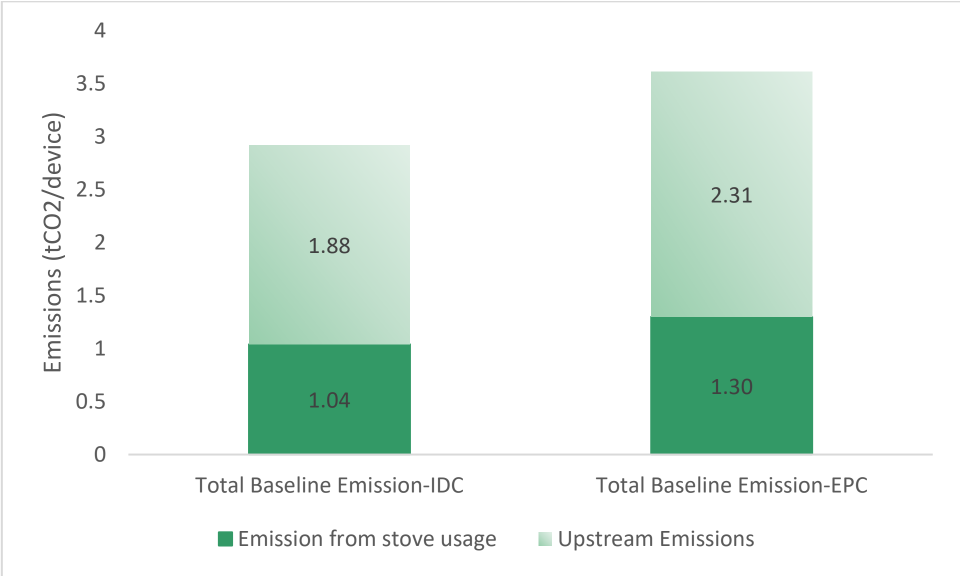


Figure 10: Contribution of upstream emissions to the total baseline emissions for CLEAR

The CLEAR methodology also accounts for emissions from renewable fraction of fuel/charcoal along with upstream emissions from other fuel such as LPG. These two factors also contribute to ERs even though impact is very small.

Lastly, under MMECD, there is a singular approach where f_{NRB} is multiplied with CO_2 emission factor before adding the non-CO_2 emission factor. Under CLEAR, for baseline emissions, f_{NRB} is multiplied with sum of CO_2 and non-CO_2 emission factor whereas for upstream emissions, f_{NRB} is multiplied with CO_2 before adding the non-CO_2. Nonetheless, this has relatively minor impact on the ERs between MMECD and CLEAR.

II. MMECD versus TPDDTEC and CLEAR-M/nM

The ERs from MMECD Case 2 show some differences to those from TPDDTEC and CLEAR (m/nm), with the variations due to some combination of the calculation method and parameter values required.

In terms of methods, ERs under MMECD are calculated for the energy used in cooking by baseline devices which are replaced by the project stove (back-calculation) whereas TPDDTEC and CLEAR-M/nM determines ERs as difference between fuel consumption in the entire kitchen in the baseline and project scenario. Further, MMECD uses the SC and fuel consumption values derived from CCT for the cooking that can be replaced by project stove whereas TPDDTEC and CLEAN (M/nM) uses fuel consumption value from KPT which is giving data for the entire cooking happening in the kitchen.

The methods also affect the reliability of the stove energy use values. MMECD uses the real time cooking data using direct measurement which accurately captures usage unlike TPDTTEC and CLEAR which are reliant on survey and field measurement. TPDDTEC and CLEAR-nM use a combination of adoption/usage survey and field measurement to arrive at input values. CLEAR-M uses a combination of survey, metering, and field measurement, however the MMECD tracks stove usage either through meters attached to the stove and/or by measuring fuel consumption.

Surveys by default are prone to bias[12] such as recall or desirability bias. Recall bias is when respondents struggle to remember what and how they cooked over a long time-period. The surveys are also vulnerable to social desirability bias[13] that occurs when respondents provide answers which is most desirable to the surveyor. KPTs also have their own strengths and weaknesses. Firstly, KPTs may sometime change the behaviour of the household in the presence of field staff. This is a phenomenon known as Hawthorne Effect[14]. Secondly, KPTs are cost and manpower intensive activity and hence are only required to be done once in two years. Thirdly, stove usage, fuel quality and availability may be seasonal and highly variable. Thus, longer monitoring frequency may not provide accurate estimates for fuel consumption.

In terms of strengths, TPDDTEC is the only methodology that accounts for change in household behaviour in terms of any increase in cooking due to a new stove, by reducing the carbon emissions saved. This usually happens when improved and clean stoves make cooking less expensive. Both TPDDTEC and CLEAR-M/nM have introduced threshold/cap values on a few parameters like baseline fuel consumption and usage/uptake to tackle the issues of inadequate monitoring of cookstove usage. MMECD encourages (para 2.1.2 of MMECD methodology) real-time measurement of energy/fuel for every device, however it currently allows sampling to be applied. Direct measurement captures the actual stove usage of the project stove(es). There are several studies[15] which have concluded that survey participants tend to overreport the usage and daily cooking events compared to data measured through meters. Furthermore, MMECD has also introduced reference values for energy/fuel consumption in the project scenario to ensure the real time data is cross-checked against credible literature to avoid over-crediting.

Differences in parameter values also contribute to the small differences in ERs between the different methodologies, as discussed in (I) above. For both TPDDTEC and MMECD, the fraction of non-renewable biomass (f_{NRB}) is calculated using the latest version of CDM Tool 30, which can be either be fixed for a given crediting period (CP) or updated periodically. In contrast, the draft CLEAR methodology determines f_{NRB} based on national or sub-national default values from the UNFCCC-supported MoFuSS model, or project-specific values calculated using MoFuSS, which is fixed ex-ante and updated only at CP renewal. Gold Standard may well decide to update the requirement for TPDDTEC and MMECD once the UNFCCC process is complete but it is premature to provide definitive comments.

III. KPT versus CCT data

As already explained in the limitation section, KPT data was unavailable for wood consumption in the baseline. For parity, ER calculation was also conducted replacing fuel consumption values derived from KPT with CCT data for MMECD Case 1 and TPDDTEC.

For IDC, the ERs calculated with CCT data using MMECD Case 1 and TPDDTEC were similar to ERs from KPT data. This could be attributed to the fact the IDC can replace most of the cooking

[12] https://www.sciencedirect.com/science/article/abs/pii/S2452292920300266
[13] https://www.sciencedirect.com/topics/psychology/social-desirability-bias
[14] https://catalogofbias.org/biases/hawthorne-effect/
[15] Comparing Cookstove Usage Measured with Sensors Versus Cell Phone-Based Surveys

happening in the kitchen thus both KPT and CCT data for IDC was representative of the actual cooking behaviour in the kitchen.

Based on the comparison above, the ERs from MMECD are similar to those from other existing methodologies. The slight differences can be attributed to variations in assumptions and parameter values. The use of direct measurement method for monitoring under MMECD eliminates the risk of introducing survey biases and uncertainties KPT and surveys are prone to. This is one of the robust methodologies currently available which strikes a balance between conservativeness, low risk and high integrity. The objective to do a comparative analysis was to effectively highlight the areas where the methodology could be strengthened which will in turn enhance environmental integrity, accuracy, and ultimately, the quality of the credits generated.

Activity 2

This activity aimed to examine the default specific energy consumption ratios provided in the MMECD with reference to project scale and evaluate charcoal CO_2 and non-CO_2 emission factor across the methodologies to provide clarity on which of the default options are most accurate.

Comparison of SC Ratios:

The current version of the MMECD methodology provides reference to a study 'Comparing energy consumption and costs – from cooking across the MECD programme' by Scott et al.[16] that may be referred to compare the CCT results used for calculating the SC value. MMECD has set SC default values based on this report which may be used by microscale projects i.e. projects that generate ERs less than 10,000 tCO_2/year. (Note that the version of Scott et al referred to in the MMECD was a pre-publication Working Paper, with SC values for EPCs, but not IDCs. The updated paper is now published, and adds in SCs for IDC, using the same methodology. Scott et al does not provide SC results for firewood use in Africa).

Under this activity, cooking diary and CCT data from Ghana was compared with the MMECD default values to understand – 1) the accuracy and reliability of the field data and 2) examine if the MMECD defaults should be applicable to small and large-scale projects.

[16] https://www.mdpi.com/1996-1073/17/13/3318

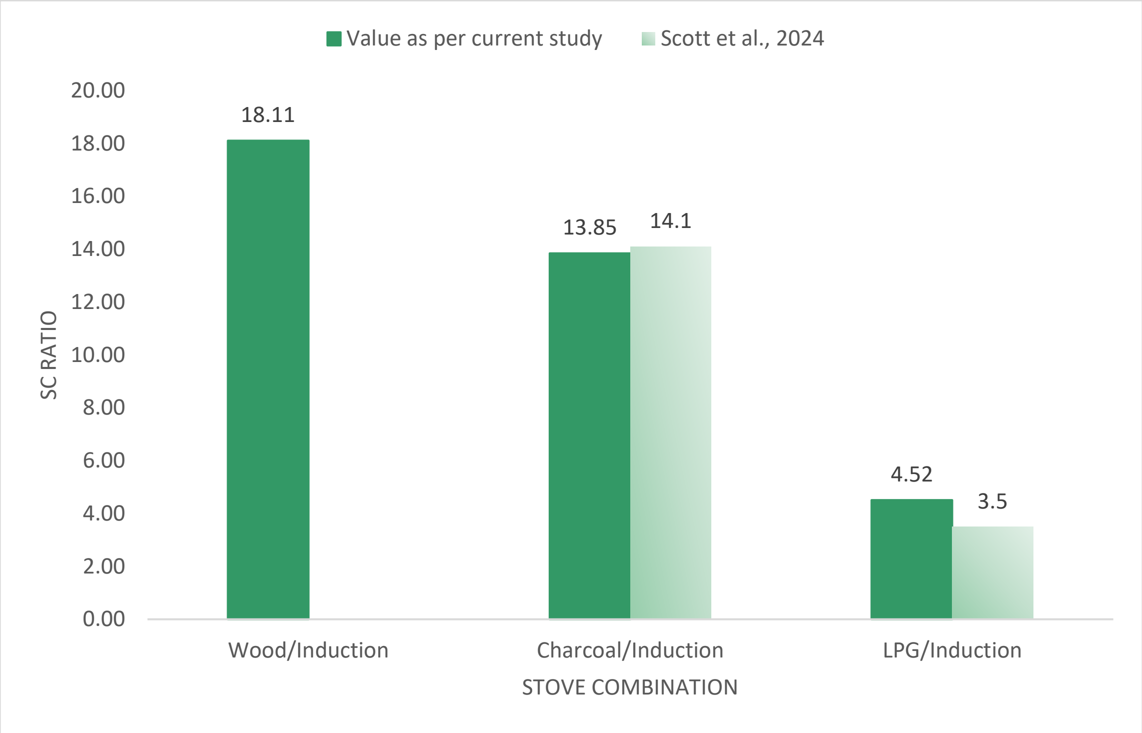


Figure 11: Comparison of SC Ratio between current study and Scott et al values for IDC

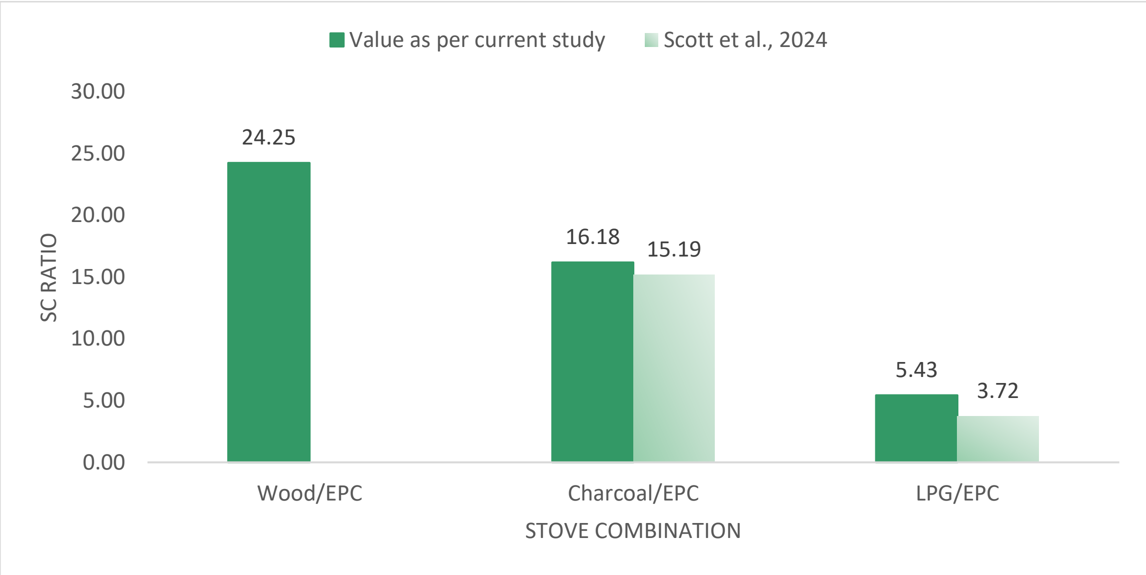


Figure 12: Comparison of SC Ratio between current study and MMECD default values for EPC

It is clear from the above graph that the SC ratios from the current study are close to but slightly higher for most of the stove/fuel than the default values provided in the MMECD methodology and the Scott et al results.

It is also important to understand the key differences between report by Scott et al. and the CCT conducted in Ghana as part of the study. The report by Scott et al. focusses mostly on urban areas of 6 African countries with 97% data points involving cooking only a single dish on each of the stoves. This is the reason the report is missing the SC value for wood as charcoal is the dominating cooking fuel in urban areas followed by LPG. However, the current study is focused only on one country with SC value being calculated based on 13 commonly cooked dishes in the country. Furthermore, as per the cooking diary, 13% of the cooking was found to be done on firewood hence, it has also been included as part of the study. Even though the data is from one country yet it is more representative of the real-world cooking.

The study supports the fact that MMECD default values are more conservative than what the real-world scenario demonstrates. Hence using default values in MMECD, regardless of project scale, can yield representative and even slightly more conservative results thus adhering to the principle of conservativeness to ensure that GHG emission reductions are not overestimated.

Comparison of emission factors for charcoal:

Under activity 1, differences in the ERs between MMECD, TPDDTEC and CLEAR was discussed and a detailed assessment of the variances in crediting scenarios was itemized. Continuing from there, the current study also evaluated the charcoal CO_2 and non-CO_2 EF provided in each of the methodology.

Methodology	**Charcoal CO_2 emission factor (tCO_2/TJ)**	**Charcoal non-CO_2 emission factor (tCO_2e/TJ)**
MMECD and TPDDTEC		
Default (only combustion)	112	5.865
Default (including upstream)	165.22	44.83
Cap (including upstream)	197.15	92.29
CLEAR		
Default (only combustion)	78.5	7.964
Default (only upstream)	115	75[17]
Default (including upstream)	~193.5	~82.96

Table 7: EF for Charcoal

MMECD and TPDDTEC as default use IPCC EF from 2006 whereas CLEAR uses the values from a study by Floess et al. from 2023[18] that has compiled a database of lifecycle emission factors for cooking fuels, drawing from peer-review literature, and the Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies Model (GREET) model. The values used by Floess et al. are the most recent.

Furthermore, ER calculation was also done replacing the MMECD default EF with the cap values given in the methodology. In doing so, the resulting ERs for IDC and EPC interventions were 2.76 and 3.44 tCO_2e per device respectively. This is roughly equivalent to the ERs yielded when applying the methodology default EF for CLEAR CCT pathway (i.e. 2.64 and 3.28 tCO_2e per device, respectively).

[17] The CLEAR methodology does not provide clarity on how the value for upstream emission has been derived. As per Annex 4 of draft CLEAR meth, emission factor of CO_2 is 115 tCO_2/TJ, CH_4 is 2.68 tCH_4/TJ and N_2O is 0.115 tN_2O/TJ. The total CO_2e from these values is 223.84 tCO_2e/TJ using GWP as per AR6, however total provided in the annex for upstream is 190 tCO_2e/TJ. Hence, for the purpose of the comparison, non-CO_2 value has been calculated as 190 – 115 = 75 tCO_2e/TJ.

[18] https://iopscience.iop.org/article/10.1088/1748-9326/acb501

Figure 13: Comparing ERs: MMECD vs. CLEAR with Cap and Default emission factor respectively

Activity 3

This activity aimed to refine the sampling approach that seems to be permissible in the MMECD methodology. Although MMECD encourages (refer to para 2.1.2 of MMECD methodology) metering or measuring stove usage and/or fuel sales for all stoves and/or customers, the current version also allows use of sampling approach. However, the sampling guidelines are not very clear, it may be valuable to better understand whether and how sampling could be undertaken using the methodology and to recommend potential best practices.

To achieve this, a comprehensive literature review of existing sampling best practices was conducted, complemented by feedback from project developers with experience in implementing electric cooking technologies or working within the clean cooking sector. The objective was to identify opportunities for improvement in the current methodology and develop actionable recommendations to enhance its effectiveness and accuracy, in case sampling will be continued to be allowable under MMECD.

Overview of the sampling best practices based on literature review:

Key to accurately estimating any monitored parameter especially stove usage/fuel sale is selecting an appropriate sample size. This is where statistical sampling plays a vital role. As per the current version of the MMECD, when sampling is applied to determine the number of households/customers, methodology directs to section 4.4 “General requirements for sampling” of TPDDTEC v4.0.

The sampling approach under TPDDTEC requires the monitored parameter to meet the 90% confidence interval with 10% margin of error. This requirement is flawed because it assumes that adoption of cookstove follows a normal bell curve. However, adoption depends on various factors such as access to fuel, level of poverty, household income and several other ethnographic variables[19]. Therefore, calculating the optimal sample size which considers all the variables specific to the project region is crucial.

While referring the literature on sampling best practices, we came across few options which suggest conservative approaches to sampling:

- Social sciences and environmental studies tend to adopt a minimum 95% confidence interval, as this necessarily increases precision and reduces the chance of being wrong. Adopting a 90% confidence level with 10% margin of error is generally only seen as appropriate for sampling small populations with minimal variance. With large population with significant variation, it is advisable to use 95% confidence level with 10% margin of error[20]. In the scientific world, 95% confidence interval is known as a strict gatekeeper that passes statistical signal while filtering a lot of noise out. It dampens false positives in a very measured and unbiased manner.[21]

- As per a study conducted by Geocene in 2024 using their stove use monitors (SUMs) dataset to calculate a statically significant sample size, as a rule-of-thumb, projects should monitor 5% of their cookstoves[22].

- In addition to sample size, capturing the various population characteristics is also essential to accurate monitoring. For surveys to generate reliable information, it is important that the sample population is representative of the entire target population. Considering the high variability that influences the cookstove adoption, to capture the actual usage, sampling a higher number and ensuring stratification across various factors as regions, income levels, and family sizes can ensure more accurate capture of stove adoption.

Sampling approach followed under MMECD:

The MMECD methodology has several parameters both in the baseline and project which allow for sampling – amount of fuel consumption in the baseline using KPT/CCT ($P_{b,i,j}$), specific energy consumption in baseline and project (SC_b and SC_p), amount of energy ($EG_{p,d,y}$)/fuel ($P_{p,d,y}$) consumed in the project scenario. The methodology refers to the need to follow the sampling requirements of section 4.4 of TPDDTEC v4.0; this is fine for baseline KPTs, but it is not clear how sampling needs to be applied to CCT, SC and two critical monitored parameters.

Data from CCT is used to calculate the amount of fuel consumed by the baseline stove and the SC value for each device (baseline and project) under Case 2. As per the CCT protocol by CCA, at least 3 tests shall be conducted on each stove/fuel combination. This can be achieved by using three cooks cooking on same device or same cook cooking on three devices of the same technology. What is not clear is how the sampling can be applied to this? Unlike KPT, CCT is not conducted for individual households and hence it is critical to define clearly how sampling needs to be applied under such circumstances.

[19] https://bezerocarbon.com/insights/a-watched-pot-never-boils-monitoring-usage-of-cookstoves
[20] https://bezerocarbon.com/insights/a-watched-pot-never-boils-monitoring-usage-of-cookstoves
[21] https://www.statsig.com/blog/95-percent-confidence-interval
[22] https://consulting.geocene.com/carbon/sums/2024/03/28/how-many-sums

For the two most critical monitored parameters i.e. the amount of energy used in the project scenario by device d in year y ($EG_{p,d,y}$) and the amount of fuel used in the project in by device d in year y ($P_{p,d,y}$), data must be continuously monitored. Even though MMECD advocates for real-time data capture for every device (100% metering) or otherwise monitored via measurement (100% measurement), yet it allows sampling to be applied. As briefly discussed above, when sampling is applied, methodology directs to section 4.4 "General requirements for sampling" of TPDDTEC v4.0. The general requirements for sampling under TPDDTEC v4.0 follow the general approach outlined in CDM's Sampling and Surveys for project activities and programme of activities which requires the parameter to meet the 90% confidence interval with 10% margin of error. Furthermore, it also states that for proportion parameter values, a minimum sample size of 30, or the whole group size if this is lower than 30, must always be applied.

It is important to understand why the above suggested approach is confusing. Generally, implementation of a project happens in a staggered manner where distribution is spread across a few days, months and/or even years. In this case how will the sample size be determined with constantly changing stove populations (phased implementation)? Sample size is usually determined after the stove distribution is completed, if that is the case, how to ensure continuous monitoring of the energy/fuel consumption or determine the energy/fuel consumption of the distributed stoves? The current version of the methodology needs to provide clarity and detailed guideline on data collection and frequency of data collection in case of sampling.

Feedback from project developers:

Given that project developers will be responsible for sampling and monitoring, it was essential to gather their input on the process to ensure practical applicability and acceptance of the methodology. The feedback received was mixed regarding the inclusion of sampling under the MMECD framework.

Some project developers strongly supported the idea of 100% metering and measuring, arguing that this method provides the highest level of accuracy and reliability. They expressed concerns that incorporating sampling could introduce uncertainty and reduce the confidence in the emission reductions reported by the project.

Conversely, other developers supported the option for sampling in the MMECD, but with enhanced guidelines to ensure rigor and transparency. They believed that sampling, if properly designed and implemented, could offer a more efficient and cost-effective approach for monitoring, especially for larger-scale projects where full metering might be logistically challenging or prohibitively expensive.

Additionally, there were suggestions that the MMECD could more clearly differentiate between projects that employ 100% metering and those that use sampling. This differentiation would allow credit buyers to make informed decisions and potentially reward projects that demonstrate a higher level of certainty through full metering. This approach would also address concerns that sampling could introduce variability and ensure that more stringent methodologies are adequately recognized and incentivized in the carbon credit market.

In summary, the feedback highlighted the need for balance between flexibility and rigor, with some developers advocating for a more inclusive methodology that considers sampling, while others emphasized the importance of maintaining high levels of certainty and transparency in emission reporting.

Conclusion and Recommendation

This report underlines that the Methodology for Metered & Measured Energy Cooking Devices (MMECD) remains the most robust, conservative, and high-quality methodology available for cookstove carbon projects. It also has recommended ways that this quality and integrity can be further improved via a few updates, which will be particularly beneficial to projects supporting electric cooking technologies.

This report has undertaken a comparative assessment of the MMECD methodology against other prominent methodologies, such as TPDDTEC V.4 and the CLEAR Methodology, to identify how they perform and to identify potential areas for further improvement to ensure that the methodology remains robust and fit for purpose. The report also compared MMECD's default SC ratio and charcoal EF values to real-world data and recent peer-reviewed literature. Additionally, it analysed best practices for sampling and incorporated recommendations from project developers to enhance MMECD's existing sampling requirements.

Through data analysis, literature review and feedback from project developers, the report has compiled a set of practical recommendations aimed at improving/refining the MMECD methodology. Key recommendations include:

Activity 1

a. MMECD should allow project developers to select either Case 1 or Case 2 based on their project's specific circumstances irrespective of the stove characteristic. The discussion under Activity 1 above demonstrates that Case 2 - especially when paired with robust CCTs - may be a more appropriate approach for high-performing devices such as IDC given the greater controllability that such technology provides to customers.

b. The current version of the methodology does not provide a clear framework or guidance on calculation of various input parameters using qualitative and CCT data for Case 2. It is open to interpretation by project developers which could lead to over- or under-crediting. The current study has developed an approach to calculate the various input parameter values such as specific energy consumption value, amount of baseline fuel used in baseline device, and proportion of cooking of baseline device values which can be adopted as is to bring uniformity across the market. This approach can be included in the ER calculation template for ease of use and standardisation.

c. The definition and descriptions of parameters in the methodology should be improved and /or explained clearly to ensure clarity.

d. Under MMECD, GS has also issued an ER calculation tool to make the ER calculation process easy for project developers. It is an excellent way to ensure uniformity within the sector. During the study, values from the ER tool were cross checked with applying the formulas from the methodology document. We identified a few issues in the Case 2 BE and PE tab.

- The calculator has the amount of electricity used in the project scenario by device d ($EG_{p,d,y}$) linked to specific energy consumption used in the project scenario (SC_p). The example given in the calculator seem to arbitrarily multiply SC_p value with 3 and household size to get $EG_{p,d,y}$. We believe this is because the SC default values from Scott et al have been interpreted to be energy used to cook one meal, with an assumption that three meals are cooked per day. But as the MMECD states for parameters MECD 7 and 8, SC values should only be used to calculate the energy ratios. The SC values in Scott et al are energy use 'per cooking event' which does not equate to a meal, and cannot be used to assemble an estimate of daily cooking energy use. Considering $EG_{p,d,y}$ value is already captured in the PE tab which is captured through the metered data, it should be linked to $EG_{p,d,y}$ value in PE tab, which is the same parameter.
- Additionally, the amount of electricity per person per day in the PE tab is linked to SC_p, again arbitrarily multiplied by 3. Considering this is a monitored parameter, it should provide some hard coded number instead of linking it to SC_p. It unnecessarily creates confusion among project developers whether to monitor this parameter or calculated it based on SC_p value.

Activity 2

a. The detailed comparison between the SC values from Ghana and results from the report by Scott et al. demonstrates that SC ratios from the current study are mostly a little higher than the default values provided in the MMECD methodology. This demonstrates that MMECD default values are more conservative than those that the real-world scenario demonstrates. Thus, we would recommend allowing the use of default values in MMECD, regardless of project scale[23] as they yield appropriate and conservative results.

b. The default CO_2 and non-CO_2 emission factor (EF) for charcoal provided in the MMECD methodology i.e. 165.22 tCO2/TJ and 44.83 tCO2/TJ (including upstream emissions) has been sourced from 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Though they may provide conservative results compared to CLEAR methodology they may not be fully reflective of more recent research. CLEAR methodology uses the dataset provided by Floess et al., 2024 which has drawn data from latest peer-reviewed literature, and GREET model. Furthermore, comparing ERs calculated using MMECD's capped EF values to CLEAR's default EF values confirms the appropriateness of MMECD's cap. We recommend that MMECD either adopt capped EF values as the default or update its charcoal EF values using the most recent available datasets.

[23] Defaults are currently restricted to projects claiming less than 10,000 tCO_2 annually.

Activity 3

a. MMECD refers to the need to follow the sampling requirements of section 4.4 of TPPDTEC v4.0 for various parameters such as amount of fuel consumption by KPT/CCT, SC value in baseline and project and two monitored parameters ($EG_{p,d,y}$ and $P_{p,d,y}$). The sampling approach is not clearly defined for projects conducting CCT. Unlike KPT, CCT is not conducted for individual households and hence it is critical to define clearly how sampling needs to be applied under such circumstances.

b. Out of several monitoring parameters, the amount of energy used ($EG_{p,d,y}$) or amount of fuel consumed ($P_{p,d,y}$) is the most critical monitoring parameter. The methodology allows for sampling for both these critical parameters. However, it is unclear on how the sampling framework should be for these two parameters which requires continuous monitoring. Also, there is lack of clarity on data collection for sampled households because sample size is determined after the stove distribution is complete. In such cases, how to ensure continuous monitoring of the energy/fuel consumption or determine the energy/fuel consumption of the distributed stoves. It is important to provide a clear guideline on sampling approach, sample selection, monitoring frequency and data collection when sampling is allowed.

c. In case sampling is allowed to continue under MMECD, there should be guidance on best practices to be followed for sampling approaches and monitoring frequency – particularly for projects implemented in a phased manner. Based on the literature review of best practices, guidance might include but not be limited to:
   - A 95% confidence level with 10% margin of error.
   - Projects should monitor at least 5% of their cookstoves.
   - Ensure the sample population is representative of the entire target population; this might require larger sample size.

d. To ensure data accuracy and reliability, the methodology should either mandate complete metering/measuring of project devices and/or customers, or encourage complete metering, while allowing sampling with best practices discussed under Activity 3 above. The alternate measures for encouraging high levels of metering could be but not limited to:
   - Adding the additional requirement to demonstrate best practices like TPDDTEC Requirements and Guidelines: Usage Rate Monitoring.
   - Applying a discount factor on overall ERs where sampling is used.
   - Providing a cap value on the amount of energy/fuel per device and/or customer which is below the current reference value for projects opting for sampling.