Malawi Clean Cooking Market Assessment as part of the World Bank ASCENT Program

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Acronyms Used

ADB - Asian Development Bank

AfDB - African Development Bank

ALRI - Acute Lower Respiratory Infections (in health context)

BII - British International Investment

BTR - Biennial Transparency Reports

CAPEX - Capital Expenditure

CCA - Clean Cooking Alliance

CCDR - Climate Change Development Report

CMR - Consumer Market Research

COPD - Chronic Obstructive Pulmonary Disease

CPI - Consumer Price Index

DALY - Disability-Adjusted Life Year

dMRV - Digital Monitoring, Reporting, and Verification

DSM & EE - Demand Side Management & Energy Efficiency

EAD - Environmental Affairs Department

EAQIP - Energy Access and Quality Improvement Project

EASP - Energy Access Scale-up Project

ECS - Emerging Cooking Solutions

EPC - Electric Pressure Cooker

ESCOM - Electricity Supply Corporation of Malawi

FE - Fuel-Efficient

FOEN - Swiss Federal Office for the Environment

GeCCo - Global Electric Cooking Coalition

GEAPP - Global Energy Alliance for People and Planet

GETF - Green Economic Transition Facility

GHG - Greenhouse Gas

GIT - Green Impact Technologies

GOM - Government of Malawi

HH - Household

ICBS - International Competitive Bidding

ICS - Improved Cook Stoves

IDB - Islamic Development Bank

IEC - International Electrotechnical Commission

IHD - Ischemic Heart Disease

IPP - Independent Power Producer

ITMO - Internationally Transferred Mitigation Outcomes

IVA - Independent Verification Agent

KPI - Key Performance Indicator

LC - Lung Cancer

LPG - Liquefied Petroleum Gas

MBS - Malawi Bureau of Standards

MCFA - Modern Cooking Facility for Africa

MCHF - Modern Cooking for Healthy Forests

MCMI - Malawi Carbon Market Initiative

MECS - Modern Energy Cooking Services

MEAP - Malawi Energy Access Project

MERA - Malawi Energy Regulatory Authority

MLPGA - Malawi LPG Industry Association

MOE - Ministry of Energy

MRA - Malawi Revenue Authority

MZUNI - Mzuzu University

NCSC - National Cookstove Steering Committee

NDC - Nationally Determined Contribution

NFPA - National Fire Protection Association

NNNF - Ngwee Ngwee Ngwee Fund

NORAD - Norwegian Agency for Development Cooperation

OIMP - Other International Mitigation Purposes

OSHA - Occupational Safety and Health Agency

PACM - Paris Agreement Crediting Mechanism

PaR - Portfolio at Risk

PAYG - Pay-As-You-Go

PBF - Performance-Based Financing

PFI - Participating Financial Institution

PIU - Project Implementation Unit

PM2.5 - Particulate Matter (2.5 micrometers or less)

PO - Participating Organization

POM - Project Operations Manual

QCBS - Quality and Cost Based Selection

RBF - Results-Based Financing

RRP - Recommended Retail Price

SACCO - Savings and Credit Cooperative Organization

SAPP - Southern African Power Pool

SDG - Sustainable Development Goal

SHS - Solar Home System

SUMs - Stove Use Monitors

TA - Technical Assistance

TOE - Tons of Oil Equivalent

UECCC - Uganda Energy Credit Capitalization Company

UNIMA - University of Malawi

VAT - Value Added Tax

VCM - Voluntary Carbon Market

VVB - Validation and Verification Body

WFP - World Food Programme

1 Executive Summary

1.1 Introduction

The ASCENT program aims to catalyse a transformative expansion of the market for Tier 4+ modern energy cooking solutions in Malawi, including electric cooking, LPG, pellets, briquettes, biogas and ethanol.

The ASCENT clean cooking program looks to support the Government of Malawi and establish a sustainable framework for developing the modern cooking market: addressing supply constraints, stimulating consumer demand and mitigating key risks within Malawi's carbon market.

The program provides significant upfront capital for the clean cooking market through a $10 million World Bank facility (from IDA and ESMAP) and offers comprehensive technical assistance. The facility enables companies to cover 70-90% of upfront costs of Tier 4+ cookstoves for lowest income households and 40-60% for middle-income households, with carbon revenue supporting fund sustainability.

The program addresses key demand and supply-side challenges. On the demand side, it tackles affordability barriers, accommodates cultural preferences for multi-pot cooking, increases awareness through targeted behavior change campaigns and addresses reliability concerns through education initiatives. On the supply side, it coordinates with ESCOM on grid capacity for electric cooking, supports fuel supply chain development, establishes mandatory Tier 4+ cookstove standards, builds local technical expertise and seeks to continue developing the national clean cooking strategy.

The program's operational components include establishing a dedicated Clean Cooking Unit within the Ministry of Energy, developing comprehensive testing and certification standards with Malawi Bureau of Standards, working to implement a Carbon Policy Framework with the Malawi Carbon Market Initiative and Ministry of Forestry and Natural Resources to continue to build trust around carbon markets, strengthening institutional capacity and creating carbon credit aggregation mechanisms.

This program will further Malawi's National Energy Compact targets that aim increase clean cooking access from 24.5% to 75% by 2030.

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1.2 Challenges, Program Solutions, Operating Recommendations for Deploying and Scaling Tier 4+ Solutions in Malawi

1.2.1.1 Demand Side

Aspect	Challenge	Program Solution	Operating Recommendations
Affordability	The high upfront costs of clean cooking appliances, such as electric pressure cookers and induction stoves, pose a significant barrier for low-income households. Many families cannot afford these devices, which can range from $100 to $200 (See Affordability Analysis).	World Bank facility, totaling $10m USD, will allow companies to cover 70-90% of upfront costs for lowest income households and 40-60% for middle-income households.	Fund manager verifies PO cookstove pricing range as part of selection criteria.
Cultural Preferences	Malawian meals usually contain two meal components. Therefore modern energy solutions need to be able to support cooking multiple dishes simultaneously in order to foster effective transitions to clean cooking (See The Malawian Diet).	TA to support SMEs supplying cooking devices that accommodate multiple pots for traditional Malawian cooking methods.	Verify POs offer multi-pot cooking solutions. Fund manager ensures cookstove distribution includes culturally-specific cooking demonstrations and recipe booklets in local languages.
Limited Awareness	There is a general lack of awareness about the benefits of clean cooking technologies. Many households are unaware of the health and environmental impacts associated with traditional fuels (See Perceptions of Cooking Stoves and Fuels).	Dedicated TA funds for behavior change campaigns highlighting affordability and convenience rather than environmental benefits. Target both women (cooks) and men (financial decision-makers).	NNNF Manager, Clean Cooking Unit within MOE, POs and NCSC coordinates with *Behaviour awareness and campaign manager* TA to develop localized marketing campaigns. Focus messaging on time savings, reduced fuel costs, and elimination of smoke-related health issues through radio, television, and community demonstrations.
Perceptions of Reliability	Traditional fuels charcoal and firewood are often viewed as more reliable compared to electric cooking. This perception discourages households from transitioning to electric cooking (See	As part of capacity building and TA, the program will hire a *Behaviour awareness and campaign manager* to help communicate, market and educate on cookstoves technologies.	MOE to hire and Clean Cooking Unit to help coordinate the *Behaviour awareness and campaign manager*. Clean Cooking Unit and POs coordinate with the manager on cookstoves product

Aspect	Challenge	Program Solution	Operating Recommendations
	Perceptions of Cooking Stoves and Fuels).		specifications and marketing.
Fuel Stacking	Many households engage in fuel stacking, using multiple cooking technologies simultaneously. This practice reflects the lack of explicit preference towards any single clean cooking solution (See Use of Cooking Stoves and Fuels).	Program recognizes and accommodates multiple cooking technologies during transition periods.	IVA monitoring accommodates partial clean cooking adoption in metrics. Carbon credit calculations adjusted for realistic partial displacement.

1.2.1.2 Supply Side

Aspect	Challenge	Program Solution	Operating Recommendations
Infrastructure Limitations	The lack of access and the lack of reliability to electricity supply limits the scalability of electric cooking solutions (See Malawi Power Network Infrastructure).	Coordinate with ESCOM on grid capacity strengthening in high-potential areas. Implement Residential Electricity Metering Program to track usage patterns and guide infrastructure upgrades.	NNNF to require POs demonstrate confirmed electricity supply for target regions. GIS mapping and network studies to identify viable deployment zones. Monthly reporting on power quality and reliability in target regions coordinated with ESCOM.
Fuel Supply Issues	Companies face challenges in securing raw materials and fuels (LPG, pellets, briquettes, organic waste etc.) which can delay the introduction of new products to the market (See Overview of Clean Cooking Fuels in Malawi).	Support supply chain development through formal agreements between POs and major suppliers. Establish seasonal planning requirements for pellet suppliers and contingency plans for LPG forex fluctuations.	POs must demonstrate supplier contracts, storage capacity, distribution networks, and seasonal planning before approval. Fund manager verifies LPG partnerships with importers (Afrox, Delta, Falcon) and pellet agreements with producers (Raiply, Pyxus) through formal documentation and site inspections.
Quality of Cookstoves	The market is dominated by low-quality, low-cost imported stoves, which often have short lifespans and do not meet durability standards (See Inventory of Modern	Establish mandatory Tier 4+ cookstove standards for program participation. Provide technical assistance to MBS for standards development and testing procedures	IVA to verify compliance with MBS cookstove standards and carbon certification requirements through product testing and field verification. POs required to provide 2-year warranties and 3-year

Aspect	Challenge	Program Solution	Operating Recommendations
	Energy Cooking Solutions).	aligned with international norms.	after-sales service commitments. Regular quality assurance audits conducted by MBS with TA support.
Limited Local Expertise	There is a shortage of local expertise and infrastructure to support the distribution and maintenance of clean cooking devices, which hinders market growth (See Inventory of Relevant Modern Energy Cooking Initiatives).	Implement dedicated capacity building program for local technicians and distributors. Fund TA support for SMEs on standards, testing, and business development.	POs required to demonstrate after-sales support capabilities before approval. Technical assistance provider to establish training program for local technicians, with certification tracking. NNNF Manager coordinates mentorship connections between established providers and emerging enterprises.
High Import Taxes	Import taxes and VAT on electric cooking appliances contribute to high costs, for example the 15% excise rate and 16.5% VAT (total 31.5%) on electric cooking devices, limiting accessibility for consumers (See Fiscal Measures).	Advocate for temporary tax exemptions on Tier 4+ clean cooking technologies. Support local manufacturing where feasible to reduce import dependence.	N/A

1.2.1.3 Policy/Regulatory Aspects

Aspect	Challenge	Program Solution	Operating Recommendations
Lack of Clear Strategy	There is no comprehensive clean cooking strategy that integrates all technologies and fuels, which hampers coordinated efforts to promote clean cooking (See Policy and Regulatory Gap Analysis).	Establish a dedicated Clean Cooking Unit within MOE to coordinate cross-sectoral implementation.	Align program with National Energy Compact targets to increase clean cooking access from 24.5% to 75% by 2030. Support revision of National Clean Cooking Strategy & Investment Prospectus.
Standards	There are no defined and enforced standards on the clean cooking products and process leading to mistrust in the	Develop comprehensive cookstove testing and certification standards based on international	Support MBS in adopting and enforcing international standards (e.g., IEC 60335-1 for electric cooking).

Aspect	Challenge	Program Solution	Operating Recommendations
	market preventing larger players entering the Malawi clean cooking market (See Policy and Regulatory Gap Analysis).	benchmarks (IEC, ISO standards).	Implement technical support program for ratifying cookstove standards. Require POs to demonstrate standards compliance through certification.
Regulatory Barriers	High import taxes and lack of quality standards for clean cooking technologies create an unfavorable environment for market players (See Relevant Regulations).	Implement Carbon Policy Framework to monetize emissions reductions and offset technology costs.	Leverage COP29's Article 6.4 framework to develop high-integrity carbon projects. Establish registry and reporting system for clean cooking carbon projects. Develop bilateral agreements under Article 6 for international carbon market access.
Insufficient Government Support	The government's prioritization of electrification over other aspects such as clean cooking has led to a lack of dedicated resources and attention to the clean cooking sector (See Local Capacity).	Strengthen institutional capacity through TA and dedicated coordination mechanisms.	Establish Clean Cooking Unit within MOE. Support LPG Development Study focusing on safety standards, regulation, and supply chain development. Coordinate carbon market initiatives through MCMI for clean cooking integration.
Monitoring and Evaluation Gaps	There is a lack of robust frameworks currently to monitor progress against clean cooking targets, which makes it difficult to assess the effectiveness of an intervention (See Policy and Regulatory Gap Analysis).	Implement quarterly and annual reporting frameworks with PIU for standardized metrics and independent verification.	IVA phone and field verification protocols. Implement standardized KPI tracking with MOE for adoption rates, consumer awareness, market prices, training participation, and regulatory compliance. Require quarterly PO reporting and consolidated annual impact assessments.

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2 Demand-Side Analysis

2.1 Current Cooking Practices

2.1.1 The Malawian Diet

The Malawian diet is relatively homogenous and mostly consists of cereals, fish and vegetables. The MECs Electric cooking Market Assessment surveyed n=40 households about their cooking preferences. They found that breakfast usually consisted of tea or coffee, porridge, potatoes or eggs, and that lunch/dinner usually consisted of a nsima[1] or rice with beans, vegetables, fish, eggs or meat (Coley et al. 2020). Most food is boiled, although eggs, potatoes and meat are usually fried.

The Assessment also identified some variation between urban and rural diets reflecting differences in lifestyles and wealth levels. Urban and peri-urban dwellers were more likely to eat eggs for breakfast. Rural inhabitants derived their protein from cheaper sources, eating a lot of beans and very little meat. Urban households also eat more food; 77% of urban household consume three meals per day, compared to 34% of rural households, who usually take two meals per day (Government of Malawi (GoM) 2020).

These insights support the findings of the Focus Group Discussions (FGDs) conducted as part of this project with n=72 primary domestic cooks. Respondents were asked to record a typical weekly meal plan. Analysis of this data showed that meals usually consisted of two elements (**breakfast**: tea plus a carbohydrate; **lunch and dinner**: nsima or rice plus a vegetable or protein). This suggests the importance of stoves that are able to hold multiple pots at a time, e.g. a two burner LPG stove. The most commonly prepared dishes were nsima (featuring in 46% of meals), tea (22%), porridge (17%), fish (15%) and rice (12%, Table 1).

Food	% of meals featuring food
Nsima	46%
Tea	22%
Porridge	17%
Fish	15%
Rice	12%
Beans	10%
Vegetables	9%
Beef	8%
Eggs	6%
Chicken	5%

Table 1: Top ten most commonly cooked foods according to Focus Group Discussions

[1] Nsima is Malawi's staple food and is similar to the ugali eaten in East Africa. It is a thick porridge made from maize flour and water that is prepared by rigorously stirring over heat.

Breakfast was typically prepared from 6-7am and usually consisted of porridge, tea and bread or tea and cassava. Lunch was typically prepared from 11am-12:15pm and usually consisted of nsima and fish, nsima and beans or nsima and vegetables. Dinner was typically prepared from from 6-7pm and usually consisted of nsima and fish, nsima and vegetables or nsima and beef (Table 2, Figure 1).

Meal	Duration of cooking	Timing of cooking
Breakfast	1 hour	6-7am
Lunch	1 hour 15 mins	11am-12:15pm
Dinner	1 hour	6-7pm

Table 2: Cooking times and duration according to Focus Group Discussions

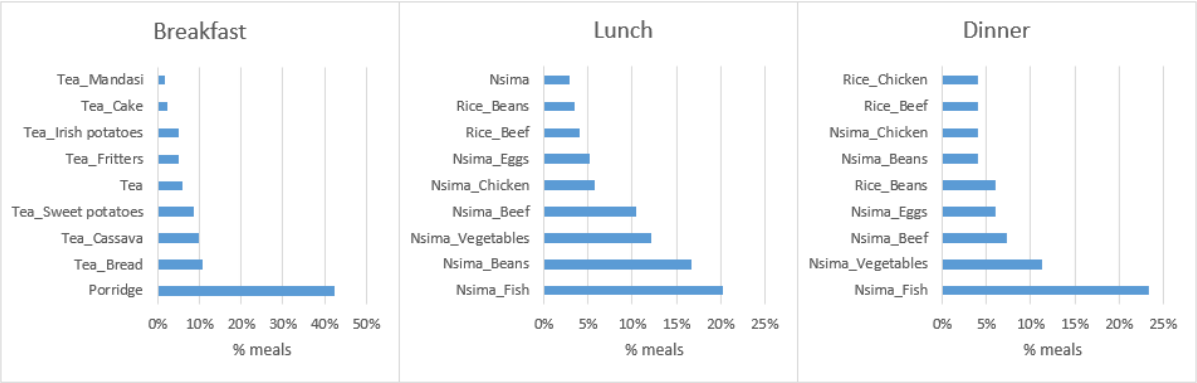


Figure 1: Most commonly cooked meals at breakfast, lunch and dinner according to Focus Groups Discussions

2.1.2 Use of Cooking Stoves and Fuels

The World Bank conducted a Multi-Tier Framework (MTF) survey with 9,195 households in rural and urban Malawi in May-June 2023 which aims to measure access to electricity and modern energy cooking solutions (Malawi Ministry of Energy and ESMAP 2024).

The MTF revealed a rudimentary cooking mix in Malawi, with 98% of respondents using biomass for cooking and 69% using three stone fires as their primary stove. The survey estimates that only 2% of the population use clean fuels, mostly electricity (1.7%). There were significant differences between rural and urban areas, as shown in Figure 2. Rural areas mostly use firewood (88%), which is usually collected, whereas urban households mostly rely on charcoal (67%) which is usually procured from unlicensed vendors. There was very little regional variation, with use of clean fuels and stoves low throughout the country.

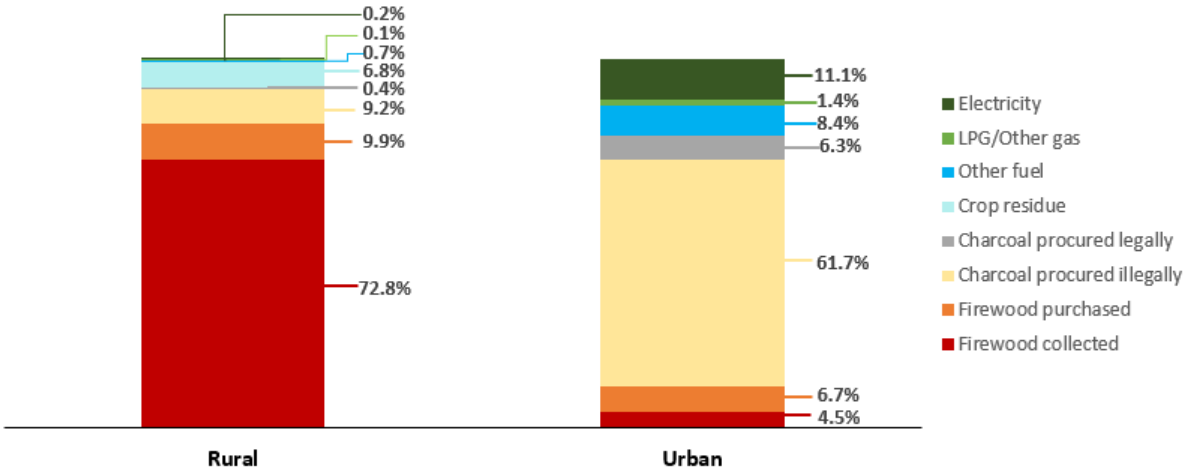


Figure 2: Share of households by type of cooking fuel and place of residence. Source: Malawi Ministry of Energy and ESMAP 2024

The MTF found that 17% of grid-connected households own an electric stove (referring to inefficient coil-heated burners, see Figure 3), 15% an electric kettle, 6% a microwave, 6% a rice cooker, and 1% a water heater (Malawi Ministry of Energy and ESMAP 2024). Off-grid households did not own any Electric cooking appliances. Wealthier households were more likely to have access to cleaner stoves and fuels (Figure 4).

Figure 3: Electric stove. Source: Malawi Ministry of Energy and ESMAP 2024

The MTF results may underestimate the level of LPG penetration in Malawi. The Modern Cooking for Healthy Forests (MCHF) programme conducted n=1600 interviews with urban households in 2022 and found far higher LPG usage rates of 6% in urban areas (USAID and FCDO 2022). This is three times the figure that they recorded in 2020, potentially showing a rapid recent expansion in LPG use. Electric cooking uptake, by contrast, has remained constant during the same period at 18%, corroborating the MTF figure. Charcoal use fell slightly from 86% in 2020 to 82% in 2022, with the majority of users (87%) using a basic ceramic charcoal jiko.

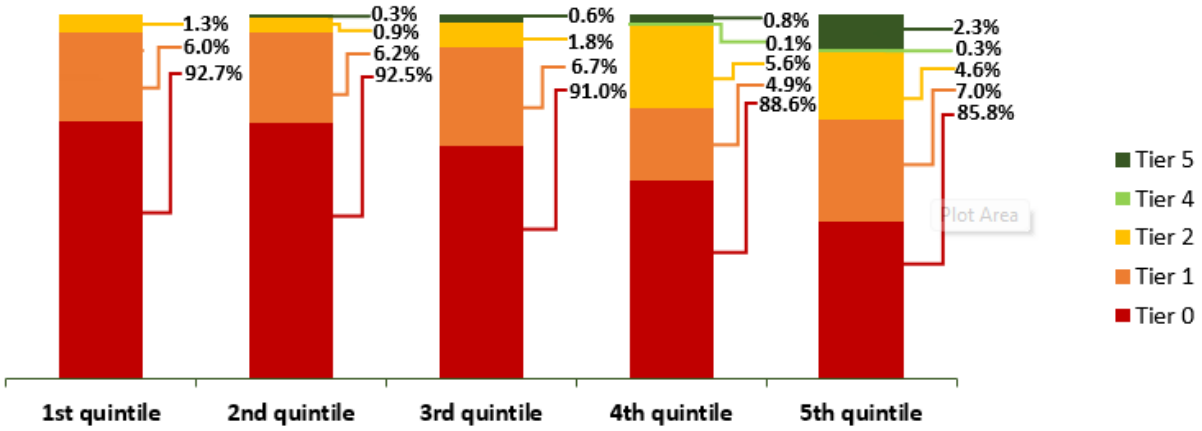


Figure 4: Clean cooking uptake by expenditure quintiles. Source: Malawi Ministry of Energy and ESMAP 2024

The MTF found that stove stacking occurred in 15% of households and fuel stacking in 29% of households (Malawi Ministry of Energy and ESMAP 2024). Fuel stacking was usually different types of biomass (e.g. charcoal and firewood) rather than a mixture of clean and polluting fuels as seen in other countries, reflecting the low penetration of clean fuels. The MECS Malawi Electric cooking Market Assessment (2020) targeted households using electricity in urban areas and noted the entrenched nature of traditional cooking methods for preparing nsima and beans. Charcoal was the default fuel for these dishes, even in clean fuel adopting households. Electric cooking appliances were most likely to be used to prepare faster cooking items like porridge, eggs, tea/coffee, potatoes, vegetables (Coley and Galloway 2020). Cooking appliances were also used to warm water for bathing multiple times per week, and this task was also usually performed on firewood or charcoal (USAID and FCDO 2022).

2.1.3 Perceptions of Cooking Stoves and Fuels

This section primarily presents results from the Focus Group Discussions, which explored perceptions of different cooking stoves and fuels. No participants had experiences with biogas or ethanol stoves, so these fuels are excluded.

Many studies and reports conducted in Malawi note the lack of awareness about the importance of switching to clean fuels which is a barrier to scaling up clean technologies (Malawi Ministry of Energy and ESMAP 2024) *[GIZ/EnDev]*. Recent efforts to address this include awareness raising campaigns funded by the Modern Cooking for Healthy Forests programme in partnership with the Government and direct efforts from private sector players, particularly those supplying LPG *[SHA, MCHF, Falcon Gas, Mount Meru]*. The Focus Group Discussions revealed misconceptions around the costs and safety of cooking with clean technologies. Further demonstrating the need for more awareness raising activities.

Traditional fuels and Electric cooking appliances were regarded as the most reliable fuels, followed by LPG and then pellets (Table 3). Dietary compatibility followed a similar pattern. The reverse, however, was observed for perceptions of cost, with traditional fuels seen as the cheapest by a large margin, and Electric cooking as the most expensive, followed closely by LPG and pellets.

	Reliability	Dietary compatibility	Cost
Traditional fuels	3.1	3.3	1.8
LPG	2.8	3.2	3.3
Electric cooking	3.1	3.4	3.5
Pellets	2.7	3	3.1

Table 3: Perceptions of different fuels according to Focus Group Discussions. Respondents scored each fuel on a Likert scale from 1 (very low) to 5 (very high). The table shows the mean values over the n=72 participants

The sub-sections below discuss perceptions of the advantages and disadvantages of each fuel in turn. Some differences were noted between places of residence. In rural areas, participants reported that firewood is widely available, culturally resonant, and seen as the most affordable option. Few rural households were aware of cleaner options or their health benefits. In urban areas, charcoal is more prevalent, and participants had greater awareness of health impacts and a higher willingness to adopt LPG or electric stoves if made affordable. Many respondents prioritised affordability over benefits like speed or environmental impact, leading them to stick with wood and charcoal options despite their downsides.

2.1.3.1 Firewood

The rural FGD revealed strong cultural ties to cooking on firewood. Some respondents also believed that food prepared on firewood had a superior taste, as illustrated by the following quotations:

> *"Firewood cooking is part of who we are; it's how our families have always done it."*

> *"Food cooked on firewood has a better flavor that's hard to match with other fuels."*

<u>Three stone fire (TSF)</u>

ADVANTAGES

- **Affordability**: There is zero cost associated with the stove, which consists of three stones arranged to suspend a pot over a fire. Firewood is often procured for free.
- **Speed of cooking**: The TSF is time-efficient for certain cooking methods (e.g. grilling or roasting) as it produces a high and direct heat.
- **Taste**: Many believe that firewood imparts a unique and desirable flavor to food.

DISADVANTAGES

- **Health and environmental impacts**: The TSF is associated with smoke pollution and deforestation.
- **Soot production**: Pots used on a TSF become blackened and can be hard to clean.

- **Time spent procuring fuel**: Time is lost in gathering firewood or other fuel, especially in urban areas.

Chitetezo Mbaula (CM)

The Chitetezo Mbaula is a clay energy-saving wood stove that has been widely distributed in Malawi.

ADVANTAGES

- **Fuel efficiency**: the CM uses less wood than a TSF and cooks food more efficiently, with head directly applied to the pot.

DISADVANTAGES

- **Health and environmental impacts**: Like the TSF, the CM generates smoke and contributes to environmental degradation.
- **Durability**: CMs wear out faster than TSFs and can be difficult to maintain.

2.1.3.2 Charcoal

ADVANTAGES

- **Cleanliness**: Charcoal stoves are cleaner and more manageable compared to wood-based options.
- **Affordability**: Charcoal stoves are relatively affordable for more households and charcoal can be purchased in affordable quantities.
- **Performance**: Charcoal stoves cook food evenly and, once heated, charcoal can cook food fairly quickly.

DISADVANTAGES

- **Speed**: Charcoal is a slow method for cooking when the time for heating up the stove is accounted for, unlike gas or electric options, which can cook as soon as turned on.
- **Environmental and health impacts**: Charcoal production contributes to deforestation. It is seen as less healthy than other cleaner fuels:

  "We know charcoal isn't the healthiest, but it's what we can afford right now."
- **Safety concerns**: Users reported burns and finger injuries.
- **Fuel quality**: Charcoal quality can vary with the rainy season.

2.1.3.3 LPG

ADVANTAGES

- **Environmental impacts**: LPG is seen as more environmentally friendly than woodfuels.
- **Speed**: The stove is quick to ignite and provides an instant, adjustable heat, significantly reducing cooking time

DISADVANTAGES

- **Affordability**: The high setup costs of LPG equipment limit its adoption. Fluctuating LPG fuel prices make it difficult for low-income households to budget. LPG is perceived as less cost-effective than charcoal.

  "Gas would make life easier, but the cost keeps us away."
- **Incompatibility with specific foods**: Some participants – including those who cook with LPG - felt that the fuel was unsuitable for preparing foods that take a long time to cook e.g. beans because of the high costs.
- **Safety**: Safety concerns related to gas storage and use limit its adoption, especially around young children. There was a fear of fires and explosions and a lack of knowledge on safe handling and storage practices.
- **Availability**: Gaps in supply chain availability mean that LPG is not considered as reliable as other fuels. There were also concerns about transporting cylinders for refilling (delivery services do not exist in all areas). There are limited distribution networks, especially in rural areas. Participants consequently reported that their LPG cylinders were often empty, forcing them to revert to cooking with traditional fuels.
- **Cultural resistance**: There were concerns about the taste differences in food cooked with LPG versus traditional stoves. There was skepticism towards unfamiliar cooking methods from those who had always used traditional stoves and fuels.

2.1.3.4 Electric cooking

ADVANTAGES

- **Versatility:** Electric stoves and appliances offer a range of cooking options.
- **Affordable fuel:** Results here were mixed. Some participants believed electric stoves and appliances are cheaper to operate compared to wood or charcoal stoves. Others had concerns about high electricity consumption and associated costs.
- **Environmental impacts**: Electric cooking is seen as the most environmentally friendly option.
- **Speed:** Electric appliances heat up instantly and cook quickly.

DISADVANTAGES

- **Upfront costs:** High cost of acquiring electric stoves makes them unaffordable. The additional costs for installation (e.g. wiring upgrading) and maintenance are also prohibitive.

  "Electricity would be nice if it didn't cost so much."
- **Electricity supply:** Frequent power outages disrupt the availability of electric cooking and force users to revert to cooking with traditional fuels. Outages are almost daily, especially during dry season when waters are low and load shedding measures are implemented. During the rainy season the outages are reduced, but

sometimes they still occur due to siltation in the intakes of the generators at the power station.

- **Safety:** There were concerns about electric shocks and fires.
- **Learning curve:** Participants reported that there is a high initial investment time to learning the optimal settings for cooking settings for different foods. Electric cooking was perceived as complex, especially for elderly community members.
- **Infrastructure:** There is often inadequate wiring and unreliable electricity infrastructure in low-income areas.
- **Cultural resistance**: There were concerns about the taste differences in food cooked with electric appliance versus traditional stoves. There was skepticism towards unfamiliar cooking methods from those who had always used traditional stoves and fuels.

2.1.3.5 Pellets

Familiarity with pellet stoves amongst participants was limited. Those who had encountered pellet technologies reported that pellet stoves provided efficient heat for cooking using sustainable fuel. Challenges included inconsistent fuel supply and stoppage before cooking is complete[2].

An academic research team conducted a quantitative survey with n=216 pellet stove users in Lilongwe in partnership with Ener-G-Africa, a private sector pellet stove company in Malawi (Zulu et al. 2024). The study found high rates of adoption up to five years after receiving the stove. Three-quarters of respondents reported that the pellet stove was their primary cooking appliance, but almost all of them continued to stack it with traditional fuels and stoves, usually charcoal. The ability to pay the stove in instalments – which is not offered by most clean stove companies in Malawi – was critical to households being able to adopt it, but households still struggled with the costs. The study also revealed a range of technical issues with the stove (Mimi Moto) which mostly related to the electrical components of the gasifier and with inconsistent quality and availability of fuel supply. These findings suggest that pellet stoves are an appropriate cooking technology in urban Malawi, but there is a need for further affordability and supply chain improvements in order for it to scale.

[2] Some gasifier stoves cannot be refuelled during cooking, meaning that they can cut out with no warning.

2.2 Ability to Pay for Cooking Stoves and Fuels

2.2.1 Costs of Cooking Stoves and Fuels

FUEL PRICES IN URBAN MALAWI

Fuel	Price (MWK)	Unit	Estimated household fuel cost (MCHF CCTs)*	Transaction size	Notes
Charcoal	Varies widely by location: • Lilongwe: 727 • Blantyre: 672 • Mzuzu: 404	Kg	**Traditional jiko**: 44,130 MWK / month **Improved jiko**: 42,270 MWK / month	Charcoal is sold in a variety of purchase quantities ranging from 1-2kg (400-1500 MWK depending on location, the most common quantity) right up to 50kg.	Source: 2024 CMS data collected by MCHF (not yet published). Prices have dramatically increased since MCHF started collecting data in 2020, as shown in Figure 5.
LPG	3245	Kg	**LPG single burner:** 31,650 MKW / month	**Full cylinder refills**: dependent on cylinder size. In Malawi the most common is 6kg (19,470 MWK). **Partial refilling**: any size, with an average of 2-3kg [Mount Meru]. **PAYG**: any size, but this technology is limited in scale and there are no active players in Malawi yet, although Vitalite have a pilot planned.	2024 regulated price set by MERA.
Electricity	173	kWh	**Induction single plate**: 16,440 MWK / month **Double hotplate**: 18,240 MWK / month **EPC**: 6,330 MWK / month	Any – customers can purchase electricity units on demand via mobile money, bank transfer or agents.	2024 regulated grid price set by MERA. There are tiered prices but this is the average domestic price used by MCHF in their 2024 controlled cooking test (CCT) analysis (not yet published).

Fuel	Price (MWK)	Unit	Estimated household fuel cost (MCHF CCTs)*	Transaction size	Notes
Pellets	440	kg	28,380 MWK / month	Dependent on provider: • **Zipolopolo**: 5kg (~2200 MWK) • **ECS**: 30kg (~1320 MWK) • **EGA**: 10kg (~4400 MWK)	Price of pellets sold by Zipolopo, as used in the 2024 MCHF CCT (not yet published).
Biogas	0	kg	0 MWK / month	Fuel generated on site from waste.	

*Table 4: Fuel prices. * - assumes no fuel stacking, please see section 1.2.2. below for full details.*

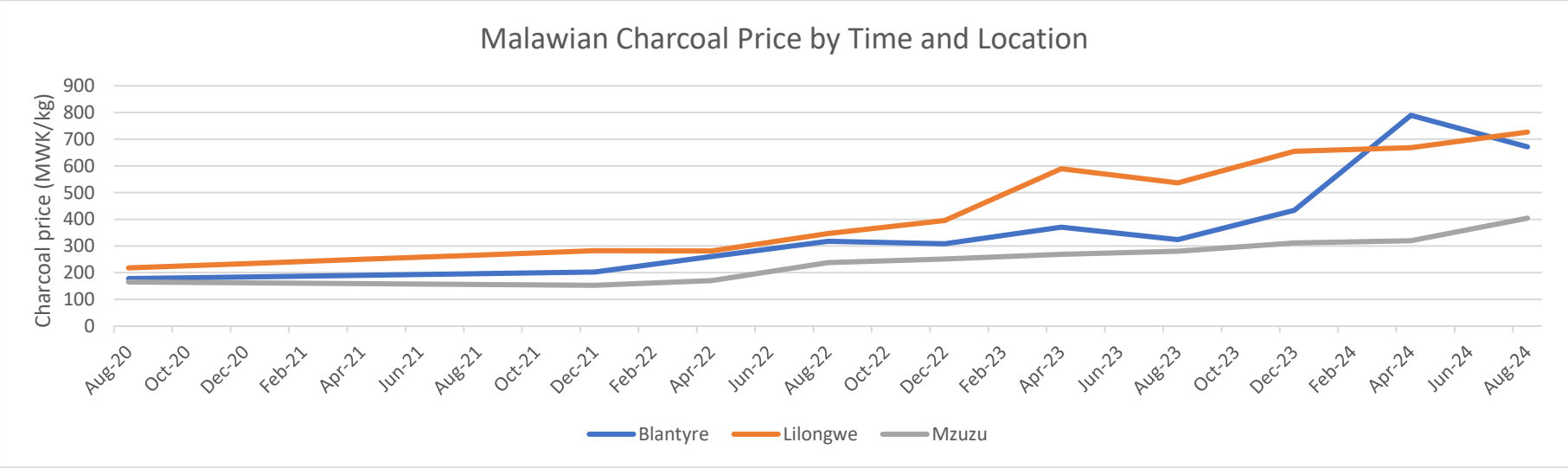


Figure 5: Malawian charcoal price by time and location. Source: MCHF 2024, not yet published. Note that missing values were imputed.

STOVE PRICES

The stove prices shown in Table 5 showing typical unsubsidized retail prices based on a full data set obtained through the project and provided in the attached Investment Plan.

Fuel	Equipment	Typical Retail Price	Source
Charcoal	Basic ceramic jiko.	1500 MWK	Mussa et al. (2020)
	Improved charcoal stove.	2600 MWK	*[Maeve]*
LPG	6kg cylinder + single burner cookstove top.	94,000 MWK.	*[Mount Meru, Afrox, 265 Energy]*
	6kg cylinder + double burner stove and accessories (hose, regulator etc).	180,000 MWK.	*[Mount Meru, Afrox, 265 Energy]*
Electricity	One burner induction stove + cookware.	280,000 MWK.	*[BURN, ATEC, GAME]*
	One pot EPC.	160,000 MWK.	*[UP Energy, GAME]*
	Double burner hot plate / electric stove.	50,000 MWK*	Market scoping in Lilongwe conducted by project team.
Pellets	One burner tier 3+ pellet gasifier stove.	95,000 MWK.	*[Zipolopolo, EGA, ECS]*
Biogas	Domestic biodigester plus two burner stove and accessories.	1,275,000 MWK.	*[Home Biogas, EcoGen]*

Table 5: Stove and appliance prices. - these double burner hot plates were found for sale in local supermarkets. These are cheaper than the induction stoves and EPCs sold by private-sector clean cooking companies but they are also less durable, less efficient and have no warranty or support services.*

2.2.2 Affordability Analysis

According to the 2024 MTF survey only 4% of households find their current cooking solution affordable and spend <5% of their total expenditure on cooking fuel (Malawi Ministry of Energy and ESMAP 2024). This finding was based on self-reported expenditures and agrees with a more nuanced analysis drawing upon controlled cooking tests (CCTs) conducted by MCHF in 2024. MCHF excluded firewood from their tests due to the low reliance on this fuel in urban areas (~11%). We have also adopted this approach in our analysis.

CCTs estimate the energy, financial and time costs of cooking typical local dishes on locally relevant appliances, enabling a direct comparison of different technologies. The results are shown in Table 6. Charcoal is the most expensive cooking fuel on an ongoing basis, followed by LPG (roughly two-thirds the cost of charcoal) and pellets. Electric cooking appliances are the cheapest, with induction stoves and hotplates around a third of the cost of charcoal, and EPC one-seventh.

Technology	Cost (MWK/day)	Time (mins/day)	Energy (MJ/day)[3]
Electric induction single plate	548	194	11.4
Electric two hotplates	608	306	12.6
Gasifier/pellet Stove	946	239	37.3
LPG Single burner	1,055	196	16.3
Improved charcoal Jiko	1,409	305	51.0
Traditional charcoal Jiko	1,471	305	53.3
EPC[4]	*211*	*165*	*4.4*

Table 6: Results of MCHF controlled cooking tests (yet to be published). These figures are based on laboratory tests and assume no fuel stacking in households.

The CCT data was combined with the MTF expenditure quintiles to estimate the proportion of monthly expenditure that is dedicated to cooking fuel for households using each technology exclusively (Figure 6). It shows that only those cooking with electrical appliances in the highest expenditure quintile spend an acceptable share of their income (10% for urban households) on cooking fuel (ESMAP 2020). According to this analysis, most cooking fuels requires more than the whole household expenditure budget for the lowest two quintiles, suggesting that the CCTs are not representative of how low-income urban households cook, or that they are relying heavily on gathered polluting fuels. This graph highlights the savings that could be realised from transitioning from purchased charcoal to Electric cooking, pellets or LPG could free up much needed budget for most urban households[5].

[3] Energy was not measured directly by MCHF and was calculated using textbook energy densities for each fuel.

[4] MCHF did not include EPCs in their CCTs. The EPC figures in the table were estimated using by multiplying the induction CCT results with the induction/EPC ratios measured in Perros et al 2023.

[5] This is less true in Mzuzu, where charcoal is half the price of Lilongwe and Blantyre.

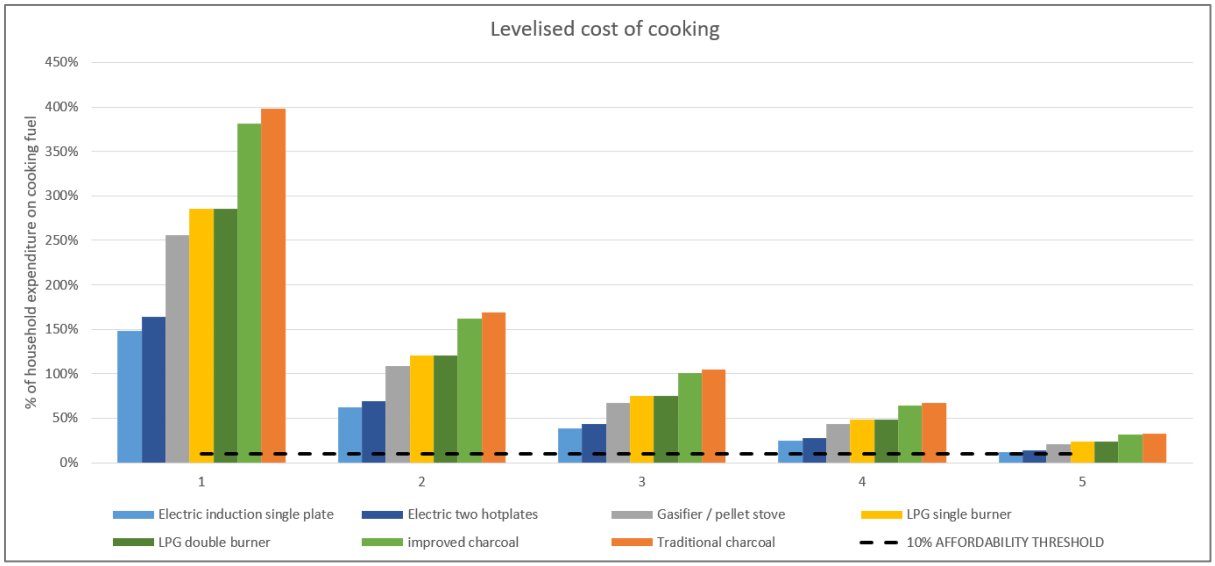


Figure 6: Levelised cost of cooking as a proportion of mean expenditure for each quintile (1=poorest and 5=wealthiest).

Figure 7 examines the upfront affordability of equipment for different cookstoves. It shows that only charcoal stoves are consistently affordable for households, and that even the wealthiest households would struggle to front the costs of electric, LPG and pellet stoves, which are all over 90% of their monthly expenditure. For the lowest income quintile this figure rises to 1000-2000%, or 1-2 years' worth of salary.

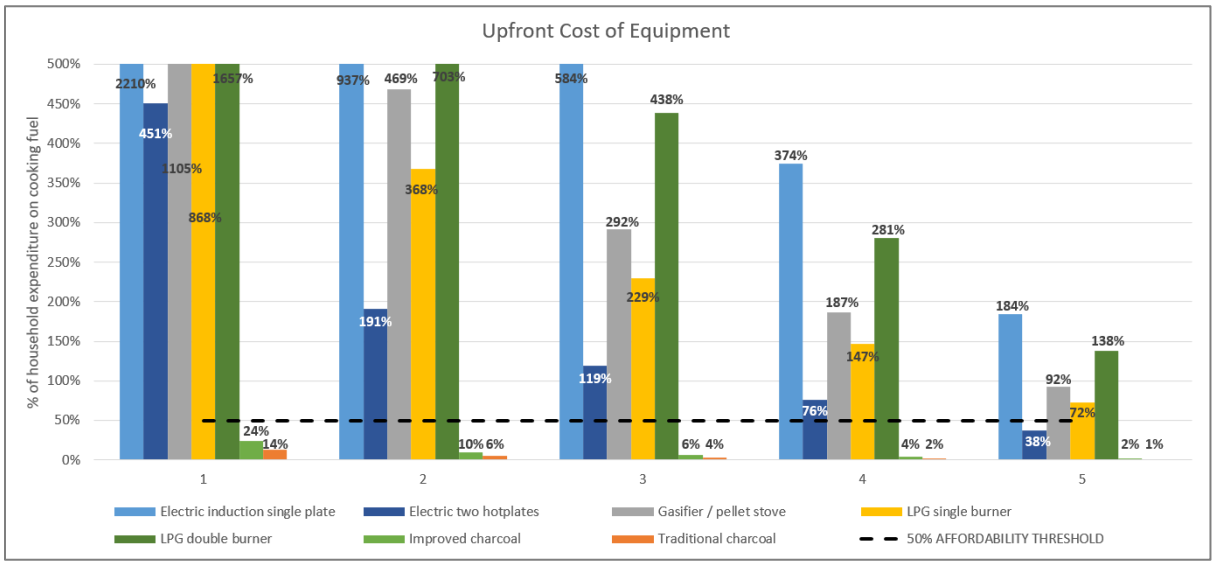


Figure 7: Upfront cost of equipment as a proportion of mean total household expenditure for each quintile (1=poorest and 5=wealthiest). Note that the y-axis has been truncated.

Together, these graphs show that transitioning from charcoal to LPG, Electric cooking or pellets would result in financial savings for all households. However, the upfront cost of equipment renders these technologies prohibitively expensive for most Malawians. Both subsidies and schemes that allow payment in installations (not currently common in Malawi) are required in order to address this barrier.

Table 7 estimates the impacts of switching from charcoal to induction stoves, hotplates, EPCs, pellet stoves and an LPG stove. It shows cost, time and energy savings for each transition, apart from time savings for the electric hot plate, which was one minute slower than charcoal. This data is used to estimate the aggregate impacts of various intervention scenarios in Scenario Analysis.

From	To	Fuel cost saving (MWK/HH/day)	Time saving (mins/HH/day)	Energy saving (MJ/HH/day)
Traditional charcoal	Induction single plate	923	111	41.9
Traditional charcoal	Electric two hotplates	863	-1	40.7
Traditional charcoal	Gasifier/pellet Stove	525	66	15.9
Traditional charcoal	LPG Single burner	416	109	37.0
Traditional charcoal	EPC	1,260	140	48.9
LPG	Electric induction single plate	507	2	5
LPG	Electric two hotplates	447	-110	4
LPG	EPC	844	31	12

Table 7: Impacts of transitioning from traditional charcoal to clean cooking technologies.

2.3 Gendered Aspects of Clean Cooking Demand

The MTF survey found that less than a third (31%) of households are female-headed[6]. These households are less likely to have access to electricity compared to male households (18% vs 29%) (Malawi Ministry of Energy and ESMAP 2024). It also found that 41% of households spend more than seven hours per week collecting and preparing fuel and this burden is normally borne by women (ibid.).

Previous research has found that female members of the household usually do most of the cooking (Coley and Galloway 2020). Males (usually heads of the households) control household finances, creating a disconnect between those who cook and those who have the most agency to change cooking fuels and technologies. This is exacerbated further in more affluent households in urban areas where cooking is done by maids.

These results were supported by the focus group discussions (FGDs) conducted as part of this market assessment. The FGDs revealed that cooking roles and fuel acquisition are managed by women in Malawian households, though men often oversee fuel payment and purchasing. While women tend to make cooking technology decisions, they often consult

[6] Where a female is the primary income provider and decision maker

men, and financial control usually rests with male household members. Consequently, men's perceptions about cooking solutions significantly influence the choices made, emphasising the need for inclusive education and outreach.

> *"Even though we talk about it together, my husband makes the final choice on what stove we buy or fuel we use."*

2.4 Distributional System Impact Assessment for Electric cooking

2.4.1 Headroom Analysis

To assess the ability of the network to accommodate the growth of electric cooking, it is essential to evaluate network constraints by conducting demand headroom analysis and power flow studies. It is important to note that network capacity headroom may vary:

- Headroom at a substation/substation group/transformer may be limited by constraints at the higher voltage level or upstream/downstream fault level.
- Demand and generation are subject to factors which can change over time and influence predetermined plans.

The flowchart diagram Network Development Methodology (NDM) presented in Figure 8 (African Energy n.d.) is a guide to computing the demand headroom (DH) for assessing and understanding the scale-up of Electric cooking demand in the Malawian national grid. It comprises a step-by-step model development workflow that processes three different network studies. It is structured with the ability to model the entire distribution network, including the MV network and LV network if required for future studies.

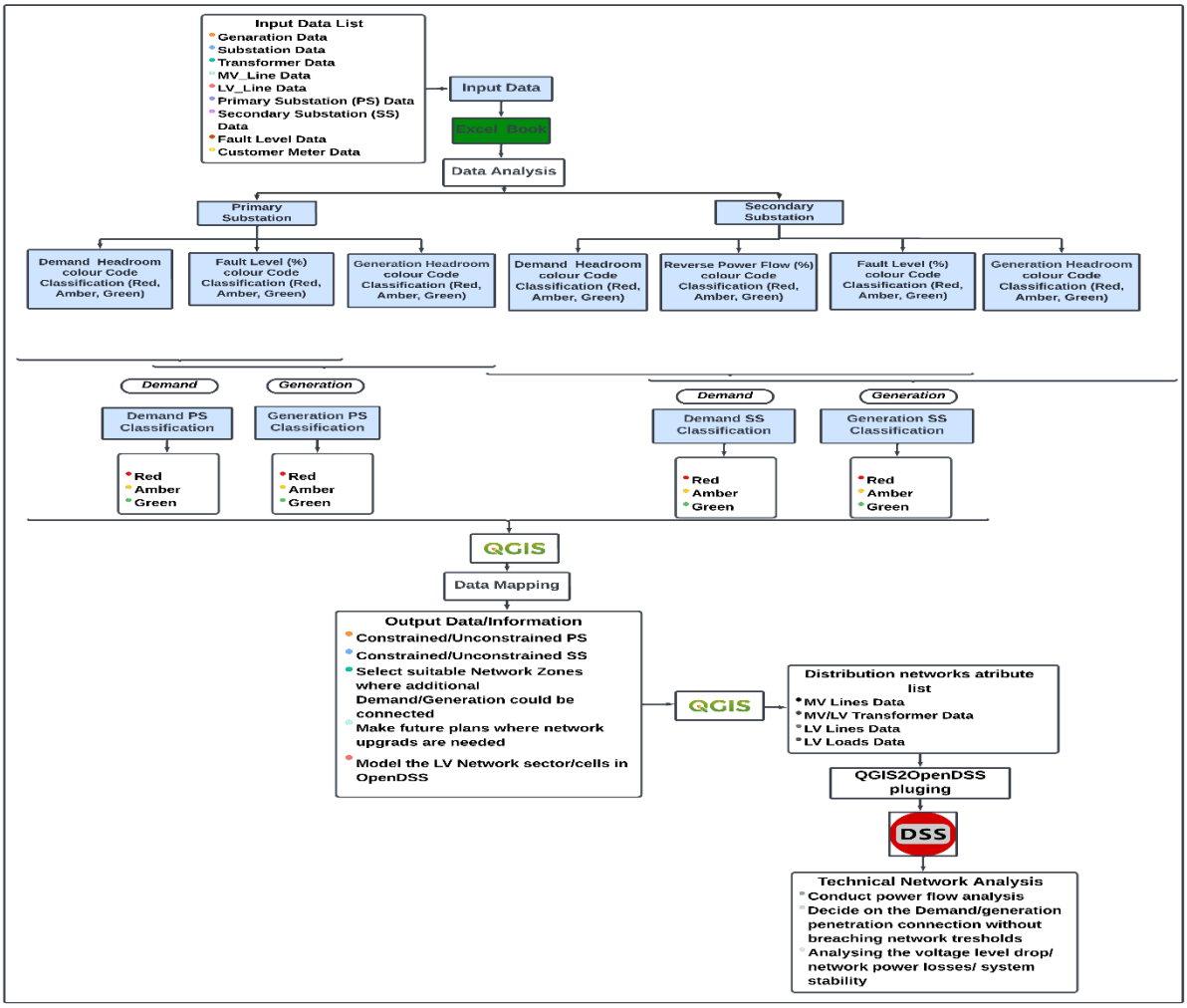


Figure 8. Network Development Methodology (African Energy n.d.)

The depth of the headroom analysis and the outputs of this work area correlate with available ESCOM substation and transformer data. In this section, the demand headroom covers primary substations (PS) with either 66/11 kV or 33/11 kV transformers as well as secondary substations (SS) with 11/0.4 kV transformers. Initially, Excel was used to correct, sort and analyze the data, which then used Quantum GIS (QGIS) as an entry point for. The database in Table 8 was shared by the Ministry of Energy and ESCOM and used to plague into the model. The headroom results do not account for the generation headroom analysis nor the upstream/downstream fault level (FL) and the reverse power flow (RPF) capability due to the absence of data.

Table 8. The main input data for the headroom data analysis and QGIS modelling

Database	Data availability (Yes/No)
GIS coordinates of PS and SS	Yes
Name coordinates of PS and SS	Yes
Transformer rating	Yes
PS maximum load	Yes
SS maximum load	Yes
PS minimum load	No
SS minimum load	No
Upstream and downstream fault level (%)	No
Reverse power flow capability (%)	No
MV feeder data	Yes

The DH of each of the PS and SS is computed as follows:

$$DH = Transformer\ Rating - Maximum\ Load$$

The DH study was completed for 18 PS out of 77 PS, the rest will need to be studied in future work. The next step was mapping the data into QGIS in the form of a heat map using Red, Amber and Green color codes to classify the PSs and SSs and prioritize where capacity exists the most for demand connection. This also provides the possibility to understand network connections and identify system constraints and limitations for eCooker deployment. Table 9 is the list of the 18 PS and their site classification in terms of DH and their total available headroom, each of the PS can be connected to more than one SS. Red reflects on DH restriction where no additional Electric cooking demand can be connected, Amber is where the SS can support 1 to 33 additional induction stoves of 1.5 kW or 1 to 50 EPCs of 1 kW, while Green is where the SS can support more than 33 induction stoves or 50 EPCs depending on the maximum SS demand headroom available.

Table 9. List of PS and their Demand headroom analysis

PS Name	Region	Overall_demand headroom Category	PS available headroom [kVA]
Area 25	center	Green	5530.46
Area 47	center	Red	0
Balaka	south	Green	2106.42
Changalume	south	Green	8665.02
Chigumula	south	Green	6051.62
Chinyama	center	Green	1550.15
Chitipi	center	Green	2694.76
City Centre	center	Green	2134.79
Dedza	center	Red	0

Dwangwa	center	Green	1505.29
Kangoma	center	Amber	4268.61
Kapichira	south	Green	2101.63
Livingstonia	north	Green	571.30
Mlangeni	center	Green	3444.07
Monkeybay	south	Amber	11560.01
Nanjoka	center	Green	4253.43
Ntcheu	center	Green	1801.30
Uliwa	north	Amber	105.74

Using the Electric cooking data and the estimated energy consumption in Table 13 and Table 14 gathered from the pilots conducted in Zambia, Tanzania and Malawi (please refer to section 3.2.5 for more detail), the number of Electric cooking appliances that can be supported at each PS was calculated as well as the additional daily (Table 13) and yearly (Table 14) generation needed to support the upscaling; the number of Electric cooking appliances and the generation requirement can vary depending on the type of appliance, their rating and the cooking energy consumption. It is important to highlight that the number of Electric cooking appliances calculated can significantly decrease once the base demand increases. Also, the additional generation required may vary depending on the daily cooking energy, therefore more focus needs to be placed on getting more accurate cooking energy consumption in Malawi.

Table 10. Electric cooking appliances and their power rating

eCook Type	Rating (kW)
EPC	**1**
Hotplate_1	**1**
Induction stove	**1.5**

Table 11. Electric cooking daily energy consumption in different countries

Country	Cooking device type	Cooking device type	Household daily energy consumption (kWh)	
Zambia	Using 100% electricity for cooking	EPC	Daily average	1.63
	Using 90% electricity for cooking plus fuel stacking	EPC	Daily average	1.1
Tanzania	Using 100% electricity for cooking	EPC	Daily average	2.06
	Using 90% electricity for cooking plus fuel stacking	EPC	Daily average	1.44
Kenya	Using 100% electricity for cooking	EPC	Daily average	1.4
	Using 90% electricity for cooking plus fuel stacking	EPC	Daily average	0.96
Malawi	MEGA (uses fuel stacking)	Induction stove	Daily min	0.2
			Daily max	2.5

Table 12. Number of possible Electric cooking appliances uptake at each of the 18 primary substations

PS Name	Number of EPC [1 kW]	Number of hotplates [1 kW]	Number of induction stoves [1.5 kW]
Area 25	5530	5530	3687
Area 47	0	0	0
Balaka	2106	2106	1404
Changalume	8665	8665	5777
Chigumula	6052	6052	4034
Chinyama	1550	1550	1033
Chitipi	2695	2695	1797
City Centre	2135	2135	1423
Dedza	0	0	0
Dwangwa	1505	1505	1004
Kangoma	4269	4269	2846
Kapichira	2102	2102	1401
Livingstonia	571	571	381
Mlangeni	3444	3444	2296
Monkeybay	11560	11560	7707
Nanjoka	4253	4253	2836
Ntcheu	1801	1801	1201
Uliwa	106	106	70

Table 13. Additional daily generation requirement to support Electric cooking uptake

PS Name	Zambia		Tanzania		Kenya		MEGA Malawi	
	EPC (100%) [MWh]	EPC (90%) [MWh]	EPC (100%) [MWh]	EPC (90%) [MWh]	EPC (100%) [MWh]	EPC (90%) [MWh]	MEGA (min) [MWh]	_MEGA (max) [MWh]
Area 25	9.01	6.08	11.39	7.96	7.74	5.31	0.74	9.22
Area 47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Balaka	3.43	2.32	4.34	3.03	2.95	2.02	0.28	3.51
Changalume	14.12	9.53	17.85	12.48	12.13	8.32	1.16	14.44
Chigumula	9.86	6.66	12.47	8.71	8.47	5.81	0.81	10.09
Chinyama	2.53	1.71	3.19	2.23	2.17	1.49	0.21	2.58
Chitipi	4.39	2.96	5.55	3.88	3.77	2.59	0.36	4.49
City Centre	3.48	2.35	4.40	3.07	2.99	2.05	0.28	3.56
Dedza	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dwangwa	2.45	1.66	3.10	2.17	2.11	1.45	0.20	2.51
Kangoma	6.96	4.70	8.79	6.15	5.98	4.10	0.57	7.11
Kapichira	3.43	2.31	4.33	3.03	2.94	2.02	0.28	3.50
Livingstonia	0.93	0.63	1.18	0.82	0.80	0.55	0.08	0.95
Mlangeni	5.61	3.79	7.09	4.96	4.82	3.31	0.46	5.74
Monkeybay	18.84	12.72	23.81	16.65	16.18	11.10	1.54	19.27
Nanjoka	6.93	4.68	8.76	6.12	5.95	4.08	0.57	7.09
Ntcheu	2.94	1.98	3.71	2.59	2.52	1.73	0.24	3.00
Uliwa	0.17	0.12	0.22	0.15	0.15	0.10	0.01	0.18

Table 14. Additional yearly generation requirement to support Electric cooking uptake

PS Name	Zambia		Tanzania		Kenya		MEGA Malawi	
	EPC (100%) [MWh]	EPC (90%) [MWh]	EPC (100%) [MWh]	EPC (90%) [MWh]	EPC (100%) [MWh]	EPC (90%) [MWh]	MEGA (min) [MWh]	_MEGA (max) [MWh]
Area 25	3290.35	2220.48	4158.36	2906.81	2826.07	1937.87	269.15	3364.37
Area 47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Balaka	1253.22	845.73	1583.82	1107.14	1076.38	738.09	102.51	1281.41
Changalume	5155.26	3479.01	6515.23	4554.34	4427.83	3036.23	421.70	5271.23
Chigumula	3600.42	2429.73	4550.22	3180.73	3092.38	2120.49	294.51	3681.41
Chinyama	922.27	622.39	1165.56	814.76	792.13	543.18	75.44	943.01
Chitipi	1603.25	1081.95	2026.20	1416.37	1377.03	944.25	131.15	1639.32
City Centre	1270.10	857.12	1605.15	1122.05	1090.88	748.03	103.89	1298.67
Dedza	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dwangwa	895.57	604.38	1131.83	791.18	769.20	527.45	73.26	915.72
Kangoma	2539.61	1713.85	3209.57	2243.58	2181.26	1495.72	207.74	2596.74
Kapichira	1250.37	843.81	1580.22	1104.62	1073.94	736.41	102.28	1278.49
Livingstonia	339.90	229.38	429.56	300.28	291.93	200.18	27.80	347.54
Mlangeni	2049.05	1382.80	2589.60	1810.21	1759.92	1206.80	167.61	2095.15
Monkeybay	6877.63	4641.34	8691.97	6075.94	5907.17	4050.63	562.59	7032.34
Nanjoka	2530.58	1707.76	3198.16	2235.61	2173.51	1490.41	207.00	2587.51
Ntcheu	1071.69	723.22	1354.40	946.77	920.47	631.18	87.66	1095.79
Uliwa	62.91	42.46	79.51	55.58	54.04	37.05	5.15	64.33

The result of the headroom analysis of the substations listed in Table 9 and illustrated in Figure 9 provides evidence that there is demand headroom for Electric cooking upscaling categorized Green or Amber, as mentioned before it is important to note that network capacity headroom may be limited or change due to various reasons:

- Headroom at a substation/substation group/transformer may be limited by constraints at the higher voltage level or by upstream/downstream fault level constraints.
- Demand and generation are subject to factors which can change over time and influence predetermined plans.

In future analysis, it will be valuable to factor in FL constraints - where the network fault current would exceed the fault current rating of switchgear or the design limit of the network. If this happened, it would represent a serious safety risk as the network could not be safely isolated in the event of a fault. Fault current constraints can affect equipment at any voltage level. Circuit breakers may be called upon to disconnect faulty equipment from the network; or energise onto faulty or earthed equipment. A range of types of faults (including 3-phase and single-phase faults) are assessed under make-and-break fault duties. Where switchgear is in excess of 95% of equipment or design rating, is consider the substation to be constrained.

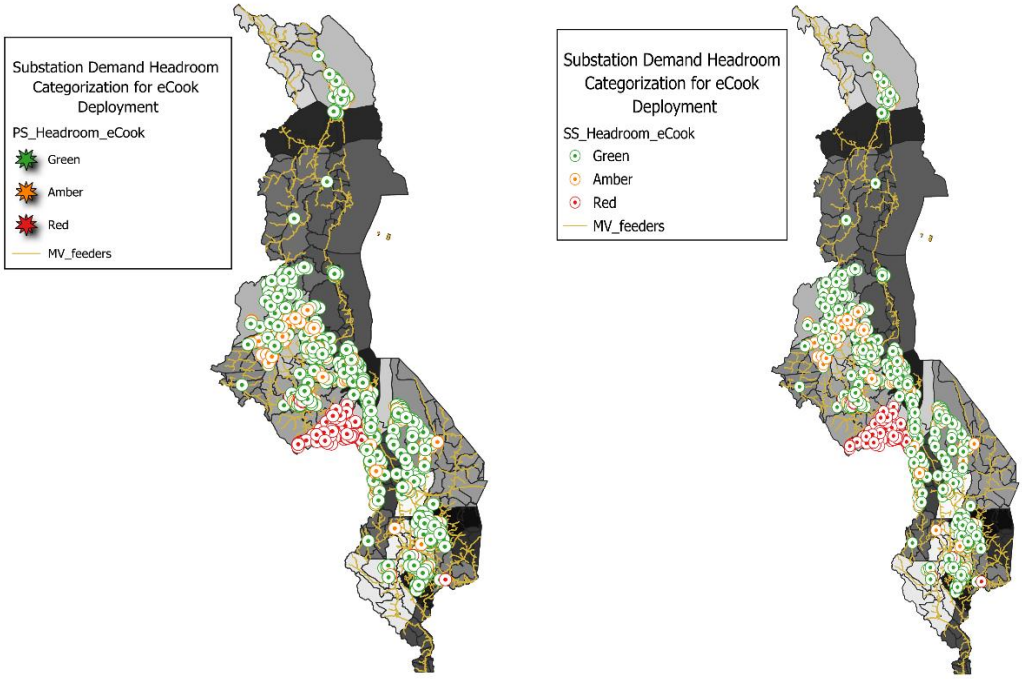


Figure 9. QGIS special headroom heat map

2.4.2 Power Flow Analysis

The challenge when operating large-scale Electric cooking appliances on the grid is demand peaks and negative effects on the network voltage fluctuations, thermal losses, power network stability problems and limited capacity of network assets, where network power flow would exceed equipment thermal ratings. Thermal constraints can affect any type of asset at any voltage level. High loading on certain assets may simply reduce their life, however significant overloading introduces safety risks. For example, an overhead line conductor will sag more if it is overloaded. To understand the technical grid limitations developed it is important to investigate how “fit for purpose” the MV and LV distribution networks to accommodate the increasing of both Electric cooking demand and demand, or indeed what design considerations or interventions would be required to make them ready for this new demand growth. The results from modelling a representative LV network and conducting power flow studies (see Figure 8) can be used to assess the system’s performance and the interventions and investment costs required. It will give an insight into the existing problems and future design requirements.

Hosting capacity analysis (Ministry of Energy 2023) is also recommended to quantify the possible integration level of distribution generation (DG) that can be added to a distribution system without negatively impacting power quality or reliability. It depends on many factors, including:

- The characteristics of the DG system.
- The location of the DG system on the circuit.

- The location and the behavior of other DG on the circuit and the existing equipment on the circuit.

It is used to:

- Evaluate how much (net) capacity from renewable-based DG units can be integrated into the current existing distribution networks without having adverse impacts on the technical limits.
- Identify the barriers that do not allow the increase of DG integration.
- Prioritize the investment needs to relieve the constraints while considering the planned investments to supply the future load increase.

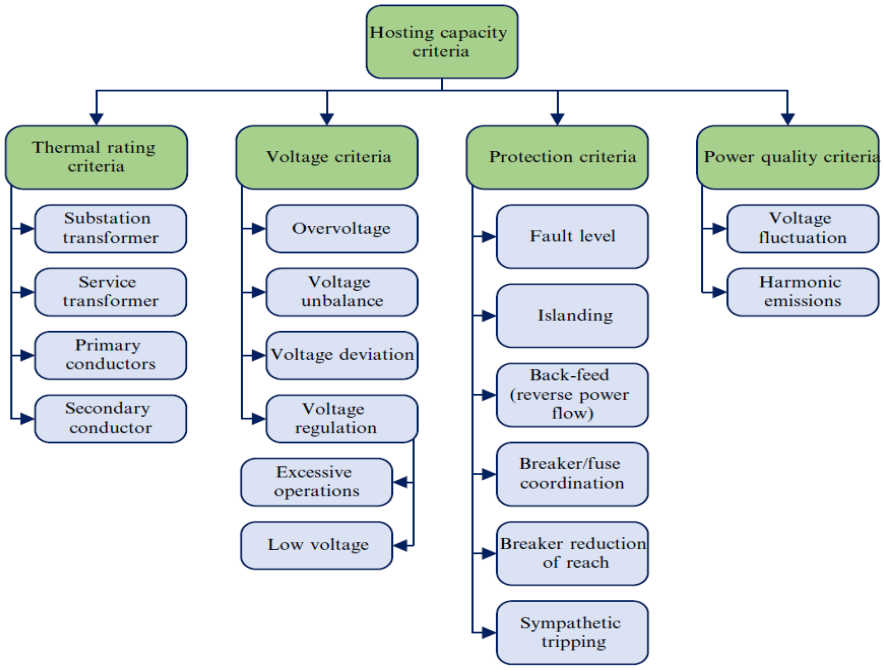
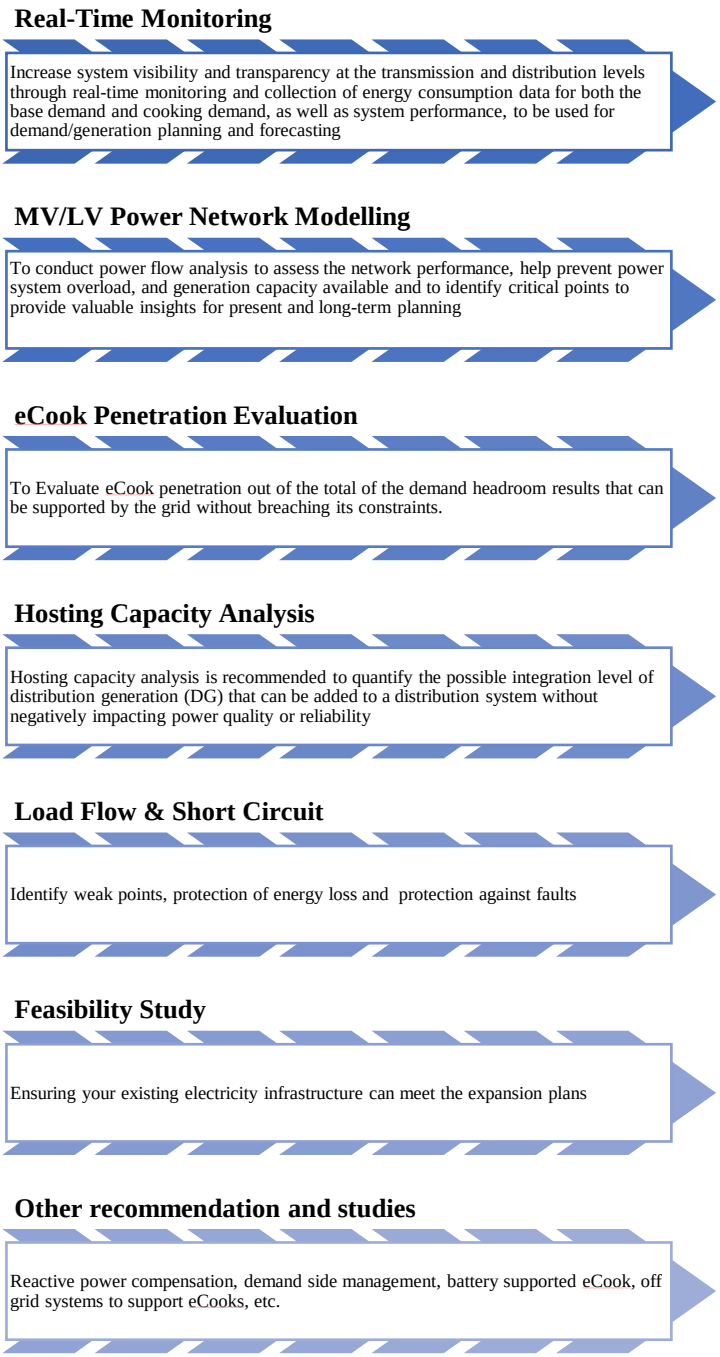


Figure 10. Hosting capacity criteria (Ministry of Energy 2023)

2.4.3 Network Interventions

The Power flow analysis as well as the hosting capacity discussed in the previous section could also be used to evaluate any of the following interventions to support Electric cooking upscaling and to manage each individual network constraint, through:



- Evaluating the Electric cooking penetration from the total of the demand headroom results that can be supported by the grid without breaching its constraints.
- Deciding on the best network solution practice (DG, grid expansion or even demand side management) for present and future planning.
- The transmission and distribution voltage levels are low compared to the ones used in UK networks, using high voltage increases the power transferred and reduces power loss over long distances owing to the resistance in the wire.

- Improving the liability of the Malawian electric grid by applying N-1 criteria to ensure that the system continues to function normally in case of disconnection of one line. The drawback of a radial grid is that if a line is disconnected for some reason, all the lines downstream also lose power. With the mesh grid, topology it is possible to find close loops and the power is delivered through multiple lines, connected to each other, making a mesh. This kind of topology is more reliable, and have fewer losses but requires bigger investments compared to the radial topology.
- Providing reactive power compensation where needed, will help improve the network's power factor and reduce energy consumption by reducing the total load current and voltage drop, in addition to reducing the power losses, improving the voltage quality, and stabilizing the operation of equipment. Another issue is aging transmission assets that is caused by many factors; to avoid this in the future, the service life of equipment can be extended by placing reactive power support so that the loading capacity of the transformer, switch, lines and other machinery equipment close to saturation is reduced and not operating at high temperature. In a similar context, European countries are investigating issues regarding the transition towards electric vehicles on utility networks, the network challenges and the benefit of coupling electric vehicles with demand management to increase their pace. Therefore, generation upgrades, innovative demand management concepts and aggressive measures to encourage customers to embrace Electric cooking technology will facilitate the transition. To determine the best operation for existing networks and in planning future expansion scenarios, detailed network studies and power flow analysis are required to help prevent power system overload, and generation capacity available and to identify critical points to provide valuable insights for present and long-term planning.
- Reserves are held principally in developed countries to maintain power system frequency within an acceptable range. Operating reserves are the electricity supplies that are not currently being used but can quickly come online in the case of an unplanned event on the system — such as a loss of generation or a transmission line — or when real-time demand is higher than forecast.
- Increase system visibility and transparency at the transmission and distribution levels through real-time monitoring and collection of energy consumption data for both the base demand and cooking demand, as well as system performance, to be used for demand/generation planning and forecasting. Previous data collected from Electric cooking field trials involve the participation of a small number of households with less intensive data-gathering. Demand in general can be influenced by irregular events and subjected to a seasonal basis (across the week and during the day) as well as fuel stacking. To understand these fluctuations and cooking patterns, long-term data (base demand and Electric cooking demand) collection and monitoring is required for a large number of households connected to both grid and mini-grids; for at least for two years. This data could also be used for long-term demand Electric cooking forecasting. Further down in line installing smart meters at the household level will support demand response and load management. etc.

- Mini-grids provide electricity to rural communities in developing countries with limited needs, but their limited size, scale and high tariffs are less efficient than large-scale mini-grids. Investing in large-scale mini-grids to supply higher power appliances (such as eCooks appliances) and even connecting them to the grid could play a unique role in improving grid stability and security, reducing transmission and distribution power losses and even providing affordable tariffs. However, they must be well managed to avoid the occurrence of system instability.
- Mini-grid design standards should be put in place to comply with grid standards, to facilitate its connection when the grid arrives. To date, no regulation standards have been introduced for mini-grids and system size, PV array capacity, types and size of the cables are selected depending on each system operator.
- Another point to highlight is even though the upfront cost of large-scale mini-grids is high, the tariff rate is low. The studies in (Keddar et al. 2021; 2020) prove that the tariff rate is correlated with the scale of the mini-grid and the energy served – the tariff decreases due to the increase in the annual total electric load served. This demonstrates that as more energy (kWh) is used, the upfront cost is divided amongst the many users. The tariff rate could decrease further when factoring energy mix into generation production. Even making use of installing large PV solar plans plays an important role, the power generated from Salima JCM solar power is sold at a rate of $0.085 kWh to ESCOM under a power purchase agreement. Connecting mini-grids to the grid or even installing distribution generator systems have positive and negative effects on the system. However, there is a need to adequately choose the acceptable amount of generation penetration and location so that the advantages are not turned into disadvantages. The optimal energy mix combination also needs investigation to achieve the lowest tariff.
- Energy metering and price incentives are common approaches to reduce peak demand and shift to off-peak. Further down in line, different types of DSM need to be assessed to understand what the right fit in the Malawi context is for both urban and rural areas. The research paper (Keddar et al. 2022), investigates eCook-supported batteries to maximise electric cooking capacity, network challenges and solutions when connecting a large scale of them. Using battery support has positive and negative effects on the system particularly if all are charged at once, which could alter the network constraints. The network could experience voltage fluctuations, system power losses and increased peak demand if all or most of the connected batteries charge during a relatively “narrow” window. Capturing such complex sets of interactions needs a broader perspective; this requires a sophisticated modelling framework to enable the transition toward battery supported electric cooking by exploring innovative and smart DSM concepts.
- The battery sizing, ageing and charging rate are critical points for electric cooking battery supported where future studies are required; charging the batteries with a high charging rate causes increases in voltage drop and violates network constraints, affecting the ageing process and performance of the battery. In addition to this,

accurate average household Electric cooking energy consumption is needed to size to avoid oversizing.

2.4.4 Distributional System Impact Assessment Conclusions

The distributional system impact assessment reveals that scaling Electric cooking in Malawi is feasible but requires substantial infrastructure upgrades and strategic planning to mitigate potential grid challenges. Key constraints include limited demand headroom at certain substations, frequent power outages, and the lack of detailed long-term energy consumption data for accurate demand forecasting. The capacity to support additional Electric cooking appliances varies significantly across substations, with areas like Dedza and Area 47 having no immediate capacity, while others, such as Monkeybay and Changalume, have substantial headroom.

Effective grid planning, demand-side management, and interventions to enhance network reliability are critical to enabling the large-scale adoption of electric cooking without compromising system stability or exacerbating voltage and thermal issues.

2.4.5 Distributional System Impact Assessment Recommendations

Capacity and Infrastructure Development:

- Prioritise investments in substations and regions with low or no demand headroom (e.g., Dedza, Area 47) to expand their capacity.
- Implement power flow studies and hosting capacity analyses to identify optimal locations for future Electric cooking deployment and grid upgrades.
- Explore transitioning to a mesh grid topology in high-demand areas to improve reliability and reduce losses.

Demand Management:

- Introduce demand-side management strategies, such as time-of-use pricing or load-shifting programs, to alleviate peak demand stresses.
- Promote staggered charging for battery-supported Electric cooking systems to prevent simultaneous high-load events.

Monitoring and Data Collection:

- Invest in real-time monitoring systems, such as smart meters, to track energy consumption patterns for both base and Electric cooking loads.
- Conduct longitudinal studies on household energy consumption to refine demand forecasting and infrastructure planning.

Interventions to Address Grid Constraints:

- Use reactive power compensation where needed to improve power factor and reduce energy losses.
- Upgrade aging transmission assets and ensure all new installations meet "N-1" reliability criteria to handle unplanned outages without service disruption.

Minigrid Policy and Standards:

- Establish mini-grid design standards that align with the national grid to enable seamless integration when grid extensions occur.
- Incentivise the development of large-scale mini-grids capable of supporting high-power appliances like Electric cooking, with provisions for future grid connection.

Pilot Programs:

- Launch Electric cooking pilots in substations with significant headroom (e.g., Monkeybay, Changalume) to gather data and demonstrate scalable models.
- Experiment with integrated battery systems to offset grid demand and evaluate their operational impacts under real-world conditions.

Demand-Side Analysis – Program Key Recommendations

- ➲ Support culturally appropriate cooking devices that accommodate multiple pots for boiling (i.e. porridge, beans) and frying to match Malawian cooking preferences
- ➲ The soaring price of charcoal means that most households will save money by switching to clean fuels. However, subsidies for upfront costs will need to cover 70-90% of for lowest income quintiles (reducing costs from 180,000 MWK to 18,000-54,000 MWK) and 40-60% for middle-income households
- ➲ Support innovative financing schemes like pay-as-you-go and on-bill financing to overcome the $100-200 upfront cost barrier for electric cooking appliances
- ➲ Target awareness campaigns to both women who cook and men who control finances to address the household decision-making disconnect
- ➲ Prioritize infrastructure upgrades in substations with limited capacity like Dedza and Area 47 before promoting electric cooking adoption in these areas
- ➲ Focus initial deployment on areas with significant grid headroom like Monkeybay and Changalume where infrastructure can support immediate adoption

TA Required

- ➲ Implement metering program for real-time energy monitoring systems to track consumption patterns and inform demand forecasting for both urban and rural cooking needs

3 Supply-Side Analysis

3.1 Overview of Clean Cooking Fuels in Malawi

This section describes the supply chains, scalability and associated costs of tier 4+ cooking fuels in Malawi, specifically LPG, electric cooking (referred to as "Electric cooking"), biogas, ethanol and processed biomass (pellets and briquettes). There is a particular focus on LPG and Electric cooking to reflect the higher levels of scalability.

Throughout the report, square brackets and italics are used to reference information gained through interviews with key informants.

3.1.1 LPG

Liquefied petroleum gas (LPG) describes flammable hydrocarbon gases including propane, butane and mixtures of these two gases. LPG is a by-product from natural gas processing and crude oil refining. It is stored as a liquid under moderate pressure in vessels including tanks and cylinders. When the pressure is released – by opening the valve on the cylinder – vapour is produced. One unit of liquid will produce around 250 units of vapour making LPG an extremely useful fuel that can be stored and transported as a liquid but then used as a gas. The portability of LPG enables it to be used in the most remote parts of the world as well as in densely population urban areas.

Cooking is the main application for LPG, with almost half the world's demand coming from this sector. When LPG displaces traditional cooking fuels - such as charcoal, wood and animal waste – it creates many advantages including lower emissions, cleaner cookstoves, improved health and quality of life. A typical LPG system consists of a cylinder, regulator, hose and cookstove. Cylinders come in a range of sizes from less than 1kg to over 50kg. Stoves can have 1, 2 or 4 burners. Double-burner stoves are generally regarded as offering the best balance of price, safety and versatility, as they facilitate cooking of two dishes at a time, facilitating more complete adoption of the fuel.

Sometimes a burner stove is fixed directly to the cylinder top Figure 11. This is a cheaper system, often a starter kit, which is popular in other SSA markets e.g. Kenya. The landed costs for a burner stove like the one shown would be under US$12 in quantities *[RealFlame India]*. Matching the stove to the cylinder is important to ensure a stable cooking facility. There have been reports of poor-quality cook stoves entering Malawi in the absence of any standards. Importers claim they apply the standards from the country of origin.

Figure 11: cylinder with screwtop burner

Supply chain

The main LPG producing regions in the world are the USA and the Middle East. The LPG supply chain in Malawi starts with the LPG producers shipping product by sea into sea fed storage facilities into adjacent countries (Tanzania, Mozambique and South Africa) from where it is hauled several thousand

kilometers (km) by road tanker into local storage. The gas is then deposited into cylinders and delivered to, or collected by, the consumer.

The freight cost will depend on the size of vessel and the amount of product that can be delivered. Because Malawi is land locked, LPG supplies are transported across countries from the sea fed terminals by road tanker. The main sea fed terminals supplying Malawi with LPG are located in South Africa, Mozambique and Tanzania. While the LPG terminal in the port of Beira, Mozambique, is nearest to Malawi, the supply there is limited and the price tends to be higher which drives the companies to buy mainly from terminals in Richards Bay, South Africa and Dar es Salaam, Tanzania *[Delta, Mount Meru]*.

There are seven LPG players in Malawi with import licenses: AFROX, Delta, IOCL, Falcon, Mt. Meru, Yogas and Gasco. They all bring the product into Malawi using road tankers of 25-26 tonne capacity. All of the LPG players use contracted road tankers from abroad except for Mt. Meru, who own and operate one road tanker *[Malawi Energy Regulatory Authority (MERA)]*. These road tankers typically travel 1,500km – 2,500km from the sea fed terminals to deliver into LPG depots in Malawi. MERA has noted that currently only three out of the seven players (Afrox, Mount Meru and Falcon or Delta) with an import license actually import product into the country. This is largely due to the recent depreciation of MWK:USD and, given the high value placed on USD, these importers are less likely to commit to supply contracts due to the risk of further depreciation. Delta also mentioned in an interview that the official rate of exchange MWK:USD is far higher than the black market rate. .

There are eight LPG depots in Malawi, seven of which are in the Central region and one in the South. Afrox has depots in both regions while the rest of the players' depots are in the Central region, which is the main population center in Malawi. The total combined LPG storage capacity is 225 tonnes *[MERA],* although research performed through this project places the total installed storage capacity at a higher level of at least 350 tonnes. Based on the 2023 full year demand and Mera's capacity figure, the overall industry depot tank turnover is 12.6 times a year (8.1 times if based on 350 tonne capacity). Despite the comfortable level of storage capacities, there are product shortages due to issues related to foreign exchange, specifically access to foreign currency and devaluation of Malawian Kwacha *[Falcon Gas]*.

The seven LPG players fill their own branded cylinders and distribute them to their customers through a network of distributors and retail outlets. As per MERA, there are a total of 124 distributors and retail outlets across the 3 main regions with 86 in Central, 34 in South and 14 in North *[MERA]*. The most common size of cylinder in the domestic sector is 6kg. The cylinders are distributed on a refundable deposit basis and the cylinder remains in the ownership of the LPG company. This is important because the cylinder owner is responsible for the on-going checking, maintenance and requalification of the cylinder[7].

[7] Maintenance and repairs of cylinders are carried out before refilling. It is mainly washing and repainting of cylinders, and replacement of any leaking valves. After a period of around 10 years cylinders are requalified. This entails cylinders being taken out of service for hydrotesting to confirm their fitness for continued use.

LPG is purchased either on an exchange (full for empty) basis or by partial filling. Partial filling is an attractive proposition for the consumer because they buy LPG in more affordable amounts rather than a full cylinder. Three years ago, the cylinder exchange model was most popular in Malawi, but more recently, the balance has shifted towards partial filling, which is available at all retail outlets. Partial filling in Malawi is carried out using 45 kg cylinders with liquid withdrawal valves to transfer product into 6kg cylinders usually in quantities of up to 3kg. This is a simple, inexpensive but inefficient way of transferring product. However, partial filling compromises the safety of the operations. This is because the cylinder cycles between the consumer and the refiller and never receives thorough inspection, maintenance and periodic requalification. Partial filling encourages cross filling of competitor cylinders and discourages investment in new cylinders. Some new business models are starting to enter the market, e.g. pay-as-you-go (PAYG) with smart cylinder valves, micro-financing for stove tops and LPG accessories, and home delivery of cylinders.

Pricing

The international price of LPG has traditionally been set by Saudi Arabia with their Contract Price (CP). This is assessed at the end of each month with the new CP being announced on the first day of the month. Any changes are to reflect the current market condition but the mechanism is not published, just the new CP for propane and butane. For 2024, the CP prices for the months January to October are as shown below:

Table 15: Historic contract pricing from Saudi Arabia

YEAR	MONTH	PROPANE USD/MT	BUTANE USD/MT	LPG (30/70) USD/MT
2025	January	625	615	618
2024	December	635	630	632
2024	November	635	630	632
2024	October	625	620	622
2024	September	605	595	598
2024	August	590	570	576
2024	July	580	565	570
2024	June	580	565	570
2024	May	580	585	584
2024	April	615	620	619
2024	March	630	640	637
2024	February	630	640	637
2024	January	620	630	627

The price of LPG to an importer is usually quoted based on CP plus a premium. The premium consists of mainly the cost of sea freight and margin for the trader. Freight cost will depend on the size of vessel and the amount of product that can be delivered. Since Malawi is a

landlocked country, the landed cost of LPG will necessarily include a road transport charge for bridging the product from sea fed terminals in Tanzania or South Africa into the country. This is done using 25-26t road tankers/trucks.

MERA controls the maximum retail price of LPG in Malawi. There is no set frequency on the adjustment of retail price. The latest LPG price adjustment was issued in October 16, 2024 and set the price at 3,740 MWK/kg, representing a 15.25% increase on the previous price set in November 2023.

Current market penetration

LPG is regarded as the most promising immediate opportunity to scale up clean cooking in Malawi due to its demonstrated growth in the market *[Modern Cooking for Healthy Forests (MCHF)]*. LPG consumption in Malawi has grown nearly 2.5 times since 2020. There was a significant jump in demand of 77% year on year which occurred in 2023 after four new players started operations in Malawi and VAT / duties on LPG and LPG equipment were removed. This growth is expected to taper down to 15 – 20% this year and the next few years *[Falcon Gas, MERA]*. Most of the growth is coming from new residential users. This segment is estimated to comprise 70% of the total demand at present *[MERA]*. Notwithstanding this significant growth, figures showed that in 2023, the number of households using LPG was estimated to be 30,787 which represents only 0.6% of the total households in Malawi *[based on data from MERA]. The MTF Report published in 2024 reflected a lower adoption rate at 0.3% [MTF]*. Demand from new users is still high and the desire to switch to LPG by non-users is strong once they learn about LPG *[Delta]*. The LPG price is also competitive to charcoal in urban areas *[Mount Meru]*. Most LPG players have held back on further expansion due to uncertainties on the country's economy. In particular, access to foreign currency and the devaluation of Malawian Kwacha has slowed down growth of demand.

The main opportunities for LPG dissemination in Malawi include:

- **High compatibility with urban market**: There is an opportunity to grow LPG adoption in urban areas, where there is existing demand and the ongoing costs of cooking with LPG could undercut the counterfactual of purchasing charcoal. Urban areas also have lowest distribution costs, the highest household income and is most likely to be receptive to awareness campaigns around gas safety (Coley and Galloway 2020). The rural market is unlikely to be penetrated by LPG in the short term due to low capacity to pay and poor infrastructure (Coley and Galloway 2020).
- **Affordability of fuel**: As demonstrated in the Affordability Analysis, the cost of LPG is around 25% less than cooking with the lower price of cooking with charcoal (1,055 MWK per day vs 1,409 MWK per day).

The main barriers to LPG dissemination in Malawi include:

- **Forex risks**: LPG is an imported fuel so forex availability and stability of currency is a critical risk to manage. Over the last 4 years the Malawian Kwacha has depreciated by approximately 50% and the average LPG global price has fluctuated between $400 to $735 per tonne (xe.com 2024; Gas Energy Australia 2024). This combination of volatile commodity pricing and Malawi's limited stabilisation measures poses risks

to consistent supply, potentially resulting in backsliding to polluting fuels when LPG is unavailable or unaffordable *[Cleaner Cooking Coalition, MCHF]*. There are serious concerns about the macroeconomic feasibility and sustainability of a transition to LPG for cooking.

- **Unaffordability of equipment**: High upfront costs of equipment and large lump sum payments for refills render affordability a challenge for most Malawians (Coley and Galloway 2020).
- **Perceptions of safety**: there is widespread perception that cooking with LPG is dangerous which can result in hesitance to adopt it as a cooking fuel (Coley and Galloway 2020). There is a need for education and training.
- **Orphan cylinders**: The MBS describes their biggest issue as tackling 'orphan cylinders' *[Malawi Bureau of Standards (MBS)]*. These are cylinders that enter the country from neighbouring countries, e.g. Tanzania, and once empty have no rightful owner. They consequently deteriorate and create a safety risk.
- **Weak regulatory environment***:* Malawi currently has no LPG standards and a relatively weak regulatory environment. This is explored more in Policy and Regulatory Environment Assessment and results in low safety standards and circulation of potentially sub-quality equipment.

3.1.2 Electric cooking

Electric cooking refers to the use of electricity as a primary source for cooking, replacing traditional fuels like firewood, charcoal, and kerosene. Electric cooking devices, such as electric pressure cookers, induction stoves, and hotplates, offer a cleaner, more efficient alternative to conventional biomass-based cooking. They are designed to reduce environmental impact, improve indoor air quality, and enhance convenience, aligning with Sustainable Development Goals (SDGs), particularly SDG 7 on clean and affordable energy.

This cooking method is gaining traction globally as grid expansion, renewable energy systems, and innovations in battery storage make Electric cooking more viable, even in areas with unreliable electricity. As part of the transition to modern energy solutions, Electric cooking has the potential to address deforestation, health issues, and economic burdens associated with traditional cooking fuels, making it an increasingly essential component of sustainable development initiatives in regions like Malawi.

Globally, Electric cooking faces challenges such as unreliable electricity access, high upfront costs for appliances, and cultural preferences for traditional cooking methods. Opportunities include leveraging expanding electrification and renewable energy systems, creating pay-as-you-go financing models, and promoting energy-efficient appliances tailored to local needs (Leary 2022). Although efforts are gaining traction in regions like sub-Saharan Africa and South Asia, 2.8 billion people globally are still cooking with solid biomass, while just 685 million are now without access to electricity (World Bank 2024). As

show in Figure 1, the global percentage of people electrified but without clean cooking is expected to remain at around 30% by 2030.

Electric cooking adoption is influenced by several economic, social, and technological factors (Odoi-Yorke 2024). The high upfront cost of Electric cooking appliances presents a significant barrier, especially for low-income households, while the recurring cost of electricity can further deter usage in regions with high or variable tariffs. Socially, traditional cooking practices and food preferences play a key role, and the adoption of new cooking technologies is often impacted by women's limited influence over household financial decisions. Technologically, a reliable electricity supply is essential for consistent Electric cooking use, and advances in energy-efficient devices, particularly those integrated with renewable energy sources like solar, are critical for increasing adoption rates.

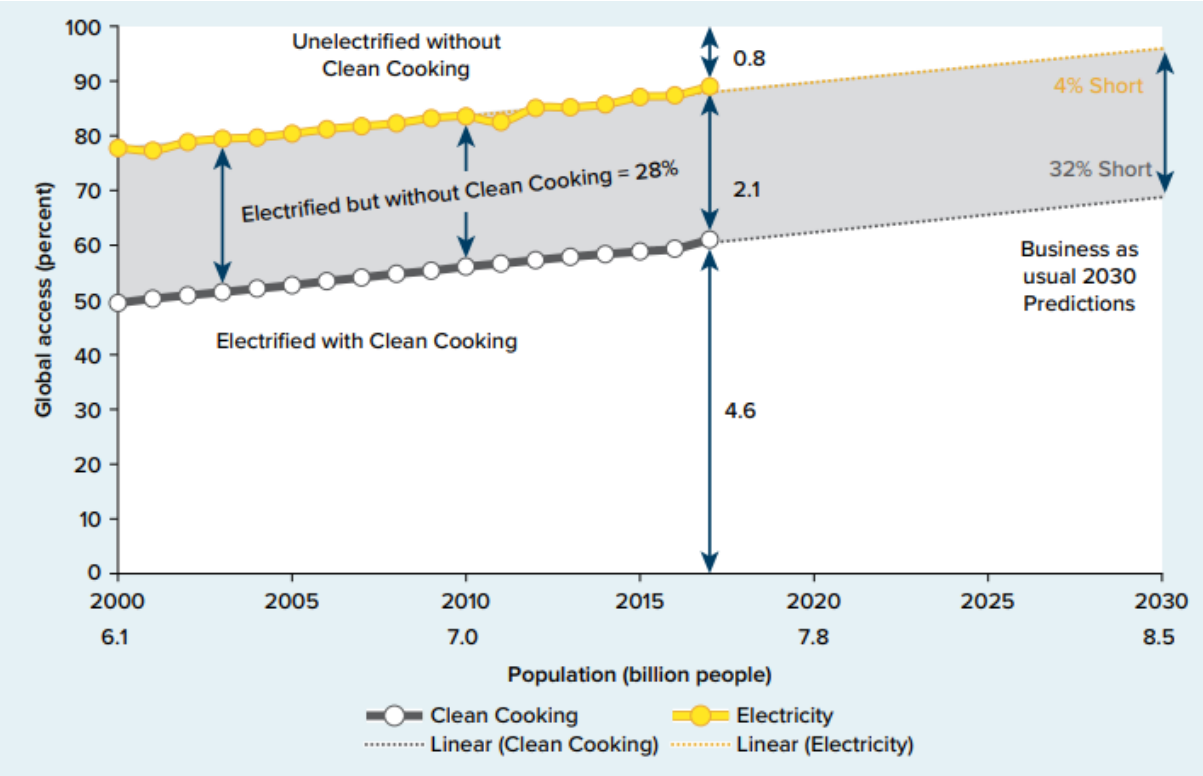


Figure 12 Actual and projected global access to electricity and clean cooking, 2000–30 (ESMAP 2020a)

Table 16 provides a list of specific eCook solutions.

Table 16 eCook solutions (general)

Appliance	Advantages	Considerations
Electric Pressure Cookers (EPCs)	Highly efficient, reducing cooking time and energy consumption. Versatile, can be used for various types of cooking.	Requires a stable power supply due to its higher power draw during cooking cycles.
Induction Cooktops	Efficient and quick heating, with precise temperature control. Reduces heat loss compared to traditional electric stoves.	Requires specific cookware (ferrous materials) and stable power supply.

Appliance	Advantages	Considerations
Electric Hotplates/Stovetops	Widely available and familiar to users. Can use any type of cookware.	Less energy-efficient compared to induction cooktops.
Microwave Ovens	Efficient for reheating and quick cooking tasks. Reduces cooking time for certain types of food.	Limited to specific cooking methods (e.g., reheating, steaming). Short but high-power usage.
Electric Slow Cookers	Low power draw, ideal for slow-cooking meals over an extended period. Minimizes peak load on power systems.	Long cooking times may not be suitable for all users or dishes.
Electric Kettles	Quick and efficient water heating. Reduces cooking time for tasks requiring boiling water.	High power usage for short periods.
Electric Rice Cookers	Energy-efficient and specialised for cooking rice and similar grains. Often includes automatic shut-off.	Requires stable power supply during the cooking cycle.
Electric Ovens	Suitable for baking and roasting. Provides a broader range of cooking options.	High energy consumption.
Electric Grills and Toasters	Provides quick and energy-efficient options for grilling and toasting.	High power usage during operation. Requires stable power supply.
Electric Fryers	Fast and efficient for frying foods.	High power draw, requires careful management of power usage.

Electric cooking business models

Business model innovation is essential for expanding Electric cooking due to the high upfront costs of electric cooking devices. Strategies such as subsidies, carbon financing, pay-as-you-go (PAYG) models, and microfinance have been proposed to improve affordability and access for consumers *[Gamos]*. In Kenya, for example, Equity Bank collaborates with KPLC to offer loans for appliances through on-bill financing[8], while Uganda's UMEME utility has explored similar models. However, utilities face challenges, as they are often reluctant to disconnect customers who default on loan payments, which complicates repayment enforcement *[Gamos]*.

[8] "On-bill financing" for clean cooking appliances is a payment mechanism where customers can obtain cookstoves without upfront costs by repaying the purchase through a monthly charge on their utility bill (e.g. electricity bill). A utility company or third-party lender provides the initial capital and customers then make gradual payments alongside their regular utility charges, with efficiency savings from the new appliance often offsetting the repayment cost.

On-bill financing helps eliminate large upfront expenses for customers, simplifying the payment process through integration with existing bills, and typically offering more flexible credit requirements than traditional loans. As arrangement often ties the payment obligation to the utility meter rather than the individual customer, enabling transferability if the property changes hands, the connection to utility service tends to result in lower default rates compared to conventional financing options (and therefore better interest rates and broader eligibility).

Digital innovations such as Internet of Things (IoT)-enabled electric pressure cookers (EPCs) provide cost-effective monitoring and verification, which can enhance the reliability of devices and secure high-quality carbon credits by verifying actual emissions reductions *[Gamos]*. Time-of-Use (ToU) pricing on minigrids has potential to encourage users to cook during off-peak times (See box 1). However, the adoption of ToU tariffs for Electric cooking by grid utilities remains limited, due to challenges of assigning tariffs to single appliances (such as cooking devices), and the lack of widespread adoption of smart meters. In Uganda, existing ToU structures sometimes fail to benefit low-income households due to high lifeline thresholds, yet IoT solutions could facilitate more efficient power management and potentially optimize ToU tariffs for Electric cooking *[Gamos]*.

Box 1: Time-of-Use Tariffs and Electric cooking on Mini-Grids

Solar PV mini-grids are increasingly recognised as a viable solution for electrifying rural and underserved communities, and will play a part in Malawi's energy access strategy. Integrating eCook into mini-grid systems presents an opportunity to enhance energy access, reduce reliance on traditional biomass fuels, and improve public health outcomes. Implementing time-of-use (ToU) tariffs—pricing electricity differently based on the time of day—can optimise the financial viability of mini-grids by encouraging energy consumption during periods of surplus generation and in turn stimulate eCook uptake in rural areas.

A study by Duke University examined the potential of ToU tariffs to improve the economics of mini-grids. Using data from Energicity, a solar mini-grid operator in Sierra Leone, the study modelled the effects of ToU tariffs on costs and revenues. The analysis revealed that delivering power during night time—when solar generation is inactive and batteries are utilised—increased overall power supply costs by approximately 60% over the system's lifespan. Implementing ToU tariffs, with a 15% reduction in daytime rates and a 15% increase during evening peak hours, could incentivise consumers to shift their energy usage to daytime periods. This load shifting has the potential to reduce per-unit energy costs and increase operator revenues by about 3.9%, contingent on consumers' responsiveness to price changes. The study recommends piloting ToU pricing and daytime subsidies to assess their effectiveness in specific community contexts.

EarthSpark International conducted a pilot project in Haiti to explore the integration of Electric cooking within solar-powered mini-grids. The project provided participants with electric cooking appliances and monitored their usage patterns. Although customers were provided electricity for cooking for free, the project found that the timing of Electric cooking demand is crucial for optimising the performance and sustainability of solar-powered mini-grids. It was observed that participants predominantly used electric cooking devices during midday hours, aligning with peak solar generation. This synchronization allowed for efficient utilisation of solar energy, reducing reliance on battery storage and minimising operational costs. However, challenges arose during periods of low solar output, such as cloudy days, when increased Electric cooking demand led to higher diesel generator usage and

occasional blackouts due to generator overdraw. This underscores the need for effective demand-side management strategies to balance load and generation capacity. The project team is exploring future possibilities to integrate weather conditions into cooking tariffs (i.e. sunny day tariffs for electric cooking).

Implementing Time-of-Use (ToU) tariffs can play a significant role in managing Electric cooking demand. By offering lower electricity rates during periods of high solar generation and higher rates during peak evening times, ToU tariffs incentivise consumers to shift their cooking activities to times when renewable energy is abundant. This load shifting can enhance system efficiency, reduce operational costs, and improve the financial viability of mini-grids.

Current state of Electric cooking in the Malawian market

The use of Electric cooking solutions in Malawi is presently limited, even in electrified areas (Malawi Ministry of Energy 2024). Despite 14% having a national grid connection, less than 2% of the population are primarily cooking with electricity. The majority of connections are in urban areas where, according to data collected in 2022, only 6-27% of connected urban households use electricity for cooking and as many as 360,000 urban households (42%) have a connection to the national grid but are not cooking with electricity at all. Instead, they heavily rely on charcoal. Due to stove and fuel affordability relative to income, and also grid outages, households are required to have multiple cooking technologies (SE4All 2022).

Notably, urban electricity access has grown from 30% in 2004 to 46% in 2019, yet the percentage cooking primarily with electricity dropped from 10% to 6% (Malawi Ministry of Energy 2024). This decline is attributed to perceptions of Electric cooking as expensive and concerns over grid reliability. Over the same time period, Malawi's electricity tariffs for domestic customers experienced several adjustments aimed at achieving cost-reflective pricing and enhancing the financial sustainability of the energy sector. For example, a 7.5% rise was implemented in 2016 to counteract economic factors (Babalwa 2016). However, electricity prices are still relatively low, with residential electricity prices at 43.35% of the world average electricity price and 55.78% of the average price in Africa, as of March 2024 (Global Petrol Prices 2024).

Malawi ranks low on MECS's global Electric cooking assessment, mainly due to limited excess power generation capacity, which restricts widespread electric cooking adoption *[Gamos]*. Unlike other regions, Malawi lacks dedicated Electric cooking companies, limiting industry development and market expansion *[Self Help Africa]*. Although electricity is viewed as the cleanest cooking option, there is considerable skepticism around the feasibility of electric cooking at a national level *[MCHF]*. Additionally, while battery-supported Electric cooking could serve rural areas with limited grid access, no trials have been conducted yet *[MCHF]*.

Box 2: Battery-Supported eCook

Battery-supported eCook combines an energy storage device with an electric cooking appliance to enable cooking even when electricity supply is intermittent. This technology is versatile and suitable for off-grid, mini-grid, and grid-connected scenarios. For off-grid and mini-grid contexts, battery-supported eCook is particularly effective when paired with solar energy, allowing batteries to charge during the day and support evening cooking. In areas with unreliable grid supply, such as Malawi, batteries can be charged during off-peak times and reduce grid strain during peak demand periods.

Battery-supported eCook has been piloted in Zambia through the Modern Energy Cooking Services (MECS) program (Leary et al. 2019d). Findings from these trials indicate that the technology offers a promising solution to unreliable and overburdened national grids or in off-grid scenarios when powered by solar PV. Additional pilots in Kenya, Tanzania, and Nepal have shown that battery eCook can increase access to clean cooking while reducing dependency on traditional biomass fuels. For example, a pilot in Kenya highlighted significant user satisfaction due to reduced cooking time and lower exposure to harmful indoor air pollution (Monk 2021).

The primary challenge of battery-supported eCook is the high upfront cost, due to the additional cost of battery, inverter and electronics. To store enough energy for at least one meal (approximately 1-2 kWh), lithium-ion batteries are the preferred choice due to their compact size and long lifespan. Lead-acid batteries, while cheaper, require significantly more space and have a shorter lifespan, posing additional challenges in small kitchen setups. Other costs include charge controllers and power electronics to ensure efficient battery usage and longevity. It is anticipated that the costs of key components, including batteries, will continue to decline, making Electric cooking solutions increasingly cost-effective in a broader range of markets by 2025 (ESMAP 2020b). Despite these barriers, the technology has shown promise in small-scale pilots. However, commercially available integrated battery-supported eCook appliances remain scarce, limiting widespread adoption.

In Malawi, battery-supported eCook offers a viable solution to mitigate peak demand challenges on the already constrained national grid. The technology aligns well with plans for expanding large-scale solar PV generation, as batteries can store surplus daytime solar energy for cooking later in the day. This approach could support the government's objectives to increase clean cooking adoption and reduce reliance on biomass.

To overcome economic barriers, innovative financing mechanisms including subsidies and pay-as-you-go models are essential to make the technology accessible to low-income households. Pilot projects are critical to test and refine the technology, assess user acceptance, and evaluate its long-term financial and operational feasibility. Lessons from these pilots could inform scaling strategies and policy interventions to promote battery-supported eCook as part of Malawi’s broader energy transition.

Electric cooking supply chain in Malawi

The supply chain for electric cooking devices in Malawi is primarily comprised of low-cost, low-quality imports from China and India, which are often available in informal markets. Such markets are unregulated, where economic activities occur outside formal governmental oversight and taxation. Products available in these markets are often sold without adherence to safety standards or quality controls, posing potential risks to consumers, and Ttese products generally lack durability, with lifespans of no more than six months, limiting their practicality for long-term use. There is also a lack of local expertise and infrastructure to support the distribution and maintenance of these devices at scale *[MCHF]*. Advanced devices like electric pressure cookers and induction stoves are relatively new to the Malawian market. However, their high prices make them unaffordable for the majority of consumers, posing a significant barrier to widespread adoption *[MCHF]*. Additionally, there is limited local expertise and infrastructure for the large-scale distribution and maintenance of these devices, further hindering market growth. Companies like BURN have entered the market with induction cookers but have sold only a few hundred units in Malawi, indicating the early and challenging stage of development for the Electric cooking supply chain in Malawi *[MCHF]*. Table 17 provides details of eCook companies currently or planning to enter the Malawi market.

Table 17 eCook companies currently working in or planning to enter the Malawi market (specific)

Manufacturer	Product	Notes	Market Price	Indicative deployment timeline in Malawi
BURN Manufacturing https://www.burnstoves.com/	Electric Induction Cooker (Malawi) Hotplates (other countries)	Cellular-enabled IoT induction cookstove allows for real–time monitoring of electricity usage “Pay-As-You-Cook” payment plans enable access to low-income households Generate carbon credits via Gold Standard’s new Metered Methodology	USD 199 for induction hob plus cookware USD 140 hotplate	300,000 eCook units deployed over the next 18 months
ATEC https://www.atecglobal.io/our-products	Induction Stove	high-efficiency, electromagnetic induction stove with ATEC’s patented IoT technology. With a Global Sim each stove has a live data connection that enables automated customer payments integration (PAYGO), live usage	USD 154.97	76,000 stoves to be deployed in 2025

		tracking and digitally verified Gold Standard carbon credits.		
Solar Chef https://solarchef.com/	PV battery Induction stove	Cooktime 75 mins Chargetime 240 mins Power 700W PV panel 435W (x2) Battery 12V 30Ah (x2) Estimate USD 20 – 120/yr in carbon credits	USD 500 per unit	Pilot soon to be deployed in Malawi.

Costs of Electric cooking in Malawi

Despite the perception that Electric cooking is expensive, research indicates that cooking with electricity may cost as little as a quarter of cooking with charcoal. However, the short-term and long-term cost perceptions among consumers need to be addressed to encourage adoption (Malawi Ministry of Energy 2024). The recent Cost of Cooking Study conducted by MCHF included electric hotplates and showed that electricity remains the cheapest cooking option when compared to charcoal, even if there was with a tariff increase of 40-50%. From the study, electric induction single plate cost 548 MK (for 194 minutes of daily cooking) versus improved Jiko stove at 1,409 MK (305 minutes) and ceramic Jiko at 1,471 (305 minutes) (MCHF).

However, the main barrier to electric cooking is the upfront cost of devices, which can be as much as $200, which is prohibitively expensive for most households. In rural areas, firewood is generally available for free, providing no incentive for eCook devices. Even in urban areas, where 25-28% of households are estimated to use electric cooking devices, affordability remains a significant issue (Malawi Ministry of Energy 2024). Without subsidies or consumer financing strategies, it is unlikely that electric cooking will be widely adopted, particularly in rural areas (MCHF). A survey of locally available eCook devices was conducted in Lilongwe, with technical specifications and costs provided in Table 18.

Table 18: Cost of electric appliances found in Lilongwe, October 2024

Name of Appliance	Type of Appliance	Technical specifications	Cost (MWK)
OBAC	Stove/oven	Hotplate 2 x 1000W Hotplate 2 x 1500 W Upper Oven 800W Down Oven 1200W	900,000
DEFY (kango)	Stove/oven	3200 W	900,000
Superior (Ferre)	Stove/oven	Hotplate (x4) 1000 W Top heater 900 W	775,000

Name of Appliance	Type of Appliance	Technical specifications	Cost (MWK)
		Bottom heater 1200 W TOTAL Power 6100 W	
Sunbeam	Double Hotplate	2000 W	46,300
Logic	Double spiral hotplate	2000 W	55,050
Sunbeam	20L compact oven	2950 W	315,500
Millex	Manuel air fryer oven	1700 W	545760
Logic	30cm Fry Pan	1500 W	85100
Hisense	Microwave	1050 W	270,900
Samsung	Microwave	1500 W	560,000
Russel Hobbs	Toaster	950 W	140,200
Logic	Air Fryer	1700 W	314,310
Sun beam	3 tier food steamer	900 W	102800
Sun Beam	Electric Health grill	200 W	90300
Milex	Air Fryer (7 L)	1600 W	292,500
Pineware	Water heating bucket	2000 W	64,350
Russel Hobbs	Kettle	2400 W	146,900
Sun Beam	Cordless kettle	2000 W	36,850
DEFY	Induction cooker	2100 W	1392600
Salton	Electric Pressure Cooker (6L)	1000 W	
GoldAir	Multifunction electric cooker (Grill/roast/slow cook)	1300W	
Logic	Electric Pressure Cooker	1000W	

Opportunities for Electric cooking in Malawian market

Despite existing challenges, there are promising opportunities to scale electric cooking, particularly in urban areas where grid stability has improved. To make electric cooking accessible to a larger portion of the population, substantial subsidies and innovative financing mechanisms will be essential in reducing the cost of Electric cooking devices *[MCHF]*. Electric cooking, is seen as an aspirational option for many Malawians, with basic devices like hotplates and kettles being widely recognized and familiar (Coley et al. 2020). A key opportunity to facilitate broader Electric cooking adoption is through on-bill financing, which enables households to spread the cost of appliances over time via their electricity bills, rather than facing prohibitive upfront expenses. Malawi's electricity utility, ESCOM, already implements on-bill financing for energy-efficient bulbs and could extend this to eCook appliances. Additionally, the Rural Electrification Fund provides support for households unable to afford initial capital costs by allowing a small deposit as a connection fee, with re-wiring costs included in the on-bill financing, where a portion of each bill goes toward covering capital expenses *[GEAPP]*.

Since February 2023, Malawi has seen an improvement in grid reliability, which has spurred greater interest in electric cooking. Although there is strong support for the Electric cooking roadmap, no performance-based grants in the clean cooking sector have yet been awarded

specifically to electric cooking companies, highlighting an area of untapped potential *[MCHF]*.

The integration of Internet of Things (IoT) technology presents a promising opportunity for expanding Electric cooking in Malawi. Companies like Groupe SEB, known for the Tefal brand, have already entered African markets with IoT-enabled electric pressure cookers (EPCs), and PowerPay is also exploring IoT applications with EPCs *[Gamos]*. IoT technology enables real-time monitoring and data collection on appliance usage, providing valuable insights into energy consumption patterns and device efficiency. This connectivity offers a dual advantage for Electric cooking adoption. First, it allows for more effective appliance management, enabling companies and users to monitor energy use and optimise device performance, which can reduce operational costs and improve user satisfaction. Second, IoT-enabled EPCs open the door to carbon credits by providing verifiable data on emissions reductions. By tracking the usage of energy-efficient cooking devices, organisations can quantify the carbon savings achieved by transitioning away from traditional biomass fuels, thus securing higher-quality carbon credits. These credits can then be sold or reinvested into Electric cooking initiatives, creating a financial incentive for expanding Electric cooking while supporting environmental goals.

Barriers for Electric cooking in Malawian market

Malawi faces several challenges in scaling up Electric cooking solutions, stemming from issues with infrastructure, affordability, and consumer perceptions. From the analysis conducted in 2.4.1, one significant obstacle is the ongoing practice of load shedding due to limited power generation during evening peak hours, the absence of additional generation support and energy mix, which disrupts electricity access for users *[MCFA]*. Currently, electrical generation capacity is not growing at a rate that keeps up with population increases, creating a supply-demand imbalance that could worsen as the demand for electric cooking devices grows *[Cleaner Cooking Coalition]*. This challenge is compounded by the low levels of electricity access and unreliable supply in grid-connected areas, deterring consumers from fully embracing Electric cooking (Coley et al. 2020) *[GEAPP]*. In the short to medium term, the high electrical demand of Electric cooking devices could further strain the grid, underscoring the need for infrastructure upgrades.

The high upfront cost of Electric cooking devices also poses a barrier, especially as electricity is perceived to be more expensive than charcoal. Without subsidies or accessible consumer financing options, Electric cooking adoption is unlikely to expand significantly, particularly in rural areas (Coley et al. 2020) *[Gamos, GEAPP, MCHF]*. Additionally, many households require re-wiring to support Electric cooking appliances due to the increased load causing safety issues on often informal wiring practices which introduces both financial and logistical challenges *[Gamos, GEAPP]*.

Limited familiarity and awareness of energy-efficient Electric cooking appliances, such as electric pressure cookers (EPCs), further hinder adoption and efforts to raise awareness through marketing campaigns and community engagement are essential for driving adoption (Malawi Ministry of Energy 2024). While EPCs are seen as suitable for the Malawian context, their acceptance remains low in some areas, and many households continue to rely

on multiple fuel sources, a practice known as fuel stacking (Coley 2020) *[MCHF, Gamos]*. Even when Electric cooking solutions are available, many households continue using firewood or charcoal alongside them, highlighting the need for broader behavioral change initiatives *[GEAPP]*.

Import taxes and VAT on electric cooking appliances also contribute to high costs, limiting accessibility. Bundling eCook systems with solar PV solutions has been suggested as a way to bypass some of these tax-related obstacles *[Gamos]*. There have been attempts to lobby for tax incentives on high-efficiency electric cooking devices, but these have not been approved by the Ministry of Finance [MCHF]. However, for widespread adoption, Malawi will require substantial upgrades to the national grid. Necessary improvements include expanding power generation capacity, upgrading transformers and distribution infrastructure (particularly in rural areas), implementing smart meters to enable Time-of-Use tariffs, and installing battery energy storage systems to manage peak loads and improve grid reliability *[GEAPP]*.

Regarding cultural and behavioral change barriers, cultural preferences for traditional cooking methods are preferred, and there is a lack of awareness about Electric cooking benefits. Reduced exposure to air pollution from charcoal compared to wood might also influence the preference for charcoal, impacting the switch to Electric cooking (Malawi Ministry of Energy 2024).

3.1.3 Biogas

Biogas is a renewable biofuel that can be used for cooking. It consists of a mixture of methane, carbon dioxide and a small quantity of other gases produced by the anaerobic digestion of a variety of biomass sources. These include livestock manure, food waste, agricultural revenues and sewage (IRENA 2017). A nutrient-rich effluent is produced alongside the gas which can be used as an organic fertiliser. Biogas systems come in a wide range of sizes and designs; the components typically include feedstock storage, a mixing area, a digester, a gas holder and digester residue storage (ibid.). They can be constructed from scratch on-site (e.g. the UNDP programme) or consist of prefabricated units (e.g. EcoGen's offering). The cooking gas is not compressed and is usually piped directly to the stove, meaning that the system is usually sited close to the kitchen. The stoves themselves are similar to LPG ones and are generally imported from overseas.

Biogas systems are often perceived as offering a one-stop circular solution to a myriad of climate and sustainable development challenges. However, the reality is that biogas systems are particularly prone to a range of well-documented barriers that can impede their adoption, such as poor construction and installation, insufficient feedstock, technical failures, suboptimal feeding practices, high investment and maintenance cost, cultural resistance from users and a lack of training provision (Boyd Williams et al. 2024). Successful biogas interventions are context-specific and require a high degree of engagement from end-users.

Biogas is not a common technology in Malawi. Between 2016 and 2018 the United Nations Development Programme (UNDP) installed 72 household digesters in villages across the country. An evaluation conducted in 2021 found that no installation lasted its operational lifespan (Boyd Williams et al. 2024). More recently a private sector player called EcoGen has held a small monopoly over the Malawian market. They have installed 1000 units since 2018 and have ambitious plans to scale under an Article 6 carbon programme.

The main opportunities for biogas dissemination in Malawi include:

- **Potential to address rural markets:** Biogas is the only clean cooking technology that can feasibly address rural markets due to Malawi's poor infrastructure and the rural population's reliance on gathered biomass.
- **Institutional clean cooking**: Due to the volume of food and organic waste produced by group establishments such as schools, hospitals and public administrations, biodigesters can be used to fuel biogas cookstoves in institutions.

The main barriers to biogas dissemination in Malawi include:

- **Affordability gap**: Biogas systems are the most expensive domestic clean cooking technology and are estimated to cost the end-user ~$800 without any subsidies *[Home Biogas, EcoGen]*. Asset financing can bridge this gap, especially as there are no fuel costs once the system is installed. However, implementing such schemes for can be challenging given Malawi's difficult financial landscape and the limited financial capacity of the rural target market.
- **Availability**: There are only two active providers in the market, Green Impact Technologies (GIT) and EcoGen (under the Sistema.bio technology), who are focussing on the Southern region. EcoGen have received terms and funding from Klik Foundation for purchasing their carbon credits.
- **Enabling environment**: High import taxes and waiver fees, coupled with the lack of quality standards and regulations, hinder the uptake of biogas. More information on this is provided in Policy and Regulatory Environment Assessment.

Key informants agreed that biogas in Malawi is suitable for a niche number of households who produce enough waste, likely from dairy farming *[Cleaner Cooking Coalition]*. The latest research in Malawi shows that micro-level factors determine the success of biogas systems, such as proximity of livestock to the digester and community dynamics. These sensitivities mean that Malawian biogas programmes are not well-suited to RBF-type incentives that prioritise distribution volumes and may result in low adoption rates *[Natalie Boyd-Williams, KTH]*. A large biogas player who is not active in Malawi has actively avoided the market because they believe it is limited in size and that is already primed to be addressed through the EcoGen programme *[Home Biogas]*.

3.1.4 Ethanol

Ethanol is a renewable biofuel made from fermenting sugar. It can be stored in small containers and easily distributed as either a liquid or a gel. Unlike other clean liquid or

gaseous fuels (e.g. LPG) it does not need to be pressurised, lowering the risk of explosion (Demekas et al. 2023). It has a wide range of uses and many competing applications e.g. as a transport fuel, and limited scale as a cooking fuel to date. Success in sub-Saharan Africa has been dominated by Nairobi-based KOKO Networks, who are positioning themselves as a clean cooking utility and currently have active operations in Kenya and Rwanda (Osiolo et al. 2023).

As of 2021 there was not a ready supplier of ethanol fuel or availability of good-quality stoves (Modern Cooking for Healthy Forests in Malawi 2021). The country currently produces 29m litres of ethanol annually, but the two major distilleries in the country (EthCo and PressCane) are unable to meet the country's current demand for blended automobile fuel due to chronic lack of feedstock. Only 65% of the required automobile ethanol is sourced locally and the remaining amount is imported from neighbouring countries, particularly Mozambique *[PressCane]*. In theory, more feedstock could be imported from Mozambique and Zambia, but the high price of molasses, costly transportation and regulated sales prices in Malawi make this unviable. Planned changes to regulations mean that the sales price of ethanol is likely to go up in the future rather than down (Modern Cooking for Healthy Forests in Malawi 2021). The combination of high price of imported feedstock and low levels of domestic production led the Modern Cooking for Health Forests Programme to conclude that ethanol is currently not a feasible clean cooking fuel in Malawi (Modern Cooking for Healthy Forests in Malawi 2021).

It is therefore unsurprising that there are no active ethanol players in Malawi, although KOKO Networks have had discussions with the government about entering the market *[KOKO Networks]*. PressCane have received investment from the UNDP's Clean Economic Transition Facility to pilot ethanol cooking consisting of a $50,000 initial grant with the potential to go up to $350,000 with further grants and matched funds *[PressCane]*.

The main opportunities for ethanol dissemination in Malawi include:

- **Potential for localised production:** this could protect against imported fuel price volatility and forex issues. Investments are being made to bring substantially more land into sugarcane cultivation e.g. the Shire Valley Transformation Programme but will take 5-8 years to yield results (Modern Cooking for Healthy Forests in Malawi 2021).
- **Existing refinement capacity**: Unlike many of its neighbours, Malawi has sufficient distillation and refining capacity in place to rapidly expand ethanol production if the feedstock issue is overcome (Modern Cooking for Healthy Forests in Malawi 2021).
- **Scalability**: Once established, ethanol cooking can be scaled up relatively inexpensively compared to competing modern fuels like LPG and electricity (Modern Cooking for Healthy Forests in Malawi 2021).

The main barriers to ethanol dissemination in Malawi include:

- **Fuel supply**: Recent cyclones have affected sugar cane production and caused shortages. Even in good years, there is insufficient production to satisfy auto industry

demand, as described in the paragraphs above. Ethanol players supplying the automobile market are struggling with forex issues to import equipment and raw materials *[PressCane]*.

- **Low levels attractiveness compared to other fuels:** A price analysis conducted by the MCHF programme concluded that a mid-point price for ethanol would be $1.25 / litre, which places it on a financial par with cooking with LPG (Modern Cooking for Healthy Forests in Malawi 2021). LPG could be easier to scale and anecdotal evidence from Kenya suggests that it lends a better user experience than cooking with ethanol.
- **Enabling environment:** Ethanol fuel prices are regulated by government, meaning that private sector players would have limited control over their sales price and margin. This could be reduced through tax waivers as non-domestic ethanol is currently subject to import taxes and all ethanol is subject to VAT. This could lead to more competitive pricing and potentially make ethanol a viable cooking option, contingent on necessary infrastructure and technology development *[MCHF]*. There are no ethanol cooking quality standards.
- **Awareness:** Because there is no ethanol cooking in Malawi at present, significant awareness raising efforts would be required to build this market.

3.1.5 Processes Biomass (pellets & briquettes)

Pellets and briquettes are solid organic fuels made from compressed material such as wood waste, charcoal dust, saw dust, grasses, straws and husks. They differ in terms of size and shape: pellets are typically bullet-sized, whereas briquettes are usually >25mm diameter and rectangular or cylindrical (Forestry Commission 2011). The higher surface area to volume ratio of pellets leads to more complete combustion upon and therefore lower levels of air pollution, making pellets preferable for domestic cooking applications *[Cleaner Cooking Coalition]*. Pellets and briquettes can be burned in any stove that compatible with wood or charcoal. Emissions classifications of tier 4 and above can be achieved by pairing pellets with a gasifier stove, i.e. a stove with a fan that actively draws air through the chamber to encourage complete combustion.

Cooking with pellets is nascent in Malawi, with just four companies specialising in these technologies (Zipolopolo, SupaMoto, Ener-G-Africa, Planet Green Africa) and serving a combined population of just a few thousand households. SupaMoto and Zipo purposefully price their pellets to undercut charcoal. SupaMoto charge 11,000 MWK for a 30kg bag (i.e. 370 MWK/kg) and report that each household uses around 160kg of pellets per year, which factors in stacking *[ECS]*. Zipo charge 2200 MWK for a 5kg bag (ie 440 MWK/kg) and report that each household uses around 120kg of pellets per year including stacking *[Zipo]*.

Pellet production in Malawi is limited and there is little available supply for cooking *[Cleaner Cooking Coalition]*. There are only two large-scale producers, Raiply and Pyxus, who mostly serve industrial users *[MCHF]*. Raiply make pellets from pine trimmings and allegedly produce 4000 metric tonnes per year which is mostly used internally for heating and

electricity production *[Zipo]*. Pyxus make pellets from groundnuts. Their production in 2023 was around 3000 tonnes which mostly went to their sister company, Alliance One Tobacco, for heating applications. Zipo buy the remaining 100-150 tonnes available from these two suppliers. They believe there is potential to produce up to 7000 tonnes of pellets from rice husks but none of the feedstock suppliers have manufacturing capability, so a dedicated plant would need to be established.

Ener-G-Africa (EGA) are hoping to set up a pellet factory in Lilongwe to support their operations. Feedstock will be sourced from their own NBS carbon projects in Mozambique, Malawi and South Africa *[EGA]*.

The main opportunities for pellets in Malawi include:

- **Localised production**: Pellets are a circular economy solution that can be produced locally from organic waste. This means that they do not require precious forex to import and are one of the most environmentally friendly cooking solutions.
- **Livelihoods:** Feedstock to produce pellets could be sourced from rural households, supporting livelihoods and therefore a just transition away from charcoal. The Cleaner Cooking Coalition are seeking funding to pilot this scheme. Their proposal involves incentivising smallholders to grow elephant grass or Napier grass and setting up district-level pellet mills and requires a $400,000 investment for a pellet plant and machinery, including a solar power supply with adequate storage. This would produce fuel for 1000 households on a daily basis (1 tonne/hour) *[Cleaner Cooking Coalition]*.
- **Affordability:** Interviewees reported healthy margins on pellets and are still able to price them to undercut charcoal. They can also be sold in any quantity, mimicking the purchase patterns of charcoal.

The main barriers for pellets in Malawi include:

- **Supply**: There is currently a limited supply of pellets and the companies who produce them prefer to sell larger quantities for industrial applications over smaller transactions for clean cooking *[MCHF]*. This means that the supply chain investment is required in parallel to growing demand.
- **User education**: Pellet cooking solutions are not well-known in Malawi. The Zipo and GIZ Dzaleka pilot revealed the need for significant user education to support adoption *[GIZ]*.

3.2 Electricity Service Quality Assessment

3.2.1 Minigrid eCook in Malawi

International experiences of eCook on Minigrids

According to MECS, Electric cooking is both feasible and cost-effective within many mini-grid settings, offering the potential for cost savings for consumers and increased profitability for mini-grid operators (Clements et al. 2024). While adding Electric cooking capabilities to existing mini-grids may seem challenging due to the need for infrastructure upgrades, planning for high Electric cooking penetration from the outset in new mini-grid projects can significantly strengthen the business case. This proactive approach allows for more seamless integration of Electric cooking, maximising benefits for both operators and users in the long term. Findings from their pilot of Electric cooking deployment on 7 minigrids show that Electric cooking increases both household and community electricity demand, though peak demand sometimes necessitates costly upgrades to mini-grid infrastructure. In Rwanda, Electrocook a company supported by EEP Africa and the Nordic Fund, was set up in 2020 with the mission to distribute 5000 EPCs. They are partnering with ARC Power to run a pilot with 50 households connected to one of ARC Power's mini-grids in Nyamata, Bugesera district (testing of an innovative financing mechanism to incorporate the EPC costs into the electricity tariff over a determined period).

Minigrid Electric cooking in Malawi

Over five years ago, reports were optimistic about the potential growth of the mini-grid sector in Malawi as a reliable source of electricity for Electric cooking (Coley et al. 2020). However, this anticipated expansion has yet to materialise on a wide scale, and experience with mini-grids in Malawi remains limited. Mini-grids still represent a promising avenue for Electric cooking due to their ability to offer stable electricity, enable pay-as-you-go (PAYG) business models, and foster community engagement (Coley 2020). Additionally, mini-grids could enhance their financial sustainability by incorporating Electric cooking as a steady demand source, thus improving overall project viability *[GEAPP]*.

Despite these opportunities, initial efforts to promote Electric cooking on mini-grids in Malawi have encountered challenges. For instance, surveys conducted by MEGA in Mulanje (see case study) reveal that even when mini-grids are available, many households continue to rely on firewood for cooking. This persistence is largely attributed to the high cost and limited accessibility of electric cooking devices *[MCHF]*.

The report, "Opportunities and Challenges for Electric cooking on Mini-Grids in Malawi," highlights both the potential and hurdles for electric cooking adoption on mini-grids in Malawi (Eales et al. 2022b). The study leverages data from a pilot Electric cooking project on a hydro mini-grid in Mulanje, using smart meter logging and surveys to assess load profiles and consumer behavior. Key findings reveal that while Electric cooking offers social, health, and environmental benefits, there are significant barriers, including limited financial resources, weak infrastructure, and low willingness to pay. Additionally, fuel stacking (using multiple cooking fuels) and insufficient mini-grid capacity during peak times limit the

effectiveness of Electric cooking. The authors suggest that carbon finance and demand-side management, such as Time-of-Use tariffs, could enhance the financial viability of Electric cooking on mini-grids. They recommend further research, piloting of business models, and community engagement to overcome the socio-economic and technical barriers, making mini-grid Electric cooking a viable option for Malawi's clean energy goals.

Piloting Electric cooking technologies on existing mini-grids, such as in Sitolo and Mulanje, could help assess which technologies are most suitable and acceptable for local communities. Hotplates, for instance, might be more readily accepted than electric pressure cookers (EPCs) in certain areas, as they align more closely with traditional cooking practices *[GEAPP]*. These pilots would offer valuable insights into the local acceptability of Electric cooking solutions and help tailor future mini-grid projects to meet community needs effectively.

Case Study: Electric cooking on Mini-Grids in Malawi – The MEGA Mini-Grid Pilot

Between March 2021 and February 2022, Atmosfair conducted a pilot study on electric cooking at the MEGA mini-grid in Mulanje, Malawi, with a peak generation capacity of 220 kW. The study aimed to understand cooking demand and assess the feasibility of leveraging carbon finance to support clean cooking initiatives in the country. The pilot involved 20 households, each equipped with an electric cooking set that included a 1.5 kW hotplate, cooking pots, and a heat retention device. Two smart meters were installed for each household—one measuring total household power consumption and the other specifically monitoring the hotplate. Participants were free to use their preferred cooking devices and fuels, allowing the study to observe real-world behavior and preferences.

The results were promising, as 89% of households identified the hotplate as their primary cooking device. With a MEGA tariff of 0.08 USD/kWh, lower than the national grid rate (0.09 USD/kWh), electric cooking was affordable, leading to an increase in household electricity demand by up to 50%. Participants reported various positive impacts, including health and cleanliness benefits, reduced spending on cooking energy, easier cooking, and a sense of modernity. However, some users noted limitations in the hotplate's versatility compared to traditional stoves, leading many to adopt fuel stacking, where multiple cooking fuels and devices are used to meet all cooking needs.

Meter data revealed that, despite the affordability of the electricity tariff and the provision of free appliances, households rarely used more than 1 kWh per day for cooking—less than half of the expected consumption if all cooking were done with electricity. This moderate usage underscores the challenge of meeting peak demand within the mini-grid's limited generation capacity, indicating that future scale-ups would need careful consideration of load management.

While further scaling up of Electric cooking on the MEGA mini-grid is constrained by generation limits, this pilot provides valuable insights. With additional investment and focus on further pilots, both on- and off-grid, the Electric cooking sector in Malawi can make more informed decisions for expanding clean cooking solutions across the country.

Tariff Structures on Mini-Grids and Their Applicability to Facilitating Electric cooking

Time-of-Use (ToU) tariffs have emerged as a promising tool to enhance the financial viability of mini-grids and encourage the adoption of Electric cooking. According to a study by Duke University, ToU tariffs can incentivise off-peak electricity usage by offering lower rates during specific hours (Mcnamara et al. 2022). This strategy, tested with a solar mini-grid operator in Sierra Leone, demonstrated that ToU tariffs not only reduce energy costs for consumers but also boost revenue and grid utilization for operators. By shifting activities like Electric cooking to off-peak times, such as midday when solar generation is high, mini-grid systems can achieve better load management and financial sustainability.

A mini-grid implemented by Self Help Africa in Dedza provides a practical example, where a daytime discount encourages users to consume electricity during daylight hours (Eales et al. 2022a). This approach aligns with findings from Bolo et al. (Emily Bolo, Tom Rnada, Joanes Atela and Haron Akala 2022), who discuss the benefits of ToU tariffs in promoting Electric cooking during times of high solar availability, reducing the need to draw from stored battery power. While some consumers are willing to adjust cooking schedules to these cheaper, midday periods, others face challenges in doing so due to convenience factors. To address this, additional demand-side management (DSM) strategies, such as community engagement, SMS alerts, timer switches, and power limiting, could support behavior change and further enhance the effectiveness of ToU tariffs.

For ToU tariffs to facilitate widespread Electric cooking on mini-grids, infrastructure and service delivery need attention. Mini-grid communities require comprehensive after-sales support for Electric cooking appliances, which can be challenging in rural areas lacking local repair facilities. Bolo et al. stress the importance of appliance standards and testing protocols to ensure that eCookers are safe, user-friendly, and suited for local cooking needs. Quality control and user training are essential, as they help minimize the need for repairs and build consumer confidence in electric cooking. Therefore, ToU tariffs, when combined with supportive DSM measures and robust after-sales service, hold significant potential for advancing Electric cooking within mini-grid contexts.

3.2.2 Off-Grid eCook in Malawi

The development of off-grid Electric cooking solutions, such as those being piloted by Kachione LLC and the World Food Programme, is in its infancy. These initiatives aim to provide Electric cooking options in areas where grid access is limited, leveraging solar power and other renewable sources (Malawi Ministry of Energy 2024).

Kachione Case study

Kachione LLC has pioneered the development of an off-grid Electric cooking solution in Malawi, targeting rural households with limited or no access to the national electricity grid. This system uses Direct DC Solar technology, delivering solar power directly to the appliance without batteries or complex controls, making it a low-cost entry-level option for off-grid users. The basic model operates effectively on sunny days, allowing households to

cook meals as long as sufficient solar energy is available, with plans to develop a lithium titanate battery for longer life and durability in challenging rural conditions.

The pilot phase saw 200 of these solar-powered cookers distributed, with a goal of expanding to 2,000 units by the end of 2024. Additionally, a new shipment of 1,800 insulated DC electric pressure cookers (EPCs) is set to arrive, further enhancing distribution efforts. These cookers are priced between $100 and $250, depending on local demand and availability, and are often sold through solar shops operated by women's groups, who manage technical support and sales at a markup. However, the high upfront costs remain a barrier for many rural households, who may need seasonal income from harvests to afford the cookers. For this reason, Kachione is exploring impact bond financing to make the system more accessible by offsetting the cost of importing solar parts and financing expansion through clean energy bonds that could be repaid over five years at a rate of $0.20 per kWh of verified cooking electricity used.

One of the challenges observed is that cooking requires significant power, which can exceed the capacity of smaller solar panels affordable to rural households. As a result, customers must often cook slower or use the appliance primarily for heating water. Solar panel prices range from $0.08/W to $0.12/W, making larger setups a considerable investment. Users have reported positive impacts, noting time savings in cooking and reduced wood collection efforts. However, long-term scale-up will require a combination of subsidies and innovative financing to overcome these cost barriers, given that approximately half of Malawi's rural population operates outside the cash economy.

Case Study: Dzaleka Refugee Camp - World Food Programme Pilot

The World Food Programme (WFP) launched a pilot project in Malawi's Dzaleka Refugee Camp to evaluate the feasibility of solar-powered electric cooking (Todd and Giese 2024). Sixty-five ECOCA cookstoves, sourced from Pesitho, were distributed to households in the camp, while an additional six units were allocated to a children's care center for institutional use. Each ECOCA unit includes solar panels, a battery pack, and insulated cooking pots that retain warmth over extended periods, along with USB ports for charging small devices. A qualified engineer managed the installation and provided guidance to participants.

Preliminary results have shown the cookers to be effective for heating water and preparing food, though cooking times tend to be longer than with traditional fuels. Users needed to adapt to the devices, adjusting their cooking practices to account for factors like battery charge, pot insulation, and available sunlight. Findings from this pilot are anticipated for publication in March/April 2024. Building on this initiative, WFP Malawi plans to launch a pilot for Institutional Cooking Solutions in early 2024, using solar-powered electric cookers in off-grid schools. These schools will serve as community energy hubs, offering access to electricity for both students and local residents.

The two case studies highlight the potential of solar-powered Electric cooking solutions in off-grid contexts, though it also underscores the need for further investment in battery technology and financial models to make the technology viable for wider adoption. With

continued support and technical assistance, Kachione aims to scale the technology and drive forward the off-grid Electric cooking sector in Malawi.

3.2.3 Malawi Power Network Infrastructure

Electricity Generation

The integration of eCook demand from cooking appliances brings both environmental and social benefits, although their capacity relies on the ability of the Malawi grid to sustain the additional power flows within the strict power network constraints, for line and asset ratings. The most critical issue experienced by power networks is related to the lack of generation capacity, in fact, individuals in Malawi who have access to electricity frequently experience "load shedding" where scheduled power outages are prevalent in the county.

The Electricity Supply Corporation of Malawi, Ltd (ESCOM) website (Electricity Supply Corporation of Malawi Limited n.d.) publishes a daily load-shedding program for different group areas affected at different periods of the day, leading to reverting back to solid fuel consumption. Load shedding is implemented for domestic customers every day, and once a week for industrial customers, with the exception of essential service.

Domestic customers are categorised into groups A, B, C, D, and E. Table 19 is a list of the total load lost in 2023 for each month due to insufficient generation, from the table, the outage at Kapichira power station had a considerable impact on Malawi generation, it was out of operation from the 24th January 2022 after its dam structures were severely damaged by Cyclone Ana, taking 129.6 Megawatts (MW), about 23% of the country's power capacity, away from the grid. It has been out of order for one year and was back into operation in April 2023. Therefore, a key drawback of Malawi power generation is a heavy reliance on hydropower with few backup options.

Consequently, even with existing baseload demand (non-eCook demand), the network is unreliable in meeting customer's demand and satisfaction. The load-shedding program and the duration of it varies depending on the targeted group and seasonal electricity generation which mainly reduces due to the extreme weather events. A load shedding event could last on average 4 hours +/-.

Table 19. Monthly Load Loss.

Month	Year 2023				Year 2024				Comment
	Load Lost (MW)	Load Lost (MWh)	Average load shedding duration per event [hours]	Maximum load shedding duration per event [hours]	Load Lost (MW)	Load Lost (MWh)	Average load shedding duration per event [hours	Maximum load shedding duration per event [hours]	
Jan	2,888.83	10813.80	3.78	25.50	272.88	1315.81	4.49	15.00	• Load shedding due to insufficient generation (Outage on Kapichira Machines due to

Month	Year 2023				Year 2024				Comment
	Load Lost (MW)	Load Lost (MWh)	Average load shedding duration per event [hours]	Maximum load shedding duration per event [hours]	Load Lost (MW)	Load Lost (MWh)	Average load shedding duration per event [hours	Maximum load shedding duration per event [hours]	
									cyclone Ana) → Year 2023 • Load shedding due to insufficient generation(Machine outages at Tedzani III and Nkula A & B Power Stations) → Year 2024
Feb	2,391.82	**9715.52**	4.27	21.62	NA	NA	NA	NA	• Load shedding due to insufficient generation (Outage on Kapichira Machines due to cyclone Ana) → Year 2023
Mar	2,585.95	**12201.25**	4.80	17.98	496.61	**1050.92**	2.21	9.65	• Load shedding due to insufficient generation (Outage on Kapichira Machines due to cyclone Ana) → Year 2023 • Load shedding due to insufficient generation and Machine outages at Nkula B Power Station (Easter Works) → Year 2024
Apr	785.46	**2906.32**	4.05	10.70	281.40	510.11	1.77	6.93	• Load shedding due to insufficient generation (Outage on Kapichira Machines due to cyclone Ana) Kapichira Machine # 1 on load on 05th April, 2023 at 17:18 pm) → Year 2023 • Load shedding due to insufficient generation → Year 2024
May	57.72	36.11	0.65	1.28	163.11	131.70	0.85	2.02	• Load shedding due to insufficient generation → Year 2023 • Load shedding due to insufficient generation (Machine outages) → Year 2024

Month	Year 2023				Year 2024				Comment
	Load Lost (MW)	Load Lost (MWh)	Average load shedding duration per event [hours]	Maximum load shedding duration per event [hours]	Load Lost (MW)	Load Lost (MWh)	Average load shedding duration per event [hours	Maximum load shedding duration per event [hours]	
Jun	263.44	286.05	1.10	3.73	NA	NA	NA	NA	• Load shedding due to insufficient generation → Year 2023
July	62.94	81.84	1.33	1.80	524.45	776.09	1.53	9.60	• Load shedding due to insufficient generation → Year 2023 • Load shedding due to insufficient generation (Machine outages) → Year 2024
Aug	465.06	**1707.23**	3.84	8.03	508.38	645.89	1.29	3.03	• Load shedding due to insufficient generation (Outage of Tedzani Power Station) → Year 2023
Sep	210.42	290.43	1.57	6.82	563.19	891.10	1.53	5.80	• Load shedding is due to insufficient generation and a measure of voltage control → Year 2023
Oct	508.17	**1617.25**	3.33	12.60	NA	NA	NA	NA	• Load shedding due to insufficient generation (Outage of Nkula A & B Power Stations) Installation of Intake Screens → Year 2023
Nov	125.68	109.71	0.99	2.65	NA	NA	NA	NA	• Load shedding due to insufficient generation (Kapichira G4 on forced outage while G1 & G2 on Load restrictions) → Year 2023
Dec	64.17	49.89	0.73	1.50	NA	NA	NA	NA	• Load shedding due to insufficient generation → Year 2023
Total		**39812.64**				**4811.51**			

Figure 13 is the average daily power generation of the Malawian electrical system in 2023, it is presented as the relative average daily load of each month. Moreover, the aggregated monthly and yearly power generation curves are shown in Figure 14 and Figure 15, respectively.

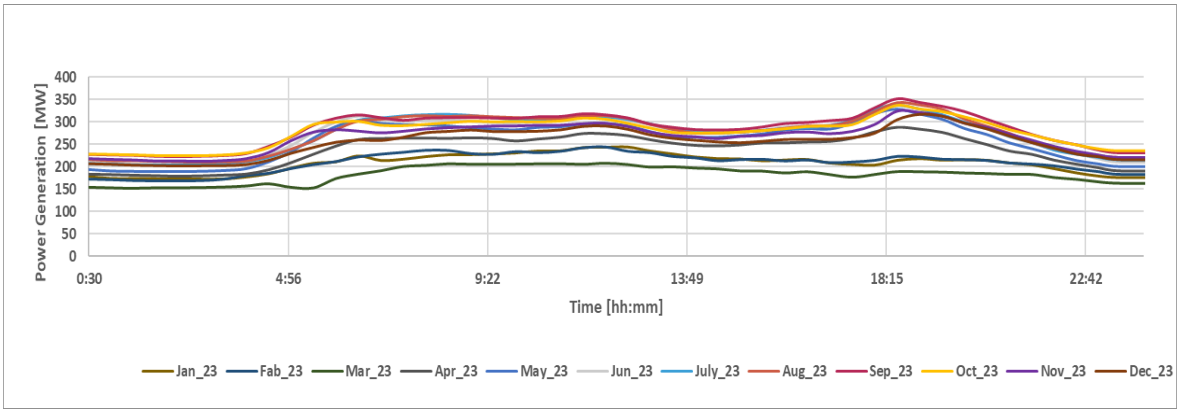


Figure 13. 2023 ESCOM average daily power generation curve of each month.

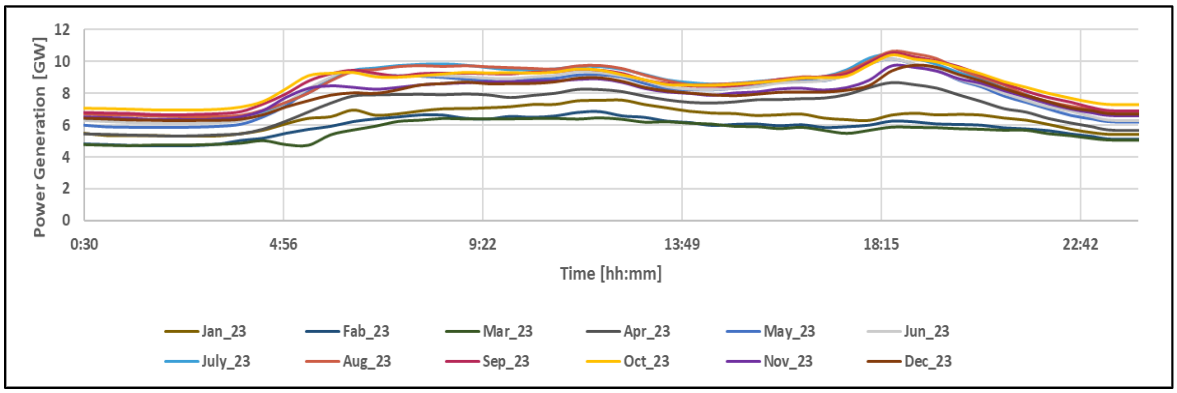


Figure 14. 2023 ESCOM aggregated monthly power generation curve.

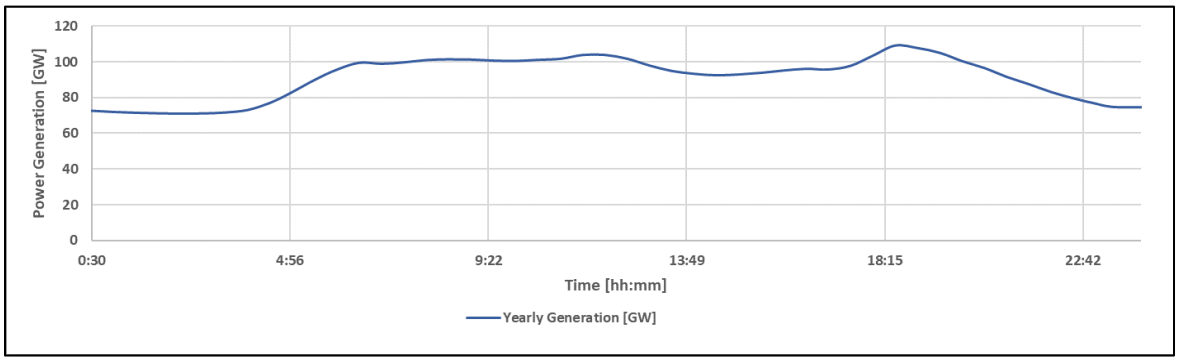


Figure 15. 2023 ESCOM aggregated yearly power generation curve.

The absence of additional generation support and energy mix have a negative effect. The current installed capacity in Malawi is heavily reliant on hydroelectric power (Government of Malawi 2019) coming from the following hydropower plants as shown in Table 20 (Nkula power station, Tedzani power station, Kapichira power station, and Wovwe power station). The current total hydropower installed is 390.15 MW, overall, EGENCO's generation capacity from diesel generators is 53.22MW and 101 of Solar plant installation. However, there is currently a lack of information on the actual capacity they are operating at and their

energy production, e.g. actual energy production from the hydropower plants that could be less than the installed capacity due to a combination of faulty aged installations, weather events and hydrological factors leading to load power outages and load-shedding.

Table 20. Malawi Operational Power Plants.

Power Plants	Capacity	Outages
	EGENCO Hydro	
Nkula A	35.10 MW	Maintenance work: 2 days 07.00-17.00 21-22 Oct 2023 (EGENCO n.d.) Maintenance work: 3 days 06.00-17.00 13-15 Jan 2024 (EGENCO n.d.)
Nkula B	100 MW	Maintenance work: 1 day 28 July 2024 (EGENCO n.d.) Maintenance work: 2 days 07.00-17.00 21-22 Oct 2023 (EGENCO n.d.) Maintenance work: 3 days 06.00-17.00 13-15 Jan 2024 (EGENCO n.d.)
Tedzani I	20 MW	Maintenance work: 1 day 28 July 2024 (EGENCO n.d.) Maintenance work: 4 hour 08.00-12.00 3 Feb 2023 (EGENCO n.d.)
Tedzani II	20 MW	Maintenance work: 3 days 26-28 Aug 2023 (EGENCO n.d.)
Tedzani III	62 MW	
Tedzani IV	19.1 MW	
Kapichira	129.6 MW	Maintenance work: 10 hours 06.00-15.00 7 Jan 2024 (EGENCO n.d.) was out of operation from the 24th January 2022 after its dam structures were severely damaged by Cyclone Ana, taking 129.6 Megawatts (MW), about 23% of the country's power capacity, away from the grid. It has been out of order for one year and was back into operation in April 2013
Wovwe	4.35 MW	Maintenance work: 10 hours 07.00-17.00 29 Sept 2024 (EGENCO n.d.)
	Mulanje Hydro	
Ruo-Ndiza	10 MW	NA
	EGENCO Diesels	
Mapanga	20 MW	No information found on the actual capacity they are operating at
Luwinga	6 MW	
Kanengo Phase I	10 MW	
Kanengo Phase II	10 MW	
Lilongwe A	5.40 MW	
Likoma	1.168 MW	
Chizumulu	0.652 MW	
	Renewables	
JCM Solar Nanjoka	60 MW	No data was shared by ESCOM on the annual yield generated by the solar plans
JCM Solar Golomoti	20 MW	
Serengeti PV Plant	21 MW	

The production is affected by several factors, ESCOM reported a power deficit of approximately 20MW of demand exceeding the supply (Table 21). A total of 1240 MW is anticipated to be commissioned between 2025 and 2030, a mix of, 470 MW of hydropower, 217 MW gas power plant capacity and 50 MW CCGT, 20 MW of battery energy storage and a

total of 433 MW of renewables and 50 MW from the Malawi-Mozambique Interconnector. The risk is, is the delay of commissioning these additional power plants and network instability.

Table 21. ESCOM generation data

ESCOM Generation Data	Jan_23	Fab_23	Mar_23	Apr_23	May_23	Jun_23	July_23	Aug_23	Sep_23	Oct_23	Nov_23	Dec_23
Monthly Energy Generation [GWh]	154.23	140.44	135.45	170.89	192.70	195.75	202.83	204.61	204.02	205.84	191.36	188.92
Yearly Energy Generation 2023 [GWh]	2187.04											
Peak Generation supplied 2023 [MW]	373.56											
Existing installed capacity [MW]	554.00											
Yearly Energy Demand 2023 [GWh]	2284.50											
Peak Demand 2023 [MW]	413.31											
Power Deficit calculated for 2023[MW]	39.75											

Table 22. Additional generation plants are anticipated to be commissioned between 2025 and 2030

Name of Developer	Location	Technology	Capacity [MW]	Anticipated commission year
Malawi-Mozambique Interconnector	Malawi-Mozambique	Interconnector	50	2025
GEAPP BESS	Kanengo	Battery Energy Storage	20	2025
Raiply	Chikangawa	Biomass	10	2025
Press Corporation Group	Nkhoma	Solar with BESS	50	2025
EGENCO	Salima	Solar	10	2025
TCRET-MZUNI	Mzuzu- Choma	Solar with BESS	20	2025
ASPIN	Phalula	Gas	142	2025
PTW	Chintheche	Solar with BESS	20	2025
JF Investments	Kasungu	Solar with BESS	30	2025
Greencells Energy	Zomba Changalume	Solar with BESS	34	2026
AZA	Salima Najoka	Gas	75	2026
Voltalia	Dwangwa	Solar with BESS	40	2026
EGENCO	Wowve II	Hydro	4.5	2026
Blue Hills	Nkhotakota	Biomass	50	2026
Virunga Power Ltd	Lichenya Hydro	Hydro	6.5	2027
Sentro Energy	Livingstonia	Hydro	15	2027
Gebis	Blantyre	Waste to Energy	10	2027
African Energy	Wowve	Hydro	10	2027

Name of Developer	Location	Technology	Capacity [MW]	Anticipated commission year
Nyika Hydro	Rumphi	Hydro	51	2027
Vidullanka Energia Ltd	Lower Dwambazi	Hydro	17	2027
EGENCO	Chinteche	CCTG	50	2027
ECL	Linthipe	Hydro	8	2027
Kindiwe Wind Farm/YM	Dedza	Wind	109	2028
Nthungwa	Lunjika	Wind	50	2028
Mpatamanga	Blantyre	Hydro	358	2030
TOTAL			**1240**	

The analysis reported in the Malawi generation development masterplan up to 2042 issued by the Ministry of Energy (Ministry of Energy 2024) outlines the possible pathway for meeting the electricity needs for Malawi from 2022 to 2024. It relies on the combination of the definition of the log-term vision for the development of the electricity sector and a focus on the short- and medium-term required investments. Throughout the study, the demand forecast prepared by Economic Consulting Associates (EAC) and published in 2023 (Ministry of Energy 2023) was used, and the results of the report made use of the base case demand forecast. Where the base case scenario reflects on the current policy targets, including the electrification targets set by the National Electrification Policy (NEP) targets by 2030 (32.4% followed by a linear increase of electrification by 2042 (56%), the implementation of the 2021 Loss Reduction Roadmap spanning 5-20 years, as well as the current long-term economic forecasts and industrial, agriculture and mining developments in the country, however, it does not factor in the up-scale of eCook. The results from the analysis outline that there is no need to install new power plants in the short term, besides the small addition of 23 MW of PV in 2026. The refurbishment of the existing diesel generators and the interconnection with Mozambique would be able to follow the demand growth, in a context where good availability of flows in the rivers leads to high shares of hydro generation. Starting from 2027, new technologies are integrated into the capacity mix: wind and biomass are installed, while the PV capacity keeps increasing, moreover, the small hydro power plant of Wovwe 2.

For the purposes of the forecast demand used in the study, it was assumed that the main end uses of electricity in urban households are lighting, cooking, refrigeration, water heating, space heating/cooling, washing, vacuum cleaning, entertainment, information and education. For this, it relied on the 2018 Malawi Population and Household Census - 453,592 households were using electricity for lighting, 75,267 households for cooking and heating, 224,521 households owned a refrigerator, and 594,713 an iron, although there is no information regarding the percentage of those households connected to the distribution network.

From the data provided, only 5.58% of households use electricity for cooking and heating, therefore the base case demand forecast from the EAC and the results from the generation masterplan underestimated and do not justify eCook demand growth. In addition to this, Table 23. Consumption of urban household appliances shows the range of household appliances and their power ratings, most appliances are characterized by low power ratings,

the ones with high power ratings are the Ion (1,000 W), kettle (2,200 W) and the hotplate (1,000 W), although these are used only by a small percentage of households together with few days of usage.

Table 23. Consumption of urban household appliances

Item	No of items	Power rating [kW]	Hours used (h per day]	Days used [days per month]]	Energy used [kWh per month]
Light					
Incandescent bulbs	4	40	6	30	28.8
Fluorescent tube lamps	4	10	6	30	7.2
TV					
32" LED TV	1	41	3	30	3.6
25" LED TV	1	150	3	30	13.5
19" LED TV	1	70	3	30	6.3
12" black and white TV	1	20	3	30	1.8
Other					
Radio	1	4	3	30	0.4
Iron	1	1,000	2	4	8
Kettle	1	2,200	0.1	10	2.2
Hotplate	1	1,000	3	30	90
Fridge (small)	1	100	4.7	30	14.3
Fan	1	10	3	10	0.3
Laptop	1	35	2	30	2.1
Phone charging	1	5	1	30	0.15

For Rural households the average monthly consumption is 47 kW, it covers lighting needs, sporadic operation of a small TV or a radio, ironing once per week, a small fridge (see Table 24) and small power needs (i.e. mobile phone charging, computer charging, fan, etc.). It aligns with observations of rural households in the region and falls within the ESMAP Tier 3 level of service.

Table 24. Consumption of rural household appliances

Item	No of items	Power rating [kW]	Hours used (h per day]	Days used [days per month]]	Energy used [kWh per month]
Light					
Fluorescent tube lamps	4	10	6	30	7.2
TV					
25" LED TV	1	150	3	30	13.5
Other					
Radio	1	4	3	30	0.4
Iron	1	1,000	2	4	8
Kettle	1	2,200	0.1	10	2.2
Fridge (small)	1	100	4.7	30	14.3
Fan	1	10	3	10	0.3
Laptop	1	35	2	30	2.1
Phone charging	1	5	1	30	0.15

To move towards eCook utilization, future studies need to factor eCook demand into the generation planning. Figure 16 is the master plan generation forecast of the Malawian national grid. Comparing both ESCOM total anticipated generation with the Masterplan generation forecast in Figure 16, with the assumption that there will be no delays in ESCOM additional generation plant commissioning:

- There is a surplus ESCOM additional generation in short-term
- ESCOM generation target and the Masterplan generation forecast start to even out towards 2031

However, is important to note that:

- ESCOM reported a 20 MW generation deficit
- The Masterplan generation forecast mainly targets the main demand growth and does not factor in eCook scaling up
- The analysis carried out are under the assumption that there will be good availability of river flows and full availability of the existing assets
- There are advantages of integrating renewables into the grid but they are also intermittent and need to be well managed
- There is always the risk of hydro power outages or less flow, therefore less power output
- Not sufficient to guarantee the stability of the isolated Malawian system in the event of sudden disconnection from the regional system and the loss of the interconnector imports
- Important to increase backup option and generation reserves

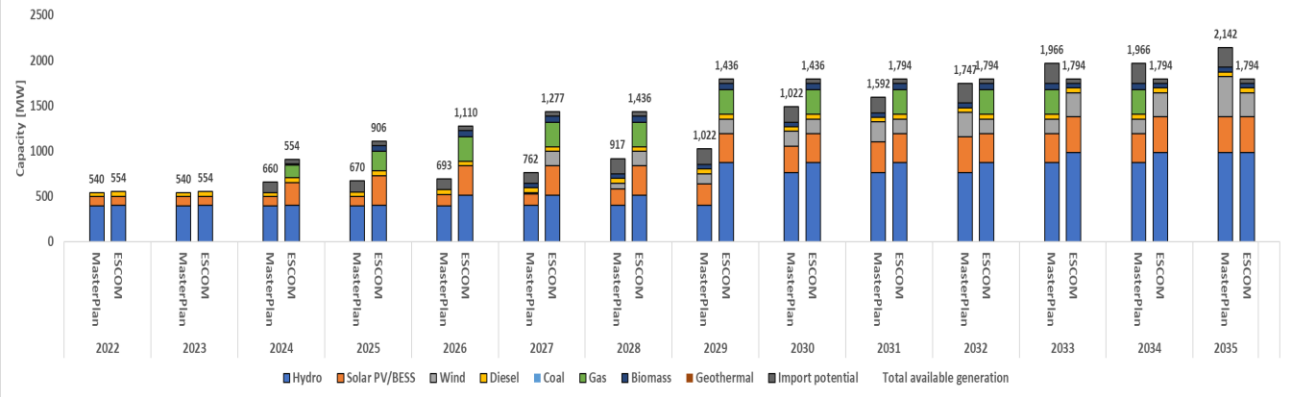


Figure 16. 2023 ESCOM and MasterPlan generation planning

Malawi Transmission and Distribution Network

The Malawi MV Network includes (Malawi Integrated Energy Planning Tool n.d.), a 1,2,888 km MV line and 7,118 MV/LV transformers. ESCOM and off-grid providers serve around 750,00 households (550,00 grid-served consumers and 200,00 off-grid consumers), while for public facilities; 3,992 are grid-served and 346 are off-grid. The main transmission line in Malawi (Global Credit Rating CO. (GCR) 2017) is the 132 kV that runs from the south connecting the major cities of Blantyre (in the south) and Lilongwe (in the centre) through two primary transmission lines, there are also sub-transmission 66 kV lines further extend the system. These transmission voltage levels are low compared to 400 kV and 275 kV used in the transmission network in Great Britain as using high voltage increases the power transferred and reduces power loss over long distances owing to the resistance in the wire.

In addition to Malawi using low voltage for transmission lines, the transformers and conductors are old and obsolete resulting in excessive power losses. The risk of having a single transmission line further north of Lilongwe is if a power failure or a short-circuit occurs, it would interrupt the power in the entire line. Looking at ESCOM's objectives, it intends to build a new 400 kV transmission line connecting its generating facilities to the two principal cities (Ministry of Energy 2023).

In a manner akin to transmission, the distribution network is limited by relatively low voltage distribution lines, which operate at 33 kV and 11 kV. These, voltages are subsequently reduced through the use of distribution transformers to 400 V/230 V. Issues in the Malawi distribution network are the ageing assets and illegal and unmetered connections, which lead ESCOM to shift the provision of electricity from a post-paid system to pre-paid meters. Efforts were made to replace the meters in individual properties with multi-phase pole-mounted meters to control several properties from a single-meter unit. In general terms, the Malawi power network faces various challenges. To assess the possibility of upscaling eCook, the first step would be to analyse the current power network operation state by evaluating electricity supply quality (voltage stability, frequency consistency, blackouts & brownouts) and reliability

Malawi Grid Reliability

Power system reliability refers to the state of the network to sustain the flow of energy at any point of time from the generation point to demand, the reliability indicator combines the factors related to outage duration or the response time, frequency of outages, the number of customers involved in interruption or their energy and power. Among the different key performance indicators (KPI) measures to evaluate the interruption and its impacts, the ones provided by ESCOM are in Table 25. The average number of times that a system customer experiences an outage during the year is 9 Interruptions per customer, while SAIDI is 19.8 hours and CAIDI is 2.1 hours. These values are understated as according to the Malawi grid code (Electricity Supply Corporation of Malawi Limited, n.d.), the power interruption reported, includes any outage in the transmission which may be due to the tripping action of protective devices during faults or the failure of transmission lines and/or power transformers, and which results in the loss of service to a transmission system User or a group of Users and the following events are excluded in the calculation of the reliability indices:

- Outages that occur outside the transmission
- Outages due to Load shedding as a result of generation deficiency, instructed by the Market and System and Market Operator
- Planned Outages where the Users have been notified at least seven days prior to the loss of power
- Outages that are initiated by the System and Market Operator during the occurrence of Significant Incidents or the failure of its facilities.
- Outages caused by any natural or manmade calamities; and Outages due to other events that the MERA shall approve after due notice and hearing

Table 25. Malawi grid reliability indicators

KPI reliability indicators	ESCOM
System Average Interruption Frequency Index (SAIFI)*	9 Interruptions per customer
System Average Interruption Duration Index (SAIDI)*	19.8 hours
Customer Average Interruption Duration Index (CAIDI)*	2.1 days

*SAIFI: the average number of times that a system customer experiences an outage during the year

*SAIDI: Represents the total number of minutes of interruption the average customer experiences.

*CAIDI: the average time required to restore service. It is calculated as total minutes of customer interruption divided by the total number of interruptions. The lower the number of minutes, the faster the utility restored service to customers.

Malawi Grid Quality of Service

Frequency Deviation

The system frequency corresponds to the heartbeat of interconnected power systems and reflects on the balance between generation and load. When the frequency deviates from its nominal setpoint, it signals either a generation surplus or a generation deficit within the whole system. The nominal frequency value within the Malawi power system is 50 Hz and the operational practice is to keep frequency deviation less than +/- 1% of the nominal value (Electricity Supply Corporation of Malawi Limited, n.d.). Figure 17 is the 2024 maximum and minimum ESCOM frequency excursion in a space of 5 minutes. Instead of getting the instantaneous values every 5 minutes, ESCOM gets the maximum and minimum every 5 minutes as it is supposed to operate within 50 Hz +/- 0.5. From the plots the frequency fluctuates beyond and bellow its nominal value, and violates the grid code limits throughout the recorded months, as shown in Table 26 the frequency increased up to 52.49 Hz in April representing a 4.98% deviation and it reached its lowest value in August, 47.74 Hz corresponding to - 4.54% frequency drop, significantly below the -1% threshold. This phenomenon appears when demand exceeds generation, frequency decreases and vice versa; too much production, there is the risk of issues with frequency and high voltage which can damage machines and equipment that feed off the grid. Too much consumption runs the risk of frequency issues, low voltage and a higher current flowing through the grid causing protection systems to trip and a sudden blackout, and could damage machines, equipment and the grid itself. Even with load shedding there is still pressure on the Malawi grid to meet the demand.

Frequency will need to be well managed within the +/- 1% limit particularly when moving towards interconnecting with other countries.

Reserves are held principally in developed countries to maintain power system frequency within an acceptable range. Operating reserves are the electricity supplies that are not currently being used but can quickly come online in the case of an unplanned event on the

system — such as a loss of generation or a transmission line — or when real-time demand is higher than forecast.

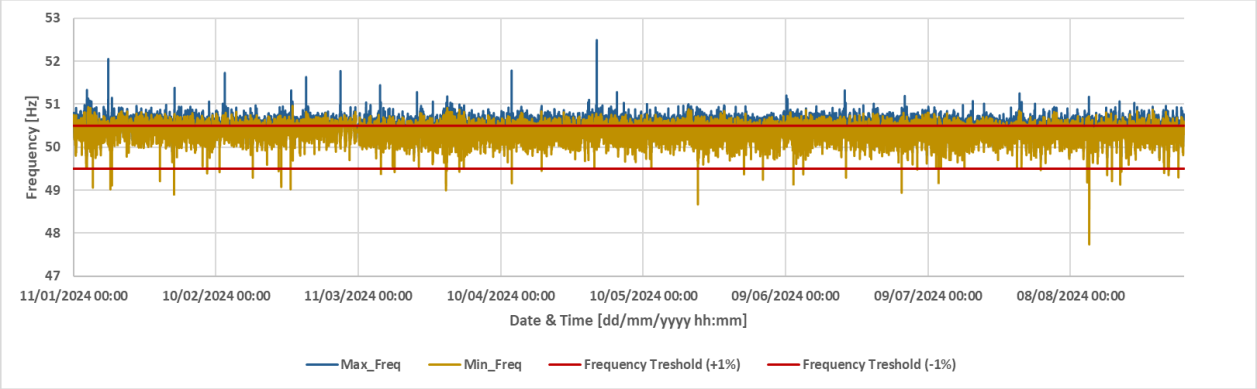


Figure 17. Maximum and minimum ESCOM frequency deviation profile measurements for the period from 11/01/2024 to 31/08/2024.

Table 26. 2024 Monthly Maximum and minimum ESCOM frequency deviation values

Month	Maximum frequency	Minimum frequency	% of frequency increase from nominal value	% of frequency drop from nominal value
Jan_24	52.05 Hz	49.02 Hz	4.1%	-1.96%
Feb_24	51.72 Hz	48.93 Hz	3.44%	-2.14%
Mar_24	51.77 Hz	49.04 Hz	3.54%	-1.92%
Apr_24	52.49 Hz	49.16 Hz	4.98%	-1.68%
May_24	51.28 Hz	48.67 Hz	2.56%	-2.66%
Jun_24	51.32 Hz	49.15 Hz	2.64%	-1.7%
July_24	51.25 Hz	48.94 Hz	2.5%	-2.12%
Aug_24	51.17 Hz	47.74 Hz	2.34%	-4.52%

Voltage Fluctuation

High Voltage Level Transmission Network

Figure 18 plots rms voltage measurements obtained at difference high voltage substation levels, the voltage level is maintained between +/-10% operational practice thresholds complying with the standard voltage level of Malawi Grid Code, although on the days listed in Table 27, the voltage drops as low as 0 kV lasting a few hours, leading to a power interruption to the power and blackout. In general, this could be caused by catastrophic equipment failure, faults at power stations, damage to electric transmission lines, substations or other parts of the distribution system, a short circuit, fuse or circuit breaker operation also severe weather or peak power demands that cannot be met from existing supply.

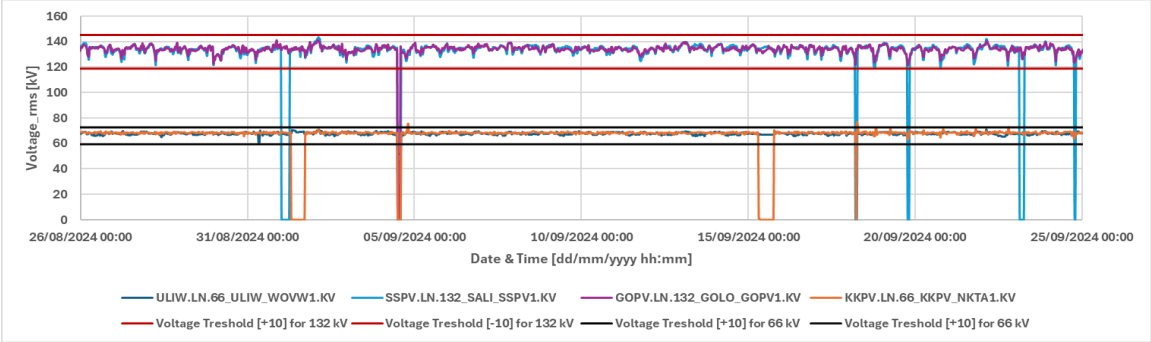


Figure 18. ESCOM Voltage measurements at different power substations for the period from 26/08/2024 to 25/09/2024.

Table 27. Power network blackoust occurred between 26/08/2024 to 25/09/2024

Power Substation	The Date of the Blackout	Voltage [kV]	The Start Time of the Blackout	The Start Time of the Blackout	Duration of Blackout
SSPV.LN.132_SALI_SSPV1.KV	01/09/2024	0	00:30:00	06:00:00	5 hours and 30 minutes
SSPV.LN.132_SALI_SSPV1.KV	04/09/2024	0	12:00:00	14:00:00	2 hours
SSPV.LN.132_SALI_SSPV1.KV	18/09/2024	0	05:00:00	06:00:00	1 hour
SSPV.LN.132_SALI_SSPV1.KV	19/09/2024	0	18:30:00	19:30:00	1 hour
SSPV.LN.132_SALI_SSPV1.KV	23/09/2024	0	03:00:00	06:00:00	3 hours
SSPV.LN.132_SALI_SSPV1.KV	24/09/2024	0	18:30:00	19:00:00	30 minutes
GOPV.LN.132_GOLO_GOPV1.KV	04/09/2024	0	12:00:00	13:30:00	1 hour and 30 minutes
ULIW.LN.66_ULIW_WOVW1.KV	04/09/2024	51.68	12:00:00	14:00:00	2 hours
KKPV.LN.66_KKPV_NKTA1.KV	01/09/2024	0	07:30:00	17:00:00	10 hours
KKPV.LN.66_KKPV_NKTA1.KV	04/09/2024	0	12:00:00	13:30:00	1 hour and 30 minutes

Medium Voltage Level Distribution Network

The Malawi Ministry of Energy produced an updated generation and transmission (Work Stream 1) masterplan up to 2024 as well as for the MV distribution network (Work Stream 2) (Minitry of Energy 2023). Work Stream 2 aimed to update the IRP of 2017 with the latest developments and available information. Within the report power flow analysis was performed using the DIgSiLENT MV Malawi infrastructure model and using the measured peak loads taken in spring 2023 to assess the current network constraints:

- Voltages limits
- (Over)loading of feeders
- Technical losses level
- Check compliance with operation & planning criteria

The operational limits for 11kV and 33kV networks which have been considered in the study are:

- Normal operating conditions: -6% and +1% of nominal voltage
- Contingency operating conditions: -11% and +1% of nominal voltage
- Overload is considered when the feeder is higher than 100% in N situation and 110% in N-1 situation

The results reveal that more feeders with high losses and drop voltages are detected in the Central Region and Southern Region as these regions comprise rural areas, small cities and one big city 'Lilongwe'. To electrify the rural parts, the power is transmitted at long distances using low voltage 11 kV lines creating significant line losses and voltage drop. The voltage drop is a problem if the voltage at the line is too low, the electric devices connected to it will not function properly.

Northern Region: where 31 feeders have been studied, Table 28 summarises the critical feeders.

- 4 feeders with voltages < 0.94 pu (i.e., 13% of the feeders)
- 0 feeders with loading > 100% (i.e, 0% of the feeders)
- 3 feeders with losses > 4% (i.e., 10% of the feeders)

Table 28. Summary of Northern Region of current distribution network's constraints

Feeder	TFO capacity [MVA]	Peak load [MW]	Power factor [-]	Min voltage [pu]	Max loading [pu]	Losses [%]
10F CHKANGAWA (33 kV)	9.130	4.70	0.93	0.88	42.37	8.49
10F CHINTECHE (33 kV)	14.705	3.25	0.98	0.93	28.87	5.68
20F KARONGA (33 kV)	15.005	1.70	0.96	0.91	13.47	5.91
1LF ULIWA (11 kV)	8.041	1.30	0.96	0.92	23.14	3.02

Central Region: where 71 feeders have been studied, Table 29 summarises the critical feeders.

- 20 feeders with voltages < 0.94 pu (i.e., 28% of the feeders)
- 3 feeders with loading > 100% (i.e, 4% of the feeders)
- 20 feeders with losses > 4% (i.e., 28% of the feeders)

Table 29. Summary of Central Region current distribution network's constraints

Feeder	TFO capacity [MVA]	Peak load [MW]	Power factor [-]	Min voltage [pu]	Max loading [%]	Losses [%]
3LF AREA 47 (11 kV)	16.60	2.73	0.82	0.91	71.63	6.28
4LF AREA 48 (11 kV)	13.35	5.76	0.96	0.94	119.02	3.62
5LF AREA 48 (11 kV)	11.95	4.70	0.94	0.93	85.76	4.40
1LF BARRACKS (11 kV)	6.77	3.80	0.95	0.91	68.40	5.80
3LF BARRACKS (11 kV)	6.00	3.98	0.95	0.93	71.66	5.04
1LF BUNDA (11 kV)	10.72	1.54	0.95	0.84	23.67	6.94
2LF BUNDA (11 kV)	13.28	1.99	0.95	0.93	30.64	10.42
3LF BUNDA (11 kV)	13.89	4.52	0.95	0.91	69.64	5.82
40F CHINYAMA (33 kV)	19.62	3.96	0.95	0.88	36,30	8.69
3LF CHITIPI (11 kV)	10.09	4.48	0.96	0.86	79.80	9.59
2LF DWANGWA (11 kV)	1.80	4.75	0.95	0.99	130.56	1.31
5LF KANENGO (11 kV)	8.27	2.17	0.95	0.92	39.22	6.13
8LF KANENGO (11 kV)	5.99	1.32	0.95	0.94	23.85	4.21
10F KANENGO (33 kV)	18.57	5.43	0.95	0.91	32.57	5.77
20F KANENGO (33 kV)	21.17	9.77	0.95	0.79	88.25	12.74
2LF KANG'OMA (11 kV)	6.36	3.62	0.95	0.91	99.51	7.25
5LF LILONGWEA (11 kV)	9.58	4.80	0.95	0.88	304.57	8.13
10F NANJOKA (33 kV)	29.97	6.08	0.90	0.88	42.78	8.07
20F NANJOKA (33 kV)	10.38	2.49	0.95	0.93	14.95	4.06
30F NANJOKA (33 kV)	15.41	2.71	0.96	0.92	18.59	4.90
2LF NKHOTAKOTA (11 kV)	8.75	1.46	0.86	0.82	44.24	6.38
2LF SALIMA (11 kV)	11.28	1.81	0.95	0.90	42.84	4.86

South Region: where 86 feeders have been studied, Table 30 summarises the critical feeders.

- 8 feeders with voltages < 0.94 pu (i.e., 9% of the feeders)
- 5 feeders with loading > 100% (i.e, 6% of the feeders)
- 6 feeders with losses > 4% (i.e., 7% of the feeders)

Table 30. Summary of South Region current distribution network's constraints

Feeder	TFO capacity [MVA]	Peak load [MW]	Power factor [-]	Min voltage [pu]	Max loading [pu]	Losses [%]
40F CHICHIRI (33 kV)	42.30	12.88	0.98	0.99	114.43	1.11
1LF CHILEKA (11 kV)	?	6.80	0.98	1.00	158.25	0.13
1LF LIMBE B (11 kV)	18.34	5.54	0.97	0.93	138.25	5.36
2LF LIMBE B (11 kV)	4.32	1.85	0.97	1.00	104.22	0.28
10F MAPANGA (33 kV)	16.51	6.83	0.98	0.93	53.05	2.92
2LF MLAMBE B (11 kV)	4.51	2.90	0.95	0.59	79.62	26.68
10F MLAMBE B (33 kV)	20.70	2.71	0.95	0.91	16.31	4.93
30F MLAMBE B (33 kV)	21.02	3.26	0.95	0.92	26.09	3.84
10F MONKEYBAY B (33 kV)	34.87	8.78	0.96	0.80	78.79	14.12
1LF ZOMBA (11 kV)	10.61	1.99	0.95	0.68	121.78	15.00
4LF ZOMBA (11 kV)	14.98	2.71	0.95	0.86	86.71	6.11

Valuable studies and outputs are discussed in this masterplan report; however, it does not consider the transition towards eCook and eCook demand growth. Therefore, moving forward in terms of eCooks the priority is to ensure the reliability and quality of service to supply the current network demand plus eCook, investing to solve network constraints, and moving on to ensuring future security and reliability of supply.

Grid and Off-grid Electricity Service per Customer

Observing Table 31, it can be seen that the difference between grid and off-grid tariffs is large, creating a burden for off-grid customers, limiting their capability to pay – the national residential tariff is $0.064/kWh, while the mini-grid tariff is in the range of USD $0.45/kWh depending on the mini-grid size and the provider making it problematic. Solar Home Systems (SHS) are installed in Malawi to provide Multi-Tier Framework; Tier-1 or Tier-2 where the customer is charged a monthly service fee, In Tier-1, customers are charged USD $12/month or higher and Tier-2 can exceed USD $25/month. To reach universal access or to encourage households to cook with electricity, affordability will require subsidies. Overall, off-grid systems (mini-grids and SHS) are primarily dominated by low electricity consumption (Tier-1 and Tier-2), where households are occasionally equipped with a small refrigerator. Due to these factors, it is more reasonable and makes more sense to support eCook uptake through the national grid unless the mini-grid tariff becomes more affordable, and the size of off-grid capacity is sufficient to accommodate eCooks.

Table 31. Grid and off-grid electricity service per customer.

Region	ESCOM National Grid tariff	Anticipated mini-grid electricity tariff	Monthly energy Expenditures (US$/month)	Anticipated ESCOM Consumption (kWh/month)	Anticipated mini-grid Consumption (kWh/month)
Northern	$0.064/kWh	In the range of $0.45/kWh	$3.82	60	8.5
Center			$3.00	47	6.7
Southern			$4.23	66	9.4

The IEP plan and the Geospatial Map published in the IEP platform are a step towards understanding the future vision of Malawi's grid, the interventions that need to be done and the estimated cost to make it happen. The tool has been used by private sector and government stakeholders to help in their decision-making, such as ESCOM, Global Energy Alliance for People and Planet (GEAPP) and GIZ Energizing Development (EnDev), but not much used in the eCook area. The current version targets 100% electrification by 2030 taking the assumption of only enabling eCooks to grid-connected households, which represents 73.1% of all households (4,126,638). The remaining rural households are not grid-connected but will be connected to off-grid systems for low electricity consumption and their cooking will be accommodated using other clean fuel where no fuelwood or charcoal is used. The other reason as mentioned before the high off-grid tariffs. An updated version of the IEP study is being conducted at the moment to factor in more achievable electrification targets that align with Malawi targets, as 100% electrification by 2030 is very ambitious and not realistic with the current Malawi electrification challenges.

There is also still a lack of understanding of urban and rural average monthly consumption per household, the IEP study used the data in Table 31 , while the demand forecast used in the Malawi masterplan was assumed to be close to 160 kWh and 50 kWh, respectively (Ministry of Energy 2023), based on information households in other countries (Zambia and Ethiopia). Therefore, more work needs to be done in this area mainly for the Malawian household consumption for both the base demand and eCook demand.

3.2.4 Current eCook Demand

Efforts to effectively transition to electric cooking in urban and rural Malawi and to obtain accurate demand forecasts, need to be coupled with enhanced monitoring of demand; base demand (no-eCook demand), electricity cooking demand and the percentage of fuel stacking used. Cooking with electricity could be coupled with fuel stacking although this is likely to underestimate actual household needs, thus accurate recording and monitoring is essential. When households start to cook with electricity, may also lead to the purchase of other electrical cooking appliances (e.g. fridges, kettles, toasters etc) and other domestic appliances (e.g. TVs, computers etc) which would exacerbate this issue. Since 2013, Modern Energy Cooking Service (MECS) (Ed Brown and Hyseni, n.d.) has been active in the eCook domain by creating phototype concepts, undertaking global market assessment, trials and evidence gathering on behaviour in Malawi, Zambia, Kenya, Tanzania, Nepal, etc at variant scales (grid, mini-grids, SHS). The data recorded in Table 32 suggests that the typical daily energy consumption per household when cooking only with electricity is 1.58-2.2 kWh/day. The eCook energy usage is caused by cooking practice, number of heating

events, type of staple food cooked and the size of the household. MECS developed a demand modelling tool for both the baseload and cooking household load representing low-income household electricity demand in remote rural areas of Sub-Saharan Africa (Mullen and Wade 2020).

The tool appliance ownership and utilisation habits are taken from the ESMAP Multi-Tier framework where the baseload daily energy consumption for households is somewhere between Tier-1 and Tier-2 (50–200 Wh per day), while energy consumption is 1.75–2.2 kWh per day for cooking only. Ideally, a household with basic lighting and phone charging under Tier-1 or Tier-2 consumes 3-50W, this situation is dire for SHS and mini-grids installed in developing countries. For example, a mini-grid with 100 household connections, sized only to serve Tier-1 and Tier-2, providing them with a 1 kW EPC is not practical when considering cooking only with electricity. The same could be said for on-grid connection due to the reliability and the QoS reported. To enable eCook deployment, systems in general terms need to be scaled up to Tier-4 and Tier-5 with a minimum of 800 W and 2 kW respectively. The dilemma is whether to adopt a short-term or a long-term solution; the current short-term situation is moving towards fuel stacking, not an ideal solution, although is a way to enable a percentage for clean cooking. A long-term vision is to move towards cooking using only clean fuels such as electricity to meet the decarbonisation targets,

Table 32. Measured and modelled eCook energy consumption

			Cooking device type	Household daily energy consumption (kWh)	Average household size (no. people)	Average daily energy consumption per capita (kWh)	Ref.
Urban	Zambia	Using 100% electricity for cooking	EPC	1.63	7.9	0.21	(Modern Energy Clean Cooking Services (MECS), n.d.)
		Using 90% electricity for cooking plus fuel stacking	EPC	1.1		0.14	(Modern Energy Clean Cooking Services (MECS), n.d.)
	Tanzania	Using 100% electricity for cooking	EPC	2.06	4.2	0.49	(Modern Energy Clean Cooking Services (MECS), n.d.)

			Cooking device type	Household daily energy consumption (kWh)	Average household size (no. people)	Average daily energy consumption per capita (kWh)	Ref.
		Using 90% electricity for cooking plus fuel stacking	EPC	1.44		0.34	(Modern Energy Clean Cooking Services (MECS), n.d.)
	Kenya	Using 100% electricity for cooking	EPC	1.4	3.1	0.46	(Modern Energy Clean Cooking Services (MECS), n.d.)
		Using 90% electricity for cooking plus fuel stacking	EPC	0.96		0.30	(Modern Energy Clean Cooking Services (MECS), n.d.)
Rural	Nepal	Using 100% electricity for cooking	Induction hob	1.58	5	0.32	(Clements et al. 2020a)
	Tanzania	Using 100% electricity for cooking (MECS modelling tool)	EPC and Induction hob	**1.75–2.2**	4.2	0.42–**0.52**	(Mullen and Wade 2020)

Table 33 shows the duration of estimated cooking times from the user surveys, of the pilot studies, conducted in Zambia, Tanzania, Kenya, Nepal and Malawi. The data shows that there is a similarity in the cooking periods, the Malawi average cooking across Urban, peri-urban and rural indicates that breakfast is usually cooked between 04:00 am and 09:00 am, lunch is from 11:00 am and 15:00 pm, while dinner is between 17:00 pm and 22:00 pm. This data was collected through research, surveys and fieldwork led by researchers at the University of Strathclyde in 2019.

Table 33. Estimated typical cooking periods for different developing countries for conducted surveys and Pilots.

Country	Breakfast		Lunch		Dinner		Ref.
	Start of Period	End of Period	Start of Period	End of Period	Start of Period	End of Period	
Zambia	**06:50 am**	**10:00 am**	**11:00 am**	**15:30 pm**	**17:30 pm**	**21:30 pm**	(Leary et al. 2019c)
Tanzania	**04:50 am**	**09:50 am**	**11:00 am**	**15:00 pm**	**17:00 pm**	**21:00 pm**	(Leary et al. 2019b)
Kenya	**04:00 am**	**09:00 am**	**11:30 am**	**15:00 pm**	**16:00 pm**	**21:50 pm**	(Leary et al. 2019a)
Nepal	**05:00 am**	**09:00 am**	**No lunch reported**	**No lunch reported**	**17:00 pm**	**21:00 pm**	(Clements et al. 2020b)
Malawi	**04:00 am**	**09:00 am**	**11:00 am**	**15:00 pm**	**17:00 am**	**22:00 pm**	(Soltowski et al. 2020a)

A pilot study was conducted in Malawi to collect eCook consumption data at the MEGA (The Mulanje Electricity Generation Agency) mini-grid, where 1.5 kW hotplates were provided to 20 households who participated in the pilot (Eales et al. 2022c). The mini-grid is a 220 kVA hydropower without storage and a tariff of only USD $0.08/kWh for non-commercial customers. The electricity is supplied to domestic customers, including smallholder tea farmers, artisans, and tea estate workers using electricity to meet lighting and domestic needs, with some customers starting to use the power for cooking.

While in 2015 only 0.8% used electricity to meet their cooking needs, this figure increased to 4.5% in 2019. The data was collected from the 20 smart meters at 5-minute intervals between March 2021 and February 2022. The measured data included voltage fluctuation, current flow, eCook power and energy consumption, power factor and frequency deviation. In the report, the eCook consumption and the technical network impacts were analyzed to give an understanding of the challenges when scaling up eCooks on Malawi mini-grids.

Table 34 shows the average energy cooking consumption of all 20 households, the key observation is that the majority of households consume less than 1kWh per day for cooking, while the average cooking consumption was expected to be within the range recorded in Table 34. Average Energy Cooking Consumption per day (kWh).if cooking exclusively with electricity. Those with low energy consumption used fuel stacking to accommodate all cooking, this may be explained by factors impacting both the supply and the demand side – seasonal shortages of water levels between August and September explain frequent blackouts and load-shedding.

Table 34. Average Energy Cooking Consumption per day (kWh).

Household no.	Average Energy Cooking Consumption per day (kWh)
HH_1	1.6
HH_2	0.9
HH_3	1.5
HH_4	0.7
HH_5	0.7
HH_6	0.6
HH_7	0.5
HH_8	1.7
HH_9	0.8
HH_10	1.1
HH_11	0.9
HH_12	0.4
HH_13	0.2
HH_14	0.0
HH_15	0.7
HH_16	2.5
HH_17	0.4
HH_18	0.4
HH_19	1.0
HH_20	0.5

The voltage and frequency levels are plotted in Figure 19 and Figure 20, for households with high eCook energy consumption (highlighted in blue in Table 32**)**. Significant fluctuations and frequency were observed, levels dropped below the voltage threshold limits of 10% and below and slightly above the frequency threshold limits of 1%. The events can be correlated with the intensive use of the hot plates where the peak occurs at similar times to the baseload peak, in this case, the current flowing in the cables is followed by high power loss leading to a high voltage drop at the customer's end. The weak and unreliable grid affects the user's perception, as the cooking takes longer at a low voltage, and the outages can leave food uncooked.

The power outages, due to overload, were seen mainly during the evening hours and sometimes the morning hours. In the scope of this study, with only 20 households from a total of 1500 using eCooks, the constrained generation mixed with power outages in the hydropower mini-grid system poses significant issues for the uptake of electric cooking. Hence, a clear indication is that the wide adoption of eCooks is not currently possible unless the power generation is reinforced. Therefore, more detailed studies, including data on household cooking consumption, technical network analysis, and historic power generation data of other mini-grid case studies are needed to clarify the challenges and the possibilities of using eCooks on these networks. It should be also noted that for thses analysis a +/- 10% voltage drop was used but for some mini-grids such as the ones installed by PowerGen, the

maximum voltage drop is limited to 4% (Williams et al. 2017) and even to 6%, which is why there is a need to standardize off-grid design.

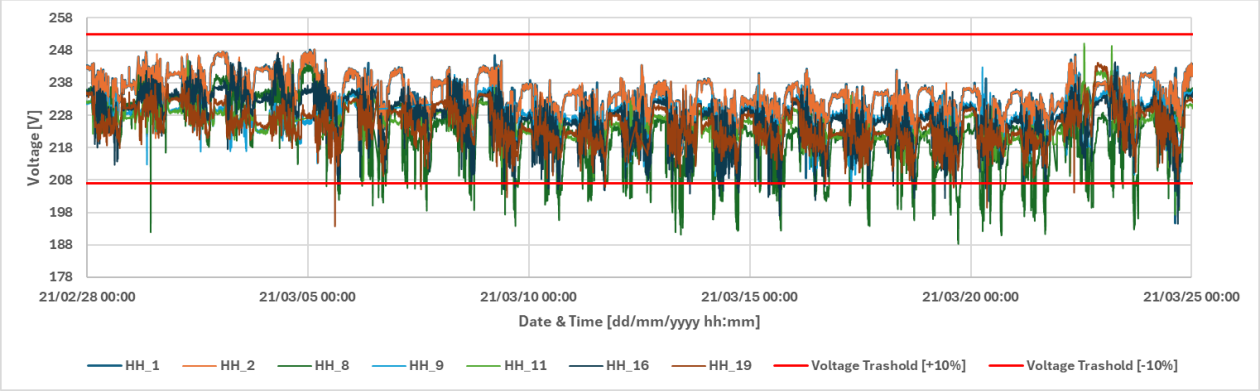


Figure 19. Voltage Variation at Different Households with High eCook Utilisation.

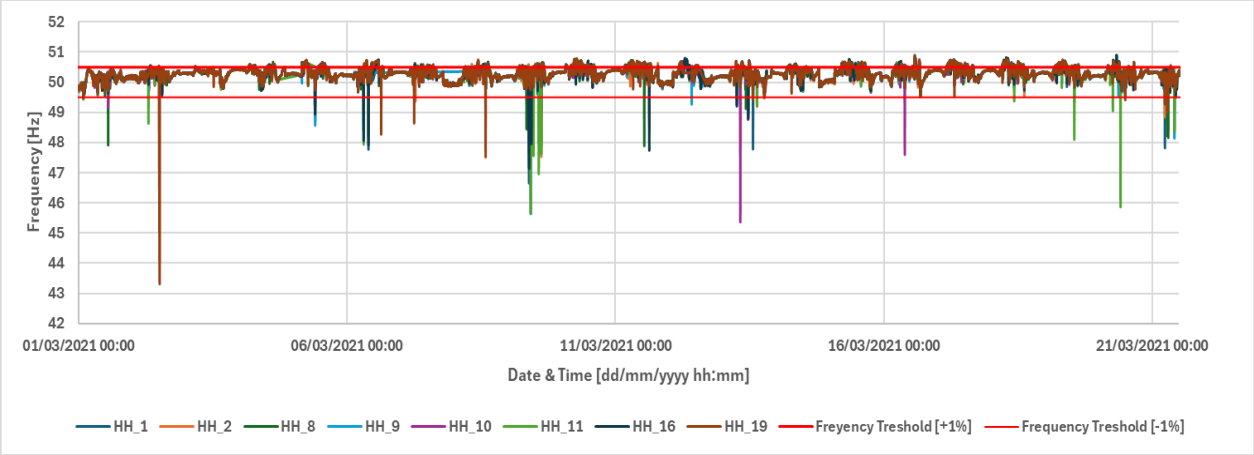


Figure 20. Frequency Deviation at Different Households with High eCook Utilisation.

3.2.5 Lessons Learnt from Other eCook Pilots

This section analyses existing studies for the impact of Electric cooking on distribution infrastructure (main national grid and off-grid), focusing on lessons learned. Table 35 lists the eCook field trials and the research studies conducted in this area. Reflecting on the findings in Table 35; studies of eCook on the main national grid and off-grid context are few and mainly focused on small numbers of customers with less intense network data-gathering, in contrast to the amount carried out examining, cooking time, ease of use, biomass/charcoal cooking cost, type of utensils used for the cooking and whether they aline with using eCooks.

The short-term nature of the studies in Table 35 concluded that the most critical network challenges when adding new loads, such as eCook appliances are related to generation capacity shortage and network overloading. Even when only supplying the baseload (non-eCook load), the network experiences several blackouts a day and an unreliable power supply. This being the case, the network will struggle to meet the new eCook load or other

new electrical loads. In other sectors, such as (transportation, heat, industry, residential and commercial) when moving towards long-term decarbonization targets.

Also, it could be argued that even with a resilient network with sufficient generation, the capacity could be used for innovative projects in the other sectors, rather than eCook. Therefore, larger systems are required and for accommodating eCook or equivalent new loads, these must be factored at the design stage. Most studies reported drops in voltage and frequency below nominal values even with low eCook penetrations which suggest cable overloading and a lack of sufficient reactive power compensation. Providing reactive power compensation will help improve the network's power factor and reduce energy consumption by reducing the total load current and voltage drop, in addition to reducing the power losses, improving the voltage quality, and stabilizing the operation of equipment.

Another issue is aging transmission assets that is caused by many factors; to avoid this in the future, the service life of equipment can be extended by placing reactive power support so that the loading capacity of the transformer, switch, lines and other machinery equipment close to saturation is reduced and not operating at high temperature. In a similar context, European countries are investigating issues regarding the transition towards electric vehicles on utility networks, the network challenges and the benefit of coupling electric vehicles with demand management to increase their pace.

Therefore, generation upgrades, innovative demand management concepts and aggressive measures to encourage customers to embrace eCook technology will facilitate the transition. To determine the best operation for existing networks and in planning future expansion scenarios, detailed network studies and power flow analysis are required to help prevent power system overload, and generation capacity available and to identify critical points to provide valuable insights for present and long-term planning. To date, no regulation standards have been introduced for mini-grids and system size, PV array capacity, types and size of the cables are selected depending on each system operator which means that individual mini-grid analysis stands in need.

Table 35. eCook pilot projects in some developing countries.

Project	Country	Topic	Year	Technical Parameters and Technical Findings	Ref.
1. Engie/Power Corner – Chitandika mini-grid project	Zambia	EPCs	2020/21	• EPCs were provided to main grid-connected customers **The main findings show that:** • Customers cooking with electricity experience challenges with load shedding and significant voltage fluctuations • Reliability and quality of the grid is a significant barrier to transitioning to using eCooks entirely • The network challenges could be mitigated by the strategic use of battery-supported electric cooking, although more detailed research in the future is necessary to demonstrate the concept. • The barriers to reaching Tiers 4 and 5 overwhelmingly refer to the reliability and quality of electricity, rather than affordability.	(Scott et al. 2020)
2. Earthspark	Haiti	Feld trial of induction stoves and EPCs for solar mini-grid customers	2019/21	• The eCook pilot was conducted in the rural community of Les Anglais in Southwestern Haiti for a minimum of 42 days. • The microgrid is a 100kW solar PV hybrid microgrid serving about 2000 people. • The pilot included 20 households connected to a community-scale solar PV microgrid and 8 off-grid households. • The PV mini-grid customers were provided with EPCs and induction stoves. • The off-grid households used cookers and stoves through the pilot. • The microgrid participants had a “SparkStove” system, while the off-grid participants had a SUNSPOT™ solar electric cooking system • Each of the systems was designed to support an electric pressure cooker (Simpot) and an induction stove. • Each device was interconnected to a smart meter that recorded 15-minute interval data for the customer's electricity consumption. **The main findings show that:** • The electric cooking pilots added a significant load to the existing microgrid operations. • Peak demand for cooking aligns with peak solar generation in rural Haiti. • On sunny days, the PV plus storage system are used to supply the extra cooking load, however, on rainy and cloudy days, the backup diesel generation comes online to supply the shortage. This also happens and on a few occasions in blackouts. • Electric cooking had some impact on delivered voltage, particularly on certain distribution lines, although overall delivered voltage stayed within normal +/- 5% ranges for the customer devices. • This finding underscores the importance of additional generation capacity and time-of-use cooking plans to prevent instantaneous demand from exceeding supply.	(Bilich et al. 2021)

Project	Country	Topic	Year	Technical Parameters and Technical Findings	Ref.
3. Unlocking electric cooking on Nepali micro-hydropower mini-grids	Nepal	Field trial of induction stoves with 10 households on a 29kW micro-hydro mini-grid	2018/19	• The pilot was conducted in Simli, a rural Western Nepali community. • Is a 29 kW micro-hydro mini-grid, that provides electricity to around 450 Households. • The induction stoves pilot included 10 Households • Quantitative and qualitative data from a cooking diary study and electrical mini-grid data were collected. **The main findings show that:** • Households typically cook at the same time, as the peak demand for electricity, exacerbating the problem of limited capacity in villages like Simli. • Voltage instability and limited hydropower plant capacity provide obstacles to electric cooking, especially as it becomes more widely adopted. • The participants also described frequent brownouts, which led to uncooked food during periods when the system was running. • For a nominal voltage of 230V, the voltage often drops to as low as 50 V for short periods of time. Hence, cooking is slower at 200 V and virtually impossible below 150 V. • Only three households continued to use their electric stoves regularly due to a lack of reliable electricity supply, showing that widespread adoption of electric cooking is currently unfeasible. • The electrical data showed that the total load at peak times reached full capacity every day, where the data was available, with a maximum of 10 households cooking with electricity. • A local and robust supply chain is required.	Academic article: (Clements et al. 2020a)
4. Accelerating Microgrid E-Cooking Through Business & Delivery Model Innovations	Tanzania	Field trial of 40 EPCs on solar-hybrid mini-grids in rural Tanzania	2019/20	• The mini-grid sites are in the Singida region of central Tanzania. • The sites were targeted for the study as they offered lower electricity rates compared to most rural microgrids. • PowerGen microgrid 1: Community: Londoni, Region: Singida, Population: 8858, microgrid customers: 203, microgrid installation date:10/30/2016, solar capacity 19.08 kWp • PowerGen microgrid 2: Community: Saranda, Region: Singida, Poppulation:1735, microgrid customers: 95, microgrid installation date:2/2/2016, solar capacity 6.36 kWp • Remote monitoring data from PowerGen's smart metering system to gauge the impact of EPCs on customer electricity consumption. • The study is limited by the short duration and the small and geographically specific • sample size. • No technical impact network studies were carried out. **The recommendations for follow-up studies are to:** • Offer EPCs across a wider variety of microgrid customers to confirm product-market fit. • Test different kWh price points to more deeply understand the willingness to pay. • Study the longer-term impacts of EPCs on customer consumption and revenues.	(PowerGen Renewable Energy Ltd et al. 2020)

Project	Country	Topic	Year	Technical Parameters and Technical Findings	Ref.
				• Study the longer-term impacts of EPCs on microgrid economics technical performance. • Study the longer-term power reliability and quality of the mini-grid with impacts of EPC demand.	
5. A2EI EPC Tanzania mini-grid trial	Tanzania	Field trial of 100 EPCs with micro-grid customers in rural Tanzania	2019/20	• A2EI installed smart meters on EPCs in 100 households, and the participants were given 6 litre, 1 kW electric pressure cookers. • In 6 hybrid mini-grid (solar PV/diesel back generation with battery, the villages are in northwestern Tanzania – 3 on islands, 3 on the mainland: 6.4-29.5 kW at various sites. Site 1-Island: 25.9 kW generation capacity, 340 connections and customers are charged a flat tariff rate. Site 2-Island: 16.2 kW generation capacity, 130 connections and customers receive a 42% reduction on the flat tariff rate. Site 3-Island: 19.1 kW generation capacity, 180 connections and customers receive a flat tariff rate. Site 4-Mailand: 6.4 kW generation capacity, 178 connections and customers receive a monthly block (a 37.5% discount from the flat tariff if they use at least 3 kWh in a month). Site 5-Mailand: 6.4 kW generation capacity, 132 connections and customers receive a monthly block. Site 6-Mailand: 12.7 kW generation capacity, 182 connections and customers receive a monthly block. **The main findings show that:** • High utilization of EPCs was seen during low-tariff scheme ($0.04/kWh). • Users experience unreliable power supply and voltage fluctuations.	(Jones et al. 2021), (Kweka et al. 2021)
6. ECO Pilot Study: E-cooker network for Urban Slums: Benefits and Barriers to implementation	Bangladesh	Monitoring of e-cooking behaviour on 25 kWp system	2020/22	• The project implemented electric cooking using the grid electricity with a Central grid-connected 25 kWp PV system (grid-tied inverter). **The main findings show that:** • The power connection from the main power line pole to the slum area is severely undersized causing a very high voltage drop. • While establishing the grid-tied inverter it was observed that the grid voltage at the PV site was too low, around 160 -170V, compared to the rated line voltage of 220/230V. • The presence of energy storage and frequent load-shedding. • In the presence of energy storage, only 5 KWh would be required via the grid, saving about 92% of the cost incurred to the government due to informal tapping of the electrical grid.	Academic Article: (Bhattacharjee 2021)
7. Assessing the Techno-economic Feasibility of eCook Deployment on a	Malawi	Technical, environmental and economic aspects of	2019	• This paper studied the technical, environmental and economic aspects of eCook mini-grids in a Malawian context which could be applied to rural areas in other less developed countries.	Academic Article: (Keddar et al. 2020)

Project	Country	Topic	Year	Technical Parameters and Technical Findings	Ref.
Hybrid Solar-Diesel Mini-grid in Rural Malawi		eCook mini-grids in a Malawian context		• ECook research to date has concentrated on collecting data for cooking diaries and market assessments. However, limited studies have assessed key power network parameters such as voltage stability, power losses, power quality and reliability. • Connecting additional loads such as eCook devices present high risks to power grids in developing countries, where the grids are weak. • It is important to understand the operational nature of eCook devices and their impact on the power system's performances to enable connecting them to mini-grids in the future. **There is a limitation for:** • Measuring the energy consumption of cooking meals with electricity in developing countries, particularly in Malawi. • Together with the lack of understanding of the technical impacts of eCook devices on mini-grids. • The next step in this research is to collect eCook power consumption data and create load profiles (with/without eCook). • Model eCook mini-grids to test the system with/without eCook loads and investigate the effect of eCook penetrations on the key power network parameters.	
8. Impact of New Electric Cooking Appliances on the Power Network, Off-Grid Microgrids and Interconnected SHSs Networks	Generic Power Network Models	Impact of New Electric Cooking Appliances on the Power Network	2020	• Rapid deployment of eCook devices without sufficient power system upgrades may cause a reduction in the overall reliability of the power supply. • Off-grid solar microgrids are primarily designed to provide basic access to electricity for Tier-1 or Tier-2. • Scaling up to satisfy electric cooking demand is possible although requires high capital costs. The current cost of (PV modules and batteries) adopting electric cooking is not considered an opportunity by most solar microgrid providers interviewed. • Electric cooking load using off-the-shelf devices is too high to be accommodated by economically viable stand-alone SHSs or by a network of interconnected SHS systems forming a microgrid. • To adapt eCook systems supported by SHS, significant up-scaling in the size of the PV array and energy and storage is required which might drive costs of the infrastructure beyond the financial capabilities of existing SHSs users. • Identifying feasibility studies of electric cooking on a grid-scale should include an analysis of future power systems expansion.	Academic Article (Soltowski et al. 2020b)(Soltowski et al. 2020a)
9. The Influence of Load Growth on Nepal's Distribution Network: Examining the Integration of Electric Cooking Stoves	Nepal	The Influence of Load Growth on Nepal's Distribution Network	2023	• The study is carried out considering two feeders: the Jorpati feeder in the Kathmandu district and the Malangwa feeder in the Sarlahi district of Nepal. The • The focus was mainly on the loading of the distribution transformer when connecting different electric cooking stove penetrations, the voltage level at the buses, and the ampacity of the feeder conductor. • The cooking loading penetrations considered are, 25%, 50%, 75%, and 100% cooking stoves to understand the potential impact on the power grid (families are not shifted towards the use of ECS at the same time, the change will be gradual during the transition phase)	Academic Article: (Shah and Paudel 2023)

Project	Country	Topic	Year	Technical Parameters and Technical Findings	Ref.
				• The results of the load flow study help to assess the electricity demand, infrastructure requirements, and potential challenges associated with the transition. **The main findings show that:** • The existing electrical systems in both Jorpati and Malangwa feeders will face challenges in handling the load growth resulting from the cooking demand in each household. • In the Jorpati feeder, after incorporating cooking stoves at each household, 23 out of 33 distribution transformers need upgradation to meet the growing load demand. Also, the feeder conductor needs to be upgraded to a wolf conductor to handle the increased load. • For the Malangwa feeder, the research indicates that introducing cooking stoves in each household will lead to overloading on almost all distribution transformers except the private one, and the feeder conductor will also be overloaded. This situation can cause under-voltage problems at the buses located towards the end of the feeder line and an increase in system power loss. • Upgrading the system before promoting the use of eCook devices in each household is a must, including distribution transformers and feeder conductors, • Is necessary to ensure that the voltage levels remain within acceptable limits and that the system can meet the growing load demand.	
10. Impact Of Cooking Appliances Shifting Hours In Rural Mini-Grids: Case Study In Ethiopia	Ethiopia	This study investigates how shifting hours of operation may impact mini-grid component sizing and their cost in a village in Ethiopia	2023	• This study investigates how shifting hours of operation may impact mini-grid component sizing and their cost in a village in Ethiopia. **The main findings show that:** • Shifting hours of electric cooking impacts the size of battery energy storage and solar PV, resulting in a system cost reduction.	Academic Article: (Gelchu et al. 2023)
11. An Overview of the Technical Challenges Facing the Deployment of Electric Cooking on Hybrid PV/Diesel Mini-Grid in Rural Tanzania—A Case Study Simulation	Tanzania	The study investigates the technical challenges facing the deployment of electric cooking on Hybrid PV/Diesel Mini	2021	• The model is a hybrid PV diesel mini-grid with 30 kWp PV, 9 kW diesel generator, 41.4 kWh lithium-ion battery, 8 kW battery converter and 10 kW PV-inverter. • 108 households are supplied by the mini-grid. • The model was tested with different eCook penetrations ranging from a non-eCook base-load to 20%, 50%, 80% and 100% eCook penetration (where the 100% eCook refers to all the 108 HHs using only eCooks for cooking as a worst-case scenario), to allow evaluation of the eCook demand met and not met without network reinforcement as penetration increases. • For the distribution and service cables, the CSA are set to 50 mm2 and 16 mm2, respectively.	Academic Article: (Keddar et al. 2022)

Project	Country	Topic	Year	Technical Parameters and Technical Findings	Ref.
				The main findings show that: • The system can meet the 0% eCook scenario and around 20% eCook. However, as the number of eCook devices increases, demand cannot be met resulting in an increase in the daily energy shortage; for 100% eCook, the energy shortage is approximately 42%. • For 50%, 80% and 100% eCook, the mini-grid fails to provide enough power to meet the aggregated load—this occurs in the morning and the evening. • In the case of 20% eCook (22 HHs using eCooks), all the daily demand is supplied by the available generation; the early morning and evening demand is met by both the battery and the diesel generator while at midday there is sufficient power generated by the PV. • The voltage drop and voltage imbalance issues can be reasonably and affordably addressed by using cables of a larger cross-sectional area. • The main issue prohibiting higher penetrations of eCook centres on generation capacity requirements. • eCook supported batteries with an innovative charging management concept that would maximize the utilization of electricity from the daily PV power and offset peak demand to a different time, by charging the batteries during off-peak hours to provide flexibility in demand	
12. Impact analysis of residential induction cooking on medium voltage distribution network system: A case study of Nagarkot feeder, Bhaktapur, Nepal	Nepal	The study investigates the impact of residential induction cooking on medium voltage distribution network system	2021	• The case study was conducted on Nagarkot feeder, Bhaktapur, Nepal, with the aim of investigating the impact of residential induction cooking (IC) as well as the feasibility of installing a distribution generation (DG). • Installing the DG in the distribution system has positive and negative effects on the system. However, there is a need to adequately choose the acceptable amount of DG penetration such that the advantages are not turned into disadvantages. • The study also analysed the impact of bundling of lines in improving the line performance and increasing the power capability of the line. • The study is carried out by performing technical analysis by load flow analysis on the feeder by calculating current, voltage profile, and power losses. **The main findings show that:** • Significant use of IC to the distribution feeder increases the losses of the feeder, reducing the voltage profile at the buses, which increases the current-carrying conductor. • Improvement in voltage profile resulting from installing DG can help mitigate the voltage drop along the feeder; However, increasing the penetration level of ICs and even the DG capacity above a specific limit may cause overvoltage or other problems. The advantage of DG installation is the reduction in overall system losses. • Bundling of lines reduces the line reactances, improves the line performance and increases the power capability of the line. • 100% IC loading is not technically feasible. The feasible penetration level of IC to the grid was found to be 25% of the households. Up to this level, the DG can improve the power loss and voltage drop to an acceptable limit.	Academic Article: (Bhattarai and Maharjan, n.d.)

Project	Country	Topic	Year	Technical Parameters and Technical Findings	Ref.
				• This improvement was also carried out using the bundling method by bundling 9 branches (in around 9 Km) can reduce the impact, up to a penetration level of 45% of IC to the grid. • On comparing DG penetration and the bundling method, the impact of IC penetration is reduced more by the bundling method.	

3.3 Clean Cooking Business Models

The Clean Cooking Alliance's Unit Economics Framework identifies two main archetypes of clean cooking business models: asset financing solutions and captive fuel distribution (Clean Cooking Alliance 2024). These are described in more detail below.

Archetype 1: asset finance solutions

Asset finance solutions help to overcome the financial hurdle of the upfront cost of equipment. There are two main approaches:

1) Pay-as-you-go (PAYG) where access to the system is contingent on payments. This is used to spread the cost of the device over time and has a hardware or software requirement.
2) Payment in installments, with a defines repayment plan for an asset that does not depend on its usage.

Asset financing solutions can be combined with any cooking solution and are most needed when the system is cost is particularly high e.g. biogas. PAYG solutions are particularly cheap to implement via electrical circuits, meaning they are often used with gasifier stoves (which have a battery and fan) and Electric cooking appliances. They can also be used with LPG but this requires a cylinder mounted valve, which is expensive and technically difficult, driving higher costs that ultimately must be absorbed by the customer.

Archetype 2: captive fuel distribution

Some ventures provide fuels as well as stoves, relying on the repeat fuel sales to generate income. Sometimes fuel is purchased on demand and sometimes providers use a subscription service to generate steady revenues. This may also be done in combination with the two archetypes above, or through variants where the stove is provided at a discount and the costs recovered through fuel sales.

3) Sales through retail points where fuel is distributed to an outlet close to customers and customer collect or refill fuel. This is the standard LPG distribution model.
4) Door-to-door distribution where fuel is delivered directly to households.

Captive fuel distribution approaches are generally incompatible with grid-connected Electric cooking solutions, as the fuel is provided by the utility rather than the stove company. They are widely used by ethanol, pellet and LPG providers.

These two archetypes are not independent and are often used in combination with each other, e.g. pellet offerings where the fuel price is elevated to cover the cost of the gasifier stove over time.

3.4 Inventory of Modern Energy Cooking Solutions

This section presents an inventory of existing modern energy cooking solutions in Malawi and at regional level. They include companies already operating in Malawi and those that are not currently active but could potentially suit Malawi's market. The information is presented by fuel and is primarily based on interviews conducted with key informants from these companies.

3.4.1 LPG

265 Energy (LPG, standard retail distribution, currently active in Malawi)

265 Energy were founded in 2018 as an LPG distributor in Malawi. As of 2024, they have grown to become the fourth largest reseller of cooking gas in the country.

Target market: 265 Energy operate in the central, southern and northern regions and target income-generating households in urban and peri-urban areas. They are currently expanding their distribution network with smaller satellite outlets and plan to establish their first bulk storage facility in the Northern region, where LPG is less commonly used at present.

265 Energy offer free training on LPG use and safety for all of their customers. Their focus on safety and quality addresses concerns about low-quality LPG regulators on the market.

Supply chain and distribution: 265 Energy are primarily an Afrox distributor but they also sell products from other brands, including their own. They have their own bulk storage tanks (2 x 10-tonne tanks) and offer door-to-door delivery to all of their customers. Customers can refuel either via cylinder exchange or partial refills; 90% of customers prefer the latter.

Equipment: 265 Energy provide a range of cylinder sizes: 3kg (own brand), 6kg, 9kg, 14kg, 19kg, 45 kg (all Afrox branded). Their main market is the 6kg and 9kg cylinders (residential cutomers) and 19kg cylinders (commercial customers). All of their cylinders are ISO certified.

Current scale and future plans: 265 Energy are currently selling 20-25 tons per month when operating smoothly. They recently introduced a 3kg cylinder targeted at the entry-level market (i.e. first time LPG users) and low-income urban households. They recently signed a partnership with National Bank PLC for flexible financing options on gas accessories. They are seeking working capital of $5-700,000 to avoid stock-outs and ensure consistent fuel supply. They are planning to allocate $2.5m towards capital expenditure to support growth.

Challenges: 265 Energy can receive an inconsistent fuel supply from Afrox due to forex issues limiting importation and insufficient storage capacity. There are cross-filling issues in the market which particularly affect Afrox cylinders. Regulatory challenges include burdensome licensing requirements and safety enforcement in the market. High interest rates (35-37%) make it difficult to finance growth and operations.

Carbon credits: None.

Delta Energy (LPG, standard retail distribution, currently active in Malawi)

Delta Energy are an official supplier and distributor of Shell LPG. They work in both Malawi and Zambia and commenced their Malawian operations in 2015.

Target market: Delta Energy operate in Malawi's central region.

Supply chain and distribution: Delta Energy source most of their LPG from Dar es Salaam, Tanzania. They also import from Mozambique and South Africa. In Malawi they two distributors and four company-owned outlets. Most customers replenish gas by partially refilling rather than cylinder swapping.

Equipment: Main demand is for 6kg cylinders with cooker tops. They have also introduced 3kg cylinders but do not regard them as a long-term solution. these cylinders and stoves are mostly imported from China. They also sell some higher quality stoves from South Africa (Tour Type brand).

Current scale and future plans: They currently sell 3500-4000 tons of LPG per month and have a 15% market share.

Challenges: The main challenge facing Delta Energy is forex shortages. They find it difficult to access forex and struggle with high premiums when it is available. This affects their ability to import gas. Other economic struggles include currency devaluation and the large gap between official and parallel exchange rates (up to 60%). They felt that LPG is seen as a luxury item and is still out of reach for most of the population. They also felt there the market has become crowded and that there is an oversupply relative to current demand.

Carbon credits: None.

Falcon Gas (LPG, standard retail distribution, currently active in Malawi)

Falcon Gas supply LPG across a number of countries in sub-Saharan Africa and entered the Malawian LPG market in 2021.

Target market: Falcon Gas target middle and low-income urban households in the four main cities in Malawi (Lilongwe, Blantyre, Zomba, Mzuzu). They have observed a shift from 30% domestic/70% commercial market share in 2020 to 70% domestic/30% commercial in 2024.

Supply chain and distribution: Falcon Gas import most of their LPG from Tanzania, with some supplementary supply from South Africa and Mozambique. The transport cost from Tanzania to Malawi is $225/ton using third-party trucks. They have 30 tonnes of storage in Malawi and 11 tonne/day filling capacity. They sell to end-users through eight distributors and also directly home delivery. They mostly do full cylinder replenishments although partial refills are gaining popularity (~2% of sales currently).

Equipment: The most popular cylinders are 3kg, 5kg, 6kg with integrated burner.

Current scale and future plans: Falcon are projecting 15-20% market growth in 2024.

Challenges: Falcon highlighted the low consumer awareness and safety concerns amongst potential users. In response to this they run their own awareness campaigns in marketplaces, schools and churches. There is also the high upfront cost of equipment presenting a significant barrier to consumers. Malawi's regulated pricing system has slow adjustments, adding to cash flow issues for companies and causing under-recoveries due to forex fluctuations. Malawi's chronic forex shortages make it difficult to pay suppliers and local financing options are expensive.

Carbon credits: None.

Green Impact Technologies (LPG and biogas, currently active in Malawi)

Green Impact Technologies (GIT) were founded in 2018 in Malawi and initially focussed on off-grid solar solutions. They expanded into clean cooking in 2019. Their current focus areas: are productive use of electricity (solar fridges, water pumps) and clean cooking. They work with LPG and biogas solutions, with LPG being the priority. They are beneficiaries of the World Bank's solar home system RBF in Malawi and the interview focussed on these experiences rather than their clean cooking operations.

Target market: For LPG it is low-income brackets in urban and peri-urban areas.

Supply chain and distribution: The average LPG-using household uses 8-10kgs of gas per month.

Equipment: 90% of LPG sales are 6kg cylinders. Their stoves are sourced from India and China, at a unit cost of $45 and a retail price of $60.

Current scale and future plans: GIT have deployed four 20 m^3 biogas systems for restaurants and households. They have one operational LPG hub for cylinder exchange from 3 kg up to 19 kg cylinders and a second hub pending approval. They have 5000 LPG customers.

Challenges: GIT struggle to access to working capital to finance their operations. They observed that their current World Bank solar RBF subsidy ($20 per unit) is insufficient to cover their operational costs.

Carbon credits: None.

Mount Meru (LPG, standard retail distribution, currently active in Malawi)

It is unclear how GIT work with LPG. Do they just finance the equipment? @sam do you know anything here?

Mount Meru are a petroleum business that operate in 16 countries across sub-Saharan Africa. They started their Malawian LPG business in 2022 and also sell LPG in Tanzania, Zambia, Zimbabwe and Rwanda.

Target market: Mount Meru target the urban market. 80% of their sales by volume are to domestic users and 20% to institutional and commercial customers.

Supply chain and distribution: Mount Meru import LPG from Dar es Salaam, Tanzania, where they have three different fuel suppliers. They use their own trucks to transport fuel by road into Malawi and currently make three trips per month. They have a central storage

facility of 24 metric tonnes and plan to install more in Southern Malawi. They work with 20+ distributors across the country and replenish gas through full cylinder exchanges (30% of their business by volume) and partial refilling (70% of their business by volume with an average refill of 2-3kg).

Equipment: Mount Meru's cylinders are imported from Kenya. The most popular cylinder size is 13kg (80,000 MWK without gas). They plan to launch 3kg cylinders shortly (anticipated to cost 30,000 MWK without gas). Their stoves sourced from India, Zambia and Zimbabwe and cost 40,000 MWK (one burner), or 58,000 MWK (two burners). They also sell a full cooking set (6kg cylinder + cooktop) for 100,000 MWK. They use Zambian and Tanzanian standards.

Current scale and future plans: Mount Meru currently sell 60 tonnes of gas per month. Last year they grew from 40,000 tonnes to 60,000; in 2024 they expect to sell 70,000 tonnes, with the increase driven by expansion to new regions. They currently have 2500 household connections. Their target is to have 6000 household connections by mid-2025 which they will achieve through the introduction of 3kg cylinder product, which they believe is key to growing the domestic market. They are exploring a number of innovative offerings to support growth such as a scheme to allow customers to pay for equipment in instalments; a cylinder delivery service to penetrate rural areas; and mobile tanker trucks for direct refilling.

Challenges: Mount Meru highlighted a number of regulatory issues in the Malawian market, including the lack of strict regulations on cylinder ownership and filling; the lack of standards for LPG equipment; and lengthy approval processes for licenses which can take several months. They also observed that there is limited awareness of LPG compared to other countries, and as a result they run their own consumer education campaigns consisting of roadshows and cooking events. The high upfront cost for cylinders and accessories makes transitioning to LPG unaffordable for many customers and there are no financing options for them at present. The regulated fuel price makes it challenging to expand to rural areas as the company has to absorb the additional transportation costs. They are lobbying MERA to provide more support for this and to speed up the approval processes for installation infrastructure.

Vitalite (LPG, PAYG, currently active in Malawi)

Vitalite were founded in Zambia in 2019 and initially focussed on PAYG solar home systems. They have expanded into new geographies and technologies. In Malawi they participate in the World Bank's off-grid solar RBF and they are piloting a PAYG LPG project in Lilongwe. This section focusses on the latter.

Target market: Urban households in Lilongwe.

Supply chain and distribution: Vitalite are responsible for all operational elements of the PAYG LPG pilot. They are partnered with LPAYGO, a new B2B company developing PAYG LPG hardware and backend software, and Afrox, who provide gas. LPAYG charge $40 per meter but believe this could reduce to $15-20 with scale. The pilot grant covers the cost of the meter so that it is not passed onto customers and gas is sold at the standard regulated price. If the pilot goes well they see potential to expand to other urban areas.

Equipment: Vitalite sell 6kg and 10kg LPG cylinders with screwtop burners. The meter sits between the cylinder and the burner.

Current scale and future plans: They are planning a pilot that will target 150 households. This has been funded by a USAID grant. So far, Vitalite have proved that the technology works but they have not yet secured the necessary buy-in from MERA and Afrox.

Challenges: A key challenge is fuel supply as there are periods where Malawi runs out of gas. The forex situation in Malawi complicates inventory financing. The lack of consumer awareness and the need for continued public awareness and support for PAYG systems. Vitalite have also experienced technical challenges in integrating the metering technology with existing LPG infrastructure.

Carbon credits: None.

Bboxx (LPG, PAYG, currently not active in Malawi)

Bboxx are a multinational solar home system company who expanded into providing clean cooking solutions in 2019 with a focus on LPG provided through PAYG and non-PAYG models.

Current scale and future plans: Bboxx have LPG projects in Rwanda and DRC. They have also previously piloted in Kenya. They target urban and peri-urban households who cook with charcoal and have more than three household members. Their expansion is currently focussed on Rwanda, where they aim to have more than 50,000 PAYG LPG customers by the end of 2025. This is the number of users required to reach profitability. In DRC they do not offer PAYG and instead provide the option to pay for equipment in instalments.

Supply chain and distribution: Bboxx partner with local LPG marketers to source fuel e.g. Total Energy in Rwanda. They offer both PAYG and upfront purchase options to address high upfront cost of equipment (both models) and the large minimum transaction for fuel when purchasing a cylinder refill (PAYG only).

Equipment: Bboxx have developed their own PAYG smart meter which they also sell to other companies.

Market expansion plans: Bboxx are looking to enter large markets with the potential for scale. This requires strong local partners (e.g. established LPG marketers). RBFs can really help with the unit economics as do the absence of import duties on equipment. They are not currently considering expansion to Malawi and are concerned about market size, low purchasing power and regulated fuel price.

Challenges: The need for user education and awareness in markets with low LPG penetration. Regulated gas prices (e.g. in Malawi) which limits margins and prevents a markup on PAYG gas.

Carbon credits: Bboxx have found that carbon credits are unstrategic as low value for LPG. They recently registered their first LPG project which generates 0.5 credits/customer/year. Therefore it is challenging to cover costs of audits and reporting.

PAYGO Energy (LPG, PAYG, currently active in Malawi)

PAYGO Energy are a Kenya-based PAYG LPG company who were acquired by Sun King in 2022. They are currently expanding operations to Zambia, Tanzania and are also considering Malawi.

Supply chain and distribution: The PAYG device attached to the cylinder and can only be unlocked by registered agents. Under their offering, the upfront cost of a system (cylinder and stove) is reduced to $10. Customers pay for gas via mobile money and in turn receive tokens to unlock gas supply. PAYGO are responsible for household fuel delivery, maintenance and a cylinder exchange service. They also retain ownership of cylinders and devices. Customers pay an increased price per kg fuel cost to cover financing and delivery costs.

Equipment: At the heart of PAYGO's offering is a flow management and control device with a 10% accuracy. They design and manufacture it in-house.

Market expansion plans: PAYGO believe that the Malawian market has potential for 500,000 PAYG LPG households over the next five years. They are yet to understand the geographical spread of customers for distribution network planning.

Challenges: The fixed LPG retail price set by MERA which removed the opportunity to charge a PAYG premium via the gas price. PAYGO's solution would be to itemise separate charges for cylinder lease, PAYGO financing and home delivery. PAYGO also observed that there are logistical challenges with fuel supply as Malawi is landlocked. The current road transport system is unsafe and inefficient but there are potential alternative rail options in development. The prevalence of partial refilling is unsafe and undermines the unique value add of PAYG LPG.

Carbon credits: PAYGO have a carbon credit project for PAYGO LPG in Kenya. There is the potential to expand to Malawi but they need clarity on Article 6.

3.4.2 Electric cooking

ATEC (grid Electric cooking induction stoves, PAYG, not currently active in Malawi)

ATEC are an Australian-based startup that provides households in the Global South with sustainable, affordable and accessible modern cooking products, namely biodigesters and induction stoves. As of 2023 they had sold over 10,000 cookstoves, consisting mostly of PAYG induction stoves in Cambodia and Bangladesh. In November 2024 they announced a $27m Electric cooking project in Malawi supported by the Klik Foundation.

Target market: The project will focus on urban grid-connected areas, specifically Lilongwe and Blantyre. ATEC anticipate that households will save $7-8 on fuel per month by switching from charcoal to electricity.

Supply chain and distribution: The stoves will be sold by the Yellow Project and Self Help Africa, through existing distribution channels.

Equipment: ATEC's stove is manufactured in China with assembly in Malawi. The target retail prices is $10 for a single-burner stove $30 for a double-burner stove, both including a cookware set. They anticipate that the average power consumption will 0.5 to 1 kW per burner per day and the expected usage is 2 kWh per household per day. This assumes that the stove will account for 40-50% of the household's cooking. The total project power draw will therefore be around 150,000 kWh/day. The product lifespan is 7-0 years and the stoves are provided with a two-year warranty. The stoves are IoT-enabled and contain meters allowing ATEC to adjust their draw from the grid.

Current scale and future plans: ATEC plan to distribute 76,000 stoves in 2025.

Challenges: ATEC are trying to secure import tax waivers. They need to unlock $15m USD in financing to launch the project. However, ATEC already have access to short-term bridge finance if the whole package is not secured in time to begin distribution.

Carbon credits: ATEC expect to generate 1 million tonnes of ITMOs by 2030 which will all be sold to the Klik Foundation. This is based off an assumption that each stove will generate 2.54 tonnes per year. The Government of Malawi will receive $3 per tonne and Klik are buying at $27 per tonne. Some of the carbon revenues will be shared with customers: users will receive usage incentive payments that are anticipated to average at $50 each. The majority of benefits will be distributed in the first 3-6 months to encourage adoption, either through mobile money or ESCOM power credits.

BURN Manufacturing (grid Electric cooking induction stoves, PAYG, not currently active in Malawi)

BURN Manufacturing is headquartered in Kenya and is Africa's leading clean cooking companies. They design, manufacture and distribute the continent's best-selling improved biomass, electric, hybrid and liquid fuel cooking appliances. They are also one of the only clean cooking companies to cover the full carbon value chain, from project design and in-house monitoring to credit issuance. They currently sell improved charcoal, improved wood and gas stoves in Malawi. However, this section focusses on their prospective Electric cooking, which are planned but have not yet commenced. BURN expressed optimism about their Malawian market entry, and have experienced significant investment interest and positive engagement with the government.

Target market: BURN have calculated that there are 400,000 people on grid who could be reached through PAYG Electric cooking products. PAYG models require mobile money integration, which has so far limited their expansion plans to urban areas.

Supply chain and distribution: BURN plan to locally assemble their induction stoves in Blantyre, which they intend to distribute under a pay-as-you-go model to enhance affordability.

Equipment: BURN's single-burner induction stove comes with three pieces of cookware. The package costs $140 to make; the typical sales price in other locations is $113, subsidised by RBFs and / or carbon credits. Under the PAYG model the upfront cost to customer is $5, with further payments $1.50/month over 18 months. The maximum power consumption of the eCook stove is 2kW with usual operation at around 1.5kW.

Current scale and future plans: BURN have Letter of Authorisation signed for 350,000 stoves and 3m credits in Malawi. They have a SPV in place that requires an equity investment of $10m to unlock a further $60m in receivables – this money is required to finance the Electric cooking market entry. However, the equity has not been secured. BURN believe that a World Bank RBF would help them to mobilise this. Their plans are to reach 1.5m households in Malawi in the next 18 months, of which 300,000 would be induction stoves. In addition to this,

Challenges: BURN's key challenge is securing the required equity investment for market entry. They anticipate that supply chain issues may arise in Malawi, particularly around availability of raw materials and VAT policies on electric stoves.

Carbon credits: Carbon credits will be core to BURN's Electric cooking operations in Malawi. They are exploring long-term carbon finance with the potential of financing through bonds, and are promoting their 100% dMRV approach as a premium feature of their Electric cooking carbon programme.

UP Energy (ICS and grid Electric cooking EPCs, PAYG, currently active in Malawi)

UP Energy are a Uganda-based carbon developer specialising in cookstove, carbon removal and safe water projects. They started an improved charcoal project in Malawi in 2021 that has distributed 60,000 locally manufactured stoves to date and will run until 2029. They are also developing an electric pressure cooker project that is due to start in 2025. The remainder of this section focusses on the upcoming EPC project.

Target market: Minigrid and grid-connected households in Malawi.

Supply chain and distribution: The EPC project will build upon infrastructure already developed through the ICS project. UP Energy have distribution hubs in the Northern region and the Southern region and setting up production centres to supply efficiently to those locations. They are exploring PAYG mechanisms for EPCs and considering partnerships with cooperatives for financing.

Equipment: UP Energy produce their own stoves, with manufacturing taking place in Uganda under the PowerUP brand. Unsubsidised price of the EPC is $100+ but they are aiming to sell it at $50-60 with a carbon subsidy. UP Energy provide a five-year warranty on their stoves.

Current scale and future plans: UP Energy are currently completing their Malawian EPC market study and plan to pilot 1000 EPCs before full-scale implementation in 2025. They are aiming to distribute 40,000-70,000 units over a five-year period.

Challenges: A key challenge is grid reliability and frequent load shedding in Malawi. Government approval processes can be difficult and the Designated National Authority has limited capacity. UP Energy flagged the need for better consultation between government and sector players. Taxes for Electric cooking are also an important barrier that needs addressing.

Carbon credits: All of UP Energy's projects rely on carbon financing. They mostly sell on the VCM but are also interested in the compliance market. They are currently in discussions with the Klik Foundation and exploring other Article 6 buyers.

Kachione (off-grid EPCs, currently active in Malawi)

Kachione were founded in 2015 with an initial focus on solar lighting systems in Malawi. They started working on electric cooking in 2020 and are now focused on providing affordable solar-powered cooking solutions for rural Malawi. They are currently self-funded with some philanthropic support ($1.5m invested) and have been supported by MECS to pilot solar Electric cooking in rural areas.

Target market: Kachione target rural areas. Their sales strategy focuses on post-harvest season when farmers have the most cash.

Supply chain and distribution: Kachione partner with local women's groups to set up solar shops in villages. They provide tech support, order fulfilment and pay rent for the shop. The women's groups earn commissions on sales by selling products with a 50% markup.

Equipment: The Electric cooking offering consists of a solar array and an EPC. The solar component consists of a 700W panel that delivers around 1kWh/day. The landed procurement cost is around $160 per system and the sales price is 250,000 MWK (~$230). They are currently developing a battery technology consisting of a high-throughput custom-designed lithium titanate unit with a 10-20 year lifespan and integrated data logging. The current cost is $100 for 100Wh but they believe this can be halved. The systems are assembled in Malawi, and the cells are sourced from China. The solar panels expected to last 20+ years and the cookers 2-3 years on average. There is a local repair system in place for broken units.

On sunny days, users can cook two thirds of their food with the system and on cloudy days this figure drops to one third. There are considerable time savings to users of 30 mins/day in wood collection and 1-1.5 hours in cooking time. They actively promote daytime cooking to minimise battery needs.

Current scale and future plans: Kachione currently have a few hundred systems deployed and are selling 20 systems per week. They hope to distribute 1000 systems by mid-2025. Their broader goal is to have 2.5m households using Kachione technology by 2030, which will likely require partnerships with other organisations. They plan to raise money through clean impact bonds to help scale financing and distribution.

Challenges: Troubles with forex access make it difficult to drive economies of scale and drive up costs. Unofficial exchange rates also contribute to this. Another barrier lies in cultural adaptation, because shifting cooking practices to daytime requires community engagement. Lack of familiarity with the technology presents another challenge and Kachione run cooking demonstrations in shops to help adoption.

Kachione's system has high upfront costs, and trying to address this with PAYG financing doubles the costs, making the solution unattractive for the target customer base. Targeting rural markets also present unique challenges as they are often working with non-cash economy households.

Carbon credits: None.

MEGA Electric Cooking Project (minigrid hot plates, payment in instalments, currently active in Malawi)

MEGA runs a 220kW micro-hydro minigrid in the Mulanje Mountain forest reserve. MEGA is a social enterprise and a licensed Independent Power Producer in Malawi. They are interested in promoting Electric cooking on their minigrid to generate revenue.

Target market: Households connected to the MEGA minigrid.

Equipment: Participants in the initial pilot (n=20) were provided with a locally sourced single-plate hotplate, a heat retention device and two cooking pots. The total cost of this was 120,000 MWK, which was subsidised to 70,000 Kwacha and paid in five installments. Participants in the pilot extension (n=100) were provided with double-plated hot plates sourced from Build Africa. Smart meters were installed to accurately measure cooking electricity consumption.

Current scale and future plans: MEGA's initial pilots distributed stoves to 120 households. Interestingly, they found that 20% of customers had already purchased Electric cooking appliances before the pilot. They are targeting 500 households with electric cooking by November 2024 with support from US-Africa Women's Fund. They are also planning a 6.5MW expansion of the minigrid with a 18-month implementation timeline. Ecooking is central to driving profitability of the minigrids and they are eventually targeting 10,000 Electric cooking customers, whose needs will be met by 2.5MW of the supply.

Challenges: MEGA's primary challenge is profitability as the minigrid is still not breaking even and relies on external support. It is hydro powered and current water levels are affecting generation; they plan to address this through the construction of a reservoir to ensure consistent supply. Over 15% of households with the double-plated cookers experienced technical issues, highlighting the need for repair and maintenance services. Fuel stacking was prevalent and limited revenues, with only 25% of a household's cooking being performed on the Electric cooking stoves on average.

Carbon credits: None.

Bidhaa Sasa (Electric cooking EPCs, ICS and LPG, payment in instalments, not currently active in Malawi)

Bidhaa Sasa is a last-mile distribution company specialising in serving rural women and smallholder farmers with products that improve their lives. They have been operating for nine years and are product agnostic but focus on clean cooking. They provide products with consumer financing and payment plans of 3-9 months. They use community leaders for customer acquisition, thus tapping into local knowledge to help find reliable customers. The leaders are rewarded with gifts, cash, training and social recognition. The model relies heavily on social capital in rural communities for marketing and credit risk management.

Current scale and future plans: Bidhaa Sasa currently operate in Kenya and Uganda. The Kenyan focus is currently Electric cooking (EPCs) whereas in Uganda they primarily

distribute improved charcoal stoves due to the lower electrification rate. They have sold around 50,000 charcoal stoves in Kenya and Uganda.

Supply chain and distribution: Bidhaa Sasa do not manufacture any products themselves and instead import them from reliable suppliers. They handle distribution logistics, consumer education, financing, delivery to the customer and installation.

Equipment: The typical price point $50 with monthly payments of $6-10 and a down payment usually equal to one monthly payment. They source their improved charcoal stoves from Biolite and did not specify their EPC supplier. They use to sell LPG stoves and accessories in Kenya but have since discontinued that product line (6kg cylinder + double burner for $70).

Market expansion plans: None at present. They would consider Malawi if there was sufficient multi-year funding support.

Challenges: Bidhaa Sasa's model incurs a long cash flow cycle taking 6-9 months from inventory purchase to customer repayment. There is a lack of subsidies or finance for LPG initiatives despite customer demand. It is difficult to ensure LPG fuel supply in rural areas. Donors are shifting away from supporting biomass cookstoves.

Carbon credits: Bidhaa Sasa are in the process of registering their first carbon programme, which is EPCs in rural Kenya.

3.4.3 Biogas

EcoGen (biogas, payment in instalments, currently active in Malawi)

EcoGen are a Malawian company that provide biogas systems in Malawi. They were founded in 2018 and are the

Target market: EcoGen supply both household and institutional systems, with a focus on household-level installations for farmers. They currently operate in Malawi's Southern region. There are four target domestic segments in Malawi: 200,000 farmers who have cows; >1m farmers with pigs; 41,000 dairy farmers; and 13,000 farmers in the Southern region.

Supply chain and distribution: EcoGen source their biogas systems from an external partner, Sistema.bio. They are partnered with the Malawi Milk Producers Association whose extensive networks help them to reach their target household market in rural areas. They have similar partnerships with the government's livestock department, Agrico (an irrigation provider), Good Neighbours (a community-based NGO) and the World Food Programme (WFP). They work with the WFP on school installations. Under their model, EcoGen are ultimately responsible for installing and maintaining systems. They also collaborate with microfinance institutions to provide finance to their customers. Their loan programme has a maximum 2-year repayment period and 36% interest rate. Through EcoGen's programme, farmers can also generate income from selling biofertilizer averaging around 70,000 MWK ($30-40) per month.

Equipment: The biodigesters and associated equipment are sourced from Sistema.bio, who manufacture their technology in India, at a cost of $200-400 depending on the

system size. They are sold to farmers at $800. However, this figure is reduced to $150 under their carbon credit programme, which covers installation and after-sales service. Systems are provided with a 10-year warranty.

Current scale and future plans: As of 2024 EcoGen has installed 1001 systems. They hope to reach 20,000 by 2026 and plan to open a new office in the Northern region in November 2024.

Challenges: Flexible financing systems are essential to render systems affordable for farmers but are also expensive to provide in Malawi's economic climate. Consumer loans are currently provided at 33% interest. EcoGen require support in a number of areas including setting up operations; expanding geographical reach; training staff; improving standard operations processes; dealing with taxation issues; financial management.

Carbon credits: Core to EcoGen's operations is their Article 6 carbon credit programme with the Klik Foundation, which is used to considerably subsidise units. They are implementing a dMRV system to track usage and efficiency.

Home Biogas (biogas, payment in instalments, not currently active in Malawi)

Home Biogas is a biogas company based in Israel who produce and sell anaerobic digesters.

Current scale and future plans: Home Biogas have sold over 40,000 biogas systems globally and currently operate in Kenya, India, El Salvador and Israel. They target farmers with 2+ cows or 10+ pigs. They mostly focus on domestic systems but do also have larger institutional products, for example they are currently providing biogas systems to over 100 primary schools in El Salvador.

Supply chain and distribution: Home Biogas manufacture their own modular units. They partner with local microfinance institutions for customer loans.

Equipment: Home Biogas systems consist of an above-ground system that looks like an inflatable bag and takes 2-3 hours to install. A typical domestic system generates five hours' worth of cooking gas and 150L biofertilizer each day. In Kenya, the full price is $750 including installation and warranty. However they currently use carbon credits to subsidise this to $380, which customers pay in three instalments.

Market expansion plans: Market entry considerations for Home Biogas are the number of farmers producing sufficient organic matter, the country's carbon framework and opportunities for government partnership. They are not interested in expanding to Malawi. They believe there are not enough dairy farmers and that the market is already dominated by EcoGen and their carbon project.

Challenges: Home Biogas's main challenge is the gap between upfront costs and future carbon revenues. For example, in Rwanda they are currently seeking financing for credits that will be sold in 2-3 years. Need for bridging solutions while carbon markets stabilise. Clean cooking RBFs don't work well for biogas due to higher system cost. Farmer reluctance to adopt new solution and poor loan availability.

Carbon credits: Carbon credits are used to subsidise system costs and generate 9-10 credits per system per year. This is much higher than other cookstoves because biogas technologies use a different methodology that accounts for both methane removal and avoided deforestation.

3.4.4 Ethanol

KOKO Networks (ethanol, retail distribution, not currently active in Malawi

KOKO Networks are the world's largest ethanol cooking company and are headquartered in Nairobi, Kenya. They operate bioethanol clean cooking utilities in Kenya and Rwanda via a novel business model using franchised kiosks to dispense liquid fuel in small amounts.

Current scale and future plans: KOKO Networks currently serve 1.3m households in Rwanda and Kenya. They focus on urban areas.

Supply chain and distribution: KOKO design and produce all stoves and hardware in-house. Manufacturing takes place in India. Customers buy fuel from KOKO Points, which are franchised kiosks placed in local businesses, and dispense liquid fuel into 2.3L canisters that are used to refuel the ethanol stove in customers' homes. Fuel is sourced both locally and internationally and is internally distributed by KOKO.

Equipment: The cookstove retail price $15 (two burner subsidised by carbon credits). Fuel cost $0.60 per litre.

Market expansion plans: KOKO's market entry considerations include government consultations, supplier agreements, carbon policy assessment and reviewing technical standards. They have conducted internal market research for Malawi. This consisted of a baseline survey of 1000 households and 200 fuel vendors. They found that charcoal prices high enough for business model validity and that there is potential for regional production and export. However, they would support for legal expenses to negotiate the investment aand offtaker agreements with the government. They would also need a arge equity investment to finance additional local production, which looks unlikely.

Challenges: The key challenge for Malawi is on the fuel supply side as there is a need for investment in large-scale bioethanol plants in order to achieve economies of scale.

Carbon credits: KOKO rely on carbon credits to subsidise their costs. They currently sell on the VCM and are considering entering the compliance market.

3.4.5 Processed biomass

C-Quest Capital / Ener-G-Africa (pellets, retail distribution, currently active in Malawi)

C-Quest Capital (CQC) have been developing and implementing carbon reduction and clean energy projects since 2008. As of 2024, they have distributed close to eight million cookstoves across sub-Saharan Africa, Southeast Asia and Central America. However, they have also been mired in recent scandal, with their ex-CEO facing criminal charges

for fraudulent carbon credit claims, and all of their credits are consequently currently frozen on the VCM.

Ener-G-Africa (EGA) was formerly CQC's manufacturing and implementation subsidiary in Malawi. EGA has since split from CQC. EGA's focus has traditionally been on addressing the rural market with tier 2 improved woodstoves, but they are now also diversifying into tier 4 pellet stoves with support from the government. This section focusses on EGA's pellet offering.

Target market: Peri-urban and urban Lilongwe and Blantyre.

Supply chain and distribution: EGA's pellet offering is completely vertically integrated. The stoves are manufactured by EGA in South Africa and imported to Malawi. They plan to open their own pellet factory in Lilongwe which will use pellet feedstock from Mozambique, Malawi and South Africa that comes from their own NBS carbon projects in these countries. The pellet plant will cost ~$200,000, will have a modular design for replicating the plant and a capacity of 150-250 tonnes per month. In the meantime, they source pellets from Pyxus and Raiply, and are considering a new partnership with Illovo Sugar.

Equipment: Pellet stoves are tier 4 (40-45% efficiency) gasifiers that include a power pack and a solar panel to run the fan. They are certified under ISO standards. Manufacturing costs are around $50 and stoves are made in South Africa. Selling price is $70 and subsidised price under the carbon programme is $35. Expect manufacturing costs to decrease with scale. Customers pay 30% of the total cost upfront and the remaining balance is spread over a three month period.

Current scale and future plans: At present EGA serve five thousand households in Lilongwe with pellets and distribute 20-25 tonnes of pellets per month. They are targeting 15% penetration in urban and peri-urban Lilongwe and Blantyre by 2034 corresponding to 120,000-180,000 households.

Challenges: EGA already have existing infrastructure in Malawi through their improved cookstove programme but they need capital to scale up on their operations and transition to more advanced technologies. They have

Carbon credits: All of CQC's projects are financed through carbon credits. Their models use a starting price for credits of $15/t in 2025, expected to increase to $25/t by 2036 using conservative methodologies. They explained that Article 6 (A6) transactions are starting at $25-28/t but not all of the money goes to the project developer. CQC's voluntary market buyers include Shell and BP. They noted a significant market in Singapore due to localised carbon tax laws. They are transitioning to dMRV projects and processes to meet future carbon market standards and streamline operations This includes using metered methodologies.

<u>Emerging Cooking Solutions / SupaMoto (pellets)(pellets, home delivery, currently active in Malawi)</u>

Emerging Cooking Solutions was founded in 2012 with the aim of replacing charcoal cooking with biomass pellets. Their main country of operations is Zambia and expanded to the Malawian market in 2022. They trade under the brand name SupaMoto.

Target market: SupaMoto target urban households in Blantyre and Zomba who cook with charcoal.

Supply chain and distribution: SupaMoto employ a utility model with stoves loaned to customers for as long as they buy SupaMoto pellets. There is no upfront cost for the customer, instead SupaMoto rely on pellet purchases to cover costs. Fuel is either delivered directly to households with electric three-wheelers or purchased from local neighbourhood agents.

SupaMoto source their pellets from Ripley and Pixus and sell them for 11,000 MWK for a 30kg bag at a 50% gross margin. They believe that their current supply chain can support up to 50,000 households given that in their experience half a tonne of pellets can support cooking for three families per year (with fuel stacking). They estimate that their customers save 50% on fuel expenditure compared to charcoal.

Equipment: SupaMoto use tier 4 Mimi Moto stoves, which are internet-connected with dMRV capabilities, and cost $100 per unit (landed cost with taxes). The usage data is recorded on blockchain.

Current scale and future plans: SupaMoto current serve 1500 households in Malawi. They are seeking pre-financing based on carbon credit purchase agreements to fund expansion and believe there is potential for 500,000 to 1,000,000 households to cook with pellet gasification stoves in Malawi.

Challenges: The current carbon market volatility and buyer uncertainty. Access to biomass supply for pellet production in Malawi. Suggested this could be alleviated by stimulation of additional pellet production and that the World Bank could provide support for the initial capital expenditure to set up a pellet factory. They estimated this would cost 300,000 – 500,000 USD and emphasised the need to simultaneously address electricity supply issues for the factory to function properly.

Carbon credits: SupaMoto currently have no carbon revenue but it is a core part of their strategy. They are waiting for A6 implementation to progress their project. They believe there is the potential for at least 2 credits/stove/year.

Zipolopolo (pellets, retail distribution, currently active in Malawi)

Zipolopolo (known as Zipo) are a Malawian company that have been distributing pellets and pellet stoves since 2022.

Target market: Zipo target charcoal users in urban and peri-urban markets.

Supply chain and distribution: Zipo source pellets from suppliers like Raiply and Pyxus. Zipo have prepaid for pellet orders in the past due to the high demand in Malawi. Zipo sell cookstoves direct to consumer, with an quoted 100% gross profit per stove.

Equipment: Zipo manufacture their own stoves in country, after founder Marcel acquired a small-size manufacturing factory 2-3 years. Zipo stoves not suitable for long cooking times (2-3 hours) – ideal for fast day-to-day cooking.

Current scale and future plans: Zipo currently serve 3,470 households and sell 360 tonnes of pellets per year. Their goal is to have 2.5m households using Zipo stoves by

2030. They have also been running a pilot in Dzaleka refugee camp with support from GIZ. This has disbursed 1368 stoves and is currently being evaluated *[GIZ]*.

Challenges: Zipo struggle with access to capital in Malawi (40% interest rates, 100% security required). They are currently self-funded as a result. Maintaining a consistent fuel supply is the most complex part of their operations and they experience significant challenges with suppliers in terms of quality, consistency and administration.

Carbon credits: They are exploring options with South Pole, Klik Foundation and the Modern Cooking for Healthy Forests project but believe that current carbon credit prices ($3/tonne) are too low to be effective.

Mimi Moto (tier 4 pellet stove manufacturer)

Mimi Moto develop and manufacture energy-efficient clean cookstoves from their headquarters in the Netherlands. Their flagship product is a tier 4 pellet stove which they sell on a B2B basis to many of the the top pellet companies in sub-Saharan Africa: EcoSafi (Kenya), Biomassters (Rwanda), Supamoto (Zambia and Malawi).

Current scale and future plans: Mimi Moto's partners have sold 75,000 cookstoves across a range of countries.

Supply chain and distribution: Mimi Moto use a B2B approach and work with distributors in various countries. They typically require container-sized order (1400 units) although smaller orders (140 units) are possible for new distributors. The distributors often want exclusivity agreements in their markets.

Equipment: The stoves are manufactured in China and priced at $50-55. This includes an integrated chip to track usage for carbon credit verification. They have a new cheaper product launched in early 2024 which is designed for fixed kitchens and priced at $33-40.

Market expansion plans: Mimi Moto to partnerships with pellet companies in Malawi, particularly those with existing pellet distribution networks. Note that one their distributors, SupaMoto, has entered the Malawian market.

Challenges: Mimi Moto noted that the pre-financing of inventory is a significant challenge for their distributors. Import duties can affect pricing and Mimi Moto are open to partial assembly solutions.

Carbon credits: The distributors hold the rights to the carbon credits. Stoves are dMRV enabled to support high

3.5 Inventory of Relevant Modern Energy Cooking Initiatives

Global Energy Alliance for People and Planet (GEAPP)

GEAPP is an international alliance that aims to tackle energy poverty and the climate crisis by developing and scaling green energy solutions in developing and emerging

economies. It is part of the Global Electric Clean Cooking Coalition (GeCCo) and is supporting the Malawian government with Electric cooking and energy access technical assistance.

Current and future work in Malawi: GEAPP is supporting Malawi's Integrated Resource Plan, which includes updating the demand forecast and the generation expansion master plan. This projects future energy demand and generates different scenarios to accommodate possible growth. They are also aiming to improve grid resilience through battery energy storage systems. Their recently completed Generation Master Plan will guide Malawi's power sector expansion and infrastructure development over the next 20 years, with updates planned to take place on a five year basis.

Potential for collaboration: GEAPP emphasized that efforts from the World Bank and other stakeholders should be aligned with Malawi's Integrated Resource Plan. GEAPP believe that by focusing on shared goals such as improving grid resilience and expanding access to clean cooking, programs from the World Bank and GEAPP can complement each other, particularly in capacity building for appliance financing and utility infrastructure upgrades.

Energising Development (EnDev)

EnDev is an impact-oriented global programme funded by Germany, the Netherlands, Norway, Sweden, UK and Switzerland, with additional co-funding from Ireland and the European Union.

Current and future work in Malawi: EnDev have been working in Malawi since 2012 with a focus on rural areas. Their main cooking product is the Chitetezo Mbaula, an improved firewood stove that can also use agricultural residue. They work with two implementers: Self Help Africa in the Southern region and MAEVE Project in the Central and Northern regions. Through this programme they have trained over 360 stove production groups across the country. They also have an institutional cooking project that disseminates improved firewood stoves and are considering moving towards higher tier solutions. They coordinate electric cooking activities in Malawi.

EnDev are moving their domestic stove focus towards higher tier solutions too. In 2024 they piloted the Zipolopolo pellet stove in Dzaleka refugee camp and disbursed 1368 stoves. They are also planning an RBF for pellet stoves and electric cooking. There will be four categories with a budget of ~200,000 euros each: local pellet stoves, imported pellet stoves, electric pressure cookers, induction cookers. The window is expected to run from November 2024 to May 2025. Companies will be free to choose their target locations and there will be a fixed incentive per stove sold in each category. They regard the RBF as a pilot that could be scaled up if it is successful. However, EnDev warned that they think there is limited market absorption ability for higher tier solutions.

Potential for collaboration: No clear opportunities for collaboration were identified. The timing of the EnDev RBF will not match that of the ASCENT programme. They raised a concern about oversubsidisation and additionality risks if there are multiple clean cooking RBFs operating in parallel in the small Malawian clean cooking market.

Klik Foundation

The Klik Foundation is the carbon offsetting grouping of Swiss motor fuel importers, and are mandated under the Swiss CO_2 Act to offset parts of the carbon emissions generated by the use of motor fuels in Switzerland.

Current and future work in Malawi: Klik signed a bilateral agreement with the Malawian government in 2022 and are developing a number of clean cooking projects: biogas with EGA, induction Electric cooking with ATEC, pellets with Zipolopolo, and a high-efficiency wood stove project with a local distributor, the Maeve project. They are aiming to procure 3-5 million tons of CO2 from Malawi across all topics, not just cookstoves. They are constitutionally unable support any fossil fuel projects including LPG.

Klik projects start with the submission of a Mitigation Activity Idea Note. If this is approved then project developers will receive a letter of intent from the governments and Klik will issue a letter of support. The technical and financial proposals are then developed and submitted, with Klik providing up to $150,000 of support for developing the proposals. The authorisation process ideally takes under a year but often requires longer due to delays in the authorisation process. The price per tonne depends on the project developer's needs but tends to be significantly higher than on the VCM. In 2023, Klik paid $28/tonne on average.

Klik are interested in Electric cooking tied to grid extension projects. They see scope for community-based clean cooking solutions. They are interested in capacity building initiatives with the Swiss Ministry of Environment.

Potential for collaboration: Klik could be interested in working with the World Bank on grid extension Electric cooking projects. They are open to exploring larger projects and government collaborations.

Modern Cooking Facility for Africa (MCFA)

The MCFA is the largest clean cooking RBF in SSA. It is funded by Nordic countries and the EU and is managed by NEFCO. It aims to support the scale-up of clean cooking solutions (pellets, Electric cooking, LPG, biogas, ethanol) in selected African countries. They introduced Malawi as a partner country in the second round (MCFA2), which ran in 2024 and is currently at the contracting stage. There are no plans for future rounds at present.

The MCFA regards carbon credits as a complementary financing source. They look for high-quality credits using the Gold Standard metered methodology and assess credit integrity in the due diligence phase. They monitor carbon project development for their grantees and adjust disbursement targets if carbon revenues become excessive. They also provide technical assistance for carbon project development. Other TA needs are also identified during the due diligence. Their focus areas are business development, operations, ESG compliance, gender inclusion, credit management and market analysis. The MCFA maintain the right to terminate a project if there is a 30% underperformance on targets.

The MCFA team emphasised the importance of fuel supply assessments to programme planning. They did not do any and have suffered badly as a result; they awarded three

Electric cooking projects in Zambia which have been grounded due to excessive load shedding. They have also faced challenges with technology supply chains, connectivity issues and consumer confidence. They believe that a weakness of their programme is their lack of local footprint and institutional presence in project countries.

Current and future work in Malawi: MCFA2 received many applications from Malawi, but none were shortlisted. This was likely because the evaluation methodology was biased so that earlier-stage projects and poorer countries with lower ability to pay scored fewer points. Malawian applications were therefore likely penalised because of the market immaturity.

Potential for collaboration: None as there are no plans for future rounds of the MCFA and no projects in Malawi.

Modern Cooking for Healthy Forests (MCHF)

The Modern Cooking for Healthy Forests (MCHF) program is a five-year initiative funded by USAID and UKAID FCDO, which began in 2019 and as scheduled originally to end in September 2024. MCHF aims to reduce unsustainable wood fuel use in Malawi by promoting more sustainable energy options and forest management practices. It is funded by both the US and UK governments and has a particular focus on reducing charcoal use in urban settings. Tetra Tech is the private company that was selected by USAID to manage and implement the program.

Current and future work in Malawi: MCHF is implementing a comprehensive five-year program (2019-2024) to address Malawi's forest degradation and unsustainable woodfuel demand. Their work spans multiple urban centers (Lilongwe, Blantyre, Mzuzu, and Zomba) where they're supporting market development for alternative cooking solutions, including successful efforts to secure tax incentives for LPG appliances and legal charcoal. In forest management, MCHF has expanded the National Forest Inventory to smaller forests following UNFCCC recommendations and is establishing a cloud-based data management system through the National Monitoring Unit. The program has achieved notable success in licensing sustainable charcoal producers, with 10 licensed producers now operating, and has supported over 700 hectares of land under improved natural resource management. Their work in Q1 2023 particularly focused on strengthening regulatory frameworks, including securing a grace period for legal charcoal producers to meet new standards and developing a standardized national charcoal valuation system.

Potential for collaboration: MCHF's market-based approach and focus on regulatory reform creates natural partnership opportunities across the development sector.

Their work with carbon finance, demonstrated by their support of Wildlife Action Group in developing a jurisdictional REDD+ project, shows potential for scaling clean cooking and forest restoration initiatives through innovative financing. In partnership with SHA, MCHF is planning to set up a carbon entity in 2025 to help clean cooking SMEs access carbon finance. These plans have not yet been formalised. The program's established relationships with both government institutions (Department of Forestry, Ministry of Energy) and private sector partners position it well for collaborative efforts in policy reform and market development.

Specific collaboration opportunities exist in working with MCHF on their clean cooking demonstration and awareness programs, data sharing for CCTs, policy advocacy, and enhancing their forest monitoring systems through technical partnerships.

NORAD

NORAD are Norway's foreign aid agency. They fund a wide range of development projects in Malawi.

Current and future work in Malawi: NORAD contribute financially to the MCFA and drove the decision to add Malawi to the second call for proposals. They are involved in the EnDev programme but are focussed on environmental aspects as they do not have much technical expertise on clean cooking.

Potential for collaboration: There is limited scope for collaboration with NORAD.

Off-Grid Solar Fund

The Off-Grid Solar Fund (OGSF) is a 100% World Bank-funded off-grid solar RBF in Malawi with a size of $20m ($14m loan, $6m grant as RBF end-user subsidy). Loan agreements are tailored to each company's needs. The grant component is as end-user subsidy intended to bridge affordability gap for rural customers. Carbon finance ownership is retained by the Ministry of Energy for future applications. The fund is locally managed by IDCL (Infrastructure Development Company Limited).

Current and future work in Malawi: The OGSF is part of the Malawi Electricity Access Project and started in 2019. As of September 2024, the fund has achieved 95% of its target of 200,000 households by June 2025, with 189,000 households electrified by nine off-grid companies. Companies submit monthly sales reports which are verified by independent agents engaged by the Ministry of Energy. The Ministry aim to verify 15% of installations: 10% through phone, 5% through field visits. Any counting discrepancies result in deductions from grant claims. The fund team has regular meetings with companies to monitor and support their financial reporting and collections.

The Ministry of Energy has been developing a remote monitoring data platform called "Prospect" to support the fund. Challenges encountered with the programme include limited rural communications and access, especially during rainy season; ensuring that systems are not installed in households that are already grid-connected; and the need for capacity building for local companies who are not used to structured project management.

Potential for collaboration: There could be administrative synergies if the OGSF is extended.

OPEC Fund for International Development

The OPEC Fund for International Development (known as the OFID) is a multilateral development finance institution established in 1976 by OPEC member countries and dedicated to delivering socio-economic impact to low- and middle-income countries. They have an ongoing clean cooking pilot in Madagascar and are commencing more work in this sector.

Current work in Malawi: The OFID received an official funding request from the Malawian government, which includes a clean cooking initiative. The original request was for $50m but the disbursement is likely to be closer to $30-40m because of exposure limits. The cooking component ($14m) would be focussed on institutional cooking (schools, hospitals, prisons) and aims to target 128 institutions. There is no specific fuel or technology focus. Implementation will be phased starting with smaller projects to test a range of approaches and then scaling up the successful ones. The project should be approved in early 2025 and will have a seven-year implementation period.

The OFID's typical financing terms are a 1% interest rate over a 20-year term with a 5-year grace period. They are considering a combination of loan and grant in the Malawian case with the grant comprising 5-10% of the loan amount. They are unsure how they will treat carbon finance in their programmes.

Potential for collaboration: OPEC are open to parallel financing with the World Bank and see potential for LPG supply chain development synergies with Saudi involvement. They have cofinanced with the World Bank on previous projects.

Self Help Africa (SHA)

Self Help Africa (SHA)

Current and future work in Malawi: SHA operates multiple programs across Malawi, with a particular focus on agricultural communities where up to 85% of the population depends on farming. Their flagship initiative is developing a Coordinating Management Entity (CME) program under the Malawi Clean Household Fund, which is setting up a Program of Activities (POA) for carbon credits in the clean cooking sector. SHA's work spans multiple districts including Dedza, Balaka, Zomba, and Thyolo, where they implement projects ranging from clean cooking solutions to women's entrepreneurship and climate resilience. Notable current projects include the Rural Women Entrepreneurs program empowering female entrepreneurs through digital tools, the SPEAR project focusing on food security for 19,878 households, and emergency response work following Cyclone Freddy. In the carbon credit space, SHA has engaged 17 companies in their initial program, with 8 continuing through the process and two reaching project validation stage.

Potential for collaboration: SHA's established presence in rural communities and with clean cooking businesses creates several strategic partnership opportunities. Their understanding of local implementation challenges positions them well to support smaller companies in navigating carbon credit processes. Specific collaboration opportunities exist in providing technical assistance for carbon credit verification and sales, developing revolving fund mechanisms for clean cooking enterprises, and integrating clean cooking initiatives with their existing agricultural and climate resilience programs.

Data sharing between organizations could enhance market understanding and program effectiveness, while coordinated education and awareness campaigns could maximize impact and reduce duplication of efforts.

There is particular potential for collaboration in helping SMEs access carbon finance, leveraging SHA's experience in supporting local companies through the complex monitoring and verification requirements. MCHF and SHA are working together to help SMEs in the space access carbon finance in 2025. SHA is leading the initiative.

3.6 Summary of Clean Cooking Solutions in the Malawian Market

Fuel and business model, current providers in the Malawian market, potential future proviers in the Malawian market, challenges, opportunities

Table 36. Summary of Clean Cooking Solutions in the Malawian Market.

Technology + business model	Providers	Potential for the World Bank RBF
LPG + standard retail model	**Current**: AFROX, Delta, IOCL, Falcon, Mt. Meru, Yogas and Gasco are the main importers, plus hundreds of distributors.	**Medium** – LPG usage is growing quickly and cooking with LPG can be cheaper than cooking with charcoal. Adoption could be widened by addressing affordability barriers, which an RBF can assist with. However, there are ongoing challenges with the weak regulatory market, and PAYG may be particularly difficult to implement because of the regulated fuel price. LPG is an imported fuel and Malawi's ongoing forex crisis means it could be risky to increase reliance on it.
LPG + PAYG	**Current**: Vitalite (pilot only) **Potential**: PAYGO Energy	
Electric cooking grid + PAYG	**Current**: UP Energy (EPCs). BURN manufacturing (induction). ATEC (induction).	**Low** – Klik have already committed to large projects with ATEC and BURN which will use up most of the estimated existing grid capacity.
Electric cooking off-grid + PAYG	**Current**: Kachione (solar EPCs). MEGA project (minigrids hotplates).	**High** – there are a couple of viable players in the market that could benefit from investment. Off-grid settings do not suffer from the same generation risks as on-grid. However, there are few minigrids in Malawi, and stand-alone off-grid solutions are extremely expensive. This means the potential market size is small.

Technology + business model	Providers	Potential for the World Bank RBF
Biogas + payment in instalments	**Current**: EGA	**Medium** – Klik already have an ambitious biogas project which will cover much of Malawi's biogas capacity. However, there could be room to bring new players into the market.
Ethanol + any model	**Current**: None **Potential**: KOKO Networks	**Low** – due to the very limited fuel supply in Malawi which will take more than five years to develop.
Pellets + door-to-door distribution model	**Current**: Supamoto	**Medium** – there is an early but competitive pellet market emerging. Pellets are affordable (can undercut the costs of cooking with charcoal), sustainable and can be locally produced. However, investment is needed to increase pellet manufacturing capacity, and it is unclear what the market potential is due to uncertainty of feedstock availability.
Pellets + retail model	**Current**: EGA, Zipolopolo	

Supply Side Analysis– Program Key Recommendations

- Focus initial LPG distribution in urban areas where it presents the most viable immediate opportunity to scale clean cooking in Malawi, as evidenced by 77% growth in 2023
- LPG forex risk creates supply disruptions during currency volatility
- Support establishment of quality standards for all clean cooking technologies, particularly for LPG equipment and electric cooking devices to counter low-quality imports and encourage large players to enter the market – e.g. Oryx Energies
- Target areas with confirmed grid stability for electric cooking, prioritizing areas like Monkeybay where headroom exists over constrained substations
- Align mini-grid design standards with national grid requirements to ensure compatibility and reliability for electric cooking
- Pellet solutions are free from forex constraints and could support rural economies but there are significant supply constraints. Companies will likely need to invest in pellet production facilities in order to meet demand.

TA Required

- LPG equipment and safety standards development
- Provide support to clean cooking SMEs for growth, cookstove standards, financing and distribution to help scale the local market

4 Policy and Regulatory Environment Assessment

This chapter of the report assesses the clean cooking policy and regulatory environment in Malawi. Carbon credits are playing an increasingly important role in financing clean cooking transitions, so the chapter starts with an overview of how carbon finance works, the Malawian carbon market, and developments from COP29.

The report subsequently reviews relevant policies and regulations for clean cooking, energy access and carbon, before considering other relevant aspects of the market, namely quality assurance, local capacity and electronic waste processes.

It then reviews lessons learned from previous programmes that are relevant to the World Bank intervention and finishes by suggesting and evaluating ways of strengthening Malawi's clean cooking enabling environment.

4.1 Carbon Finance in the Cookstove Sector

Carbon financing is a mechanism by which projects can mitigate climate change by preventing climate-warming pollutants from entering the atmosphere or by removing pollutants that have already been emitted. One carbon credit represents one metric ton (tCO2e) of carbon dioxide emissions. Companies or individuals can offset their climate impact by purchasing carbon credits from accredited projects. One of the main carbon finance project types is cookstoves.

In order to issue carbon credits, projects must certify their project activities against a carbon accounting methodology, which is maintained by private standards bodies (typically, non-profits). Once a project is approved by an external auditor, it becomes registered on a public registry that keeps track of the carbon credits issuances linked to that project. When an entity (typically, a company) wishes to offset its carbon emissions, the carbon credits are 'retired' from a registry, meaning that a credit is taken out of circulation for a fee, and cannot be counted for another reduced or removed ton of CO_2.

Carbon finance is well-established in Malawi. The first projects appeared in 2008 and the majority are still active (Figure 1). There has been a renewed interest in carbon finance in the last 6 years, with 95 projects (63% of the total) having begun operations since 2018. Most projects (82%) fall into the Household Devices category, which includes clean cookstoves and water purifiers, and most use the Gold Standard registry to certify their emissions reductions activities (AlliedOffsets Premium Dashboard, 2024).

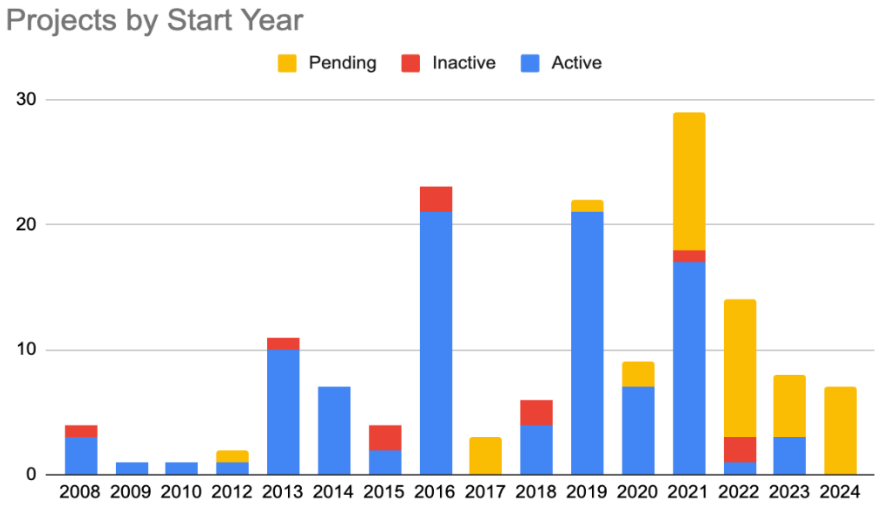


Figure : Carbon projects in Malawi by start year and current status

There are a number of challenges with cookstove carbon credits, which stem from the way that the methodologies measure a project's impact against a hypothetical scenario in which the project did not take place. It is therefore difficult to prove with certainty that the project's activity has actually *reduced* carbon emissions from entering the atmosphere. In order to calculate the carbon impact, developers must plug estimates into an emissions reduction calculation. This may lead to a lack of precision, compounded by reliance on default inputs to reduce the burden of measurement for project developers.

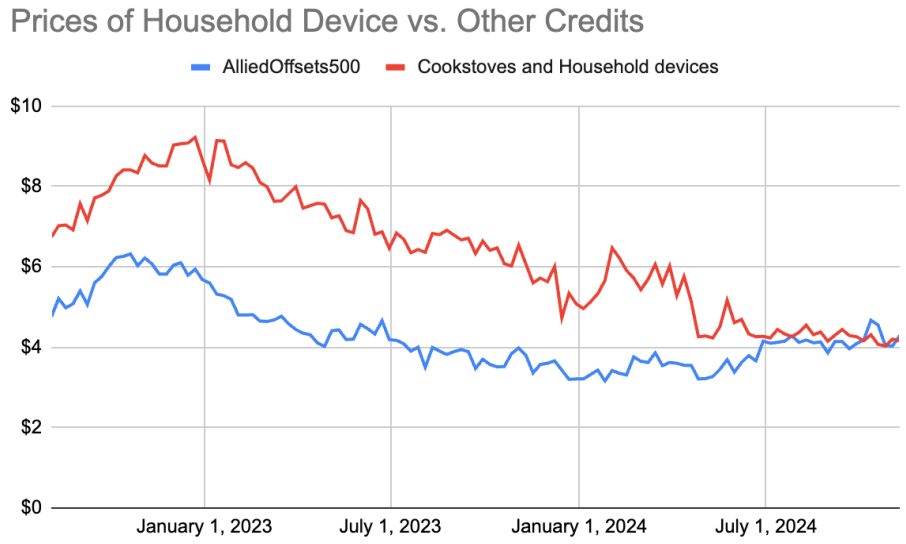
Concerns about the integrity of cookstove carbon credits have dominated headlines in 2023-2024. A review of project issuances found projects to be overclaiming their climate benefit by 9.2x on average (Gill-Wiehl et al. 2023). Recently, ex-CEO of C-Quest Capital, one of the largest cookstove project developers and a company with a large footprint in Malawi), was charged with multi-million dollar fraud (Greenfield 2024). This has revealed a need to reestablish trust in the market.

The clean cooking sector has rapidly responded with development of new methodologies and the establishment of a Clean Cooking Carbon Credits working group led by the Clean Cooking Alliance. There has been a particular push towards digital measurement, reporting and verification (dMRV) processes, which link actual stove usage to credit issuances, although this represents only a small number of projects and credits available to buyers as of now. dMRV methods for clean cooking include (Richter and Eales 2023):

- **Stove Use Monitors (SUMs):** These sensors are retrofitted to stoves and typically record stove temperature, a proxy of usage, provide an objective record of how much the stove is being used. While useful, SUMs are expensive and add complexity to operations, requiring regular downloads and maintenance.
- **Smart meters**: Modern cooking devices can be equipped with self-embedded meters to track fuel consumption. They are often more cost-effective than SUMs, focusing on measuring quantities other than temperatures, and are usually deployed as part of pay-as-you-go (PAYGO) business models that improve affordability for end-users.

- **Fuel purchase records**: These can be used to demonstrate customer payments for fuel and therefore estimate the amount of stove usage.
- **Data aggregation platforms**: These platforms can aggregate data across multiple providers to automate various results-based financing processes, such as tracking subsidies paid and confirming customer payment data. This can reduce manual verification requirements and provide valuable insights into program progress and sector trends. A platform is currently being developed in Rwanda that aims to track access to modern energy cooking services and report on sector developments, supporting targeted interventions, evidence-based policymaking, and accurate reporting to stakeholders.

Traditionally, the sustainable development co-benefits of clean cooking projects (gender, health, poverty) led their credits to trade at a premium relative to other sectors. However, this has eroded over the course of 2023-2024, with concerns about over-crediting of projects and even fraud dominating headlines (Greenfield 2024; Gill-Wiehl et al. 2023). As of November 2024, household devices credits are no longer trading at a premium price on the open VCM (Figure 2). The volatility of credit prices and the fickle nature of their demand are two of the main drawbacks of carbon credit financing. Without a guaranteed stream of income to project developers, it is difficult to create a long-term business case. Cookstove and household device credit prices generally follow general voluntary carbon market price trends (AlliedOffsets 2024). The AlliedOffsets500 represents the price of the top 500 carbon projects that have been retired since January 1st, 2020, weighted by the number of credits each one has retired.



Different clean cooking stoves and technologies generate variable numbers of carbon credits. Table 1 provides estimates of issuances for the clean cooking technologies

relevant to the World Bank Malawi intervention design based on interviews with project developers[9].

*Table 37. Typical carbon credit issuances for different types of cookstove technologies. * indicates use of metered methodology, which is higher quality and what companies are now aiming for -> means lower issuance but higher price.*

Fuel / technology	Typical credit issuances (tCO2e/stove/year)	Reference
LPG	0.5 - 4*	[Bboxx, PAYGO Energy]
Electric cooking - induction	0.3 - 2.5*	[ATEC]
Biogas	3 - 10	[Home Biogas]
Pellets	2 - 4*	[ECS]

4.1.1 Malawi's Engagement in Carbon Markets

Malawi remains a slowly growing presence in international carbon markets. The country has actively participated in the Clean Development Mechanism (CDM) under the Kyoto Protocol and has a portfolio of projects registered under various voluntary carbon market standards.

Malawi has 144 projects registered from independent standards (75% from Gold Standard, 16% from Verra, 0.7% from Plan Vivo), and legacy projects from the Clean Development Mechanism (8.3%) participation under the Kyoto Protocol, with 82% being household devices projects.

Malawi's carbon market engagement presents both opportunities and challenges. The Kulera Landscape REDD+ Program, which successfully generates Verified Emission Reductions (VERs), exemplifies Malawi's potential in using carbon finance for local conservation and livelihood improvement. However, the absence of a robust domestic carbon credit infrastructure limits the country's ability to scale such projects and fully benefit from Article 6 mechanisms under the Paris Agreement.

High transaction costs for certification and monitoring hinder participation, especially for smaller projects in clean cooking and household energy efficiency. Reliance on international standards like Verra and the Gold Standard increases costs and time requirements for certification. The absence of domestic crediting mechanisms across Sub-Saharan Africa has led to innovations, including the World Bank's Carbon Initiative for Development's Standardized Crediting Framework (SCF). By standardizing baselines, the SCF aims to simplify certification processes, reduce costs, and improve accessibility

[9] Please note that Gold Standard is considering changing the crediting process for LPG projects, potentially allowing them to make higher issuances. The comment period is ongoing at the time of writing – November 2024.

for local developers, thus broadening the continent's carbon financing base (Carbon Initiative for Development, 2020). Malawi has yet to leverage such innovative carbon finance mechanisms to reinforce its clean cooking strategy.

The Malawi Carbon Market Initiative

The Malawi Carbon Market Initiative (MCMI) is a government-led effort established through the cabinet and operating under the Ministry of Finance. Its overarching aim is to foster the growth and development of Malawi's carbon market, positioning it as a key driver for increased financing through carbon initiatives. The MCMI's primary objectives include engaging local developers to ensure a steady pipeline of carbon projects, upholding the quality and integrity of carbon credits produced in Malawi, and promoting the equitable distribution of carbon revenues among communities. Recognizing carbon as a national resource, the initiative places significant emphasis on ensuring equitable benefit sharing.

Hurdles and bottlenecks faced by the MCMI include the lack of adequate regulations, the country's diminishing market share compared to other nations, and limited capacity in the operational aspects of the carbon market. To address these hurdles, the MCMI has actioned two items: capacity building, which involves training developers, and policymakers to fill both institutional and individual capacity gap; and, discussions around the establishment of a dedicated fund to provide soft loans within Malawi *[MCMI]*.

4.1.2 COP29 Developments and Implications

Approval of Article 6.4 Framework

Article 6.4 of the Paris Agreement establishes a framework for a centralized international carbon market. The new rules allow countries to trade carbon credits, enabling international cooperation to tackle climate change. This flexibility can help countries meet their climate targets more cost-effectively.

On the first day of COP29, negotiators from nearly 200 governments endorsed a framework to create a new structure for a UN-led global carbon market. This opens the door to selling cookstove carbon credits on the compliance market, which could allow for trading of higher volumes of credits at higher prices.

Financial Resources for Developing Countries

Approval of Article 6.4 is expected to direct substantial financial resources to developing countries, potentially saving up to $250 billion annually in climate plan implementation.

Enhanced Market Integrity

The UN oversight and new standards aim to ensure that carbon credits are generated through activities that genuinely reduce or avoid greenhouse gas emissions.

Potential for Market Growth

The agreement is expected to increase supply of higher-integrity carbon credits and ensure that the international carbon market operates with integrity under UN supervision. This could revitalize the carbon finance market, which has been facing challenges due to integrity issues and low prices.

4.2 Current Policies and Regulations

This section reviews: current policies, quality standards, safety standards, roadmaps and policy commitments, tax exemptions and fiscal measures that are relevant to Malawi's clean cooking sector.

4.2.1 Relevant Policies

4.2.1.1 National Charcoal Strategy 2017-2027 (Ministry of Natural Resources Energy and Mining 2017)

The National Charcoal Strategy (NCS) envisions "A more climate-resilient Malawi with an adequate supply of affordable, safe, and reliable energy sources for cooking and heating, where deforestation has been reversed, and a larger share of cooking and heating energy comes from modern sources". In the short-term, the NCS sees increased use of improved biomass stoves as the priority, and observes that "With dependency rates on charcoal and firewood already among the highest in the world, alternative energy sources underdeveloped, and population growing rapidly, biomass fuels will remain a major part of Malawi's energy mix for decades to come". LPG is identified as the most promising alternative urban fuel in the medium-term. Electric cooking is regarded as a longer-term solution once there has been further investment into power generation and expansion of electricity access due to prevailing chronic power shortages.

The strategy focusses on seven interconnected pillars, which are (1) promote alternative cooking and heating fuels; (2) promote adoption of fuel-efficient cookstove technologies; (3) promote sustainable wood production; (4) strengthen law enforcement for charcoal production and marketing; (5) regulate sustainable charcoal production; (6) support livelihoods; and (7) promote information, awareness and behaviour change communications. Pillars 1 and 7 are most relevant and are detailed below.

Pillar 1: promote alternative cooking and heating fuels

Electric cooking: Electricity demand currently exceeds supply; adoption and use for cooking is low; and, the costs of connection, appliances and tariffs are high.

The NCS therefore frames Electric cooking as a long-term solution with a core objective of strengthening the supply. Strategic actions towards this goal include increasing and diversifying generation capacity, expanding and improving the transmission network, promoting adoption of energy-efficient technologies and behaviours, providing fiscal incentives to reduce installation fees for electricity and cooking devices (e.g. duty and VAT), creating an Independent Power Producer (IPP) framework to attract investment, and expanding rural electrification.

These actions align with the National Energy Policy and progress is underway on strengthening Malawi's electricity supply. However, seven years after the creation of the policy, duty and VAT still apply to Electric cooking appliances, and MERA are actively promoting LPG as an alternative to Electric cooking because of the continuing generation bottlenecks [*MBS*].

LPG: Adoption of LPG is low; safety fears are high; and, affordability of fuel and equipment is a challenge for many Malawians. However, with rising charcoal prices and unpredictable electricity supply, LPG is becoming more attractive to urban, middle-high income groups, reflected by increases in supply/demand and growth in the private LPG sector.

The NCS seeks to promote adoption of LPG for urban and semi-urban domestic and institutional/industrial heating and cooking**.** Strategic actions towards this goal include conducting an LPG market study, conducting a cost-benefit analysis to determine the impact of removing duty and VAT from LPG and associated equipment, considering other fiscal incentives to promote adoption, developing standards and certifications for LPG canisters, regulating LPG importers and retailers and supporting the private sector on awareness campaigns.

Since development of the NCS, fiscal measures have been implemented to support LPG, LPG standards have been developed (although they are still awaiting approval), importers and retailers have become regulated and government is actively promoting LPG. A comprehensive market study on LPG is yet to be conducted.

Briquettes and pellets: The adoption of briquettes and pellets is low due to designs that have focused on small-scale production and limited feedstock. However, growing industrial demand for biomass energy could change this, with potential to scale production from sawdust and rice husks.

The NCS aims to foster the development of commercially-viable briquettes/pellet production, with market linkages to proximate industrial and institutional buyers (e.g., tobacco estates, hospitals, schools, etc.). Recommended actions include assessing pellet production potential, conducting a market assessment to quantify market demand around production areas, promoting adoption within targeted production areas, developing briquette and pellet production standards, and provide fiscal incentives to support market-oriented sustainable production e.g. duty and VAT waivers for machinery.

Little progress has been made against these objectives.

Biogas: Biogas technologies have existed in Malawi for over 20 years but sustained use is practically non-existent. The reasons for this include limited availability of organic matter and inadequate maintenance training.

However, the NCS sees potential for promotion of tubular biogas digesters in small to medium-scale institutions to significantly decrease firewood consumption in short to medium term, including integration into new building design. It therefore seeks to facilitate the promotion of tubular biogas digesters that utilize sewerage and human waste to meet institutional cooking and heating needs. Strategic actions include identifying sites for piloting, building technicians' capacity, providing fiscal incentives (e.g. duty and VAT waivers) to reduce costs, and developing biogas standards.

Little progress has been made against these objectives.

Pillar 7: Promote information, awareness and behaviour change communications

This part of the NCS aims to provide relevant information, raise awareness, and promote positive behavioral change related to the seven NCS pillars. This will be achieved through producing concise briefs to communicate policy, laws and regulations to target audiences; disseminating evidence-based best practice with exchange of ideas between stakeholders; and creating a monitoring and evaluation system for NCS implementation and impact assessment.

Since the creation of the NCS, the National Cookstove Steering Committee (NCSC) has been created as a hub of monitoring progress and knowledge exchange. Concise briefs are yet to be created, likely because many of the intended regulations, standards and fiscal measures are yet to be implemented.

4.2.1.2 Malawi Renewable Energy Strategy 2017-2030 (Government of Malawi 2017)

This policy focuses on transitioning to renewable energy and sustainable bioenergy solutions, including cleaner cookstoves in order to reduce the country's dependence on biomass and firewood. It proposes biogas and biomass briquettes/pellets as the most promising renewable energy cooking options. It does not directly mention Electric cooking, but key elements of the strategy that could enhance the feasibility of grid-connected electric cooking include planned grid upgrades and expansions to increase capacity and reliability, supported by initiatives like the Millennium Challenge Corporation Compact and the World Bank's Energy Sector Support Project.

The strategy also emphasises the role of Independent Power Producers (IPPs), encouraging investments to introduce additional renewable energy generation sources. Over 40 IPPs have expressed interest in developing renewable projects, including solar, wind, and hydro, which would provide a more stable power supply conducive to electric cooking. Additionally, the strategy targets the development of at least 50 clean energy mini-grids by 2025, which would extend electricity access to regions remote from the main grid, potentially supporting Electric cooking in these areas.

Lastly, the exploration of a Renewable Energy Feed-in Tariff aims to promote the growth of renewable energy sources, offering a more consistent power supply that could further support electric cooking adoption across Malawi.

Through the strategy, the Ministry of Energy commit to a number of concrete actions to support the transition to renewable cooking energy:

- Support and lead the NCSC to work towards targets for 2020 and beyond.
- Complete a study into the impacts of additional fiscal incentives – such as VAT relief – on clean cooking adoption.
- Develop efficiency standards for stoves and a certification model.
- Roll out 60 biogas minigrids pilot schemes and conduct a study on the pilot impacts after three years of use.

Since the policy was introduced in 2017, a number of fiscal waivers have been implemented for clean cooking (see Section 1.2.3) and the NCSC has grown in influence.

Efficiency standards for stoves have been drafted (see Section 1.3). There are only a couple of commercial minigrids in Malawi.

4.2.1.3 National Energy Policy 2018-2023 (Government of Malawi 2018)

The National Energy Policy 2018 aims to increase access to affordable, reliable, sustainable, efficient, and modern energy for all citizens in Malawi. It prioritises several clean cooking fuels whilst recognising that biomass will remain the country's primary energy source for the near future, and "*strongly advocates for the private sector to take a leading role in the implementation of energy sector interventions*". The Policy consists of an Implementation Plan and a Monitoring and Evaluation Plan with time-bound deliverables. However, these are all now outdated, as the Policy extends only to 2023 and has not been updated.

It focuses on eight priority areas: (1) electricity; (2) biomass; (3) petroleum fuels; (4) bioethanol and biofuels; (5) LPG, biogas and natural gas; (6) coal; (7) nuclear energy; and (8) demand side management. The sections below elaborate on the priority areas that are relevant to clean cooking.

Priority Area 1: Electricity

This includes plans to incentivise distribution licensees to create schemes that facilitate consumer access to electricity and promote the use of basic energy-efficient electrical appliances. The policy outlines strategies such as removing duty and VAT on energy-efficient domestic electric cooking and water heating appliances, and introducing lifeline tariffs to help low-income households access electricity. Additionally, the Government of Malawi (GoM) commits to intensifying the electrification of rural trading centres and villages, providing funding for off-grid rural electrification schemes through the Rural Electrification Fund.

Priority area 2: Biomass

The Policy sets a target to roll out two million efficient biomass cookstoves by 2030. In order to do this, the Government will build strong partnerships with the private sector and NGOs (including PPPs) to promote the manufacture, supply, use and financing of improved cook stoves, brick kilns, charcoal kilns and biomass briquettes and pellets. They will also ensure that low income and marginalized groups have equitable access to, control over and benefit from biomass technologies through targeting interventions at low income and marginalised groups. This will be achieved by entrusting and empowering local authorities to promote the utilisation of efficient biomass technologies through the introduction of District Energy Officers, with individualised District Implementation Plans. As of 2024, the District Energy Officers are in the process of being rolled out throughout the country.

Priority area 4: Bioethanol and other biofuels

The Policy focuses on biofuels as a transport energy. It references supporting the production of bioethanol for cooking and lighting, but there are no concrete actions or performance indicators relating to this.

Policy priority area 5: LPG, biogas and natural gas

The Government commits to ensuring availability of LPG, biogas and natural gas in sufficient quantities at affordable prices for industrial (electricity generation, heat) and domestic use. This will be achieved through implementing institutional reforms for investments in and utilisation of LPG, biogas and NG; promoting tax and other fiscal incentives for large scale investments; implementing a phased program to accelerate penetration of LPG and NG; providing customs duty and VAT incentives to promote wide availability of small LPG cylinders and gas cookers; and providing fiscal incentives to help financially viable companies construct their own storage facilities that meet prescribed minimum stockholding requirements.

The policy also announces programmes aimed at building the capacity of the LPG, Biogas and Natural Gas Industry through awareness campaigns, and by promoting regulations and standards on supply & distribution of LPG cylinders. The Government also plans to promote an industry that actively strengthens the participation and economic empowerment of local women, men and the youth by encouraging citizens from these groups to become entrepreneurs and employees in industry.

Policy priority 8: demand-side management

Priority Area 8 (Demand Side Management) aims to establish appliance testing, labelling, and standards, including energy performance standards; reduce or eliminate import duty and taxes on energy-efficient products; conduct public awareness campaigns; offer financing for energy efficiency measures with loan repayment options through utility bills; and promote the use of energy-saving electrical and biomass-fueled devices.

4.2.1.4 Malawi's Nationally Determined Contributions (NDC) 2021 (Ministry of Forestry and Natural Resources 2021)

Malawi's aims to reduce emissions by 12.8-18.1 MtCO2e below business as usual by 2030. The energy sector accounts for 85% of the total mitigation potential and key measures meet it include: deploying improved cookstoves; promoting renewable energy sources such as hydropower and solar PV; improving energy efficiency; and exploring carbon capture and storage (CCS) for future grid-based thermal power plants.

The NDC highlights Malawi's reliance on international assistance to meet its ambitious targets. The NDC's estimated implementation cost of $46.5 billion underscores the financial challenges Malawi faces due to limited domestic resources. The document emphasizes the role of market-based approaches, with reference to the Clean Development Mechanism (CDM) under the Kyoto Protocol as a mechanism that can encourage private-sector involvement in achieving climate targets.

4.2.1.5 The National Climate Change Management Policy (NCCMP) 2016 (Ministry of Natural Resources 2016)

The NCCMP serves as the guiding policy for Malawi's efforts in climate adaptation and mitigation across various sectors, including agriculture, energy, forestry, industrial processes, waste management, water resources, and wildlife. Its key policy objectives include: i) effectively manage the impacts of climate change by building and sustaining social and ecological resilience, ii) stabilizing greenhouse gas concentrations in the

atmosphere at a level that prevents dangerous human-induced interference with the climate system while allowing sustainable development, and iii) integrating climate change considerations into planning, development, coordination, and monitoring across key sectors.

However, the NCCMP lacks specific mandates for carbon market activities, which restricts effective engagement in carbon financing opportunities that could support large-scale clean cooking projects and enhance emissions reductions. Additionally, overlaps between climate and energy policies result in fragmented action plans without a cohesive strategy, limiting the comprehensive application of policy.

Addressing these gaps requires integrating a dedicated carbon market framework within the NCCMP. Such a framework would set goals for carbon credit generation, streamline project approval processes, and create clear incentives for private-sector investment, securing additional funding for initiatives like clean cooking.

4.2.2 Relevant Regulations

4.2.2.1 Regulatory Framework for Mini-Grids in Malawi (MERA 2020)

The "Regulatory Framework for Mini-Grids" in Malawi provides comprehensive guidelines for the development, operation, and regulation of mini-grids to promote sustainable electrification. It includes provisions for flexible ownership models, allowing community-based, public, private, and public-private partnerships to manage mini-grids, which could increase access to electricity for Electric cooking. The framework also supports Time-of-Use (ToU) tariffs to encourage off-peak electricity usage, potentially making Electric cooking more affordable during cheaper hours. Additionally, it discusses potential subsidies, including capital and operational assistance, to improve the financial viability of mini-grids, though these are not yet implemented. Terms for grid interconnection are outlined to ensure that mini-grids remain functional and beneficial to Electric cooking users as the national grid expands.

However, the framework's cost-reflective tariffs could lead to higher costs for consumers if subsidies are inadequate, posing affordability challenges for widespread Electric cooking adoption. Furthermore, the technical and licensing requirements for larger mini-grids may present obstacles for some developers, potentially limiting mini-grid availability for Electric cooking in certain regions.

4.2.2.2 LPG Regulations

There are many draft LPG standards that have been prepared by the Malawi Bureau of Standards and once they are ratified by MERA there will need to be personnel on the ground with the skill sets to implement and enforce them. The following sections discuss key aspects of the current LPG market configuration.

<u>The Branded Cylinder Recirculation Model (BCRM)</u>

LPG is unusual because the packaging is more expensive than its contents. A 3kg cylinder will cost two or three times more than the cost of 3kg of LPG. If well-maintained an LPG cylinder may be reused over a hundred times in its life. In order for this to happen the cylinder must be thoroughly inspected, maintained – and periodically re-qualified –

every time it is refilled. This is done at the cylinder filling plant by professionally qualified personnel. When empty LPG cylinders are exchanged for full ones the empty cylinder will go back to the filling plant to be inspected before being refilled. This branded cylinder circulation model (BCRM) ensures the integrity of the cylinder, prolongs the life of the asset, and encourages investment.

From discussions with the local Malawi distributors, the majority of LPG is currently sold in small quantities through partial filling. Partial filling is where the cylinder, which is in the hands of the consumers, is brought to a retailer and LPG is dispensed into it. This may be as little as a few hundred grams of LPG. The problem with partial filling is that the cylinder cycles between the consumer and partial re-filler and is never thoroughly checked or maintained. Cylinders that are partially filled will deteriorate and become unfit for purpose and unsafe. Control over these cylinders becomes weak and the original brand owner will often lose their assets. Partial filling therefore adversely impacts investment.

The advantage for the consumer is that the purchase price is much less than the cost of a full cylinder exchange. This mode of purchase is similar to other consumer products like sugar, rice and washing powder, where these products are re-packaged into smaller affordable quantities. The Malawi LPG industry should phase out the partial filling practice and re-introduce the BCRM which was common just a few years ago. The affordability of a full LPG cylinder must be addressed in ways other than by partial filling.

Regulated price

The maximum LPG retail price is regulated by the government. To shield consumers from frequent price swings due to the monthly changes in global LPG prices, and currency exchange rate fluctuations, a Price Stabilization Fund (PSF) is used.

A levy is imposed on every kg of LPG purchased by consumers that contributes to the PSF. At times when the product cost goes beyond MERA's established cost structure, LPG companies are reimbursed for the additional cost from the fund. The PSF in theory provides transparency to the LPG pricing although the reimbursement process may be lengthy and require detailed supporting documents. The PSF is not a mechanism to regulate the retail price of petroleum products which is largely influenced by external factors.

Only a few countries today maintain such a price stabilisation fund for petroleum product (e.g. Thailand, Vietnam and Chile source: PIDS Public Webinar 09 June 2022 *https://pdiswebs.pids.gov.ph*). A better approach is for government to support free and open market competition.

MERA Regulatory Framework

MERA has drafted a regulatory framework for LPG. Detailed comments on the framework from the project team's experts can be found in Appendix 1: LPG regulations evaluation.

The framework is generally in line with best practices. It could be improved by:

1. Simplifying the licensing requirement for retail outlets and focusing on compliance to safety standards. Most retail outlets in other countries are not

stand-alone shops and are simply part of another existing business i.e. gasoline stations, etc. Simpler licensing requirements can help expand the retail outlet network and broaden access of LPG to consumers.

2. Storage licenses should apply only for LPG resellers and not for own use such as restaurants to lessen regulatory requirements and promote use of LPG by the commercial segment. Storage of LPG for own use should rather be monitored for compliance with safety standards by other pertinent authorities.
3. Clearly stating the cylinder requalification interval
4. Clearly stating the bulk tank and road tanker requalification interval.
5. Clearly stating the fire protection requirements for LPG installations.
6. Clearly stating the permitted filling tolerances for cylinders.
7. Mandating scrapping of cylinders by crushing to prevent illegal re-use.
8. The "LPG standard" mentioned in the Sixth Schedule is not the typical LPG Specification used in the industry and importers will not be able to certify to their compliance, which could constrain the market. Malawi should decide whether to follow the South African or Tanzanian LPG Specification here.

4.2.3 Roadmaps and Policy Commitments

4.2.3.1 Cleaner Cooking Energy Compact (Ministry of Energy 2021)

The Cleaner Cooking Energy Compact (CCEC) was put forward by the Ministry of Energy and the National Cookstove Steering Committee in September 2021 and consists of a plan to provide cleaner cooking solutions to all households and institutions in Malawi by 2030 as mandated by Sustainable Development Goal (SDG) 7.1 (universal access to affordable, reliable and cleaner energy services) and SDG 7.2 (increase substantially the use of renewable energy in the mix). The CCEC consists of a set of aims, which are aligned with the National Energy Policy, and targets.

Ambition 7.1: Universal access to cleaner energy services

The CCEC aims to scale local production of transitional firewood stoves, leveraging distribution incentives to reach remote rural areas and to leave nobody behind. It also aims to scale the availability of ultra-efficient charcoal stoves and a mix of alternative sustainable cooking fuels (sustainably produced charcoal, briquettes, pellets, biogas, LPG, electricity). It plans targeted civic education campaigns to push for the transition.

Ambition 7.2: increase the renewable energy share

The CCEC aims to harmonise policies and coordinate implementation efforts for environmental sustainability**.** This involves developing a list of approved incentives and producing sub-sector reports. It also aims increase the availability of affordable low-consuming electric devices, to strengthen law enforcement for sustainable sourcing of wood fuel, to incentivize private sector investment into ICS manufacturing plants and sustainable commercial forestry, and to ensure the availability of affordable LPG, biogas and natural gas.

CCEC Targets

These are based on assumptions of a population of 25m by 2030 (21m rural and 4m urban)

- 60% of rural households transitioned to stove stacking by using more than one fixed and/or portable efficient wood stove.
- 40% of rural households transitioned to at least one efficient wood stove by 2030.
- 30% of urban households transitioned to ultra-efficient charcoal stoves by 2030.
- 10% of urban households transitioned to sustainably produced, licensed charcoal by 2030.
- 10% of urban households transitioned to LPG by 2030.
- 3% urban households transitioned to self-sustaining biogas systems, pellets, briquettes and other alternative biomass fuel solutions.
- 15% urban households transitioned to low-consumption electric cooking by 2030.
- 100 commercial users have transitioned to renewable energy including sustainable biomass.
- 3 programmes implemented by government to build capacity of LPG, biogas and natural gas.
- An additional 2m ICS by 2025.
- An additional 3m stoves for both biomass and alternative cooking fuels by 2030.
- CSO community initiatives ensuring that 55,000 rural men and women per year trained to make and use ICS using locally available materials.
- Customs, excise and VT exemptions for efficient stoves and alternative sustainable fuels in place.

The World Bank estimate that a total investment of ~$600m is required to achieve the CCEC targets, comprising $149m for SDG7.1 and $447m for SDG7.2. There is not yet an implementation plan in place for the Energy Compact (World Bank 2022).

Following the release of the CCEC, SE4All developed a Malawi Integrated Energy Plan (IEP) that used geospatial analysis and modelling to optimise the mix of technologies and investments to meet SDG7 targets (SEforAll 2022). A key finding of the analysis is that the CCEC is under-ambitious and that almost 40x more households could cook with tier 4 technologies that the CCEC's projections (20,291,176 versus 661,946). Our own analysis, which is presented in Supply-Side Analysis, finds that the IEP's assumptions are overinflated, but agrees that the tier 4 market potential in Malawi exceeds the CCEC's goals.

Recommendation:

There is also currently no regular and robust framework in place to monitor progress against the CCEC. The World Bank's 2024 Multi-Tier Framework survey is a huge improvement but these types of data collection activities need to be conducted more frequently in order to monitor progress against targets with any confidence.

4.2.3.2 Electric cooking Roadmap (Malawi Ministry of Energy 2024a)

The "Malawi Electric cooking Roadmap" outlines a strategic plan to accelerate the adoption of Electric cooking in Malawi. Despite having one of the world's highest shares

of renewable energy, only a small fraction of Malawian households use electricity for cooking, with most relying on unsustainably sourced biomass. The roadmap identifies key barriers to Electric cooking adoption, such as the perceived high cost of appliances and unreliable electricity supply. It aims to address these issues through a series of actions, including strengthening the national grid, promoting energy-efficient technologies, and offering fiscal incentives to reduce costs.

The roadmap is structured around three pillars: improving the supply by integrating Electric cooking into electricity access planning, increasing demand by making Electric cooking more affordable and raising awareness, and enhancing the enabling environment through capacity building and policy support. The goal is to transition to clean cooking, reduce deforestation, and improve health outcomes while aligning with Malawi's broader energy and climate goals. The document calls for coordinated efforts among stakeholders to build on these initiatives and create a sustainable path toward universal access to clean cooking in Malawi.

4.2.3.3 Malawi Carbon Market Initiative Roadmap 2025-2030

Currently funded by the government, the MCMI is also forging collaborative partnerships with international experts to bolster its activities.

Its roadmap for the period 2025-2030 outlines several key priorities. A cornerstone of this roadmap is the development of a comprehensive regulatory framework for Malawi's carbon market. Collaborating with the Ministry of Natural Resources and Climate Change and the UNDP, the MCMI aims to have this framework in place by the first quarter of 2025. Another major focus is a thorough review and stocktaking of existing carbon projects in the country to better understand the current landscape (Rumble and Gilder 2023). Lastly, to facilitate the growth of the market, the MCMI is also working to connect carbon buyers with project developers. It maintains a database of buyers and their specific requirements and offers matchmaking services free of charge. Although specific targets for the volume of carbon credits to be issued have not yet been set, the MCMI is expected to play a pivotal role in Malawi's implementation of Article 6 arrangements under the Paris Agreement. These responsibilities will be formally articulated within the forthcoming Article 6 Framework *[MCMI]*.

The MCMI collaborates closely with several key institutions. Among these are the Ministry of Natural Resources and Climate Change, which has overarching responsibility for climate change policies, and the Environmental Affairs Department, which contributes to environmental management and regulation. The initiative will also work in tandem with a new Carbon Office, currently under development, which will oversee Malawi's carbon market activities.

Operating at a level equivalent to a ministry, the MCMI aims to propose requirements for all new market participants to register and comply with national carbon market regulations. It has been involved in the process of establishing a fee structure for participants, with proposed charges for administrative services, ITMO issuance, and insurance. These fees are expected to be finalized alongside the regulatory framework by Q1 2025. Through these comprehensive measures, the MCMI is positioning itself as a central pillar of Malawi's evolving carbon market *[MCMI]*.

4.2.3.4 *Malawi National Energy Compact 2025 (Government of Malawi et al., 2025)*

Malawi's National Energy Compact sets ambitious clean cooking targets, aiming to increase access from the current 24.5% to 75% of households by 2030.

This will involve providing cleaner cooking solutions to 100,000 urban and 490,000 rural households annually, distributing 146,000 advanced woodstoves each year alongside 117,000 LPG cookstoves, 53,000 electric cookstoves, 80,000 biogas cookstoves and 40,000 ethanol/paraffin-based cookstoves annually. The strategy includes establishing a Clean Cooking Fund, implementing innovative financing mechanisms such as carbon credits and providing tax exemptions on clean cooking technologies to overcome affordability barriers.

4.2.4 Fiscal Measures

Table 2 summarizes taxes for clean cooking fuels and equipment according to the Malawi Revenue Authority (MRA).

*Table 38. Taxes for clean cooking fuels and equipment. * indicates that although a policy has been introduced to exempt Electric cooking appliances from taxes, this is yet to be gazetted, meaning it is not yet implemented as standard practice. This process involves securing funding from the Ministry of Finance (MoF) to implement the policy, which in turn requires the MoF to conduct a fiscal incentive study. The timeline on this is unclear but it could take more than a year to complete.*

Item	Customs duty	Excise rate	VAT	Source
Cooking stoves and appliances for gas, liquid and wood fuels	Free	15%	16.5%	(MRA 2023; 2017)
Cooking stoves for other solid fuels (charcoal and pellets)	30% (2% for COMESA and free from SADC)	15%	16.5%	(MRA 2023; 2017)
LPG fuel	5% (free from SADC and COMESA)	Free	0%	(MRA 2017; 2019)
LPG cylinders	Free	Free	0%	(MRA 2017; 2019)
Electric cookers (microwave ovens, cooking plates, kettles, rice cookers etc)	Free*	Free	16.5%	(MRA 2023; 2017)

Item	Customs duty	Excise rate	VAT	Source
Pellets	10% (free from SADC and COMESA)	Free	16.5%	(MRA 2017)

The application of these tax and duty waivers is not consistently applied and LPG companies sometimes have to challenge MERA at the border to have the charges removed. Electric cooking devices are supposed to be customs exempt, but this has never been implemented and poses a barrier to adoption (Malawi Ministry of Energy 2024b) *[SHA, BURN]*. There have been attempts to lobby for further tax incentives on high-efficiency electric cooking devices, but these have not been approved by the Ministry of Finance. The macroeconomic situation in Malawi is challenging, with currency depreciation and an overall worsening economy, making it difficult to push for policy changes or incentives that could reduce the cost of electric cooking devices *[MCHF]*.

4.3 Quality Assurance and Enforcement

The Malawi Bureau of Standards (MBS) are responsible for preparing and publishing Malawian standards. A list of ratified standards relating to cookstoves are shown in Table 3. Clean cooking stove testing quality standards in Malawi are lacking, with most companies choosing to certify under British or ISO standards, e.g. BS ISO 19867-12018, ISO/TC 285 and ISO/TR 1986-3:2018. Challenges associated with applying the international standards include high tech equipment requirements, a kitchen set up that may not reflect the local context, and dish choices that do not reflect local cooking methods and traditions (Mlowa et al. 2024) *[Gamos]*. MBS has some capacity to conduct basic tests, but companies generally outsource testing operations to other countries with established and dedicated facilities, e.g. Zipo used CREEC in Kenya and CERER in Senegal *[SHA]*.

Numerous relevant standards are in development. Voluntary standards for clean cooking tier testing in Malawi have been drafted (World Bank 2022). The Ministry of Energy is working with the Malawi Bureau of Standards to develop Electric cooking efficiency standards, with the process expected to take two to three years *[MCHF]*. A number of LPG standards have also been drafted and are awaiting approval from the MBS board *[MBS]*. They are based on South African and ISO standards and cover: (1) gas cylinders; (2) shut off valves; (3) hoses; (4) single stage regulators; (5) appliances including cookstoves; (6) inspection and testing procedures; (7) design, operation and maintenance of gas installations; (8) testing stations and periodic inspection; and (9) reconditioning of cylinder valves (a practice not recommended but accepted in South Africa).

MERA and the Malawi Revenue Authority (MRA) are responsible for ensuring compliance to standards *[MBS, SHA]*. According to those working in the cookstove sector in Malawi, standards are generally only enforced when companies are seeking tax waivers, and this usually consists of requests for documentation rather than audits or testing activities. Both development partners and private sector players reported that standards have been

used by MERA and MRA in the past to even punish licensed firms, allowing unlicensed LPG and charcoal players to continue operations unscathed *[MCHF, SHA]*.

One of the MCHF's key priorities was legal enforcement and prosecution of non-sustainable and illegal charcoal sellers. MCHF has been working for over five years with the Ministry of Forestry and Natural Resources and still, enforcing laws and regulation around this area has been extremely difficult. This is due in part to the capacity of the Malawi Police and the lack of transparency in the supply chain from rural to urban *[NCSC]*.

Table 39. Standards concerning cooking fuels and appliances. Source: Malawi Bureau of Standards website https://mbsmw.org/

Fuel	Standard
Solid fuel (charcoal, firewood)	MS 155:2000 SOLID FUEL COOK STOVE – TYPE II – SPECIFICATION (3 p) V Specifies the requirements for the solid fuel cook stoves with a pottery liner intended for cooking.
	MS 158:1995 COOKSTOVE, SOLID FUEL (TYPE 1) – SPECIFICATION (8 p) M Specifies requirements for solid fuel cook stove, which incorporates one or more ovens and has a cooking surface which includes at least one simmering area of sufficient size to accommodate the number of utensils required and operates with minimum smoke emission.
	MS 480:1995 COOKSTOVES, SOLID FUEL – TYPE 1 – METHODS OF TEST (6 p) V Covers methods of test for solid fuel cookstoves – (Type 1) for the purpose of verification and ascertaining of relevant performance and construction.
Electric cooking	MS 17:1984 SAFETY OF ELECTRICAL APPLIANCES – SPECIFICATION (48 p) M Covers the safety of electrical cooking, heating, motor-operated and magnetically controlled domestic appliances for use at voltage above 42 V and not exceeding 250 V to earth. It also covers other electrical appliances, for use in that voltage range, that are available to members of the public for use in circumstances not covered by specific safety legislation.
	MS-IEC 60335-2- 15:2005 HOUSEHOLD AND SIMILAR ELECTRICAL APPLIANCES – SAFETY – PART 2- 15: PARTICULAR REQUIREMENTS FOR APPLIANCES FOR HEATING LIQUIDS (M) Deals with the safety of electrical appliances for heating liquids for household and similar purposes, e.g. kettles, coffee-makers, steam cookers. To be used by laymen in light industry and on farms.

Fuel	Standard
	MS-IEC 60335-2- 39:2004 HOUSEHOLD AND SIMILAR ELECTRICAL APPLIANCES – SAFETY - PART 2- 39: PARTICULAR REQUIREMENTS FOR COMMERCIAL ELECTRIC MULTIPURPOSE COOKING PANS (M) Deals with the safety of electrical commercial multi-purpose cooking pans, not intended for household use. Typical use is in restaurants, canteens, bakeries, butcheries, etc. Their rated voltage is not more than 250 V for single-phase appliances and 480 V for other appliances. It also covers the electrical part of appliances using other forms of energy.
Ethanol	MS 573:2007 ETHANOL – SPECIFICATION (9p) M Specifies requirements for four grades of ethanol, i.e. Food grade, industrial grade, analytical grade, and fuel grade ethanol. It applies to ethanol that is of agricultural origin (starch or sugar based).
Pellets / briquettes	MS 858:2023 SOLID BIOFUEL – SUSTAINABLE CHARCOAL AND CARBONISED BRIQUETTES – SPECIFICATION (SECOND EDITION) (20P) M Specifies requirements and methods of sampling and testing for sustainably produced charcoal and carbonized briquettes are derived from wood forest, plantation, sustainably harvested wood and other forest products, by-products and residues from wood processing industry, chemically in treated wood, herbaceous biomass, fruit biomass, aquatic biomass , agro-industrial residues.

4.4 Local Capacity

There are no Malawian academic institutions researching clean cooking, although Mzuzu University has an Energy Department with an electrification and renewable energy focus; they run technical courses and have been involved in designing local minigrids and biogas systems (University of Strathclyde and Community Energy Malawi 2018).

Instead, international researchers and institutions dominate the energy access research space. The UK-funded Modern Energy Cooking Services (MECS) research programme based at Loughborough University funded a market assessment for modern energy cooking services in Malawi and the Electric cooking roadmap. They also partnered with Atmosfair and MEGA to pilot Electric cooking on the MEGA minigrid. The University of Strathclyde's Global Renewables Centre has long-established links with Malawi and has worked on a range of off-grid electrification projects, including minigrids Electric cooking with MECS. Dr Natalie Boyd Williams of ETH Zurich in Switzerland holds a fellowship focussing on sustainable biogas futures in Malawi and its interactions with the voluntary and compliance carbon markets. The UK-funded Climate Compatible Growth Programme (University of Cambridge, Oxford University, University College London, Imperial College) is expected to commence a Malawian partnership in 2025, and has a focus on energy and transport transitions.

The Malawian clean cooking market is nascent. It is mostly comprised of a number of small local companies, although larger international entities are also starting to enter the market. The local companies need help formalising and streamlining their operations so that they can grow their businesses and compete *[SHA]*. The support required is company-specific and covers topics such as project management, training staff, implementing standard operating procedures, accessing carbon finance, accounting and financial management *[Zipo, Mega, Vitalite, SHA]*. EnDev and GETF have run some training courses in the past, but these have been more targeted at the more mature off-grid solar and productive end use markets than clean cooking, and an incubator-type approach that provides consistent support over a longer period may be more effective [SHA]. There is also a significant capacity gap regarding the level of monitoring required for RBF and carbon projects, as there is typically little focus on tracking and follow-up once stoves have been sold. Companies need substantial on-the-ground, in-country assistance to navigate these processes and comply with requirements [SHA].

The Malawian government are perceived as not understanding or appreciating clean cooking. The Ministry of Energy is overwhelmingly focussed on electrification and the lack of knowledge on the topic was evident through conversations with other relevant Ministries as part of this project.

This gap in focus could be addressed through creating a government-based Clean Cooking Unit to raise the profile of clean cooking amongst relevant stakeholders. Such an approach has been successfully implemented in Kenya, where the country's clean cooking strategy is overseen by a Technical Working Group who meet regularly and is comprised of representatives from different Ministries, national institutions, development partners and sectoral associations.

4.5 Electrical Waste Management Practices

The Malawi National Waste Management Strategy 2019-2023 primarily addresses waste management in broad terms, focusing on municipal, industrial, and hazardous waste streams (Malawi Government 2019). However, it does not explicitly cover Electric cooking waste management. The strategy outlines priorities such as promoting waste segregation, recycling, and developing environmentally sound infrastructure, which could be extended to Electric cooking waste if it were formally recognized as a distinct category under electrical and electronic equipment waste. Currently, any Electric cooking waste generated is likely managed as part of broader electronic waste (e-waste) practices under this general framework strategy. Effective management will require coordination across government bodies, private sector partnerships, and community engagement, which could be leveraged to address Electric cooking waste as well. The Malawi communications Regulatory Authority (MACRA) and the Environmental Affairs Department (EAD), among other stakeholders, are actively assessing the e-waste situation and are developing recommendations for effective interventions.

Efforts by the E-waste Statistics Partnership (GESP) (see https://ewastemonitor.info/e-waste-data-and-statistics-in-malawi/) provide additional context. Through national quantification assessments and capacity-building initiatives, Malawi is advancing its e-

waste data collection, which will aid in the integration of e-waste, including potential Electric cooking waste, into national policy. In April 2021, a workshop supported these goals by focusing on capacity-building for data collection and the foundation of an e-waste monitoring system.

4.6 Lessons Learned from Previous Programmes

4.6.1 Incentive Structures for Electric cooking

Literature points to various mechanisms that encourage consumers to shift their electricity consumption to off-peak times. These include time-of-use (TOU) tariffs, demand-response programs, and financial incentives like rebates or discounts for off-peak usage. The challenge is twofold for cooking: the time people want to cook will coincide with peak demand, exacerbating constraints; and technologically it is difficult to set a tariff that would only apply to one appliance, so other demand behaviour may be impacted as a side effect

The Local Constraint Market (LCM) trial, led by National Grid ESO in the UK, seeks to tap into new sources of flexibility to manage grid constraints, particularly in response to the growth of renewable generation in Scotland (ESO 2022). This initiative provides incentives to balance electricity supply and demand, offering a cost-effective alternative to traditional balancing methods. By enabling asset-level metering, the LCM trial promotes user engagement and encourages off-peak usage, potentially benefiting applications like electric cooking. This approach may reveal valuable insights into how localized incentives can shape consumer behavior in electricity markets. Other examples in the UK include flexible tariffs offered by companies like Octopus, which aim to shift demand away from peak times for electric vehicles and heat pumps. Historically, tariffs like Economy 7 and Economy 11 supported the adoption of storage heaters by providing similar off-peak incentives.

Academic insights on tariff structures for Electric cooking suggest that incentive-based demand response systems and carefully designed tariff policies can play pivotal roles in encouraging the adoption of electric cooking while managing demand effectively. Paudyal and Ni (2019) explore a smart home energy optimisation system that uses incentive compensation to manage time-shiftable appliances, such as electric ovens. Their study reveals that offering higher financial incentives for more significant shifts in cooking times encourages users to adjust their energy consumption, reducing peak demand without sacrificing convenience. This approach not only promotes energy-efficient behaviors but also balances user engagement with privacy concerns.

From a broader perspective, Rubanda et al. (2023) emphasize the importance of designing tariff policies that align investment recovery with consumer satisfaction. Their research in East Africa indicates that while many countries implement administered pricing for electricity, these policies are often ad hoc and shaped by political concerns over accessibility and affordability. They highlight that uniformity in tariff design should not be pursued without considering local contexts, suggesting that effective tariff structures require careful application of globally accepted principles. Together, these

studies underline the importance of flexible, context-sensitive tariff structures in promoting Electric cooking adoption and managing energy markets effectively.

Uganda

In 2021, the regulator introduced an Electric cooking tariff in Uganda, offering a discounted electricity rate for monthly consumption between 81 and 150 kWh (Kersey 2024). This "Cooking Tariff" is a strategic initiative by the Ugandan government aimed at reducing reliance on charcoal and other biomass fuels by making electric cooking more affordable than charcoal for household use. Beyond cost savings, the tariff promotes the health benefits and convenience associated with clean cooking options. The tariff operates under a Declining Block Tariff Structure, which applies lower rates for electricity consumption beyond a specified threshold. With this tariff, domestic customers pay UGX 412 per unit of electricity for consumption between the 81st and 150th units, as approved by the Electricity Regulatory Authority (ERA).

However, the initiative has faced criticism, especially concerning its impact on informal settlement residents (ERA 2021). Average monthly electricity consumption in these areas typically ranges from 20 to 30 kWh, meaning many residents fall below the threshold necessary to benefit from the discounted Electric cooking rate. This shortfall underscores broader concerns within energy justice, which emphasise the need for inclusive policies that support a fair energy transition without marginalising those who rely on traditional systems. While the Electric cooking tariff encourages electric cooking uptake, all households within this consumption bracket benefit from the lower rate, regardless of whether they use electricity specifically for cooking. Integrating smart Electric cooking appliances that monitor consumption could help identify which households within the Electric cooking bracket are actually using electricity for cooking, allowing for more targeted support and a clearer assessment of the tariff's effectiveness.

Kenya

In Kenya, discussions among the Energy and Petroleum Regulatory Authority (EPRA), Kenya Power and Lighting Company (KPLC), and the MECS team led to a significant advancement for the Electric cooking sector with the introduction of a new customer tariff band for those consuming between 30 and 100 kWh per month (Leary et al. 2023). While not explicitly labeled as an "Electric cooking tariff," this new band is intended to promote the adoption of electric cooking by targeting the typical electricity consumption range of low-income households, making Electric cooking more accessible. The tariff band acts as a transitional rate, positioned between the lifeline and standard tariffs, allowing households to gradually increase their electricity use without facing a steep rise in costs.

Effective from April 1st, 2023, this discounted tariff is available to more than 8 million domestic customers under KPLC who fall within this usage range. The development of this tariff involved collaboration among various stakeholders, emphasising the value of inclusive discussions in shaping supportive policies for sector growth. Even amid a 30-50% rise in electricity prices overall, this new tariff band provides a critical opportunity to stimulate demand in the Electric cooking sector, supporting both affordability and access for households considering a shift to electric cooking.

On bill financing for eCook in Zambia

Modeling in Lusaka suggests that battery-supported cooking with energy-efficient appliances is already the most cost-effective solution for users facing load shedding (ESMAP 2020). With scheduled blackouts lasting around four hours, a battery sized to meet half of a household's daily demand (approximately 0.42 kWh) would enable customers of the Zambian utility, ZESCO, to cook at any time. If ZESCO implemented an on-bill financing model to distribute the high upfront costs, customers could enjoy electric cooking for as little as $3–$5 per month based on a 20-year repayment period, which includes equipment and battery replacements. Even in a private-sector model with a shorter five-year repayment horizon, the monthly cost would only increase to $5–$6, still making it cheaper than cooking with charcoal.

In scenarios with more severe load shedding that require a battery size supporting a full day's cooking (1.26 kWh), costs would increase to $6–$9 per month under the utility model, remaining comparable with charcoal prices. For a private-sector model, costs would slightly exceed charcoal rates. These findings highlight that battery-supported Electric cooking could be a financially viable and practical alternative to charcoal, especially with supportive financing mechanisms.

Malawi

Malawi currently has on peak and off-peak tariffs but only for large industrial users (ESCOM 2024). For Malawi, aligning industrial and residential incentive tariffs could be highly beneficial.

Given the parallels in energy access challenges and reliance on traditional cooking fuels, a targeted tariff that lowers the cost of electricity for specific consumption brackets could encourage more households to adopt electric cooking.

This approach addresses affordability concerns, shifts load to encourage more even distribution and can stimulate demand without overwhelming the grid, especially if combined with efforts to improve grid reliability and capacity.

4.6.2 LPG Transitions

Indonesia 3kg conversion campaign (Pertamina and WLPGA 2011)

In 2004 kerosene was consumed by 48 of 52 million (m) households in Indonesia. The majority of households used it for daily cooking. A smaller portion of kerosene was used as lighting fuel by households, fishermen and small industries.

Kerosene was subsidised and represented a large proportion of the state budget. In 2007 the government decided to switch the population away from kerosene to LPG. All citizens meeting the program requirements would have the right to receive the free 'Initial Package', consisting of a 3 kg LPG cylinder, a first gas-fill, and a one-burner stove, hose, and regulator. The initial program goal was to convert 42m households and micro businesses nationally. This was later increased to 54-58m units.

As the programme ramped up the supporting infrastructure also grew with new storage facilities, cylinder filling plants and supporting equipment manufacturing factories

including cylinders, valves, regulators, stoves and hoses. Within 6 years Pertamina had distributed over 54m packages to households, and small-medium sized enterprises.

By 2012 the volume of subsidised LPG had exceeded 3.6 million tonnes/year (mt/yr). This was calculated to have reduced CO2 emissions by nearly 8.5million mt/yr.

The programme has been gradually extended across the country and today PT Pertamina, through PT Pertamina Patra Niaga, distributes LPG in 3 kg cylinders in 411 cities, through a distribution channel consisting of 33 LPG Terminals, over 5,500 LPG 3kg Dealers and in excess of 250,000 LPG 3kg sub-dealers. This reaches over 95% of the population.

The programme has been extended recently to the farmer and fishing sectors where 140,000 fishermen are using LPG engines in their boats and 80,000 farmers are using LPG in their irrigation pumps.

India Community Kitchens

In 2000 Hindustan Petroleum launched a programme to provide LPG access to rural communities who were reliant on traditional dirty fuels for cooking such as wood, kerosene and charcoal. Their proposition was based on households bringing fresh food ingredients to a community kitchen facility in the village fitted with LPG stoves and water heaters. Instead of spending hours each day collecting wood to light fires in their homes they would lease the LPG cookstoves and water heaters in the community kitchen for a few rupees an hour. The facility was managed by a trusted senior village representative who would buy LPG from Hindustan Petroleum, supported by micro finance, and lease out the kitchen to the householders at a small premium which allowed him/her to pay the interest on the loan.

In addition to providing clean cooking fuel and hot water the LPG could also be used to generate power using a small LPG generator. This provided lighting and power for mobile phones, TV's and computers. Within a few years the number of community kitchens had grown to over 3,000 and today some still operate in the most remote rural areas of India.

4.6.3 Clean Cooking Programmes in Malawi

4.6.3.1 MCHF (Tetra Tech 2020; 2023; 2019)

Programs

The Modern Cooking for Healthy Forests initiative operates three primary energy access programs in Malawi:

- **Alternative Energy and Clean Cooking Initiative** works to increase adoption of clean cooking technologies in urban areas, with particular emphasis on LPG and improved cookstoves.
- **Sustainable Charcoal Production Program** develops legal charcoal value chains through licensed producers and improved production techniques.

- **Consumer Finance and Market Development** program creates innovative financing mechanisms to make clean cooking solutions more accessible to households.

Financing Size

The program operates under USAID Contract 72061219C00005, awarded to Tetra Tech ARD for $22.1 million in September 2019. Additional financing includes $1.1 million through performance-based grants for the cleaner cooking sector and €6.26 million from the Irish Embassy's Green Economic Transition Facility.

Results

The program has achieved several significant outcomes in its initial implementation period:

- Increased urban household adoption of LPG from 2.1% to 6.1% between 2020-2022
- Expanded the number of licensed sustainable charcoal producers to ten
- Established consumer financing partnerships with major employers like the National Organization of Nurses and Midwives
- Developed and implemented the Charcoal Valuation Technical Order to standardize sustainable production
- Created two dedicated working groups under the National Cookstove Steering Committee focused on charcoal alternatives and LPG adoption

Future Plans

MCHF funding from USAID was cut in February 2025 and the current future of MCHF is uncertain.

Focus Areas

The program concentrates efforts in five key areas:

- Urban and peri-urban clean cooking adoption
- Sustainable charcoal production and commercialization
- Market system development and financing
- Policy and regulatory framework enhancement
- Forest conservation through improved energy access

Main Donors

The program receives primary funding from USAID, FCDO and the Irish Embassy (through the Green Economic Transition Facility).

Lessons Learned

RBF

Companies receiving RBF as part of the MCHF grant initiatives have experienced working capital deficits due to the gap between milestones and cash disbursement. Some participants have even reported negative net income over the 2022-2023 financial year due to over extensive marketing and growth targets *[MCHF]*.

Data Collection

The MCHF program has been built on systematic data collection, starting with the 2018 USAID-PERFORM Wood Fuel Supply and Demand Analysis which first demonstrated that Malawi would face a national wood fuel deficit by the following year (MCHF 2024). Building on this, MCHF then conducted biennial Urban Cooking Consumer Market Research in 2020 and 2022, which provided statistically significant data showing increases in urban household LPG adoption alongside decreases in illegal charcoal use. The research helped quantify not only fuel usage patterns but also how economically disadvantaged households pay 30-50% more for charcoal due to purchasing in smaller quantities.

Building upon these insights, MCHF has also been able to bring in other NGOs and partners to invest in the sector. They have injected $1.1m into the cleaner cooking sector to date through performance-based grants while simultaneously working to improve forest management, support sustainable enterprises, and strengthen regulations. This has helped attract other donors, e.g. the Irish Embassy's setting up of the €6.26M Green Economic Transition Facility specifically designed to scale up alternatives to illegal charcoal.

4.6.3.2 Self Help Africa (SHA) (Self Help Africa 2024; 2023)

Programs on Clean Cooking and Energy Access

Rural Energy Access through Social Enterprise and Decentralisation (EASE): This program is a collaboration between Self Help Africa, the University of Strathclyde, Community Energy Malawi, and WASHTED, funded by the Scottish Government. It aims to combat energy poverty through infrastructure development and capacity building.

Livelihoods Chitetezo Project: Operating in Zomba and Machinga regions, this project integrates clean cooking and water access initiatives.

EnDev - Chitetezo Mbaula Commercialization: This initiative focuses on the commercialization of the Chitetezo Mbaula improved cookstove in Southern Malawi.

Financing Size

Undisclosed finances for individual programs in Malawi. Total SHA funding from Irish Aid in 2023 was disclosed at 4,900,000 EUR representing 11% of funds – this places total funding at ca. 45m EUR.

Results

EASE:

- Established Malawi's first District Energy officers to promote renewable energy.
- Implemented solar PV microgrids and energy hubs, reaching 10,000 households.

Livelihoods Chitetezo Project

- Generated over 1 million carbon credits.

- Created economic opportunities through production groups and sales agents, alleviating the burden of fuel collection for households.

EnDev - Chitetezo Mbaula Commercialization:

- Sold 120,000 stoves, transitioning the market from pre-commercial to pioneering phases
- Implemented quality assurance, distribution infrastructure, and market development strategies

Future Plans

The organization's future strategy emphasizes sustainable energy development through market-based approaches. Their plans include expanding the Rural Energy Access through Social Enterprise and Decentralisation (EASE) program, which has already reached 10,000 households. The strategy focuses on deploying appropriate renewable energy infrastructure and establishing sustainable business models. A key innovation has been the placement of Malawi's first District Energy officers in Dedza and Balaka, creating a framework for local energy planning and implementation that can be replicated in other districts.

Focus Areas

The energy access programs concentrate on three main areas of intervention. First, the deployment of solar PV microgrids and energy hubs in rural communities, particularly in Dedza and Balaka districts. Second, the commercialization of improved cookstoves through the Chitetezo Mbaula initiative, which strengthens market systems and supply chains. Third, the integration of renewable energy with productive use applications, supporting local enterprises and agricultural activities.

Main Donors

The energy programs benefit from diverse funding sources, with the Scottish Government serving as the primary funder for the EASE project. The European Union has provided significant support through the EnDev program, particularly for the cookstove initiatives. Additional funding comes through partnerships with organizations such as Irish Aid, GEAPP, and various international development agencies.

Lessons Learned

Companies participating in SHA programs have significant operational limitations due to insufficient cookstove distribution networks, especially North of Kasungu.

From SHA's experience, there is also an abundance of lower tier cookstoves being distributed, and programmes focusing on higher tier cookstoves are rare. Furthermore, SHS have found that carbon credit initiatives for local companies are not feasible due to the lack of tracking and documentation. Field assessments and programs have shown an absence of customer documentation systems and tracking software, creating data gaps *[SHA, NCSC]*.

4.6.3.3 GIZ EnDev (EnDev 2024; 2019; 2023; 2024)

Programs

GIZ EnDev has implemented several key programs in Malawi aimed at improving energy access and promoting sustainable energy solutions. Main initiatives include:

Improved Cookstoves (ICS) and Thermal Energy

EnDev Malawi strengthens the market for improved cookstoves through comprehensive business development support to private enterprises. Key initiatives include:

- Distribution of Chitetezo Mbaula cookstoves to reduce wood consumption and indoor air pollution
- Promotion of specialized stoves including:
    - Chitofu 3-in-1 for smoking, frying, and parboiling fish
    - Mayankho and Rocket stoves for social institutions and schools
- Development of fuel-efficient fish processing cookstoves for fishing communities

Solar Energy Access

This component focuses on expanding solar energy access through:

- Distribution of Pico PV and Solar Home Systems for off-grid households
- Business development support for solar product retailers, including:
    - Technical and marketing proficiency training
    - Policy advocacy for improved market conditions
    - Strategic support to grow small and medium-sized enterprises

Productive Use of Energy (PUE)

Supported by European Union co-funding, this component employs market-based approaches through:

- Demand-side interventions to increase awareness of PUE technologies
- Supply-side support using:
    - Business Development Services (BDS)
    - RBF mechanisms
- Targeted support for MSMEs in rural commercial and agricultural sectors
- Partnership with Global Energy Alliance for People and Planet to implement the Ag-Energy initiative, providing solar solutions for rural farmers and farmer groups

Healthcare Energy Solutions

Originally launched as part of the BMZ COVID-19 response, this component includes:

- Solar power system installation for health facilities
- Provision of solar-powered refrigerators for vaccine storage
- Implementation of cooking shelters at health facilities

EnergIce Component

Co-financed by the Icelandic embassy, this component focuses on:

- Thermal energy solutions for social institutions
- Solar electrification of schools and health facilities
- System maintenance and operational support

- Integration with fishing community initiatives through efficient fish processing technologies

Financing Size

The total budget allocated for EnDev's activities in Malawi is approximately EUR 26,386,000 from 12/2012 to 12/2024.

4,900,000 EUR of this comes from a 20,000,000 EUR envelope that has been allocated across Liberia, Malawi, Niger and Uganda to support demand-side subsidies for off-grid solar products and./or cooking technologies. This program is scheduled to end September 2025 and is cofinanced by Directorate-General for International Cooperation (DGIS) of the Netherlands Ministry of Foreign Affairs.

This funding supports various projects aimed at enhancing energy access and promoting sustainable energy solutions (EnDev, 2024).

Results

Expected households to be reached from the program is 2,178,000. Current status is undisclosed.

Future Plans

EnDev has outlined ambitious expansion plans for its Malawi operations, focusing on strengthening the distribution networks for improved cookstoves and solar home systems. The organization is actively developing deeper partnerships with local government bodies and private sector entities to create sustainable energy solutions. A key component of this growth strategy involves implementing innovative financing mechanisms specifically designed to accelerate the adoption of clean cooking technologies across the region – an RBF window is planning to open for electric cookstove and pellet stove companies.

Focus Areas

The organization's commitment to inclusive development is reflected in three core focus areas. Through its Leave No One Behind initiative, EnDev ensures energy solutions reach marginalized and low-income households, while its gender equality program actively supports women's empowerment through targeted initiatives and support for female-led organizations. The organization has also prioritized the enhancement of energy access in health facilities and educational institutions, recognizing the critical role reliable power plays in service delivery.

Main Donors

EnDev's programs in Malawi benefit from a robust donor network led by Germany's Federal Ministry for Economic Cooperation and Development (BMZ) and the UK's Foreign, Commonwealth & Development Office (FCDO). Additional financial support comes from international partners including the Global Energy Alliance for People and Planet, the European Union, and the IKEA Foundation, creating a diverse funding base that enables comprehensive program implementation.

Lessons Learned

GIZ/EnDev successfully integrated their cookstove program with Malawi's Social Cash Transfer Programme (SCTP) to reach the ultra-poor. They distributed vouchers to 130,000 of the most vulnerable households to receive free improved cookstoves. This enabled direct access to cleaner cooking for the most vulnerable, created awareness of cleaner cooking technologies, and has helped catalyse the broader market.

While this approach successfully reached vulnerable populations and created some market awareness, the 2021 Report notes that market-based approaches have limitations in contexts like Malawi where:

- Willingness to pay remains low even with relatively low stove prices
- Free firewood availability reduces the economic incentive to purchase efficient stoves
- Very poor economic conditions mean many households cannot afford market prices

While RBF and market approaches can help develop the cookstove sector, reaching the poorest may require alternative non-market-based approaches that embrace "leave-no-one-behind" principles. This suggests a hybrid model may be needed combining market development with targeted subsidies for the most vulnerable.

Furthermore, it is important to plan the exit strategy from the beginning, especially for RBF, to work towards sustainable retail prices.

4.6.4 Carbon Credits

The World Bank has had multiple projects promoting the use of carbon finance across multiple countries. As part of this research, we have identified two key engagement pathways: one national and one programmatic.

National Pathway

Under the national pathway, the World Bank has operated the Forest Carbon Partnership Facility (FCPF) and the Transformative Carbon Asset Facility (TCAF). In both of these programs, the funding for emissions reductions is contributed directly by the World Bank to the countries where the interventions are made. In 2024, FCPF made payments of over $111m to countries, while Uzbekistan became the first country to receive TCAF payment in June 2024, totaling $7.5m (Padin-Dujon 2024; Pandey 2023).

The World Bank has created a place to house the emissions reductions made by countries in the Carbon Assets Tracking System (CATS). This is a registry that enables the Bank to track the emissions issued by countries and any retirements or cancelations made.

Programmatic Pathway

The programmatic way involves World Bank carbon credit-generated projects being certified against international standards. This has the benefit of relying on existing methodologies, and can crowd in more activity from other organizations and private sector actors by providing a blueprint for project implementation. The Energy Access and

Quality Improvement Project (EAQIP) in Rwanda is an example of this programmatic approach.

EAQIP uses the Standardized Crediting Framework (SCF), which is a Rwandan national program, to generate carbon credits for its work in increasing access to off-grid electricity and clean cooking solutions. The SCF is designed to be a simplified replacement for the Clean Development Mechanism. The Carbon Initiative for Development (Ci-Dev) is the intended buyer of the carbon credits generated by the project. The Ci-Dev grant will purchase emission reductions up to $10.5m and potentially an additional $4.4m (Development Bank of Kigali 2021).

The agreement between Ci-Dev and the Rwandan Ministry of Finance and Economic Planning (MINECOFIN) for the sale and purchase of emission reductions mandates a number of subsidiary agreements. The revenue from the sale of emissions reductions is expected to go to the Development Bank of Rwanda (BRD) to replenish the funds used for the government's subsidy RBF mechanism. However, the sources note that the World Bank cannot stipulate or track the use of the funds once they are paid to the Rwandan government.

One concern cited by interviewees has been Ci-Dev's requirement that project developers forego carbon rights and transfer them in direct agreements to the fund. This has prevented certain developers from engaging in the program *[C-Quest Capital; Self Help Africa]*.

4.7 Policy and Regulatory Gap Analysis

4.7.1 Clean Cooking (general)

Gap	Action
Lack of governmental capacity on clean cooking.	Create a government-based Clean Cooking Unit to raise the profile of clean cooking amongst relevant stakeholders. Such an approach has been successfully implemented in Kenya, where the country's clean cooking strategy is overseen by a Technical Working Group who meet regularly and is comprised of representatives from different Ministries, national institutions, development partners and sectoral associations.
No domestic standards for stove testing.	The standards have been drafted and need to be ratified by MBS.
No domestic stove testing facilities.	Create a stove testing facility capable of testing to both national and ISO standards. However, we believe this is low priority compared to other actions given the ease of access to stove testing in neighbouring countries.
No local academic research capacity on clean cooking.	Engage local universities in the World Bank programme. Create partnerships with international institutions who are specialists in clean cooking (University College London, Loughborough University, University of Berkeley, Stockholm Environment Institute etc) to transfer knowledge and capacity.
Local companies tend to operate informally and at a small scale making it hard for them to compete with international players.	Fund a business incubator programme for local clean cooking companies providing business support and training, with the goal of improving access to funding (carbon credits, RBFs, grants, equity, debt etc).

Gap	Action
Lack of clear clean cooking strategy and roadmap across all technologies (not just Electric cooking).	Support government to create integrated clean cooking strategy and roadmap that covers all fuels and technologies. Malawi's National Energy Compact sets out the following targets: 100,000 urban and 490,000 rural households annually, distributing 146,000 advanced woodstoves each year alongside 117,000 LPG cookstoves, 53,000 electric cookstoves, 80,000 biogas cookstoves and 40,000 ethanol/paraffin-based cookstoves annually. From analysis in 3.1.4 and 3.1.3, ethanol cookstove targets are not relevant and biogas will be extremely hard due to high upfront CAPEX for households. These targets must be revised.
No regular and robust framework in place to monitor progress against clean cooking targets	Fund regular (annual) data collection to monitor clean cooking progress. This could be done relatively cheaply through a remotely administered SMS or USSD code survey, or more thoroughly through the MTF methodology.

4.7.2 Clean Cooking (technology-specific)

Technology	Gap	Action
LPG	Lack of ratified standards.	The standards have been drafted and need to be ratified by MBS. Create plan and dedicate resources for effective enforcement of standards.

Technology	Gap	Action
LPG	Partial and cross filling are common practices, which risks undermining the safety of Malawi's LPG sector.	Introduce regulations to implement a Branded Cylinder Recirculation Model (BCRM).
LPG	MERA controls the maximum retail price of LPG in Malawi. There is no set frequency on the adjustment of retail price. This limits margins for retailers and can create cashflow deficits as companies wait for reimbursement from the price adjustment fund. It also restricts access to the rural areas because of the high distribution costs which are not recoverable.	Remove price regulation policy, or consider regional pricing in order to incentivize distribution throughout the country.
LPG	There is currently no regulatory framework in place for LPG.	A Regulatory framework is in draft but can be improved to comply with best practices as detailed in Section 1.2.2.4.
LPG	The LPG market is fragmented but is growing fast. There is a need for better coordination between the different market players, policy makers and regulators.	It is recommended to establish a Malawi LPG Association that represents all the local players. This body would then represent the industry in discussions with government and consumer groups. A guide to establish such as Association has been produced by the WLGA (Good Industry Practice Guide to LPG Associations - World Liquid Gas (WLGA)).
Electric cooking	High prices of Electric cooking appliances are exacerbated by the lack of tax incentives (including 37% add-on taxes and duties).	Abolish customs duty on Electric cooking devices.
Electric cooking	Lack of Electric cooking efficiency standards.	The standards are in development. Provision of additional support could accelerate this process.

Technology	Gap	Action
Electric cooking	Lack of effective eWaste management.	The Malawi Communications Regulatory Authority (MACRA) and the Environmental Affairs Department (EAD), among other stakeholders, are actively assessing the e-waste situation and are developing recommendations for effective interventions. Provision of additional support could accelerate this process.

4.7.3 Carbon Finance

Gap	Suggested Actions
High upfront costs and technical capacity gaps make carbon finance inaccessible to local companies.	Create locally based carbon developers or provide technical assistance to local companies.
The absence of a robust domestic carbon credit infrastructure limits the country's ability to scale such projects and fully benefit from Article 6 mechanisms under the Paris Agreement. This is enhanced by limited coordination between relevant parties e.g. the ministries responsible for climate change, energy, forestry, and environmental management	Provide technical assistance to support the development of a comprehensive and standardised carbon market framework for Malawi to support both voluntary and compliance-driven markets. Develop a dedicated unit within the Ministry of Natural Resources and Climate Change to manage and support carbon market initiatives. This unit will oversee project registration, carbon credit certification, and the maintenance of a national carbon market registry, creating a centralized body to streamline Malawi's carbon market operations.

Gap	Suggested Actions
Malawi faces institutional capacity constraints in managing and verifying carbon credits, particularly within Article 6.2 frameworks. Insufficient local expertise in Monitoring, Reporting, and Verification (MRV) compels reliance on international standards, increasing costs and prolonging timelines for certification, which impacts smaller projects, such as clean cooking.	Strengthening local MRV capacity is essential for Malawi to independently certify emissions reductions, produce credible ITMOs, and participate effectively in global carbon markets. Training officials in carbon project development and MRV would reduce dependency on external validation, improve project approval efficiency, and strengthen Malawi's capacity to generate ITMOs. Regular monitoring of cookstove performance, emissions reductions, and adoption rates will ensure that initiatives remain aligned with national climate goals. Reliable data collection and analysis are critical for reporting emissions reductions under Article 6 and verifying carbon credits.
Malawi lacks a digitised national greenhouse gases inventory and a comprehensive carbon registry to track project transactions.	Support the creation of a digitised GHG inventory to improve data collection, emissions reporting, and transparency, making Malawi more attractive to investors. By implementing these digital tools, Malawi could align with international standards, increasing the credibility of its emissions reductions and building the infrastructure necessary for generating ITMOs.
Malawi requires considerable financial support to meet its climate and sustainable development goals. Carbon finance could help fill this gap.	Explore bilateral agreements with carbon credit buyers under Article 6, establishing transparent pricing and revenue-sharing models to make Malawi an appealing partner. Implement a fee structure to fund sustainable development goals, support NDC targets, and strengthen Malawi's carbon market. Establishing corresponding adjustment fees will help mitigate overselling risk, ensuring project longevity. Examples of fee structures from other countries are provided in Appendix 2.

Policy and Regulatory Environment Assessment – Program Key Recommendations

- Leverage COP29's Article 6.4 framework approval to develop high-integrity carbon projects that can generate substantial financial resources for clean cooking initiatives
- Establish registry and reporting system for clean cooking carbon projects
- Establish more bilateral agreements under Article 6
- Coordinate with the MCMI to integrate clean cooking into national carbon strategies, facilitating access to international carbon markets.
- Draft LPG standards and certification requirements to address safety concerns and improve supply chain reliability
- Support the Branded Cylinder Recirculation Model for LPG distribution to ensure cylinder safety and quality, phasing out partial filling practices
- Establish Clean Cooking Unit in MOE to focus National Energy Compact targets to increase clean cooking access from 24.5% to 75% of households by 2030
- Support updated clean cooking policies with updated and realistic technology-level targets

TA Required

- Develop and improve LPG safety standards, regulations and certification
- Establish a dedicated Clean Cooking Unit within government to raise the profile of clean cooking among ministries, coordinate cross-sectoral implementation, monitor supply chain feasibility and advocate for updated policy targets
- Develop comprehensive carbon market framework with mandates for carbon activities, including process and reporting system for clean cooking carbon projects
- Technical support for SMEs – cookstove standards, testing, business development and carbon finance

5 Design of the Intervention Strategy

The proposed intervention strategy looks to support the GOM and establish a sustainable framework for developing Tier 4+ modern cooking market by addressing supply constraints, stimulating consumer demand, and mitigating key risks within Malawi's carbon market.

5.1 Program Design

The program will allocate US$10 million as a grant to the GOM, via the MOF, to expand clean cooking solutions in Malawi, targeting 150,000 households with Tier 4+ technologies including electric cooking, LPG, pellet stoves, biogas, ethanol and briquettes.

US$7 million is earmarked for a clean cooking loan facility. Instead of repayment in cash, the debt service will be covered by NNNF aggregating carbon credits from POs and selling these credits. After covering debt service and transaction fees, surplus carbon revenues will be returned by NNNF to POs after 5 years.

The initiative will leverage carbon finance to help POs scale operations, with total estimated CAPEX greater than the total facility - US$9.06 million. Conversely, if carbon revenues are insufficient to cover the outstanding loans, they will be converted into grants.

US$3 million is earmarked for technical assistance that will support revision of the national roadmaps and policies around clean cooking and carbon policy.

Implementation will be managed by the MOE through a new dedicated clean cooking window incorporated within the existing NNNF.

5.2 Targets and Impact

The program aims to deploy Tier 4+ cooking solutions to approximately 150,000 households before 2030.

The carbon revenues resulting from sales of the carbon credits from the program are expected to cover repayment of the interest and principal of the facility, with any excess revenues shared with companies. The aim of this structure is to encourage financial sustainability for the facility and expand the program’s reach beyond initial targets.

Short-term Targets (1 year):

- Transition greater than or equal to 10% of target households from sub-Tier 4 (ie traditional) cooking solutions to Tier 4+ cooking solutions (ie electric cookstoves and LPG stoves)
- Target urban and peri-urban areas surrounding Lilongwe and Blantyre; until supply-chain infrastructure for electricity and other fuels is constructed in other regions
- Establish a dedicated clean cooking loan window under the NNNF
- Launch technical assistance procurements:

- Carbon Policy Framework Development
- LPG Development Study - Safety Standards, Regulation and Policy, Supply Chain
- IVA for clean cooking
- Public Awareness and Behavior Campaign
- Market Facilitator for Clean Cooking Technologies
- Revision of National Clean Cooking Strategy & Investment Prospectus, including strengthening the GOM capacity to draft and ratify cookstove standards, safety standards and Tier 4+ policies
- Technical Support for SMEs - Cookstove Standards, Testing, Business Development
- Sample Residential Electricity Metering Program - assessing localized demand for a sample of urban households

Program Targets until 2030 (5 years):

- Transition 150,000 households from sub-tier 4 to Tier 4+ modern cooking solutions
- Focus on urban areas, where charcoal use is most prevalent
- Primary target regions are Lilongwe and Blantyre, continue to assess POs target in GSA applications households supply-chain infrastructure for electricity and other fuels
- Support the Government of Malawi and the relevant departments in developing and operating robust carbon frameworks for project registration, emissions tracking, and third-party verification
- Generate revenues from the resulting carbon credits to achieve financial sustainability and expand the program beyond its initial targets

Long-term Targets (beyond 5 years):

- Continue to support the Malawi National Energy Compact
- Expand target regions beyond Lilongwe and Blantyre, assess POs target households supply-chain infrastructure for electricity and other fuels
- Maximize the value of carbon credits by securing new bilateral agreements under Article 6 with countries like Singapore and Sweden
- Expand the clean cooking program to rural areas, leveraging synergies with off-grid electrification efforts
- Strengthen and expand the fuel supply chains for Tier 4+ solutions, focusing on electrification

5.3 Programs in Other Countries

As part of its assessment, the team has reviewed programs in other countries to incorporate best practices into the design of the program for Malawi.

5.3.1.1 Rwanda

In Rwanda, the Energy Access and Quality Improvement Project (EAQIP) clean cooking component is focusing on transitioning households from traditional biomass fuels to cleaner alternatives. The program is supported by various funding sources, including IDA and ESMAP CCF.

- US$17 million (US$10M from IDA, US$7M from ESMAP Clean Cooking Fund (CCF))
- 160,000 households

The program provides RBF subsidies to incentivize clean cooking companies to deliver Improved cookstoves, LPG or electric cooking solutions.to households. This includes financial support for the installation of clean cooking technologies.

The RBF instrument in the Rwanda EAQIP project makes payment against certified emission reductions (CER) resulting from the sustainable dissemination clean cookstoves. These carbon revenues from Ci-Dev can provide additional revenue streams for clean cooking interventions.

Technical assistance

- Policy and coordinated oversight for clean cooking technologies, aligning initiatives with national energy strategies
- Management of the Branded Cylinder Recirculation Model and
- Business development training for clean cooking enterprises, focusing on developing scalable business plans, expanding market reach and building technological capabilities
- Consumer engagement via awareness campaigns to highlight benefits, address adoption barriers and implement strategic behavior change communication
- Monitoring and evaluation, developing comprehensive tracking frameworks for installation impacts and KPIs

Implementation

- Rwanda Development Bank (BRD) is the main implementer of the clean cooking component.
- The Rwanda Development Bank (BRD) has signed Grant Subsidiary Agreements (GSAs) with 19 clean cooking companies that have registered about 160,000 clean cooking installations
- As part of the agreement when accepting RBF grants, private companies are required to transfer ownership of their carbon credits to BRD

5.3.1.2 Ghana

Ghana Energy Sector Recovery Program's clean cooking component – heavily focused on LPG - allocated IDA and ESMAP CCF funding towards transitioning households from charcoal and firewood.

Titled the National LPG Promotion Programme (NLPGPP), it was launched in 2022 and the program's first phase covered in this World Bank financing runs from 2024-2027, as part of the broader NLPGPP that extends to 2030. Program highlights:

- US$17 million total (US$10M IDA + US$7M ESMAP CCF)
- 457,000 beneficiary units (450,000 households + 7,000 commercial/institutional)

The program targeted households transitioning from biomass fuels, commercial caterers (6,739) and secondary schools (261).

Activities include direct incentives for clean cooking companies as a 70% subsidy RBF grant for LPG stove packs (stove, regulator, hose, clips, fire blanket), focusing on areas with CRM implementation or guaranteed LPG supply plus technical assistance for policy development and sector coordination.

Technical assistance

- Support for policy development and sector coordination, including oversight of the National LPG Promotion Programme and management of the Cylinder Recirculation Model rollout
- Business development services for clean cooking enterprises
- Consumer education and behaviour change campaigns
- M&E and data collection
- ISO certification for testing laboratory

Implementation

- Ministry of Energy leads implementation through PCU
- National Steering Committee provides coordination and project management
- Independent verification by Kintampo Health Research Centre (KHRC). KHRC is supported by UNICEF Ghana and is an African-based research organisation.
- Coordination with National LPG Promotion Programme and Cylinder Recirculation Model

5.3.1.3 Niger

Similarly, the Niger Haské project designed an RBF window specifically to support and strengthen the clean cooking market. Program highlights:

- US$15 million (US$7.5M IDA, US$7.5M ESMAP MDTF)
- 550,000 households (3.3 million people) – 60,000 Tier 4+

The project targets three user segments: market-purchased traditional fuel users (charcoal and firewood), rural households collecting fuel and LPG users.

Activities include strengthening existing cookstove enterprises, supporting self-built clay stoves in rural areas and expanding LPG access through subsidies and technical assistance.

Specific targets include transitioning 490,000 households to improved biomass stoves (Tiers 2-3) and 60,000 households to LPG (Tier 4+). Expected outcomes include reducing CO2 emissions by 1.4 million tons, decreasing wood consumption by 2.3 million tons, and saving households US$10-65 annually. At least 20% of funds will target women-led enterprises, and 25% will support refugees and host communities (110,000 households).

Technical assistance

- Stakeholder capacity along the value chain, with emphasis on government regulation
- Technical assistance for each market segment: improving stove designs and training producers for market-based biomass users, optimizing LPG distribution and quality control systems and providing training for rural clay stove construction
- Business model development will explore financing options beyond cash sales

Implementation

- The Directorate for Renewable Energy and Cooking Energies (DEREC) manages technical activities for clean cooking – division within Ministry of Petroleum, Energy and Renewable Energy
- National Agency of Solar Energy of Niger (ANERSOL) provides fiduciary support
- A fund manager and verification agent hired to administer RBF grants and subsidies

5.3.1.4 Uganda

In Uganda a Tier 4+ clean cooking intervention program was approved in 2022, supporting LPG, Electricity, Ethanol, Biogas and Briquettes. Program highlights:

- US$18.5 million (US$13.5M IDA, US$5M from private sector investments)
- Additional facility of US$107 million IDA WHR (Window for Host Communities and Refugees) open to clean cooking
- 300,000 households (1.6 million people)

The Uganda Energy Access Scale-up Project (EASP) targets three key segments: households currently using biomass fuels, public institutions including schools and health centers, and communities in refugee-hosting districts.

Through the Uganda Energy Credit Capitalization Company (UECCC), the program extends working capital through participating financial institutions (PFIs) including commercial banks, SACCOs, and microfinance institutions to support the clean cooking transition.

To facilitate market development, EASP provides multiple financing mechanisms: (i) Working capital debt finance supports clean cooking SMEs, (ii) consumer credit through microfinance institutions helps make solutions more affordable for end users ,(iv) RBF

grants from ESMAP CCF incentivize SMEs to enter and scale in challenging markets, (v) the Contingent Risk Guarantee facility through the Clean Technology Fund, which helps de-risk lending for PFIs by reducing their exposure when financing private companies.

Table 40: Assumption for Costs for Key Clean Cooking Technologies in Kampala from EASP PAD (2022)

Technology	Purchase Unit	One-off costs (US$)	Usage (years)
Improved Household Cooking Stoves to use woody biomass charcoal, briquettes	Twin stoves cooking stoves with capacity range of (5 to 15 liters)	20 – 50	5
LPG	Cylinders for household of 12.5 kg	54 for cylinder 40 for burners	10
Household biogas systems	For utilization of domestic waste including animal waste and other biodegradables to generate gas for cooking	2,000 – 5,000	20
Ethanol stoves for cooking	Double burner stoves	100 – 150	3
Electric cookers	-	100 – 1,000	5

Technical assistance

- Policy development and standards improvement
- Market intelligence and business development support
- Consumer awareness campaigns
- Gender-focused entrepreneurship training
- Institutional capacity building

Implementation

- UECCC disbursed all funds
- Ministry of Energy and Mineral Development (MEMD), Private Sector Foundation Uganda (PSFU) identified institutions, classified technology providers and approved disbursement of funds on installation of the systems
- Financing through participating financial institutions
- Independent verification of results
- Coordination with refugee response agencies

5.3.1 Case Studies in Off-Grid Electrification and Electric Cooking Programs

The integration of off-grid electrification solutions with electric cooking, particularly mini-grids and SHS, is limited but has been piloted by MECS in Haiti, Kenya, Tanzania and Nepal.

Strategic planning for electric cooking during the design phase of mini-grids can lead to higher revenue generation for infrastructure investments and improved load management. Anticipating additional demand from electric cooking helps mini-grid

developers appropriately size generation and storage capacities, thereby reducing the need for costly retrofits and ensuring efficient energy distribution.

5.3.1.1 Haiti, EarthSpark International

In 2020, EarthSpark International integrated EPCs into 2 solar mini-grids in Haiti for 20 households. There were several instances where the totalizer meter for the subnetwork was forced into 'Protect' mode, causing immediate blackouts in sections where cooking participants were cooking at the same time. In general however the project has been a success with 10% of Earthspark customers in Haiti are now electric cooking users. [10]

5.3.1.2 Kenya, Kenya Power

The Oloika mini-grid in Kajiado County, Kenya, installed in 2015, is a 13.5kWp PV system with 38.4kWh battery storage run by a cooperative with support from Kenya Power (KPLC). From EPC introduction, grid demand grew from 10kWh/day to over 28kWh/day.[11]

5.3.1.3 Nepal, NAMHUS

The National Micro and Mini Hydropower Users Society (NAMHUS) in Nepal is working to enable electric cooking in the Jhumsa Khola Micro Hydro Project. This 68kW community-owned micro-hydro power plant serves 503 consumers in the Palpa District of Gandaki Province. While initially developed for basic energy access, the project has struggled with financial sustainability. NAMHUS aims to improve this by increasing demand through electric cooking. The project scheduled end date is October 2025.[12]

5.3.1.4 Tanzania, PowerGen

PowerGen deployed EPCs in rural microgrid communities in Tanzania's Singida region. PowerGen introduced EPCs on 8 Tanzanian mini-grids, with 6 participating in a focused study. The mini-grids, primarily solar PV with battery storage and backup generators, range from 6 kW to 25 kW peak capacity, serving communities of 100 to 350 connections.

In-person training and financing options were crucial to customer adoption. Service areas were selected specifically because they had lower electricity rates that made the EPCs cost-competitive with charcoal.

Within the first four months of the pilot, customers at 2 sites increased their electricity consumption by 19.5% after adopting EPCs. The EPCs were well-received for their time-saving benefits and plug-and-play compatibility with existing infrastructure.[13]

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[10] Electric cooking can improve health, reduce climate impacts, and boost business models for universal electrification. (2020). EarthSpark International. https://www.earthsparkinternational.org/clean-cooking.html

[11] MECS Cooking Support on Mini-Grids (COSMO) challenge fund - Modern Energy Cooking Services. (2025, January 21). Modern Energy Cooking Services. https://mecs.org.uk/challenge-fund/current-funds/mecs-cooking-support-on-mini-grids-cosmo/

[12] National Micro and Small Hydropower Users Society Nepal. (2024). National Micro and Small Hydropower Users Society Nepal. https://namhus.org/ongoing-project

[13] MECS-TRIID Project Report (public version) Accelerating uptake of electric cooking on AC microgrids through business and delivery model innovations. (2020). https://mecs.org.uk/wp-content/uploads/2020/12/MECS-TRIID-PowerGen-Project-Report.pdf

5.3.1.5 Malawi, Kachione

Kachione LLC produced and distributed 65 Solar Home Systems with Insulated Solar Electric Cookers (SHSw/ISECs) to customers throughout the Machinga District of Malawi between June and September 2019.

Field evaluations in Malawi's Machinga District indicated that about 1/3 of customers effectively utilized the ISEC technology even during the rainy season. Customers primarily used the system for heating water rather than cooking full meals and the system provided approximately 10-30% of household cooking energy needs. User patterns followed a log-normal distribution, with some households being much more efficient users than others.

5.4 Investment Plan for Malawi

The core objective of the investment plan is to transition the maximum number of households from firewood and charcoal to Tier 4+ modern cooking solutions, simultaneously building a sustainable clean cooking market framework for the public and private sector.

5.4.1 Clean Cooking Business Models

In Malawi's existing clean cooking sector, a few key players operate across different technology segments:

Table 41: Business models by clean cooking company in Malawi

Technology Type	Company/Provider	Business Model
LPG distributors	265 Energy Delta Energy Falcon Gas Green Impact Technologies (GIT) Mount Meru EGA	Standard retail model
	Vitalite	PAYG model (pilot phase)
Electric cooking (grid-connected)	UP Energy	PAYG model
	BURN Manufacturing	PAYG model
	ATEC	PAYG model
	EGA	Standard retail model
Electric cooking (off-grid)	Kachione	PAYG model for solar-powered EPCs and hotplates
	MEGA project	PAYG model for solar-powered EPCs and hotplates
Biogas	EcoGen	Payment in installments
Pellets	Supamoto	Combined door-to-door distribution and retail
	EGA	Combined door-to-door distribution and retail
	Zipolopolo	Combined door-to-door distribution and retail

5.4.2 Program Partners

5.4.2.1 Local Banks and Financing Institutions

- Standard Bank Malawi
- National Bank of Malawi
- CDH Investment Bank
- FDH Bank
- First Capital Bank Malawi Limited
- NBS Bank

- Centenary Bank Malawi
- Ecobank Malawi

These local financial institutions are used by local clean companies for accounts.

Microfinancing for Companies

Local banks can develop specialized microfinancing products tailored to clean cooking companies' needs, particularly focusing on inventory financing and distribution support. The success of Standard Bank Malawi's partnership with 265 Energy demonstrates how banks can effectively structure consumer financing options for premium products like full solar home systems. Standard Bank Malawi offers a simplified application process for the financing, with a maximum repayment period of up to 5 years, a negotiable interest rate and using the solar home system assets as collateral.

This model could be expanded to Private Sector/Civil Society organizations, enabling them to reach more customers with higher-value cooking solutions.

Working Capital Solutions

Local banks can provide working capital solutions to POs that address the specific cash flow challenges faced. For banks with sufficient liquidity, they can help finance operating expenditure via working capital loans to cover the gap between when suppliers are paid to when cash reaches the PO account. The NNNF could provide transaction support to facilitate these agreements if a PO is facing a working capital deficit.

These financial products can help POs manage inventory cycles, support marketing/distribution and maintain consistent operations between carbon credit issuances. However, these solutions tend to be very expensive for the PO and do not necessarily work with transactions requiring foreign exchange.

5.4.2.2 Co-Financing and Parallel Financing Options

High Likelihood: based on discussions with county representatives and ongoing public procurement announcements

- OFID
- Swiss Klik Foundation[14]
- AfDB

Low Likelihood: based on discussions with county representatives and ongoing public procurement announcements

- UKAid / MECS
- GIZ Energizing Development (EnDev)
- Green Economic Transition Facility (GETF)
- Irish Embassy
- Modern Clean Cooking Facility for Africa (MCFA)
- Norwegian Agency for Development Cooperation (Norad)
- Islamic Development Bank (IDB)
- Asian Development Bank (ADB)

[14] Swiss Klik Foundation provide secured offtake agreements for carbon credits. Unlike other institutions in 5.4.2.2, they do not provide development funding.

- British International Investment (BII)

Unknown

- Osprey Foundation
- Ministry of Foreign Affairs of the Netherlands

Large Scale Upstream Support

AfDB's $2 billion commitment to funding clean cooking solutions in Africa (African Development Bank Group, 2024) represents a significant opportunity for upstream market development.

Their current tendering for technical assistance in Malawi, opened in October 2024, could help strengthen the enabling environment and support market research.

RBF

The Modern Cooking Facility for Africa's (MCFA) EUR 16 million RBF grant window, with ticket sizes between EUR 500,000 to 2.5m, while currently closed, provides a model for results-based support that could be replicated or expanded(*Apply for Funding - Modern Cooking Facility for Africa*, n.d.).

This complements EnDev's planned Africa-wide SME support program from 2027, alongside the ~200,000 EUR RBF Grant facility for Electric cooking and Pellets, will help build business capabilities among clean cooking enterprises.

MCHF previously ran a program called MCHF Accelerator, which provided PBF to clean cooking companies.

Direct Financial Support and Co-Financing

GETF's combination of matching grants up to $300,000 and technical assistance presents an immediate opportunity for parallel financing (Green Economic Transition Facility | Sustainable Energy Solutions in Malawi | Home, 2024).

The OFID's significant commitment of $20-30 million for institutional cooking, along with their current suggestions to provide $2-3 million in grants, could substantially expand the program's reach (Boudaoui, 2024).

Irish Aid financially supports GETF and may indicate potential for additional funding streams for future programs. This study was unable to contact Irish Aid directly.

The Osprey Foundation's existing partnerships with organizations like the Clean Cooking Alliance and BURN will work to support market development through strategic partnerships. This study was unable to contact Osprey Foundation to understand if they are open to funding partnerships.

Technical Assistance and Capacity Building

The MECS program has expertise in modern energy cooking solutions that could support technology validation and market research, alongside strong connections with UK Aid, raising £44 million of UK Aid funding recently (£44 Million Government Funding Boost Will Help Give 10 Million People Access to Clean Cooking | News and Events | Loughborough University, November 2024). The Ministry of Foreign Affairs of the Netherlands and

NORAD could potentially provide technical assistance and knowledge sharing based on their experience in similar markets.

5.4.2.3 Carbon Markets

Recommendation for NNNF Clean Cooking Window Engagement with the VCM"

Implementation of the NNNF Clean Cooking Window should seek to engage reputable voluntary carbon market participants, such as carbon credit brokers, exchanges and data pricing platforms, for the following purposes:

- Assess optimal market rates and trends through forward contracts, spot sales, or auction mechanisms. Brokers and exchanges include Gold Standard Marketplace, Verra Registry, Xpansiv CBL, or Climate Impact X among others.
- Adopt best practices of methodologies from recognized carbon standards (eg. Gold Standard, Verra VCS, CDM, protocols under Article 6.2 and Article 6.4 to align with frontier digital Monitoring, Reporting and Verification (dMRV) solutions to track stove usage and emission reductions, while streamline and support domestic third-party validation and verification bodies (VVBs) to meet buyer requirements.
- Engage institutional buyers: corporates, airlines, financial institutions seeking long-term offtake agreements for revenue stability of carbon projects.
- Policy Enhancement: Support MOE and MOF in refining clean cooking and carbon market policies.This will include capacity building exercises to train local stakeholders on carbon project development, MRV protocols, and financial management.

Voluntary Carbon Markets

Cookstove companies in Malawi can engage with the VCM through several established pathways. Working with reputable carbon credit brokers and exchanges such as CTX or directly with corporate buyers through platforms like Xpansiv provides access to a diverse pool of potential purchasers. In July 2024, CTX completed the auction of 1.5 million carbon credits, from a project disseminating ‘Chitetezo Mbaula’ cleaner cookstoves. The project, run by Hestian Innovation, received a Letter of Authorisation (LoA) from the Ministry of Natural Resources and Climate Change, which confirmed commitment to leverage 12.5% of total proceeds to support ongoing Environment, Climate and Carbon initiatives (Carbon Trade Exchange). CTX remains engaged in Malawi’s voluntary carbon market.

These platforms require projects to meet rigorous verification standards and demonstrate clear additionality and sustainable development benefits. For clean cooking projects specifically, developers must work with recognized carbon standards like Gold Standard or Verra, to align with approved methodologies while documenting both emissions reductions and social co-benefits, e.g. improved DALYs/health outcomes for women and children.

To strengthen Malawi's position in the VCM, project developers can implement emerging digital Monitoring, Reporting, and Verification (dMRV) technologies, such as Stove Use Monitors (SUMs) and smart meters, which provide more reliable data on cookstove usage and emissions reductions. These technologies, combined with innovative project

structures that integrate clean cooking with sustainable fuel production, can help restore buyer confidence and potentially command premium prices. The implementation of the recently approved Article 6.4 framework from COP29 also presents new opportunities, as buyers have demonstrated willingness to pay premiums of $10 or more above market rates for cookstove credits ($6.15 per tonne for all Tiers) for high-integrity credits that contribute to verifiable sustainable development outcomes (AlliedOffsets Premium Dashboard, 2025).

The voluntary carbon market has various private sector initiatives to define high-integrity. Industry initiatives such as the Integrity Council for the Voluntary Carbon Market (IC-VCM)'s Core Carbon Principles (CCP) labels, ratings from private ratings agencies (BeZero, Sylvera, Calyx and others), and methodology approvals by the Methodology Expert Panel (MEP) in support of the Article 6.4 Supervisory Body in drafting standards which meet criteria of the Paris Agreement Crediting Mechanism (PACM).

Existing Buyers of Carbon Credits in Malawi

The Swiss Klik Foundation plays a role in providing secured carbon credit offtake agreements, which helps derisk investments in the sector. Following approval and awarding of letters of intent and support from Klik and the government, Klik undertakes pre-purchasing agreements for ITMOs at a unit cost of $28 per tonne according to 2023 figures. This could be particularly valuable for the NNNF program, which can ensure project activities are aligned to market best practices of robust carbon accounting and dMRV pre- and post-issuance of carbon credits. Klik Foundation retains the rights of carbon credits as stated within pre-purchase agreements. Similarly, the NNNF will be the owner of credits within its portfolio, procured from clean cooking companies.

Switzerland is the only short-term buyer of ITMOs from Article 6 projects in Malawi, these have come through the buyer entities: Klik Foundation and Swiss FOEN.

First Bilateral Agreement: Klik Foundation & FOEN in Malawi

Since Switzerland's bilateral agreement execution with Malawi in 2022, the Klik Foundation has emerged as a prominent force in the country's carbon market. The Swiss Federal Office for the Environment (FOEN) oversees Switzerland's emissions reduction strategy, which includes certifying carbon credits generated abroad to ensure they meet stringent Swiss standards, and works with Klik to procure these projects. FOEN negotiates and oversees Switzerland's bilateral agreements for carbon credit trading, including the Malawi-Switzerland agreement that Klik operates under.

Demand for ITMOs from Switzerland are driven by the revised CO_2 Act, where fuel importers are also required to offset a portion of greenhouse gas emissions abroad through carbon offset projects. Between 2022 and 2030, approximately 35 million tonnes of CO_2 must be mitigated via international measures.

With an ambitious target of procuring 3-5 million tons of CO_2 credits from carbon projects, the organisation will continue its central role in shaping Malawi's carbon credit landscape. Through Articles 5 and 6 of the Swiss Federal Act on the Reduction of CO_2 Emissions, FOEN provides regulatory guidelines for carbon credit projects, including those in Malawi, that Klik may seek certification for:

- Projects must reduce greenhouse gases, including CO_2 CH_4, N_2O, and fluorinated gases, are eligible for attestations). Fossil fuel projects (e.g. LPG clean cooking programmes) are excluded.
- Conservativeness: Emission reductions must be calculated conservatively
- Permanence: For carbon storage projects, proof of a minimum 30-year storage duration is mandatory
- Start of Implementation: Projects should commence no more than three months prior to application
- Preventing Double Counting: Measures must be in place to prevent the same emission reductions from being used for multiple purposes
- Sustainable Development: Applicant must demonstrate how the project contributes to sustainable development in the host country (i.e. NDC alignment)
- Legal Compliance: All applicable environmental and legal standards must be met

Table 42: FOEN 2025-2030: Spending on procuring ITMOs)

Category	Contractual Expenditure (million CHF)	Attestations Under Contract (million tonnes CO_2)	*Cost per Attestation (CHF/t CO_2)*	Cost per attestation ($/tCO2e)
Programs Transportation	120	0.68	*176*	198
Programs Businesses	395	3.13	*126*	142
Programs Buildings	126	1.09	*116*	130
Programs Agriculture	20	0.14	*145*	163
Projects	147	1.31	*112*	126
Domestic	**808**	**6.35**	***127***	**143**
Abroad	**158**	**5.89**	***27***	**30**

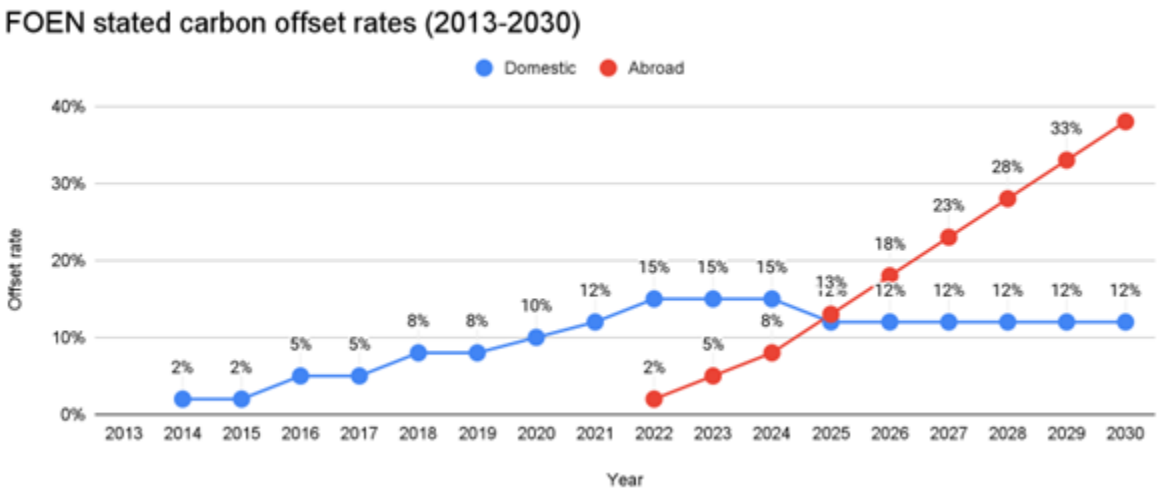


Figure 21: FOEN Stated Carbon Offset Rates until 2030

New Bilateral Agreement Partners (Medium/Long term)

Singapore: From January 2019, Singapore implemented a carbon tax, taxing companies for each ton of CO2 emitted. Effective from January 2024, the carbon tax was raised to S$25/tCO2e (USD 18.63/tCO2e[15]) with and will be raised to S$45/tCO2e (USD 33.54/tCO2e) in 2026 and 2027, with a view to reaching S$50-80/tCO2e (USD 37.27 – USD 59.63/tCO2e) by 2030 .

If Malawi and Singapore sign a bilateral agreement then top buyers are Shell, Chevron, CCP, Changi Airport Group, Asahi Kasei, GlobalFoundries, Veolia as well as a list of exchanges ACX, STX and others.

Sweden: Sweden's carbon tax was introduced in 1991 at a rate corresponding to SEK 250 /tCO2e and has gradually been increased to SEK 1,450 (USD 132.78 /tCO2e) in 2024, for fuels with 100 % fossil content, for example, natural gas or coal[16]. Sweden is another option of a country with whom Malawi could sign a bilateral agreement.

The rising carbon taxes in markets like Singapore and Sweden present compelling opportunities for high-quality carbon offset projects in Malawi. As companies in these jurisdictions face increasing compliance costs - with Singapore's carbon tax set to reach up to USD 59.63/tCO2e by 2030 and Sweden's already at USD 132.78/tCO2e - they have growing incentives to seek cost-effective offset solutions through bilateral arrangements.

Bilateral agreements between Malawi and these nations could create direct pathways for major emitters to purchase high-quality offsets from verified clean cooking projects. For instance, in Singapore, prominent companies like Changi Airport Group could benefit from accessing offsets that typically cost less than their domestic carbon tax obligations.

[15] Last updated Nov 29, 2024, 16:30 UTC 1 SGD = 0.745356 USD, Xe Corporation Inc. (2025). Xe.com
[16] Last updated Nov 29, 2024, 16:30 UTC 1 SGD = 0.0915750 USD, Xe Corporation Inc. (2025). Xe.com

This direct market access would allow Malawi's clean cooking initiatives to command premium prices compared to the VCM.

5.4.2.4 Partner List

The following list is non-exhaustive, but represents a significant portion of the named organisations and actors in both the Malawi clean cooking market, and the broader international clean cooking market in general, focused on those partners that can deliver for the purposes of the program:

Table 43: Partner List

Name	Type	Active in Malawi	Potential
4AIR	Carbon Credit Project Developer	No	Yes
ACT Commodities	Carbon Credit Buyer	No	Uncertain
ACX	Carbon Credit Buyer	No	Yes
Air Liquide	Carbon Credit Buyer	No	Yes
Allcot	Carbon Credit Buyer	No	Yes
Asahi Kasei	Carbon Credit Buyer	No	Uncertain
Asahi Kasei Corporation	Carbon Credit Buyer	No	Uncertain
BeZero	Carbon Credit Rating Agency	Yes	-
Brenntag	Carbon Credit Buyer	No	Uncertain
CCP	Carbon Credit Buyer	No	Uncertain
Changi Airport Group	Carbon Credit Buyer	No	Uncertain
Chevron	Carbon Credit Buyer	No	Uncertain
Climate Impact X	Carbon Credit Buyer	No	Uncertain
ClimatePartner	Carbon Credit Buyer	No	Uncertain
CO2balance	Carbon Credit Buyer	Yes	-
Evonik	Carbon Credit Buyer	No	Uncertain
Evonik Industries	Carbon Credit Buyer	No	Uncertain
Evonik Operations	Carbon Credit Buyer	No	Uncertain
Forliance	Carbon Credit Buyer	No	Uncertain
GenZero	Carbon Credit Buyer	No	Yes
GlobalFoundries	Carbon Credit Buyer	No	Uncertain
Infineon	Carbon Credit Buyer	No	Uncertain
Nedbank	Carbon Credit Buyer	No	Yes
Micron Semiconductor	Carbon Credit Buyer	No	Uncertain
New Forests	Carbon Credit Buyer	No	Uncertain
New Forests Asset Management	Carbon Credit Buyer	No	Uncertain
PacificLight	Carbon Credit Buyer	No	Uncertain
PCS	Carbon Credit Buyer	No	Uncertain
Pollination	Carbon Credit Buyer	No	Uncertain
Removall Carbon	Carbon Credit Buyer	No	Uncertain

Name	Type	Active in Malawi	Potential
Sembcorp	Carbon Credit Buyer	No	Uncertain
Shell	Carbon Credit Buyer	No	Yes
Siltronic	Carbon Credit Buyer	No	Uncertain
Soitec	Carbon Credit Buyer	No	Uncertain
South Pole	Carbon Credit Project Developer	Yes	-
Standard Bank	Carbon Credit Buyer	No	Yes
STX	Carbon Credit Buyer	Yes	-
Sylvera	Carbon Credit Rating Agency	Yes	-
The Nature Conservancy	Carbon Credit Buyer	Uncertain	Uncertain
Trafigura	Carbon Credit Buyer	No	Uncertain
Vanguard International Singapore	Carbon Credit Buyer	No	Uncertain
Veolia	Carbon Credit Buyer	No	Uncertain
Vitol	Carbon Credit Buyer	No	Uncertain
YTL PowerSeraya	Carbon Credit Buyer	No	Uncertain
AERA	Financing/Carbon Credits	No	Uncertain
AlliedOffsets	Financing/Carbon Credits	Yes	-
BIX Capital	Financing/Carbon Credits	Yes	-
Dziwani Investments	Financing/Carbon Credits	Yes	-
Kawandama Hills Plantation	Financing/Carbon Credits	Yes	-
Swiss Klik Foundation	Financing/Carbon Credits	Yes	-
CDH Investment Bank	Financing/Carbon Credits	Yes	-
Ecobank Malawi	Financing/Carbon Credits	Yes	-
FDH Bank	Financing/Carbon Credits	Yes	-
First Capital Bank Malawi Limited	Financing/Carbon Credits	Yes	-
National Bank of Malawi	Financing/Carbon Credits	Yes	-
NBS Bank	Financing/Carbon Credits	Yes	-
Standard Bank Malawi	Financing/Carbon Credits	Yes	-
Centenary Bank Malawi	Financing/Carbon Credits	Yes	-
AfDB	International Funders/Implementers	Yes	-
ATEC	International Funders/Implementers	Yes	-
Atmosfair	International Funders/Implementers	Yes	-
Bidhaa Sasa	Private Sector/Civil Society	No	Yes
CI-Dev	International Funders/Implementers	No	Yes
Clean Cooking Alliance (CCA)	International Funders/Implementers	Yes	-
Cleaner Cooking Coalition	International Funders/Implementers	Uncertain	Uncertain
Community Energy Malawi	International Funders/Implementers	Yes	-
Energy and Environment Partnership	International Funders/Implementers	Yes	-
Energy Sector Management Assistance	International Funders/Implementers	Yes	-
Eni's Clean Cooking Programme	International Funders/Implementers	Yes	-

Name	Type	Active in Malawi	Potential
EPA	International Funders/Implementers	Uncertain	Uncertain
GIZ Energizing Development (EnDev)	International Funders/Implementers	Yes	-
Global Affairs Canada	International Funders/Implementers	Yes	-
Global Electric Cooking Coalition	International Funders/Implementers	Uncertain	Uncertain
Global Energy Alliance for People and	International Funders/Implementers	Yes	-
Global LPG Partnership	International Funders/Implementers	No	-
Global Women's Network for the Energy	International Funders/Implementers	Uncertain	Uncertain
Green Economic Transition Facility	International Funders/Implementers	Yes	-
Irish Aid	International Funders/Implementers	Yes	-
MECS	International Funders/Implementers	Yes	-
Ministry of Foreign Affairs of the	International Funders/Implementers	Yes	-
Modern Clean Cooking Facility for Africa	International Funders/Implementers	No	-
Modern Cooking for Healthy Forests in	International Funders/Implementers	Yes	-
Norwegian Agency for Development	International Funders/Implementers	Yes	-
Off-grid Market Development Fund	International Funders/Implementers	Yes	-
OFID	International Funders/Implementers	No	Yes
Osprey Foundation	International Funders/Implementers	Uncertain	Uncertain
PERFORM project	International Funders/Implementers	Uncertain	Uncertain
SEforALL	International Funders/Implementers	Yes	-
Self Help Africa (SHA)	International Funders/Implementers	Yes	-
SEMPRA	International Funders/Implementers	Uncertain	Uncertain
Tony Blair Institute	International Funders/Implementers	Uncertain	Uncertain
UNDP	International Funders/Implementers	Yes	-
USAID	International Funders/Implementers	No	No
World Bank	International Funders/Implementers	Yes	-
World Food Programme (WFP)	International Funders/Implementers	Yes	-
World Resources Institute (WRI)	International Funders/Implementers	Yes	-
Energy and Environment Partnership	International Funders/Implementers	Yes	-
Modern Cooking for Healthy Forests in	International Funders/Implementers	Yes	-
District Energy Officers	Ministries Departments and Agencies	Yes	-
EGENCO	Ministries Departments and Agencies	Yes	-
Environmental Affairs Department (EAD)	Ministries Departments and Agencies	Yes	-
ESCOM	Ministries Departments and Agencies	Yes	-
Malawi Bureau of Standards	Ministries Departments and Agencies	Yes	-
Malawi Carbon Market Initiative	Ministries Departments and Agencies	Yes	-
Malawi Confederation of the Chambers	Ministries Departments and Agencies	Yes	-
Malawi Energy Regulatory Authority	Ministries Departments and Agencies	Yes	-
Malawi Investment and Trade Centre	Ministries Departments and Agencies	Yes	-
Malawi Police Service	Ministries Departments and Agencies	Yes	-

Name	Type	Active in Malawi	Potential
Ministry of Energy (MOE)	Ministries Departments and Agencies	Yes	-
Ministry of Finance	Ministries Departments and Agencies	Yes	-
Ministry of Forestry and Natural	Ministries Departments and Agencies	Yes	-
Ministry of Gender Children Disabilities	Ministries Departments and Agencies	Yes	-
Ministry of Local Government	Ministries Departments and Agencies	Yes	-
Ministry of Natural Resources and	Ministries Departments and Agencies	Yes	-
National Cookstoves Steering	Ministries Departments and Agencies	Yes	-
National Organization of Nurses and	Ministries Departments and Agencies	Yes	-
265 Energy	Private Sector/Civil Society	Yes	-
AFROX	Private Sector/Civil Society	Yes	-
Alinafe	Private Sector/Civil Society	Yes	-
Bboxx	Private Sector/Civil Society	No	Uncertain
Bluewaves	Private Sector/Civil Society	No	No
BURN Manufacturing	Private Sector/Civil Society	Yes	-
Chigodi Gases Lilongwe	Private Sector/Civil Society	Yes	-
C-Quest Capital	Private Sector/Civil Society	No	Yes
Delta Energy	Private Sector/Civil Society	Yes	-
EcoGen Malawi	Private Sector/Civil Society	Yes	-
Ecosafi	Private Sector/Civil Society	No	Uncertain
EKI Energy	Private Sector/Civil Society	Yes	-
Emerging Cooking Solutions (ECS)	Private Sector/Civil Society	Yes	-
Ener-G-Africa (EGA)	Private Sector/Civil Society	Yes	-
Energy Solutions Limited	Private Sector/Civil Society	Yes	-
Envirofit International	Private Sector/Civil Society	No	Uncertain
Falcon Gas	Private Sector/Civil Society	Yes	-
GAME	Private Sector/Civil Society	Yes	-
Gamos	Private Sector/Civil Society	Yes	-
Gas Man	Private Sector/Civil Society	Yes	-
Green Gas	Private Sector/Civil Society	Yes	-
Green Impact Technologies (GIT)	Private Sector/Civil Society	Yes	-
Hestian Innovation	Private Sector/Civil Society	Yes	-
HomeBiogas	Private Sector/Civil Society	No	Uncertain
Industrial Oxygen Co. Ltd	Private Sector/Civil Society	Yes	-
Infinity Energy	Private Sector/Civil Society	Yes	-
IOCL	Private Sector/Civil Society	Yes	-
IXO World	Private Sector/Civil Society	Yes	-
Kachione LLC	Private Sector/Civil Society	Yes	-
KOKO Networks	Private Sector/Civil Society	No	Yes
Malasha Briquettes	Private Sector/Civil Society	Yes	-

Name	Type	Active in Malawi	Potential
Malawi Improved Cookstove Project	Private Sector/Civil Society	Yes	-
Mimi Moto B.V.	Private Sector/Civil Society	Yes	-
Mount Meru	Private Sector/Civil Society	Yes	-
Mulanje Electricity Generation Agency	Private Sector/Civil Society	Yes	-
Namuleri Energy	Private Sector/Civil Society	Yes	-
PAYG	Private Sector/Civil Society	Yes	-
Payment Systems Malawi	Private Sector/Civil Society	Yes	-
PressCane	Private Sector/Civil Society	Yes	-
TETRA TECH	Private Sector/Civil Society	No	Yes
UP Energy	Private Sector/Civil Society	No	Yes
Vitalite	Private Sector/Civil Society	Yes	-
Yellow / Maeve Project	Private Sector/Civil Society	Yes	-
Yo Gas	Private Sector/Civil Society	Yes	-
Zippo (Zipolopolo)	Private Sector/Civil Society	Yes	-

5.4.3 Financing Arrangements

The institutional structure builds on NNNF's existing successful management of off-grid solar.

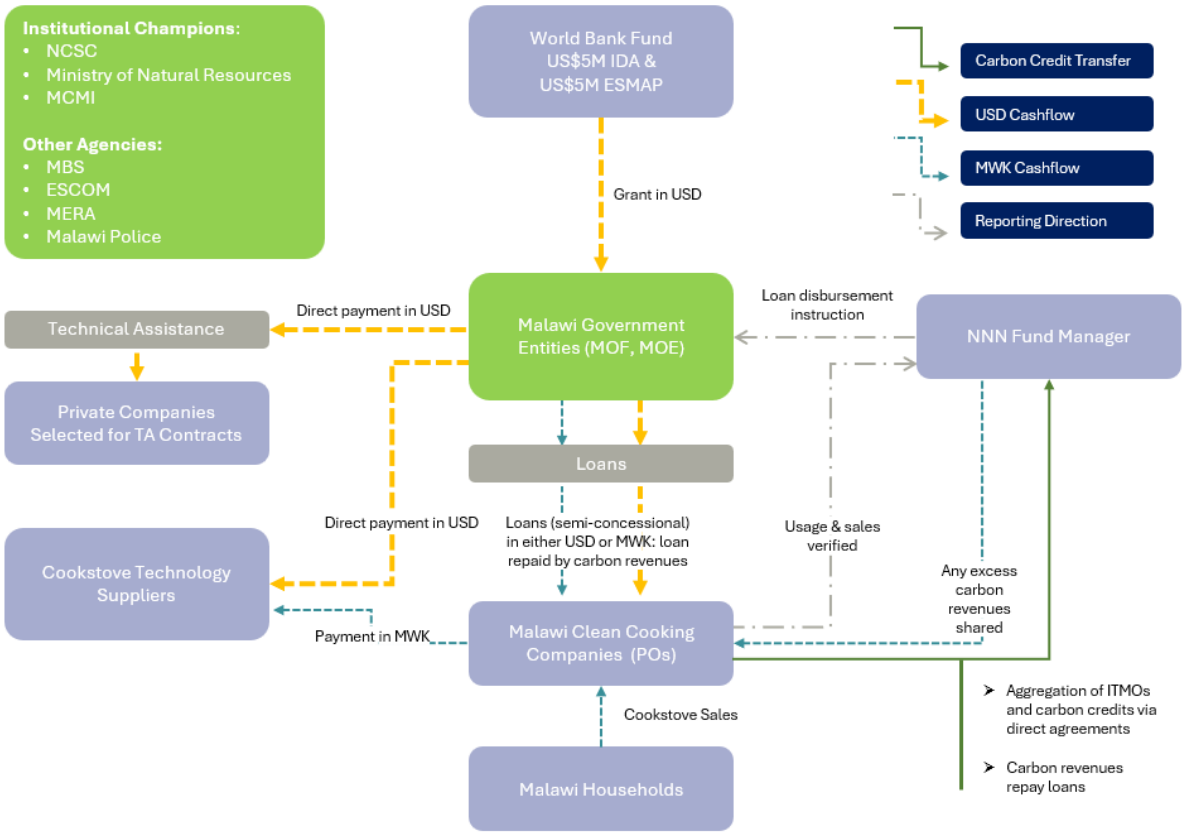


Figure 22: Table 40: Institutional Structure and Cashflows for the Program

5.4.3.1 Institutional Champions

The MOE is the natural candidate to serve as the primary champion authority for ASCENT's clean cooking component, under the existing framework of the NNNF. A dedicated Clean Cooking Unit will be set up within the MOE to provide technical advisory to the NNNF in selecting POs and managing the program.

Institutional champions (other government agencies and authorities) alongside agencies receiving TA such as MBS, ESCOM, MERA and Malawi Police will be instrumental in supporting a successful outcome of the program (See Malawi Government Program Roles and Responsibilities for details).

NNNF's Fund Manager will be appointed to oversee administrative operations and portfolio management. POs i.e. private companies will receive loans in exchange for carbon credit ownership. IVA will validate program results from PO, the loan recipients, and the implementation partners.

Financing Terms

Grant to Malawi Government	
Size:	USD 10 million
Loan Facility to POs	
Size:	USD 7 million
Tenor:	4 years
Grace Period:	12 months
Interest Rate:	20% p.a.
Repayment:	Equal instalments, carbon revenue used to service debt, convertible to grant if carbon revenues insufficient
Technical Assistance to POs/Government	
Size:	USD 3 million

Fixed cost allocation for:

- Carbon Policy Framework Development
- LPG Development Study - Safety Standards, Regulation and Policy, Supply Chain
- Independent Verification Agency (IVA) for clean cooking
- Public Awareness and Behavior Campaign
- Market Facilitator for Clean Cooking Technologies
- Facilitation of Carbon Finance Transactions
- Revision of National Clean Cooking Strategy & Investment Prospectus
- Technical Support for SMEs - Cookstove Standards, Testing, Business Development
- Residential Electricity Metering Program - assessing localized demand

Sustainability Mechanisms: /NNNF aggregates ITMOs and carbon credits

Expected annual revenue: USD 1.25 million

Total projected carbon revenue over 6 years: USD 11 million

Revenue covers debt service and provides additional funding if in excess.

5.4.3.2 Structural Assumptions

Structure of the Model

The model first categorises Tier 4+ cooking technologies, to find a central tendency for unit costs and pricing, then works towards calculating the financing requirement based on a target number of households adopting the new technology and therefore the subsidy

amount required to decrease prices to adoption levels and distribute the cookstoves via private companies.

The investment plan and model are built around the following assumptions:

- Loans and/or grants are provided to a limited portfolio of *companies* (in our model this is limited to 4 but can be expanded)
- Each *company* focuses on distributing one type of cookstove
- Cookstoves are categorised into types to simplify unit costs and RRP assumptions, and: LPG 3kg Cylinder + Cookstove Top, LPG 6kg Cylinder + Cookstove Top, LPG 1 Burner + 6kg Cylinder, LPG 2 Burner + 6kg Cylinder, eCook EPC, eCook Induction, eCook Hotplate, Pellet, Biogas, Bioethanol
- All cookstoves purchased are sold in each period
- One cookstove distributed to one household returns one household converted from charcoal

Starting with Affordability

The affordability analysis revealed a substantial financial gap in households accessing to clean cooking technologies in Malawi, particularly concerning upfront costs. While traditional 3-stone firewood stoves and some charcoal stoves remain financially accessible, modern clean cooking solutions such as electric, LPG, and pellet stoves present a significant financial barrier, for example EPCs requiring 90% or more of monthly household expenditure even for wealthy families in the top quintile (See 2.2.2).

This challenge is especially acute for the lowest expenditure quintile, where Tier 4+ clean cooking equipment can cost up to 20 times their monthly expenditure. Despite the potential for financial, time, and energy savings from transitioning to advanced technologies like induction stoves and EPCs, the prohibitive initial investment creates a substantial market barrier. This analysis suggests that a comprehensive intervention strategy combining targeted subsidies - and instalment payment schemes - will be necessary to bridge the affordability gap and facilitate widespread adoption of clean cooking solutions across Malawian households.

Cookstoves and Target in the Model

Three primary and representative clean cooking technologies are proposed: EPC, LPG 6kg Cylinder with Cookstove Top, and Pellet stoves, with a strategic implementation timeline from 2025 to 2029.

The program aims to reach 150,000 households through a graduated adoption approach over the program period, starting at 10% market penetration in year 1 and scaling to 25% in later years - a measured and realistic approach to market development.

Financial Structure

The financial architecture of the program is built on a grant from the World Bank (IDA and ESMAP), then loaned to private companies to help subsidise the upfront price of the cookstoves, stimulate distribution and repaid with carbon revenues.

The repayment of the loan is not from revenues generated from company sales of cookstoves or other services, instead explicitly from carbon revenues generated by usage of these cookstoves (and therefore the CO2 eq emissions avoided).

The loan can then be converted to grant in the event carbon revenues are unable to repay the debt service.

Impact on Fuel Demand

The program potential impact raises significant concerns regarding the pressure that accelerated clean cooking adoption will place on fuel supply chains across all three key technologies.

LPG Supply

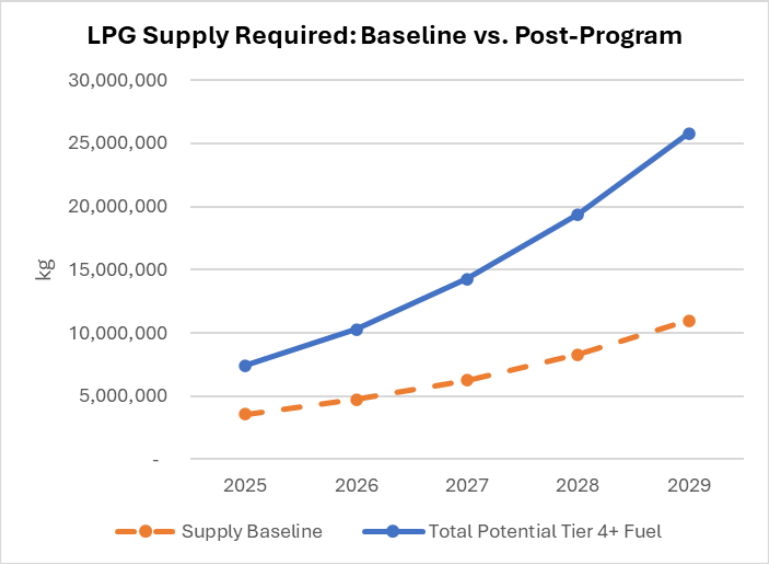


Figure 23: LPG new demand post-program, considering the 2024 baseline vs. new LPG cookstoves distributed

For LPG, while the current market size of 1.5-3 million kg per annum can theoretically accommodate growth from 14,657 households in 2022 to the projected 94,564 households by 2030, the program's ambitious target of 25% market penetration will require rapid scaling of distribution infrastructure (see Figure 23).

Pellet Supply

The pellet fuel market faces immediate and critical supply constraints.

Current domestic production capacity of 7,200 tons per annum is already nearly saturated by existing non-cooking industrial demand of 6,250 tons, primarily from the tobacco sector (see Figure 24).

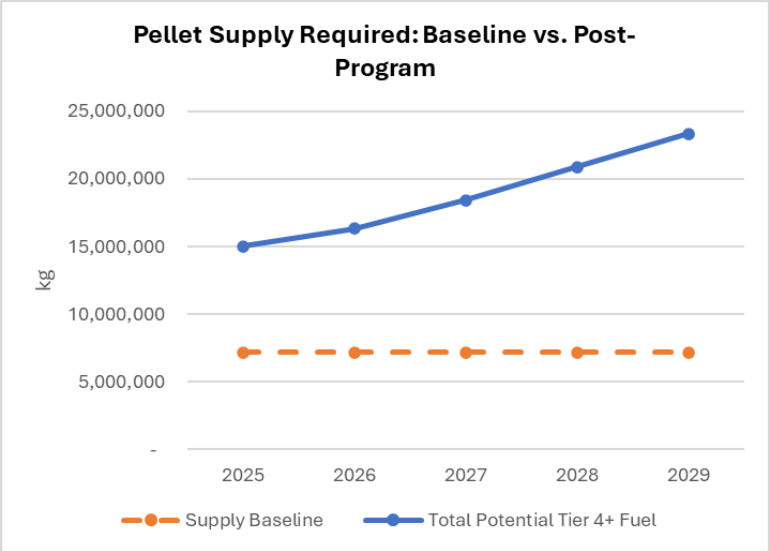


Figure 24 Pellet new demand post-program, considering the 2024 baseline supply vs. new pellet cookstoves distributed

Electricity Peak Supply vs Demand

The most severe supply pressure appears in the electricity sector, where analysis suggests that program success could drive peak demand in 2025 from 438 MWp to approximately 902 MWp by 2029.

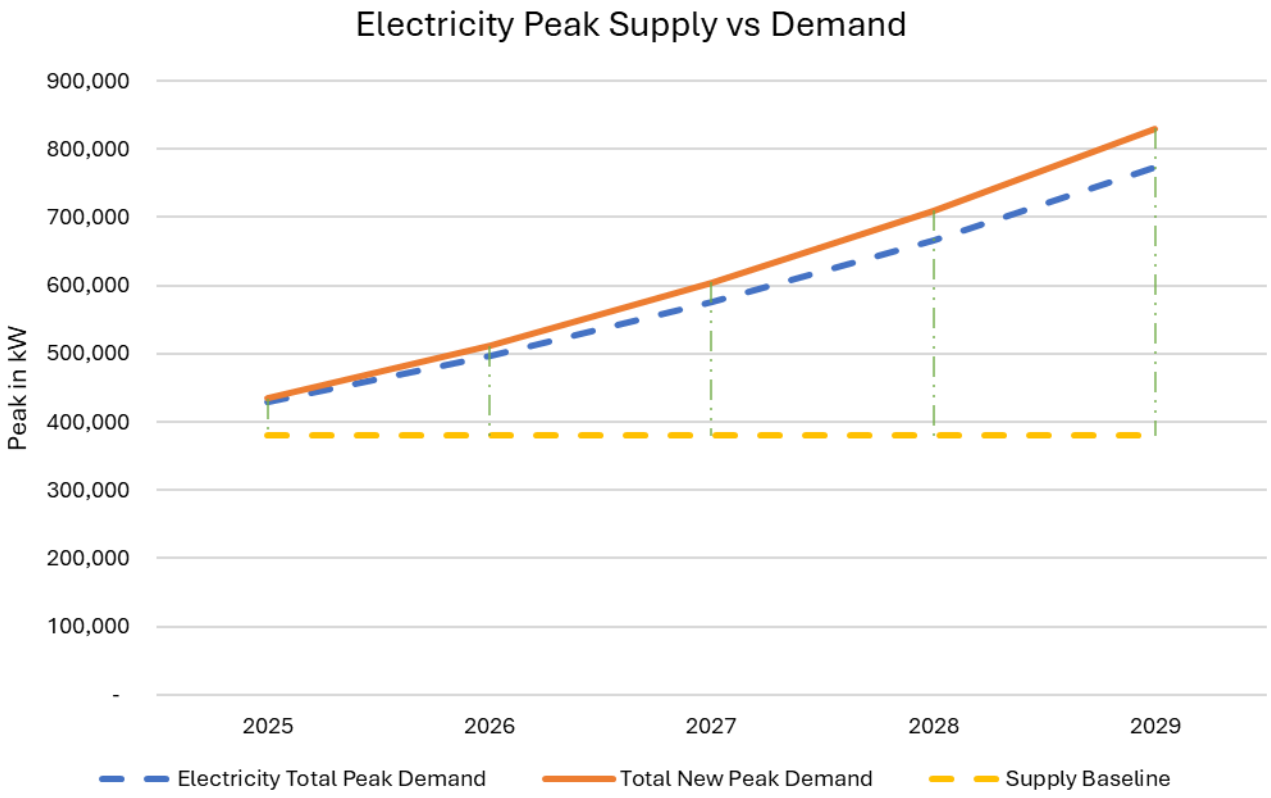


Figure 25: Electricity new peak demand post-program, considering with 2024 baseline vs. new electric cookstoves distributed

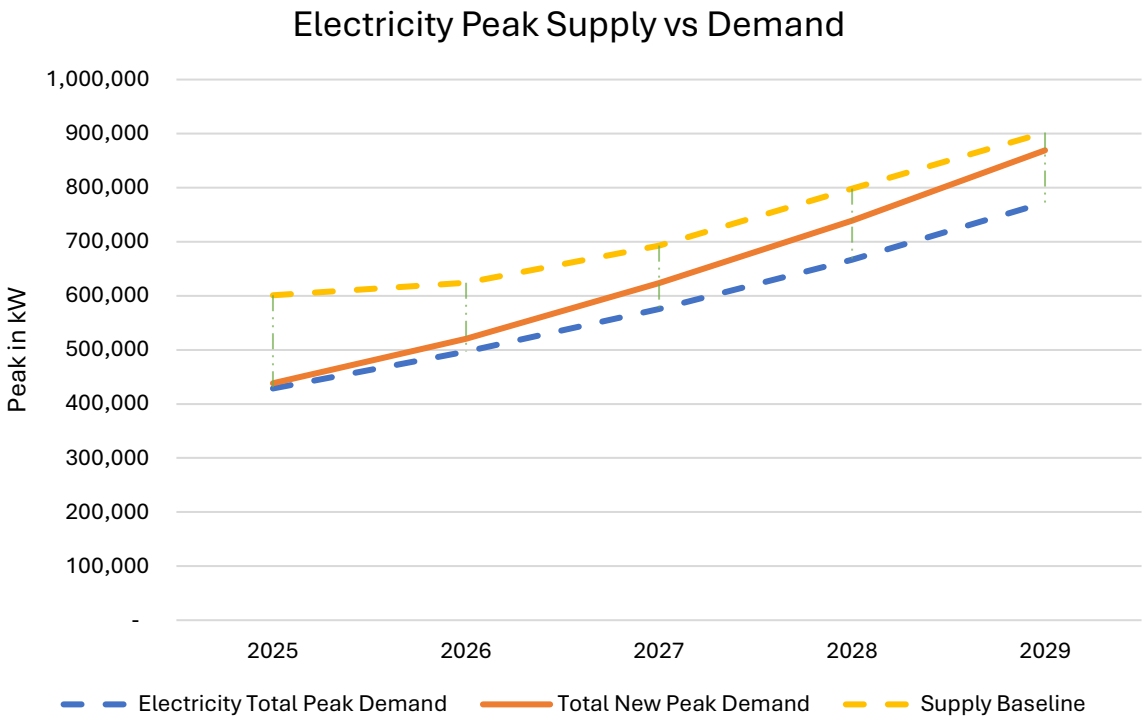


Figure 26: Electricity new peak demand post-program, considering with ESCOM Generation Master Plan vs. new electric cookstoves distributed

Figure 25 displays the peak grid supply baseline from ESCOM historical generation readings (excluding maintenance months for Kapichira). Figure 26 displays grid supply from the ESCOM Generation Master Plan. Comparing the two supply scenarios in Figure 25 and Figure 26, any delays or gaps to the generation and supply of electricity with an increased supply of electric cookstoves, would lead to a fourfold increase in demand and place unprecedented strain on generation and distribution infrastructure.

5.4.4 Scenario Analysis

5.4.4.1 Fuel Pricing: LPG Price Increases

Based on the fuel consumption data (see Affordability Analysis), household spending on fuel ranges between $9.96 to $24.36 per month for charcoal depending on whether they are living in the Zomba (lowest pricing) or Lilongwe (highest pricing).

Regarding LPG ongoing fuel costs, the cost of a 3kg or 6kg cylinder and cookstove amounts to approximately 670 MWK ($0.39 USD) per day or 20,126 MWK ($11.84 USD) per month.

Consumption Baseline

Table 44: Charcoal monthly cost baselines

Charcoal (Urban Low)	USD/HH/Month	9.96
Charcoal (Urban High)	USD/HH/Month	24.36
Charcoal Lilongwe	USD/HH/Month	24.36
Charcoal Blantyre	USD/HH/Month	22.52
Charcoal Mzuzu	USD/HH/Month	13.56
Charcoal Zomba	USD/HH/Month	9.96

LPG Price Changes

Table 45: LPG Price Changes, 15% and 40% increases

a. LPG Current Price

Ongoing Fuel Cost per Stove Type Inclusive of VAT	Daily (MWK)	Monthly (MWK)	Daily (USD)	Monthly (USD)
LPG 3kg Cylinder + Cookstove Top	670.88	20,126.29	0.39	11.84
LPG 6kg Cylinder + Cookstove Top	670.88	20,126.29	0.39	11.84
LPG 1 Burner + 6kg Cylinder	670.88	20,126.29	0.39	11.84
LPG 2 Burner + 6kg Cylinder	670.88	20,126.29	0.39	11.84

b. LPG price increases by 15%

Ongoing Fuel Cost per Stove Type Inclusive of VAT	Daily (MWK)	Monthly (MWK)	Daily (USD)	Monthly (USD)
LPG 3kg Cylinder + Cookstove Top	771.51	23,145.24	0.45	13.61
LPG 6kg Cylinder + Cookstove Top	771.51	23,145.24	0.45	13.61
LPG 1 Burner + 6kg Cylinder	771.51	23,145.24	0.45	13.61
LPG 2 Burner + 6kg Cylinder	771.51	23,145.24	0.45	13.61

c. LPG price increases by 40%

Ongoing Fuel Cost per Stove Type Inclusive of VAT	Daily (MWK)	Monthly (MWK)	Daily (USD)	Monthly (USD)
LPG 3kg Cylinder + Cookstove Top	1,080.11	32,403.33	0.64	19.06
LPG 6kg Cylinder + Cookstove Top	1,080.11	32,403.33	0.64	19.06
LPG 1 Burner + 6kg Cylinder	1,080.11	32,403.33	0.64	19.06
LPG 2 Burner + 6kg Cylinder	1,080.11	32,403.33	0.64	19.06

In a scenario where LPG prices were to increase by 15%, this daily cost would escalate to 771 MWK ($0.45 USD) and rising to 23,145 MWK ($13.61 USD) per month. A more significant price increase of 40% would result in daily costs of 1,080 MWK ($0.64 USD) and monthly expenses of 32,403 MWK ($19.06 USD).

The analysis suggests that a 15% or even 40% price increase would not make LPG more expensive than charcoal in target urban areas: Lilongwe and Blantyre. However, a 15% increase would remove Mzuzu, with charcoal in Zomba already more affordable than LPG on a monthly basis.

5.4.4.2 Impact of Variation in Carbon Prices

This analysis examines the sensitivity of carbon credit pricing and its impact on the financial viability of the clean cooking portfolio. The assessment begins with core assumptions regarding the target household numbers across different fuel types (i.e. Electricity, LPG, and Pellets), with plans to monetize 100% of carbon credits generated across all fuel categories.

Assumption for Carbon Revenues

Table 46: Carbon Revenue Key Inputs

Fuel Type	Target HH	Portion of Credits Sold	Credits Generated per Year	Carbon Credit Prices from 14/10/2024[17]
Electricity	55,000	100%	0.50	8.00
LPG	65,000	100%	2.50	7.50
Pellets	30,000	100%	2.00	9.30

[17] AlliedOffsets. (Retrieved 14th October, 2024). AlliedOffsets Carbon Market Database. AlliedOffsets . https://alliedoffsets.com/reports.

Effect on Portfolio

Table 47: Effect of Carbon Credit Prices on Portfolio Cashflows

The Variation of Market Price	Cashflow to Company (Without Carbon Revenue)	Carbon Revenue	Debt Service (Interest & Principal Repaid)	Excess Carbon Revenue Post Debt Service	Deficit Amount (Total mismatching cashflow between carbon revenue repaid and scheduled repayment)
140%	(1,243,794)	15,416,430	9,800,875	7,886,655	(8,280,414)
120%	(1,243,794)	13,214,083	9,800,875	5,966,586	(8,497,623)
100%	(1,243,794)	11,011,736	9,800,875	4,046,517	(8,714,832)
90%	(1,243,794)	9,910,562	9,800,875	3,086,482	(8,823,436)
80%	(1,243,794)	8,809,389	9,800,875	2,126,448	(8,932,040)

The analysis demonstrates significant sensitivity to carbon credit price fluctuations. At the baseline price point, the portfolio generates carbon revenue of $11,011,736 USD, with excess carbon revenue after debt service of $2,802,723 USD. When prices decrease to 90% of the baseline, excess carbon revenue after debt service contracts to $1,842,688 USD, and at 80% of baseline, it further diminishes to $882,654 USD.

Conversely, the model shows improved financial performance under scenarios with higher carbon credit prices. At 120% of the baseline price, excess carbon revenue after debt service increases to $4,722,792 USD, while at 140%, it reaches $6,642,862 USD.

The analysis reveals that while debt service obligations can be met across most price scenarios, the margin for financial stability narrows significantly as carbon credit prices decline. At 80% of the baseline price, the excess carbon revenue after debt service drops to levels that could challenge the portfolio's ability to maintain consistent debt payments while also supporting ongoing operations.

Recommendations for preventing deficit cashflow or default events on the debt service include (i) sculpting repayment of the debt service around carbon revenue receipt and (ii) extending the tenor of debt service beyond the 4 year period from the OGMDF.

5.4.4.3 Impact if Credits are not Sold (LPG Credits)

In the case of LPG credits not being sold (reduce Portion of Credits Sold to 0%), total carbon revenue decreases from $11,011,736 USD to $9,600,346 USD.

Note that, given the relatively low carbon revenues of LPG compared to electric cookstoves and pellet stoves, excess carbon revenue post-debt service does not decrease as repayments from LPG companies will not be met in the base case from carbon revenues.

5.4.5 Other Analysis

5.4.5.1 Sizing Loan Facility: Sensitivity on Portfolio Returns and Debt Service

This analysis examines the financial implications of varying the loan facility size from $9 million to $5 million while maintaining fixed household targets.

Table 48: Sensitivity on Sizing Loan

Loan – Facility Size	Cashflow to Company (Without Carbon Revenue)	Carbon Revenue	Debt Service (Interest & Principal Repaid)	Excess Carbon Revenue Post Debt Service	Deficit Amount (Total mismatching cashflow between carbon revenue repaid and scheduled repayment)
9m	756,206	11,011,736	12,601,125	2,459,709	(11,515,082)
8m	(243,794)	11,011,736	11,201,000	3,253,113	(10,114,957)
7m	(1,243,794)	11,011,736	9,800,875	4,046,517	(8,714,832)
6m	(2,243,794)	11,011,736	8,400,750	4,839,921	(7,314,707)
5m	(3,243,794)	11,011,736	7,000,625	5,633,325	(5,914,582)

The cash flow to implementing companies demonstrates significant sensitivity to loan size adjustments. Starting at a positive $756,206 USD with a $9 million facility, it steadily declines by approximately $1 million USD with each $1 million reduction in the loan amount, ultimately reaching -$3,243,794 USD at a $5 million facility size.

Throughout all scenarios, the carbon revenue remains constant at $11,011,736 USD, with the fixed household targets.

Debt service requirements show a proportional relationship with loan size, decreasing from $12,601,125 USD at $9 million to $7,000,625 USD at $5 million. This reduction in debt service obligations leads to an inverse effect on excess carbon revenue post debt service (i.e. the potential excess which can be returned to companies), which increases from $2,459,709 USD to $5,633,325 USD as the loan size decreases. However, this improved excess carbon revenue comes at the cost of reduced operational capacity, as evidenced by the negative impact on company cash flows.

The deficit amount, while substantial across all scenarios, shows improvement as the loan size decreases, moving from -$11,515,082 USD at $9 million to -$5,914,582 USD at $5 million. This suggests that while smaller loan sizes may reduce overall program deficits, there is a clear mismatch in carbon revenues received versus the scheduled repayments (on an annual equal instalment basis as in the OGMDF).

5.4.5.2 VAT Impact on Affordability

This analysis examines how VAT at 16.5% impacts the affordability of clean cooking solutions across Malawi's household wealth quintiles, using MTF 2023 expenditure data.

For the lowest wealth quintile, LPG was already unaffordable even before VAT, with monthly operational costs exceeding 150% of household expenditure. The addition of VAT only marginally increases costs but does not change the fundamental issue of inaccessibility.

For middle-income households (Quintile 3, 41,950 MWK/$24.68 USD monthly), VAT affects both affordability and the choice of cooking technology. Without VAT, monthly LPG costs account for 41% of household expenditure, rising to 48% with VAT. For electric cooking alternatives, the EPC's monthly operational cost increases from 5,681 MWK ($3.34 USD) to 6,619 MWK ($3.89 USD), shifting from 13.5% to 15.8% of expenditure. The impact on upfront costs is also notable – an EPC system increases from $76-86 USD to $89-100 USD with VAT, equivalent to 3.5-4 months of expenditure.

For the highest-income households (133,025 MWK/$78.25 USD monthly), VAT has a minimal impact on affordability. Monthly LPG costs increase from 13% to 15% of household expenditure with VAT, while even premium options like induction cookers remain accessible, rising from $120-258 USD to $140-300 USD – equivalent to just 1.5-3.8 months of expenditure.

While VAT policy can ease cost burdens for middle-income households, it is not the most critical factor for clean cooking adoption, especially for the poorest households. A more comprehensive approach – including subsidies, financing mechanisms, and infrastructure investment – may be more effective in expanding access.

5.4.5.3 Supply Chain Risks

The supply chain infrastructure presents significant operational challenges for clean cooking implementation in Malawi.

Electricity

Unreliable electricity supply and inadequate distribution networks severely constrain the scalability of electric cooking solutions, with frequent load shedding disrupting cooking availability.

LPG

The LPG supply chain faces structural challenges that could impact program success. Current partial filling practices at retail locations compromise both safety and quality control, as cylinders often lack proper inspection and maintenance. This practice undermines cylinder ownership systems and discourages investment in new equipment. Furthermore, Malawi's heavy reliance on LPG imports from Tanzania, Mozambique, and South Africa exposes the market to foreign exchange fluctuations and transportation cost variability. The ongoing forex crisis has particularly strained the situation, making it increasingly difficult for companies to secure necessary foreign currency for imports. Regulatory hurdles, including complex licensing requirements and inconsistent safety enforcement, further complicate market development.

Pellets

The pellet market presents its own distinct set of challenges. Current domestic production capacity is nearly saturated by existing industrial demand, primarily from the

tobacco sector, creating immediate supply constraints for cooking applications. Quality and consistency issues in pellet supply could potentially disrupt cooking operations and impact user satisfaction.

5.4.5.4 Product Awareness

The market also suffers from low awareness, requiring substantial investment in consumer education to drive adoption. Additionally, the focus of current producers on industrial applications has created a gap in household-sized pellet offerings, necessitating new investments in production capacity.

5.4.5.5 Product Quality

The market faces quality control issues, particularly with the influx of low-cost imports from China and India that often fail to meet durability standards and create safety concerns.

A notable shortage of local technical expertise further compounds these challenges, limiting both distribution capabilities and maintenance support.

5.4.5.6 Carbon Revenue and Pricing Risks

The intervention's financial sustainability faces several challenges related to carbon credit mechanisms.

Price volatility in carbon markets could significantly impact program viability, with analysis showing that even moderate price decreases could create substantial deficits. Operational risks include potential delays in carbon credit issuance and monetization, which could create misalignment between scheduled debt repayments and actual revenue receipt.

5.4.5.7 Carbon Credit Ownership

The current structure has faced resistance from companies regarding the requirement to transfer all generated carbon credits to the program, potentially limiting their revenue opportunities. Additionally, the program's dependence on a single carbon credit buyer creates vulnerability to market shifts and reduces negotiating leverage.

5.4.5.8 Tax Burdens

The tax burden, particularly VAT, creates additional affordability pressures. Middle-income households face reduced technology choices due to tax impacts, potentially forcing them toward less optimal cooking solutions.

This tax structure appears to have a regressive effect, with lower-income households bearing a disproportionate burden relative to their purchasing power. Increases in excise and tax on carbon, clean cooking goods and services, may heavily effect lower income households.

5.5 Implementation

5.5.1 Operating Recommendations

5.5.1.1 Selection of POs

Alongside operational, technical, commercial and financial due diligence on the POs, POs for the facility must demonstrate Malawi-specific criteria for their technologies around supply chain feasibility for fuel/electricity and pricing of cookstoves.

POs must demonstrate supply chain feasibility for regions in which households are purchasing the cookstoves,

Table 49: PO fuel and electricity supply verification

Technology	Criteria	Verification
LPG	Partnerships with importers (Afrox, Delta, Falcon, ...)	Contracts
	Storage capacity and cylinder inventory	Facility records
	Distribution network coverage	Maps, routes
	Cylinder exchange programs	Reports/studies/model
	MERA compliance	Certificates
	Market adoption targets in HH/Sales	Strategy, milestones
Pellets	Agreements with pellet producers (Raiply, Pyxus)	Contracts
	Retail network	Sales data
	Seasonal supply planning	Contingency plans
	Market adoption targets in HH/Sales	Strategy, milestones
Electric	Projected load modelling to assess grid capacity, technical specifications and assumptions for power consumption	Reports/studies/model
	After-sales support	Service plans
	Market adoption targets in HH/Sales	Strategy, milestones

Based on our assessment, the price for cookstoves in 2024 should fall within the following ranges.

Table 50: PO pricing ranges

Technology Type	Price Range (MWK)	Approx. Price Range (USD)
Electric Cookstoves	160,000 - 300,000	$94.50 - $250
LPG 6kg Cylinder + Cooktop	94,000	$52.20
LPG 3kg Cylinder + Cooktop	Lower than 6kg	< $52.20
Pellet stoves	70,000 - 95,000	$70 - $100
Biogas systems	1,600,000 (without subsidies)	$800

5.5.1.2 Carbon credit aggregation and sales

The program's repayment structure can be reinforced by aligning debt service obligations with projected carbon revenue streams based on cookstove deployment schedules.

This approach allows repayment terms to be tailored to match expected revenue flows. If carbon revenues are not generated quickly enough in the initial years, there is a risk of missed payments, potentially triggering the loan being converted into a grant.

However, by structuring debt repayments around the anticipated timing of carbon revenue receipts, the risk of shortfalls can be minimized, ensuring a more sustainable repayment process.

5.5.1.3 Priority Order of Technical Assistance

The following TA must finalised before the NNNF clean cooking window disbursements:

- Carbon Policy Framework Development
- Revision of National Clean Cooking Strategy & Investment Prospectus, including strengthening the GOM capacity to draft and ratify cookstove standards, safety standards and Tier 4+ policies

The following TA should be finalised before Y1 ends of the NNNF clean cooking window to prevent supply chain constraints:

- LPG Development Study - Safety Standards, Regulation and Policy, Supply Chain
- Residential Electricity Metering Program - assessing localized demand at the household level

The following TA can in parallel of the NNNF clean cooking window disbursement period:

- Independent Verification Agency (IVA) for clean cooking
- Facilitation of Carbon Finance Transactions
- Market Facilitator for Clean Cooking Technologies
- Technical Support for SMEs - Cookstove Standards, Testing, Business Development
- Public Awareness and Behaviour Campaigns

5.5.2 Non-Governmental Program Roles and Responsibilities

Table 51: Roles and responsibilities of parties during the fund operations stage

Parties	Roles and Responsibilities
World Bank	• Implementation support to the Fund Manager and PIU • Provide guidance and advice on the implementation of NNNF • Review and make grant disbursement to government • Review and issue no-objection letter for International Competitive Bidding (ICB), Quality and Cost Based Selection of Consultant (QCBS) if value exceeds the threshold of prior review • Process requests for restructuring of the Project (if needed) • Review and approve any revisions of the POM requested by Fund Manager • Coordinate sales of ITMOs and carbon credits by Fund Manager to Carbon Initiative for Development (Ci-Dev)
Fund Manager	• Sign agreement with MOE • Shortlist clean cooking companies as Participating Organizations under NNNF based on pre-determined eligibility criteria • Evaluate the business plans and negotiate loans, grants and TAs terms with POs for eligible system installations • Disburse results-based loans to POs in line with completed contracts signed with MOE • Ensure that agreement with POs transfers ITMOs and carbon credit ownership to the NNNF • Monitor cookstove usage to make sure all requirements are met • Ensure that POs meet all financing requirements • Assist POs on processes and procedures • Responsible for overall day-to-day management and coordination of the portfolio under the Fund • Manage the implementation of NNNF elements related to convertible debt and technical assistance financing windows • Prepare annual implementation progress reports, as described in agreement signed between Fund Manager and MOE • Prepare annual financial reports of the NNNF

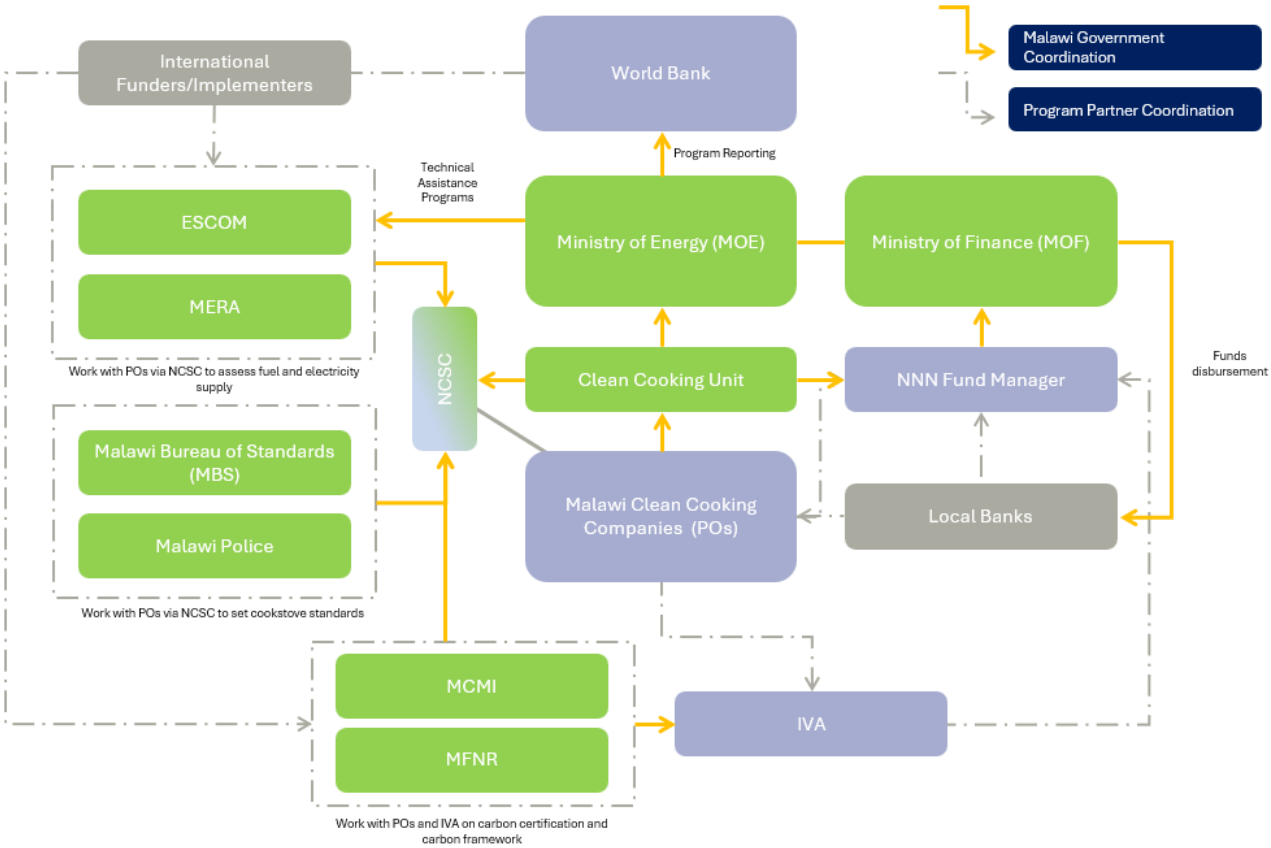
Parties	Roles and Responsibilities
	• Coordinate with MOE to handle issues, if any, during project implementation • Make quarterly reporting to World Bank, MoF and MOE
Participating Organizations (Borrowers)	• Make sales of Tier 4+ cookstoves in urban households • Ensure reporting of cookstove sales on a monthly basis • Ensure compliance of cookstoves • Execute Participation Agreement • Transfer ownership of ITMOs and Carbon Credits to NNNF – project dependent, revenues exclusively received based on RBF milestones • Implement and operate the project as per the requirements set forth in the Participation Agreement • Provide a minimum of 2 years of warranty for main unit and an after sales contract that commits to the availability of spare parts and technical service for a maximum of 3 years after the installation of the system • Provide feedback when requested by Fund Manager through questionnaires, evaluation workshops, etc. • Assist Fund Manager in understanding problems and barriers to implementing clean cooking program • Participate in meetings and trainings offered by the Fund Manager
Independent Verification Agent	• Review the claims and customer data management (collection and storage) of the PO • Review and verify the integrity of PO's sales and end-user portfolio tracking systems which will include but not limited to; full names of the customers and contact details, exact geographic location, specifications of the products, date of delivery, type of product, pricing, repayments, and whether warranty and after-sales services are offered by the PO • Conduct telephone survey verifying the sales of the cookstoves • Conduct field survey to ascertain the presence of the cookstoves products in end user households and regions • Verify that the products delivered to the beneficiaries meet VeraSol Certified Standards • Verify down payment/deposit/part-payment made by customer and repayment period • Verify pricing of Cookstoves sold on cash and on credit or Pay-As-You-Go (PAYG) • Reconciliate all transactions in the claims with the data/records maintained by each POs • Prepare the report explaining the validity of the claims from POs

5.5.1 Malawi Government Program Roles and Responsibilities

Parties	Roles and Responsibilities
Ministry of Energy (MOE)	• Sign and manage agreements with Fund Manager for NNNF implementation • Sign agreements with Participating Organizations (POs) for loan and grant disbursement • Monitor Fund Manager compliance with World Bank Financing Agreement requirements • Record and monitor debt disbursed by the Fund Manager • Ensure procurement compliance with World Bank regulations • Monitor loan repayments from carbon revenue sales • Establish and manage the Revolving Fund from NNNF reflows • Facilitate ongoing discussions between Fund Manager and World Bank
Ministry of Finance (MOF)	• Manage fund disbursements to the NNNF • Receive and review quarterly financial reports from Fund Manager • Coordinate with local banks on financial arrangements • Monitor carbon revenue streams and debt service arrangements • **Monitor** financial sustainability of the program
Clean Cooking Unit *Within MOE*	• Serve as the central coordination point between **POs, NNNF Manager and MOE** • Oversee day-to-day program implementation • Coordinate with NCSC **on quarterly meetings and operational support** • Support PO selection process with technical expertise • Monitor cookstove deployments and usage**, report to MOE** • Coordinate **TA** delivery to relevant parties
ESCOM	• Work with POs via NCSC to assess electricity supply • Implement partnerships with electric cookstove POs • Support Residential Electricity Metering Program TA • Support Technical Assistance programs related to energy supply chains
MERA	• Work with POs via NCSC to assess fuel and electricity supply • **Ensure** regulatory compliance for LPG and other fuel sources • Collaborate on LPG Development Study TA • Support Technical Assistance programs related to energy supply chains

Malawi Bureau of Standards (MBS)	• Work with POs via NCSC to set cookstove standards • **Coordinate with TA provider to draft and publish national standards for stove testing** • Support Technical Assistance for SMEs on Cookstove Standards and Testing
Malawi Police	• Support safety standards implementation for fuels, particularly LPG
MCMI	• Work with POs and IVA on carbon certification and carbon framework • Coordinate with Fund Manager on ITMO and carbon credit ownership transfers • Support Carbon Policy Framework Development **with TA provider** • Assist with monitoring and verification of carbon reduction claims
MFNR	• Work with POs and IVA on carbon certification and carbon framework • **Support** Carbon Finance Transactions **for NNNF with TA provider** • Support Carbon Policy Framework Development

5.5.1.1 Coordination between Malawi Government and Program Partners



5.5.2 Technical Assistance

5.5.2.1 Revision of National Clean Cooking Strategy & Investment Prospectus[18]

For the clean cooking market, it is recommended to expand on the Malawi National Energy Compact 2025 by calling for stronger coordination, focus and revised targets based on the Supply-Side Analysis.

As an example, Tanzania's National Clean Cooking Strategy (2024-2034) includes: detailed situational analysis of fuel usage patterns showing 90% biomass dependence; specific health impact data on respiratory diseases; clear environmental degradation metrics; economic burden quantification; technology-specific implementation pathways; institutional coordination frameworks between ministries; multi-stakeholder engagement mechanisms; detailed financing models; and a comprehensive monitoring and evaluation framework with performance indicators. Malawi could adopt this structure while tailoring content to its own context and current 24.5% clean cooking access baseline.

While existing policies set broad targets for cookstove deployment, a new dedicated **Clean Cooking Unit** could coordinate interministerial implementation.

5.5.2.2 Technology-Specific Clean Cooking Policy and Regulation Change

The national clean cooking strategy would be supported by developing **national standards for stove testing** - addressing a gap in the current Malawi Renewable Energy Strategy 2017-2030 which lacks specific quality assurance mechanisms for these products.

The limitations in current regulatory frameworks for both LPG and electric cooking must be addressed.

Building on the Electric cooking Roadmap, eliminating customs duties would help remove fiscal barriers to importing and selling electric cookstoves and developing tighter product standards will help improve trust in the market.

For LPG, the National Energy Policy 2018-2023 mentioned regulations but has not ratified them. Implementing a Branded Cylinder Recirculation Model and reforming price regulation policies will help scale the alternative fuel strategies outlined in the National Charcoal Strategy and the National Energy Policy.

5.5.2.3 Carbon Market Frameworks

The carbon finance policy review identified gaps in the NCCMP 2016, which currently lacks specific mandates for carbon market activities and the existing frameworks.

Developing a comprehensive carbon market framework through the Ministry of Natural Resources and Climate Change, including mechanisms for monitoring, reporting, and

[18] Please refer to Component C for detailed analysis on the policies related to clean cooking in Malawi.

verification would strengthen Malawi's ability to implement its NDC 2021 commitments. This includes creating a digital greenhouse gas inventory system and establishing bilateral agreements under Article 6 - elements not present in current policy frameworks but essential for accessing international climate finance opportunities.

5.5.2.4 Residential Electricity Metering Program

Accurate metering allows for the collection of detailed data on household energy consumption, including base demand (non-Electric cooking) and Electric cooking demand. This data is essential for understanding cooking patterns and fluctuations in energy use, which can vary seasonally and daily. Basic scope includes:

- Install smart meters to track household energy consumption
- Conduct network studies to assess grid capacity, headroom
- Use GIS and communications to show headroom to POs to distribute grid-connected electric cookstoves to feasible areas

Metering programs would also open demand response opportunities, allowing utilities to incentivize off-peak usage through time-of-use (ToU) tariffs. This can help shift cooking loads to times when the grid is less stressed, improving overall system efficiency

5.5.2.5 Independent Verification Agency (IVA)

Develop verification approach for reporting on POs and households. For POs, conditions set out in the direct agreements with the NNNF, including KPIs, project milestones, financial health and legal conditions. For households, phone and in-person verification to certify installation, usage and monitor awareness and behaviour related to the product.

The IVA standards of verifying usage for households must be back-to-back to the certification of carbon credit issuances, as carbon credit issuances will be central to the repayment of the facility.

5.5.2.6 Technical Support for SMEs - Cookstove Standards, Testing, Business Development

The technical support program for POs will work from the standards developed from MBS.

The program will: partner with testing labs to validate products, conduct quality assurance workshops, implement business training, connect entrepreneurs to mentors, review market inventory, explore financing options including microfinance and PAYG models, establish metrics to measure compliance, create feedback channels, address challenges through bulk purchasing agreements and promote cookstove benefits for cost, health, safety and environment. The program will also monitor supply chain bottlenecks with SMEs to ensure POs' household customers can access electricity and/or fuels required for stove usage.

5.5.3 Capacity Development

5.5.3.1 Electric Cooking (Safety Standards, Regulation, Stove Development, Capacity Building)

Table 52: Relevant International Standards for Electric cooking devices

Standard/Guideline	Description	Reference
IEC 60335-1	Safety of household and similar electrical appliances – General requirements	https://webstore.iec.ch/en/publication/61880
IEC 60335-2-9	Safety requirements for electrical cooking appliances	https://webstore.iec.ch/en/publication/61318
IEC 60730	Automatic electrical controls for household appliances, useful for appliances with advanced functionality like smart cooking features	https://webstore.iec.ch/en/publication/66089
ISO 14001	Environmental management systems. Could guide energy-efficient and environmentally friendly designs for eCook appliances	
ISO 50001	Energy management systems. Useful for assessing energy efficiency in the design and operation of eCook systems	
IEEE 1547	Standards for distributed energy resources interconnected with electricity grids, relevant for integrating eCook technologies into power systems	
IEEE 519	Harmonic control in electric power systems, addressing potential power quality challenges from high eCook adoption	
Global Alliance for Clean Cookstoves Guidelines	These standards focus on cookstove performance, including thermal efficiency and emissions, which can inform eCook device standards in ensuring clean and efficient cooking solutions	https://cleancooking.org/binary-data/RESOURCE/file/000/000/223-1.pdf
National Grid Codes	Align eCook deployment with grid codes relevant to power quality, reliability, and safety in Malawi, ensuring compatibility with local electrical systems	https://mera.mw/download/grid-code_june-2022/

Entities to Support

- MBS
- MERA
- MOE
- ESCOM
- ACADEMIA

Required Experience

- Proficiency in creating and updating safety standards for electrical appliances, particularly cooking devices.
- Experience in advising on energy regulations and safety protocols, including designing monitoring and implementation plans
- Experience of capacity building within institutions, specifically experience of and ability to train and support institutions in implementing and monitoring standards.
- Experience of electric cooking technologies and their implementation in SSA

Assistance Required

- Conduct workshops to assess existing standards and develop new ones specific to Electric cooking appliances
- Provide training for MBS and MERA staff on testing, certification, and enforcement of Electric cooking standards
- Support in drafting regulations and guidelines for the safe use and promotion of Electric cooking technologies and their integration on the electricity network, topics to include:
    - Raise awareness of generation and network infrastructure intervention requirements for large scale eCook deployment
    - Ensuring smart meters installed for energy consumption monitoring are appropriately sized for high-power appliances
    - Ensuring meter and protection devices installed at power substation level are appropriately sized to handle rapid Electric cooking adoption and demand increase to mitigate power quality and reliability challenges
    - Ensuring households have adequate wiring that can safely handle power requirements of Electric cooking appliances. Solutions should concentrate on supplying resources for wiring installations (along with relevant financing options) that adhere to minimum safety standards to facilitate Electric cooking while being aligned with consumer needs and aspiration
    - Ensuring deployment of remote power quality monitoring, long-term remote energy consumption monitoring, and wiring inspections are adequate
    - Ensuring eCook interventions comply with grid code power quality and reliability standards, considering variation of grid vectors due to power network infrastructure, demand, generation supply and how a user is connected
    - Planning for and dealing with impact of eCook deployment on power quality, voltage fluctuations, associated user's perception, and potential damage to eCook devices
    - Ensuring eCook interventions align with Malawi Grid Code

Suggested Duration and Frequency of Support

- 6 months of intensive support, including monthly workshops and bi-weekly training sessions.
- Quarterly reviews and refresher training over the next 18 months to ensure standards are effectively implemented and updated as needed.

Targeted TA Support Overview

	TA Focus	Support Actions
Malawi Bureau of Standards (MBS)	Provide expertise to develop, update, and enforce safety and performance standards for Electric cooking appliances.	Conduct capacity-building workshops on testing and certifying eCook devices. Develop guidelines to align Electric cooking standards with international norms (e.g., IEC, ISO). Supply testing equipment and resources for consistent quality assurance.
Malawi Energy Regulatory Authority (MERA)	Help draft and enforce regulations for safe eCook integration into the electricity grid.	Assist in creating licensing frameworks for eCook devices and associated technologies. Train MERA staff on monitoring energy consumption and addressing compliance issues. Develop regulatory guidelines to ensure eCook deployment meets grid safety and reliability standards.
Ministry of Energy (MOE)	Support policy formulation and alignment with national energy goals.	Assist in developing Electric cooking policies that address energy access, affordability, and sustainability. Provide expert input on scaling eCook deployment while managing grid impacts. Facilitate interagency coordination to integrate Electric cooking in broader energy strategies.
Electricity Supply Corporation of Malawi (ESCOM)	Strengthen technical capacity for Electric cooking grid integration and demand management.	Conduct training sessions on infrastructure upgrades, such as substation sizing and smart metering. Support in developing monitoring tools for energy quality and consumption trends.

		Provide technical solutions to mitigate voltage fluctuations and ensure grid stability.
NGOs and Civic Society Organizations	Enable effective community engagement and awareness campaigns.	Develop culturally appropriate materials and tools for Electric cooking advocacy. Train staff on behaviour change strategies and community outreach. Provide resources for workshops and demonstrations to promote safe and efficient Electric cooking practices.
Private Sector	Enhance the capacity of eCook manufacturers and retailers.	Provide training on product standards, safety, and consumer education. Offer guidance on marketing strategies and financing models to increase eCook adoption. Facilitate partnerships between private players and regulatory bodies to ensure compliance and innovation.

5.5.3.2 LPG Technical Assistance (Safety Standards, Regulation, Capacity Building)

Assistance Required

- Conduct training on LPG product knowledge and the consumer proposition for LPG in the domestic, commercial and industrial sectors
- Conduct training on various LPG standards, codes of practice and good industry practice guides
- Review of country standards, regulations and codes of practice
- Carry out joint inspection and audit of existing local LPG depots
- Arrange visits to other locations for learning purposes
- Assist in setting up technician's training program for Malawi
- Emergency response planning and training

Required Experience

- At least 20 years of experience in LPG industry (including Africa)

- Expert with international LPG standards and industry best practices and experience of their relevance and application in Africa (NFPA 54 & 58, LGUK Codes (Liquid Gas UK, 2017)
- Exposure to LPG downstream supply and distribution chain i.e. from refinery/natural gas production sites to LPG retail outlets & consumers
- Expert with requirements of bulk and cylinder market segments, especially bulk road transport and cylinder management
- Comprehensive global network of equipment manufacturers and LPG companies

5.5.3.3 Biogas and Pellets/Briquettes

Assistance Required

- Review of relevant country standards, regulations and codes of practice
- Conduct training on various pellet/biogas standards and codes of practice with relevant stakeholders
- Work with MBS to develop standards for capture, treatment and storage of biogas, to be based on relevant international standards (e.g. ISO 24252:2021) and tailor them appropriately to the local market and context
- Work with MBS to develop standards about pellet fuel production, to be based on relevant international standards (e.g. EN 15234-1: 2011) and tailor them appropriately to the local market and context
- Work with MBS to get standards ratified and formally approved
- Work with MERA on a plan for enforcement of standards
- Carry out training on the new standards with relevant players e.g. biogas companies and pellet producers

Required Experience

- Experience with international biogas/pellets standards (including fuel supply) and industry best practice
- Ideally also experience of their relevance and application in Africa (how to modify them for country contexts)

5.5.3.4 Behaviour awareness and campaign manager

Our research has suggested that there are widespread misconceptions about the costs of cooking with modern fuels, which are perceived to be very high.

It is widely acknowledged that consumers resonate more with the affordability and convenience benefits of clean cooking than the environmental and health ones.

Required Experience

- Experience running country-level marketing campaigns in Malawi for consumer products

- Deep understanding with Malawian context and consumers (ideally a local company)
- Experience with clean cooking or energy a bonus

Assistance Required

- Consult with relevant stakeholders (EnDev, Self Help Africa, Ministry of Energy, MCHF, Falcon Gas, Mount Meru, Clean Cooking Alliance) on previous experience with behaviour and awareness campaigns in Malawi. Focus on what has worked to date, what has not worked, and where are the gaps.
- Conduct market research e.g. consumer research groups to understand barriers/misconceptions around clean cooking uptake and what kind of messaging resonates
- Conduct surveys to understand current cooking practices, perceptions of Electric cooking, and potential barriers to adoption
- Gather already-existing data to feed into behaviour change campaigns e.g. CCT results
- Develop and test marketing messages for different clean cooking fuels and technologies. Utilise appropriate marketing channels such as radio, television, and social media to disseminate information and success stories related to Electric cooking.
- Create culturally appropriate educational materials highlighting the benefits and safe use of Electric cooking appliances. For example, leaflets in picture form with user instructions, to help those who may not be able to read.
- Create and disseminate a Malawi eCookbook book similar to Kenya, containing recipes for how to cook local cuisine cooked with eCook devices. Topics to cover should include health, costs, time saving and environmental benefits of Electric cooking, training on how to use eCook devices, their different functionalities and settings as well as how to use them efficiently.
- Implement marketing campaign
- Develop indicators for evaluating the success of the behavioural intervention
- Evaluate marketing campaign*

5.5.3.5 Carbon Finance

In order to help companies in Malawi make full use of carbon financing, a program of technical support to be created. While there is a lot of interest in this type of financing, there is a general lack of expertise and understanding of how carbon financing works.

The program will be aimed at both sides of the transaction: the funders and the companies receiving the funding.

Assistance Required

- Preparing educational materials to present to financial institutions and SMEs. This includes slides and written content.

- Delivering educational presentations to key potential investors in carbon credit projects, as well as to project developers.
- Preparing template emission reduction purchase agreements (ERPAs) and other relevant contracts.
- Stakeholder mapping. The technical expert should conduct a thorough stocktake of relevant projects, insurance providers, investors, buyers, verifiers, and other parties relevant to the carbon financing.
- Facilitating introductions between interested investors and project developers. The technical expert will help to connect funders to opportunities in Malawi.
- Facilitating introductions to other relevant stakeholders. This includes buyers of credits, insurance providers, registries, relevant legal firms, etc.
- Transaction support. The technical expert will be expected to provide support services throughout the investment. This includes providing a price reference, advising on the terms of the investment, and answering any relevant questions. As the expert will not be paid by either party, the expectation is that they will stay impartial and will not have a vested interest in either side of the transaction.
- Credit sale support. If the carbon financing does not include a credit offtake component, the advising expert will also be asked to help find buyers for credits, either as an off-take pre-issuance, or following the issuance of the credits. This includes identifying potential buyers of credits, advising during negotiations, etc.

Suggested Duration and Frequency of Support

The technical expert is expected to spend considerable time at the start of the project to map out stakeholders, prepare educational materials, and begin liaising with the relevant stakeholders. We anticipate this will take a minimum of 6 months.

Following this, the expert will be required to participate on an ad hoc basis. We expect this will take several years, accounting for project investment, setup, registration, credit issuance, and post-issuance support.

Required Experience

The technical experts should have a wealth of experience in the carbon markets. This includes:

- Experience in financial services: An intimate understanding of how lending institutions, equity investors, grantmakers, and streaming companies operate, with experience in carbon and / or other environmental commodities being key. Additionally, experience in insuring carbon credits and / or other environmental commodities would be beneficial.
- Carbon project operations and credit issuance: Experts should have experience in the carbon project lifecycle. This includes conducting feasibility studies for carbon project opportunities, project development based on successful feasibility study, project design document creation, project registration, and ongoing project management.

- Liaising with government officials: As carbon markets are increasingly brought close to government entities (for example, via Article 6.4), it's important for the technical expert to be comfortable working with government officials and relevant non-governmental entities.
- Carbon credit sales: The successful experts should have experience in marketing credits and selling to companies. This includes the entire sales cycle, from initial conversations and answering client questions, to contract negotiations and transfer of credits to client's registry account.
- Providing educational services: As the role requires educating a wide range of stakeholders on a novel financing technique, the ideal organization or technical expert will have experience delivering educational support services to SMEs and financial institutions.

5.5.3.6 Carbon Policy, processes and frameworks to government and agencies

The key targets of the support include the following institutions:

1. Ministry of Natural Resources and Climate Change: leads climate policy and oversees carbon market strategies..
2. Malawi Energy Regulatory Authority: Develops regulatory frameworks for carbon markets in the energy sector.
3. Malawi Carbon Market Initiative : Central to Malawi's carbon market development and private sector participation.
4. University of Malawi and Mzuzu University: Provide research, technical expertise, and capacity building in MRV systems.

A dedicated local institution is recommended to build expertise in carbon market validation and verification, focusing on Monitoring, Reporting, and Verification (MRV), dynamic MRV (dMRV), and adherence to international standards. Supported by MCMI, this institution would provide specialized training in emissions quantification, risk assessment, and safeguard compliance.

Assistance Required

1. Workshops and Training Programs

- NDC Alignment: Clarifying authorized activities and ITMO unit purposes.
- Mitigation Activity Development: Covering additionality, baseline setting, and MRV integration.
- Article 6 & Bilateral Trade: Explaining tracking procedures and mitigation outcome registries.
- Sustainability & Safeguards: Training on integrating sustainable development in projects

2. Technical Advisory Services

- Reporting & Compliance: Support in fulfilling Article 6 reporting obligations.
- Authorization & Adjustments: Training on corresponding adjustments to prevent double counting.
- Registry Management: Assisting in national carbon registry development for ITMO tracking.
- Validation & Verification: Supporting MCMI in establishing a local validation and verification body

Expertise and Experience Required

To support carbon project activity development and implementation, technical experts should have:

Deep understanding of Article 6 mechanisms under the Paris Agreement, particularly:

- Cooperative approaches under Article 6.2
- Paris Agreement Crediting Mechanism (PACM)
- Proven expertise in carbon markets, including: integrity initiatives for transparency, avoiding double counting, and maintaining high-quality carbon credits
- Mitigation methodologies, which involve defining baselines, assessing additionality (proving that the project goes beyond business-as-usual scenarios), and ensuring that emission reductions are measurable and verifiable
- Monitoring, Reporting, and Verification (MRV) systems
- Corresponding adjustments and management of ITMO registries
- Knowledge of bilateral trade agreements and their implications for carbon markets, including the role of such agreements in facilitating cross-border emissions trading and cooperation under Article 6
- Experience in capacity building, including workshops and technical training programs for government stakeholders

5.5.4 Monitoring and Verification

5.5.4.1 Establishment of KPIs

Adoption Rates (no. of HH reached, no. of cookstoves sold)

Percentage increase in households adopting alternative energy (AE) and fuel-efficient (FE) cooking technologies as their primary cooking fuel, with a target of reaching 150,000 households by 2029

Consumer Awareness (random sampling for Lilongwe and Blantyre, digital monitoring for search volumes etc.)

Number of awareness campaigns conducted and the reach of these campaigns, measured by surveys assessing public knowledge of clean cooking benefits in target regions.

Market Price Changes of Fuels and Cookstoves (USD, data collection from MOE)

Collecting from the MOE the market prices of traditional fuels in USD vs MWK, (e.g., charcoal) versus clean cooking solutions to assess economic viability, alongside the market prices of cookstoves in USD vs MWK as well.

Training and Capacity Building (no enrolled/certified)

Number of individuals trained in sustainable cooking practices and business models, particularly targeting women and youth.

Regulatory Compliance (% certified)

Number of clean cooking distributors and suppliers compliant with new Malawi Bureau of Standards (MBS) regulations.

5.5.4.2 Quarterly Reporting

By POs to Fund Manager

- Number of sales for cookstoves
- Sales progress against targets
- Outstanding principal balance
- Principal and interest overdue
- Collection efficiency data
- Technical inspection or usage reports
- Suppliers' service records

Fund Manager's Consolidated Report

Contains:

- Aggregate cookstove figures and geographic distribution
- Grant disbursement tracking and verification results
- Cumulative adoption capacity
- Consumer awareness campaign results and reach
- Impact metrics including household income data

- Price monitoring for fuels and cookstoves
- Training program progress and certification rates
- Portfolio at Risk (PaR) analysis
- Collection rates and loan performance
- Jobs created by POs during the period
- Independent verification results for installations

Adoption Metrics

Metric	Unit	Collection Method	Frequency
Household Adoption Rate	Number of households	Field surveys + distributor reports	Monthly
Cookstove Sales Volume	Units sold	Vendor reporting	Monthly
Geographic Distribution	% by district	GIS mapping + sales data	Quarterly
Target Achievement Rate	% of quarterly target	Calculated from above	Quarterly

Consumer Awareness

Metric	Unit	Collection Method	Frequency
Urban Area Awareness	% of surveyed population	Random sampling surveys	Quarterly
Digital Engagement	Search volume index	Digital analytics	Monthly
Campaign Reach	Number of households reached	Campaign tracking	Per campaign
Knowledge Retention	% correct responses	Structured interviews	Quarterly

5.5.4.3 Annual Reporting Framework

Fund Manager's Consolidated Report

Contains:

- Audited financial statements from POs (within 3 months of fiscal year end) – Management accounts fallback if unavailable
- Comprehensive impact assessment
- Overall program performance against targets
- Market transformation progress
- Gender inclusion metrics
- Environmental and social safeguards compliance
- Training and capacity building outcomes
- Debt portfolio performance analysis
- Detailed verification summary for the year
- Documentation of lessons learned

Other ad hoc/event-based reporting

- Any breaches of facility covenants (TBD on default events)
- Major changes in PO operations or ownership
- Significant market developments affecting program
- Environmental or social incidents
- Changes in regulatory compliance status
- Milestone achievement reports

Reporting structure suggestions:

20XX, Annual Performance Summary

Total Households Reached: [X,XXX]

Annual Adoption Growth: [XX%]

Market Price Change: [±XX%]

Certification Rate: [XX%]

Training Completion: [XX%]

Suggested Impact Metrics to measure on a YoY basis:

Category	Metric	Annual Target	Achieved	Variance
Environmental	Carbon Emissions (tCO2e)			
Social	Household Savings (USD)			
Economic	Market Value (USD)			
Health	PM2.5 Reduction (%)			

Budgeting/Costs:

Component	**Budget (USD)**	**Actual (USD)**	**Efficiency Ratio**
Training			Cost / trainee
Marketing			Cost / HH adoption
Monitoring			Cost / data point
Technical Support			Cost / supplier

Strategic Planning :

Priority Area	Current Status	Next Year Target	Required Resources
Adoption			
Awareness			
Market Development			
Capacity Building			
Standards			

The Fund Manager is responsible for compiling and presenting all reporting to:

- ASCENT/MEAP Project Coordination Technical Committee (Quarterly)
- ASCENT/MEAP Steering Committee (Quarterly)
- Ministry of Energy (As required)
- World Bank (As required)

Guidelines on implementation:

1. All data must be validated through cross-referencing multiple sources where possible
2. Quarterly reports due within 15 days of quarter end
3. Annual report due within 30 days of fiscal year end
4. Independent verification required for all impact metrics
5. Data storage and handling must comply with data protection regulations
6. Regular calibration of measurement tools and methods required
7. Standardized templates/Excels must be used for all reporting

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9 Appendix

9.1 LPG regulations evaluation

4.3 "…..It is the responsibility of the own or user to submit the cylinder for periodic inspection….." Burden should not be placed on the user to return cylinder for periodic inspection.

4.3.2 "….the condition of the cylinder remains in doubt, additional test shall be performed to confirm its suitability for continued service, or the cylinder shall be rendered unserviceable.." Should specify that scrap cylinders must be crushed by hydraulic press to prevent their illegal re-use.

5.2 *Table 1 - Safety Distances for LPG Tanks Installations*. Should adopt latest NFPA 58 standards on Safety Distances.

5.20 Inspection and Quality Monitoring "Depot shall check the composition of the product(s) upon delivery to ensure that product is compliant with minimum requirements of LPG given in **Table 3** below..". Table 3: Requirements for LPG. The parameters indicated in Table 3 are not the usual elements tested for LPG quality control. This should be replaced with the standard LPG specifications used in the industry and MBS have to decide what specifications to adopt i.e. South Africa or Tanzania LPG standards since the bulk of the supply comes from these two countries.

6.4 Guidelines for Filling LPG Cylinders The filling of small LPG cylinders shall be carried out only by or under the direct supervision of a trained person that has been assessed as **competent** . Need to define "competent" and in this regard I suggest that Malawi set up procedure to accredit or certify "competent LPG persons or technicians".

6.4.3.3 Inspection after filling cylinders with LPG .After filling, check each cylinder either by weighing or by ullage space determination (bleed filling), to ensure that it is still within the appropriate mass tolerance. MERA should specify the tolerance level particularly the lower limit below which it becomes an underfilling violation. This could be 0.1 to 0.2kg of declared content e.g. for 14kg cylinders filled quantity should not be below 13.9kg when it leaves the filling plant.

5.17 *Fire Prevention — Design, Instructions and Training*. Should include requirements for fire protection i.e. sprinkler system, fire water requirement, etc. rather than referring to SANS 10400 which is not specific to LPG installations.

No mention on frequency of cylinder requalification

LIQUID FUELS AND GAS (PRODUCTION AND SUPPLY) (LIQUEFIED PETROLEUM GAS) REGULATIONS, 2021

This document is an update and consolidated version of the MERA Regulatory Framework 2020.

Division 4—Storage licence - Should clarify that this license applies to storage of LPG for resale otherwise it will apply also to restaurants and industrial users storing LPG for its own use. The latter group should have a different set of requirements or even waived from such license.

Division 6—Retail licence – retailing of gas is very different from liquid fuels and should have different and simpler requirements to support the expansion of retail outlet network. Requirements should mainly focus on safety of workplace, training of employees. Furthermore, in line with promoting BCRM, refilling in retail outlets should be prohibited.

101.—(1) Road tankers shall have a maintenance schedule that defines the frequency and scope of inspection for each item that is to be maintained.

(2) The frequency of maintenance referred to in subregulation (1) shall be determined by— Must state the interval for tank requalification.

118. (3)*Above ground LPG storage tanks shall be cladded with fire resistant materials*. Not necessary unless required by risk assessment as a mitigating measure.

133. (4)All gates at the area shall be designed to open outwards and kept locked unless access to the tank is required..

136. (14) Fire protection in major gas installations shall be carried out in terms of a rational design as prescribed in SANS 10400. *Suggest to amend this and adopt NFPA 58 or UK LPG Code of Practice requirements for fire protection. South Africa National Standard not suitable for LPG installations.*

152. periodic inspection of LPG cylinders; *Must indicate interval*

168. (3)When an LPG cylinder is tested to prove its fitness for further service, stampings shall be made on the valve bung or on the shoulder if an information plate is fitted. collar plate or shroud.

(a) 169. in printed markings, applied by permanent labelling on all cylinders of 9 kg capacity or less—

(i) a warning that the cylinder shall not be placed on stoves or hot plates and shall be used in the upright position; and

(ii) the maximum mass of gas, in kilograms, that the cylinder is allowed to contain.

(iii) Date due for next periodic inspection

170. (4)LPG cylinders that are marked as damaged and rejected shall be withheld and removed from circulation as prescribed in the relevant MS. Cylinders shall be scrapped by crushing using hydraulic press to prevent illegal re-use.

Division 5—Filling Procedure Provided that where automatic mass measurement is not available, qualified operators shall ensure that cylinders are filled accurately by continuously observing the scale during filling (tolerance shall be: +2 for over-filling and -3 for under-filling). Does not seem right. Suggest this be amended to +0.3kg for overfilling and -0.2kg for underfilling to protect consumers from excessive underfilling.

180. Emergency plans shall be developed to cover all realistic scenarios that could occur, including medical emergencies in all sites with LPG. Emergency response plan should also include scenarios involving LPG tanker road incidents

9.2 Article 6 Fees Examples

The draft version of Malawi's Article 6 Framework is expected to be published after COP29, and indicates Malawi is willing to apply corresponding adjustments of about 17 million tonnes of carbon dioxide equivalence until 2030. Concerns around overselling were observed from consultations with project developers and donors in Malawi *[MCMI]*.

Kenya's Article 6 Fees, drawn from the Climate Change (Carbon Markets) Regulations, 2024 document:[19]

Fee Category	Fee Details

[19] Ministry of Environment, Climate Change and Forestry. (2024). *The Climate Change (Carbon Markets) Regulations, 2024*. Kenya Gazette Supplement No. 105 (Legislative Supplement No. 40).

Application Fees	- Carbon Project Application Fee for Citizens: KES 10,000 ($77) - Carbon Project Application Fee for Non-Citizens: KES 100,000 ($772)
Project Design Document Fees	- Carbon Project Design Document Fee for Citizens: KES 100,000 ($772) - Carbon Project Design Document Fee for Non-Citizens: KES 200,000 ($1554)
Administrative Fees	- Upon DNA Approval: - Projects with annual issuance ≤15,000 credits: KES 150,000 ($1158) - Projects with annual issuance >15,000 credits: KES 300,000 ($2316)
Issuance Fees	- For first 15,000 tonnes CO2 equivalent issued annually: USD 0.10 per carbon credit - For issuance exceeding 15,000 tonnes annually: USD 0.20 per carbon credit
Corresponding Adjustment Fees	- USD 4 per unit of Internationally Transferred Mitigation Outcome (ITMO)

Ghana's Carbon Market Fees for creating authorised ITMOs, credits listing A6.4 activities

Table 6: List of fees, costs for creating authorised ITMOs, carbon offset credits and Article 6.4 mechanism

NO.	Fee Type	Activity category	Fee level (US$)	Timing of fee payment	Fees Description	Fee Justification
1	Mitigation Activity Participant or Entity Application Fees	Grant-based small-scale mitigation activity[41].	300	At the time of submitting the completed participant or entity forms to the CMO	Fees are paid by an activity developer who must create a MAP account on the GCR to obtain MID for the first mitigation activity aiming to generate authorised MOs for transfer either on the GCR or registry linked to a pre-approved ICS in this framework. Fees paid by voluntary carbon project developers seeking formal recognition to create an account on the GCR and list carbon offset credit for recording on the GCR.	Introducing the mitigation activity participant or entity application fees is to pay for administrative and management expenses incurred by Carbon Market Office and minimise redundancy in account creation.
		Small-scale mitigation activity[42]	500			
		Large-scale non-forestry project.	1000			
		Forestry project	500			
2	Mitigation Activity Identification (MID) Fee	Grant-based small-scale mitigation activity	200	At the time of submitting the completed participant or entity forms to the CMO	Fees paid by activity developer seeking to create MID for additional mitigation activity other than the first activity created into the same MAP account.	
		Small-scale mitigation activity	300			
		Large-scale non-forestry project	500			
		Forestry project	300			
3	Unique Identification Number (UIN)	All entities - service providers carbon credit brokers validation/verification entities	400	At the time of submitting the completed participant or entity forms to the CMO	Entities pay a one-time fee to receive a formal letter of identification with a UIN for recording on the GCR. Any new activity the entity gets involved in shall attract an additional $300 fee.	

9.3 Project Appraisal Document Narrative

Component 4 - Clean Cooking Solutions (US$10 million)

75. **In Malawi, approximately 98 percent of households rely on firewood and charcoal for daily cooking, a dependency that drives severe deforestation and land degradation while threatening agricultural productivity, food security, water resources, and hydroelectric capacity**. This over-reliance on solid biomass, much of which is harvested unsustainably, also heightens the country's vulnerability to climate-related shocks. Transitioning to modern cooking solutions faces significant barriers, including limited access to alternatives, low awareness, and affordability challenges. According to the 2023 Malawi Multi-Tier Framework (MTF) household survey, 69 percent of households still use threestone stoves, followed by 22.5 percent using improved cookstoves (ICS), 6.5 percent using traditional stoves, and only 2 percent using clean fuel stoves, including 0.3 percent LPG and 1.7 percent electric stoves. Rural households predominantly rely on three-stone stoves (78.1 percent), compared to just 14 percent in urban areas. Urban areas, in contrast, see higher adoption of improved cookstoves (72.4 percent) and clean fuel stoves (11.1 percent), compared to rural adoption rates of 14.2 percent and 0.2 percent, respectively. Additionally, 14.5 percent of households practice "stove stacking", using multiple stove types for cooking, while 40.6 percent spend over seven hours per week collecting and preparing fuel.

76. **Affordability remains a major obstacle, with only 4.3 percent of households spending less than 5 percent of their total budget on cooking fuel**. According to the MTF survey, willingness to pay for clean fuel stoves is similarly low; only 18 percent of households are willing to pay the full price of an LPG stove upfront, and nearly a third are unwilling to pay under current financing options. However, willingness increases with price reductions, with 48.2 percent of households willing to pay upfront when the price is reduced by 33 percent. Addressing these barriers requires a multifaceted approach, including raising awareness, increasing access to affordable and diverse cooking technologies tailored to consumer needs, and implementing financial mechanisms to bridge affordability gaps.

77. **The fourth component is designed to expand access to modern energy cooking solutions across Malawi**. With a US$10 million allocation—US$7 million dedicated to the clean cooking facility and US$3 million for technical assistance—the component aims to provide Tier 4 and Tier 5 cooking solutions to approximately 150,000 households, benefiting an estimated 645,000 individuals. Core technologies include electric cooking, LPG, and pellet stoves, which are already available in the Malawian market. Retail prices for these solutions range from US$52.20 for a 6kg LPG package (cylinder and cooktop) to US$94.50 for electric pressure cookers (EPCs), bringing the total estimated CAPEX to US$9.06 million. The US$7 million financing allocation will empower local medium-sized clean cooking companies to reach these targets by leveraging carbon financing to ensure scalability and sustainability over and after the Project's duration.

78. **The program's carbon revenue potential will drive its financial sustainability and incentivize scaling**. Based on the World Bank's 2024 clean cooking market assessment in Malawi, Tier 4 and Tier 5 cooking technologies can achieve annual emissions

reductions ranging from 0.5 to 2.5 tCO2 per cookstove (including electric, LPG, and pellet cooking technologies). The carbon revenues generated through this facility will depend on prevailing carbon market prices, and the Project is actively exploring opportunities to secure carbon buyers from the compliance market. Based on preliminary engagements, there will be surplus after deducting debt service and transaction fees. Surplus carbon revenues will be returned to participating companies, enabling reinvestment in operations and expansion.

79. **This component will be implemented by MoE through the NNNF operating a dedicated clean cooking window, following the same implementation framework as Component 2 of the Project**. Through this window, the NNNF will provide loans to competitively selected small and medium-sized companies offering modern energy cooking solutions, including electric cooking, LPG, pellets/briquettes, biogas, and ethanol. The specific allocation of loans, financing terms, eligibility criteria, and fund flow will be detailed in the NNNF's POM.

9.4 Investment Plan

See shared Excel file.