Rwanda

eCooking Market Assessment

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The MECS/EnDev eCooking Market Assessments

This study is one of a series of publications produced jointly by Energising Development (EnDev) and the Modern Energy Cooking Services (MECS) Programme. This series of market assessments offer strategic insight on the current state of electricity access and clean cooking in eight countries across sub-Saharan Africa and South Asia. These studies identify the key opportunities and challenges to the scale up of electric cooking in the coming decade and conclude with a series of recommendations for targeted interventions that could support the development of emerging eCooking sectors. The market assessments are structured according to the MECS transition theory of change (TToC), which consists of three interrelated dimensions: the enabling environment, consumer demand and the supply chain.

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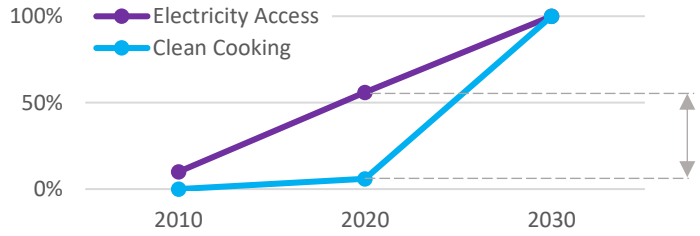
Executive Summary

Over the last decade, Rwanda has been enjoying strong economic growth rates, creating a favourable environment for new businesses and lifting people out of poverty. The Government of Rwanda (GoR) has been actively working towards economic development and reforms in the financial and business sectors which is demonstrated in the improved business climate between 2010 and 2016, with the country moving from 139 to 38 on the annual World Bank Doing Business Report [1]. Rwanda has also made significant progress in electrification with coverage increasing from 10% in 2010 to 66.8% in 2021 [2]. The total installed generation capacity in Rwanda is currently 235.6 MW; of which 11% of the available capacity is imported, the rest is domestically generated: 50.6% through hydrological resources, 43.3% thermal, and 5% solar [3]. However, most of the population still rely on polluting fuels such as firewood, charcoal and other biomass for cooking (approx. 98%) [4, 4a]. Currently 0% of Rwandans use electricity as their primary cooking fuel. Given the traditional Rwandan cuisine, which is largely compatible with electric cooking appliances, such as Electric Pressure Cookers (EPCs) and rice cookers, there is a high potential to transition households to incorporating electric cooking in the future fuel mix. The GoR and the private sector have expressed interest to pursue this opportunity, however, it is currently in its early stages.

Rwanda data snapshot from MECS eCooking Global Market Assessment [5]:



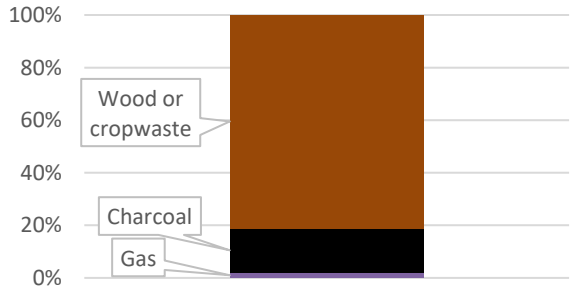
Source: Source: MININFRA (2021) & CFET (2020)[1]

50% connected to electricity, but still primarily cooking with polluting fuels in 2020

Cooking energy

Primary fuel use:

0% cook primarily with electricity



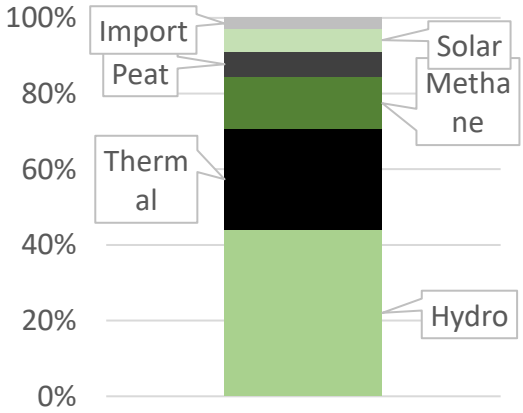
17% cook primarily with commercialized polluting fuels (charcoal)

98% cook primarily with polluting fuels

Electricity generation

On-grid:

~57% renewable



~80MW surplus power generation

High reliability: SAIDI*SAIFI = **29hrs/year**

[1] CFET (2020) National Survey on Cooking Fuel Energy and Technologies in Households, Commercial and Public Institutions in Rwanda; Ministry of Infrastructure and Ministry of Finance: Kigali, Rwanda.

Off-grid:

~6000 households connected to mini-grids 6 solar, 10 hydro mini-grid developers

~2.3m off-grid lighting/appliance customers (mostly SHSs)

eCooking GMA viability scores/rankings

Overall:	On-grid eCooking:	Mini-grid eCooking:	Off-grid eCooking:
76th/130	**96th/130**	**97th/130**	**17 th/130**

Key opportunities

- Rapid expansion of access to electricity in last 10 years
- High urban access to electricity (>90%) and reliable supply
- Increased private sector interest in eCooking for both on- and off-grid contexts, reflected in the recent uptick in eCooking pilots, interventions and research in the country
- Inclusion of eCooking in the largest Clean Cooking Results-based Financing (CC-RBF) to date
- EPC largely compatible with popular 'heavy foods'
- Strong ecosystem for innovation and political will for change
- Fluctuations in LPG prices due to international market supply-demand shifts (e.g., prices going up significantly in recent months, pushing many to switch back to charcoal or firewood)

Key challenges

- LPG actively promoted by the GoR and an aspirational fuel for many
- Electricity commonly perceived as 'too expensive for cooking' and changing the taste of certain foods
- A relatively high cost of grid electricity (a domestic rate per kWh stands at RWF255 (~$0.25) for users <100kWh per month)
- Low awareness of eCooking and low availability of electric cooking appliances, particularly EPCs
- Low income, particularly in rural areas (GDP per capita in 2020 estimated at $816)

Potential impacts of scaled uptake in most viable market segment

If 40% of Rwanda's grid-connected charcoal users (2.9m ppl, 0.7m HHs) switched to eCooking, the WHO's BAR-HAP tool [6] suggests that:

- 669 DALYs/yr avoided
- 0.54m tonnes/yr CO2eq emissions reduced
- 0.21m tonnes/yr reduction in unsustainable wood harvest
- 133m hrs/yr of women's time saved (191hrs/HH/yr)
- 14 months payback for eCooking appliances ($80/HH upfront cost, $75/HH/yr savings on fuel energy costs)
- 236 GWh demand for electricity stimulated

For further detail, please see *Appendix D: Impact of Scaled Uptake*.

1 Introduction

Clean cooking and electricity access in Rwanda

Increasing access to clean cooking and electricity are among the top priorities for the GoR, as reflected in the **Energy Sector Strategic Plan** (ESSP) [7], the **Rural Electrification Strategy** (RES), and the **National Electrification Plan** (NEP). The ESSP divides the energy sector in Rwanda into three main sub-sectors, namely electricity, biomass, and gas and petroleum, with each playing a key role in Rwanda's transition to a middle-income country. Electricity is playing an increasingly important role in Rwanda's economic activity and the ESSP identifies it as one of the main drivers of Rwanda's growth in the next decades. To ensure the efficient development of the power system, a **Least Cost Development Plan** (LCDP) and **Master Plan** for the sector has been developed by the Rwanda Energy Group (REG).

The target electrification rate is **100% by 2024**: 52% of households connected through on-grid and 48% connected through off-grid solutions at Tier 2 and above. In order to achieve the ambitious targets for the electricity sector, the ESSP estimates that a target cumulative generation capacity of 556 MW will be needed. As of December 2020, Rwanda had a cumulative installed generation capacity of 238 MW. Consumption of on-grid electricity is as follows: households (51%), industry (42%), public sector (7%).

Biomass consumption remains high. At 85%, biomass energy is the most important source of energy in Rwanda. Households use 91% of biomass, with the remaining consumption shared between industry (4%), non-energy usage (2%) and commercial and the public sector (both 1%). Reducing reliance on firewood, and in doing so improving health, developing economic opportunities by reducing the time spent collecting wood, and preserving the country's forests is a priority for the GoR. Advanced biomass fuels such as pellets and briquettes are proposed by the GoR as alternatives to displace firewood and charcoal, particularly in rural areas. Biomass is largely consumed for cooking, with wood used by rural households and charcoal by urban households.

The GoR has set a goal to reduce the number of households using wood and other biomass fuels from 83% in 2017 to 42% by 2024. It hopes to achieve universal clean cooking access by 2030. Under the Nationally Determined Contribution (NDC) framework, the GoR have also committed to disseminating modern efficient cook stoves to 80% of the rural population and 50% of the urban population by 2030. The policy target for LPG adoption was set at 40% of the population (across residential, institutional, and industrial sectors) by 2024. In addition to LPG, other promoted alternatives to meet the overall 42% target include biogas, electricity, and improved high-efficiency biomass cookstoves (including pellet- and briquette-burning stoves). There is no specific (and separate) target for eCooking.

2 Enabling environment

eCooking policy outlook: Strong policy in place in both the electricity access and clean cooking sectors. However, clean cooking and electrification are largely treated as two separate problems calling for different policy interventions. There is a need to connect clean cooking and electrification policies through evidence-based advocacy and stakeholder engagement on the advantages in doing so. Evidence base on the advantages of scaling up eCooking is still limited. Evidence generated through current and upcoming pilot projects and the work carried out by Energy 4 Impact (E4I) with the support from MECS, will be critical in changing the narrative and will present better opportunities for influencing future policies and interventions.

Key policy stakeholders: Ministry of Infrastructure (MININFRA), Rwanda Energy Group (REG)- consists of Energy Utility Corporation Limited (EUCL) and Energy Development Corporation Limited (EDCL), Rwanda Utilities Regulatory Authority (RURA), District governments, Rwanda Standards Board (RSB)

RISE (Regulatory Indicators for Sustainable Energy) scores:

73%	60%	90%	62%
Electricity Access	Clean Cooking	Renewable Energy	Energy Efficiency

Targets:

Electricity access	**Clean cooking**
100% electricity access by 2024 (grid/off-grid)	100% clean cooking access by 2030

Key government/NGO programmes creating the enabling environment in which eCooking can scale:

- Energy Sector Strategic Plan (ESSP)
- Rural Electrification Strategy (RES)
- National Electrification Plan (NEP)
- Nationally Determined Contribution (NDC)
- Rwanda Energy Access and Quality Improvement Project (EAQIP) funded by the World Bank: USD 150 million (a USD75 million grant and a USD75 million loan) for its largest clean cooking operation in Africa.
- Clean Cooking Fund (CCF), which is hosted by the World Bank's ESMAP, will provide USD20 million for clean cooking, with USD10 million provided as a grant and USD10 million extended as a loan. The project will leverage an additional USD30 million in public and private sector investments. eCooking is covered.
- Biomass Energy Strategy (BEST) which sets out a strategy to reduce reliance on wood and charcoal (as well as making their use more sustainable).
- National Strategy for Transformation (NST): the sector objective is to halve the number of households using traditional cooking technologies to achieve a balance between supply and demand of biomass through promotion of energy efficient technologies.
- Energy and Environment Partnership Trust Fund (EEP Africa), hosted and managed by the Nordic Development Fund (NDF) and the Austrian Development Agency; a clean energy financing facility, EEP Africa provides early-stage grant and catalytic financing to innovative clean energy projects, technologies and business models in 15 countries across Southern and East Africa. In Rwanda, the fund is currently financing projects in different subsectors including hydropower, solar PV, and clean cooking.
- SNV-implemented EnDev's programme (2019-2020) supported local workshops and produced and disseminated 20,000 ICS. As an expansion to the programme, EnDev signed a co-financing agreement

with the EU (until October 2025) under the project ""Reducing climate impact of cooking in Rwanda through improved cooking energy systems" (ReCIC) to support the achievement of the BEST strategy.

- **GIZ**, through the **EnDev Programme**, have also supported clean cooking projects. Until 2011, EnDev Rwanda supported the biogas sector by building digesters to supply rural households. The target group for the domestic biogas programme was households in rural areas that own cattle in a stable near the homestead.
- **Green Gicumbi**- a GCF-funded project led by FONERWA which aims at increasing the resilience of vulnerable communities to climate change.
- **MECS** focus exclusively on modern energy cooking services. In Rwanda, it has provided funding for studies on socio-technical transitions to eCooking [8] and a market assessment of modern energy cooking in Rwanda [9], including through ongoing household cooking diary studies being conducted by **E4I**.
- **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). Another pilot, in partnership with Access to Energy Institute (A2EI), is planned for on-grid areas with 150 households.

Key barriers/drivers in the enabling environment:

- While the primary focus of the (GoR) is to boost commercial and industrial uses of electricity in the country, the current low household demand for electricity might be further triggered by making energy efficient and affordable electric cooking appliances more available, which would also help with the current oversupply of electricity.
- Rwanda has received a significant amount of funding to support the development of its energy sector and transition the country to clean energy, including for cooking. The CC-RBF is expected to speed up the progress substantially over the next few years.
- eCooking is in very early stages in Rwanda and there has not been any active efforts by the GoR to promote it. However, eCooking is included in the CC-RBF and the current studies and pilots conducted by MECS and E4I, and private sector players (e.g., ARC Power and Electrocook) should build the necessary evidence to spark further interest among policymakers and international stakeholders involved in Rwanda's energy sector.

For further detail, please see *Appendix A: Enabling Environment*.

3 Consumer demand

What's on the menu?

In a typical week, a Rwandese household might prepare:

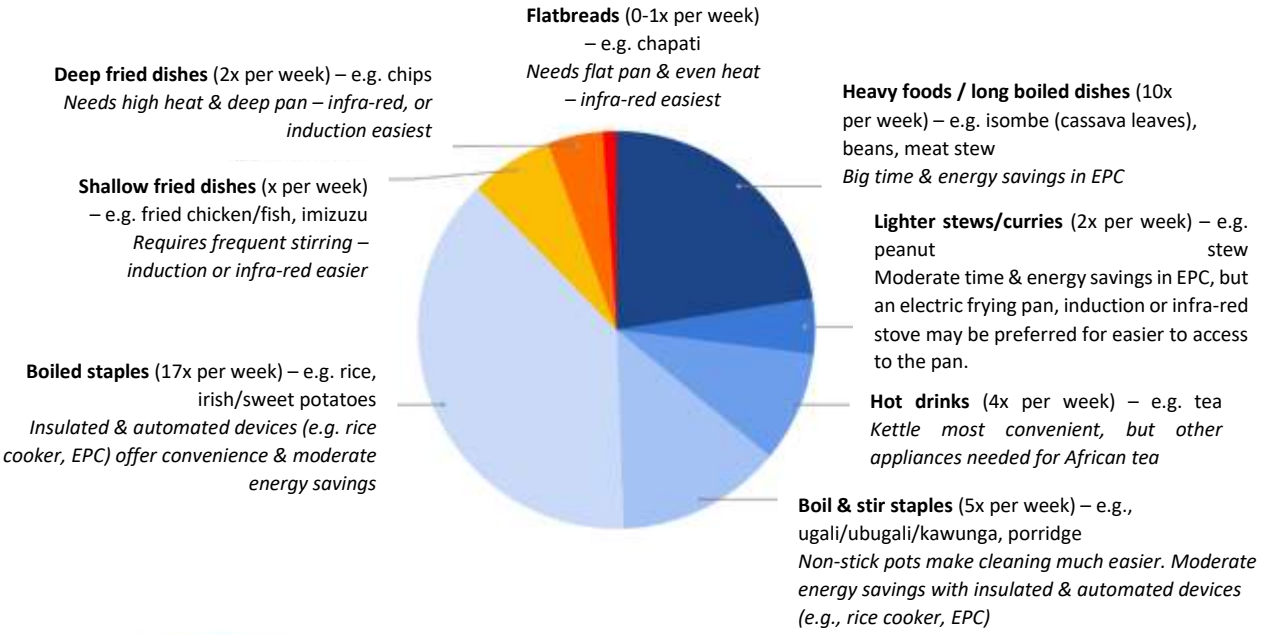


Figure 1: Visualisation of the results of a culinary analysis carried out during this market assessment by asking local team members to map out the dishes that a typical Rwandese household might prepare in an average week and assessing their compatibility with modern energy-efficient appliances.

Popular meal combinations in Rwanda include:

- *Ugali/ubugali/kawunga, boiled veg and meat stew* – ugali, ubugali and kawungu are thick porridges that are boiled and vigorously stirred. They're very easy to cook in an EPC or rice cooker (as are boiled vegetables) and the non-stick pot is much easier to clean, although most people won't believe you until you show them so may prefer an induction or infra-red stove. Meat stew is a 'heavy food' that requires boiling for over an hour to soften the meat, so there are big time and energy savings with an EPC.
- *Imizuzu, boilo and salad* – Similar to above as Imizuzu is a thin porridge made from millet flour, boilo is a meat soup that is typically boiled for over an hour. Salad doesn't require cooking.
- Rice, cabbage and plantain – A rice cooker is an obvious choice here, but the cabbage and plantain usually require frying, meaning that an infra-red/induction stove will likely be the preferred option so that a shallow pan that is easier to stir can be used.
- *Porridge/igikoma and tea* - EPCs can cook porridge and African tea very easily (without pressurizing), however many people will choose a sufuria (saucepan) on an infra-red/induction stove instead.

Most viable energy-efficient appliances: **EPCs, rice cookers, induction, infra-red, kettles, microwaves**

Key marketing messages: **energy-efficient appliances offer substantial time and cost savings and enable multi-tasking. Reduction of smoke as well as reduction of cooking time (especially for long-cooking foods). EPCs are the cheapest and most convenient way to cook heavy foods.**

Key demand side barriers/drivers:

- Limited awareness of the range of the available modern energy-efficient electric cooking appliances and their compatibility with Rwandan cuisine.

- Deep-rooted social-cultural perceptions built over histories of biomass dependency and widely-promoted intermediary technologies such as improved biomass cookstoves, including the perception that food cooked with electricity doesn't taste the same and that electricity is 'too expensive for cooking'.
- Cooking with energy-efficient electric appliances such as an EPC can be much cheaper than popular cooking fuels, yet the high upfront cost of energy-efficient appliances is prohibitive for the low- and middle-income households that would stand to benefit the most.
- Mobile money relatively widely adopted (61% penetration, growing year on year).

Key demand creation programmes:

- Currently none. Electrocook planning to run awareness campaigns and lobby the GoR to actively include eCooking in their policies and promote uptake (e.g., through tariff breaks).

Key market segments:

- *Urban charcoal users* – 65% of households located in urban areas use charcoal as cooking fuel. In rural areas, that number stands at 6%. Unlike firewood, charcoal is almost always purchased, creating an attractive existing expenditure to convert into electricity units. Charcoal prices oscillate depending on the season (dry/rainy) and have been on the rise also because of the Covid-19 pandemic. Charcoal is typically preferred for heavy foods, as it burns slowly and many people believe it is the cheapest way to cook them. EPCs offer a highly attractive modern alternative that can greatly reduce expenditures on cooking fuel, however the upfront cost is a substantial barrier for many who use charcoal, which can be purchased in small quantities. As majority of the urban charcoal users are grid-connected, there is an opportunity to transition them to cleaner fuels, including electricity (currently 0.19% of households use it for cooking [10]). However, the relatively high electricity tariff for households is another barrier to be considered.
- *LPG users* – 5.6% of urban households use LPG, and only 0.2% of rural ones do. In 2018, only eleven importers were supplying the country with cooking gas. The importers transport all LPG by road tankers of 10-20 metric tons through either Kenya or Tanzania. The retail shops vary from petrol service stations, supermarkets, and independent distributors, who sell the gas in different sizes ranging from 6kg to 50kg. There is an active push by the GoR to promote uptake of LPG in urban areas.

For further detail, please see *Appendix B: Consumer Demand*.

4 Supply chain

Key domestic eCooking appliance manufacturers: No in-country manufacturers.

Key eCooking appliance distributors: (Von) Hotpoint, Mika, Black and Decker, Femas, Smifer, and Bosch, among others. These brands are imported from Dubai, China and Europe via Dubai, and distributed through local retail stores.

Innovative eCooking pilot projects:

- **ARC Power**, a South African start-up established in Rwanda in 2017, developed a financial model to show the viability of e-cooking for rural mini grids in Sub Saharan Africa. ARC Power piloted the use of EPCs (in 5 households connected to the mini-grid) and electric hotplates (also 5) and have been selling procured electric cooking appliances to their customer, along with heat-retention bags (a local version of the 'wonderbag').
- **Electrocook** 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. In this pilot, Electrocook will be testing an innovative financing mechanism to incorporate the EPC costs into the electricity tariff over a determined period. Another pilot, in partnership with Access to Energy Institute (A2EI), is planned for on-grid areas with 150 households. The company is in the process of sourcing EPCs from Midea, a manufacturer based in China.
- **E4I** have been funded by MECS to pilot EPCs and infrared stoves in 25 grid-connected households in Kigali. Various tariffs (with electricity top ups) have been tested and a Cooking Diary study conducted. Analysis of the collected data is currently underway.

Key supply side barriers/drivers:

- Early piloting of innovative consumer financing mechanisms underway to enable low-income households to unlock low-cost cooking with energy-efficient appliances.
- Limited availability of EPCs and other energy-efficient electric cooking appliances, with no local manufacturing and therefore complete reliance on imports, which additionally raises the price of appliances.
- Limited access to after-sales services for modern energy-efficient electric cooking appliances.
- Reliability of electricity high in urban areas, lower in rural areas where connections exist. Majority of rural customers connected to off-grid solutions, such as SHSs (10W-50W) which currently cannot support electric cooking appliances.

Popular appliances in Rwanda today:

- Task-specific appliances such as rice cookers and kettles are popular amongst higher-income urban households.
- EPCs are not commonly used and have only recently broken into the market. Today, no more than 5 different models are on sale through retail channels.
- Hotplates are not commonly used though kitchen stoves with a combination gas and electric plates are available.
- Induction and infra-red stoves have yet to see any uptake, as LPG is more readily available and strongly promoted with LPG stoves widely available.

Table 1: Import volumes and typical retail prices for selected eCooking appliances in Rwanda.

Appliance	**Sales volumes (Jul-Dec 2019 import data)**	**Typical retail price (MECS & E4I Survey – online retailers in Kigali)**
Oven/cooker (gas/electric)	No available data	RWF200,000-500,000 (USD200-500)
Hotplate (1 burner)	No available data	RWF35,000 (USD35)
Rice Cooker	No available data	RWF40,000-60,000 (USD40-60)
Kettle	No available data	RWF40,000-70,000 (USD40-70)
Electric Pressure Cooker (EPC)	No available data	RWF80,000-100,000 (USD80-100)
Microwave	No available data	RWF100,000-150,000 (USD100-150)
Induction/infra-red stove (1 burner)	No available data	RWF85,000 (USD85)

Relative cost of eCooking vs. popular cooking fuels:

- The table below indicates that eCooking is likely to be slightly cheaper than purchased biomass, but slightly more expensive than LPG.
- Mini-grid tariffs are roughly double the highest tier of the regular grid tariff, meaning that cooking all your food with electricity would be more expensive than other fuels, however cooking part of the menu with energy-efficient appliances will likely still be cost effective (e.g. heavy foods with EPCs).

Grid electricity tariffs:

- **Lifeline (0-15kWh/month): RWF89/kWh** (USD0.090/kWh)
- **Regular (>15-50kWh/month): RWF212/kWh** (USD0.21)
- **Regular (>50kWh/month): RWF249/kWh** (USD0.25)
- **Mini-grid tariffs**:

Private sector avg.: RWF560/kWh (USD0.56/kWh)

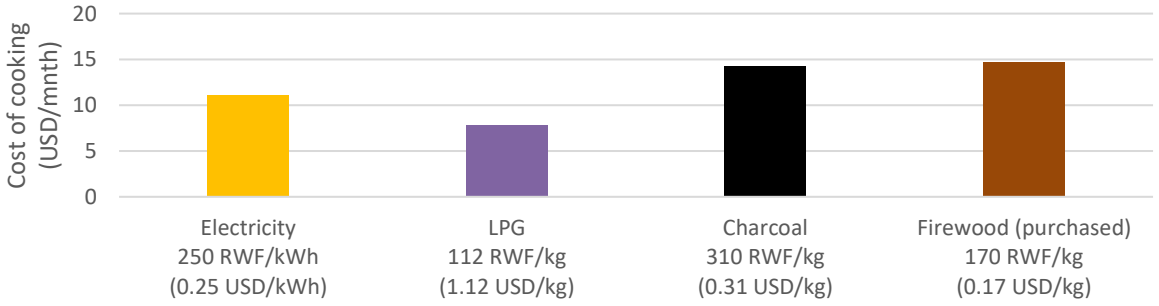


Figure 2: Cost comparison of different cooking fuels based on international averages for cooking energy demand from ESMAP (2020) and local electricity/fuel prices obtained during this market assessment.

For further detail, please see *Appendix C: Supply chain & delivery models*.

5 Recommendations for interventions

Table 2: Decision matrix/board highlighting key factors and viability of specific interventions.

		Current status (inc. summary of key opportunities & challenges)	**Recommended interventions (highlight most important in bold)**
Market segments	**On-grid**	Majority of urban population now connected to the national grid but uptake of electric cooking appliances has been low. Grid reliability in urban areas is high. Utility are willing to stimulate demand for surplus power. However, electricity tariffs are relatively high as compared to the wider region. Limited evidence on the cost-benefits of cooking with energy efficient eCooking appliances. E4I currently conducting a pilot with 25 households using EPCs and infrared stoves.	Support utility to develop a cooking with electricity demand stimulation programme and to consider tariff breaks for households adopting electric cooking. Support knowledge creation on the economics of cooking with electricity and the socio-cultural acceptance of eCooking solutions. Advocate for tax exemptions for AC electric cooking appliances.
	Mini-grid	One (small) pilot has been conducted on a solar mini-grid and another (larger) one is underway (Electrocook and ARC Power). Tariffs are major barrier.	Explore viability of carbon finance to enable dedicated subsidised cooking tariffs. Explore various tariff structures jointly with financing of the appliances.
	Off-grid (SHS)	No pilots of eCooking conducted on SHSs to date. Most SHSs are sold in rural areas and do not exceed 50Wp. However, most are sold on PAYG and could potentially include super energy efficient cooking appliances as upgrades.	Advocate for tax exemptions for DC electric cooking appliances. Support SHS companies interested in piloting DC EPCs.
TToC dimensions	**Supply chain**	Product fit of EPCs established with early pilots, but limited availability in retail outlets. No mainstream financing options available to buyers in retail stores.	Raise awareness of the CCF RBF to develop local supply chains for (affordable) EPCs. Leverage existence of private eCooking distributors and support development of reliable supply chains.
	Consumer demand	Early pilots indicate cultural compatibility of EPCs with local cuisine with product adjustments likely needed (e.g. extra pot). Social acceptability has been high in pilots, but most consumers unaware of this new appliance. Cost remains a barrier but opportunities to alleviate it under CCF RBF.	Set up consumer awareness campaigns involving a blend of live cooking demonstrations, TV and social media to shift perceptions around affordability of eCooking. Leverage trust placed in GoR's messaging and new technology support. Support development of financing schemes for electric cooking appliances (capex), in addition to the CCF RBF (e.g., through bank loans, MFIs, SACCOs etc.).
	Enabling environment	Current policy framework supportive of clean cooking & electrification in separate strategies but does not connect the two. LPG the dominant fuel being pushed for urban areas, however, a mix of LPG and electricity could be highly desirable to curb the use of charcoal, particularly in light of rising LPG prices.	Support MININFRA and REG on leveraging the fast expanding and good quality grid network for clean cooking. Support the development of joined up energy policy that connects the clean cooking and electricity access domains through evidence-based advocacy.

Appendices

These appendices present further detail on each of the three dimensions explored in this market assessment.

Appendix A: Enabling Environment

Clean cooking and electricity access, and their place in the national agenda

Increasing access to clean cooking and electricity are among the top priorities for the GoR, as reflected in the **Energy Sector Strategic Plan**[2] (ESSP), the **Rural Electrification Strategy** (RES), and the **National Electrification Plan** (NEP). The ESSP divides the energy sector in Rwanda into three main sub-sectors, namely electricity, biomass, and gas and petroleum, with each playing a key role in Rwanda's transition to a middle-income country (MININFRA, 2018). Electricity is playing an increasingly important role in Rwanda's economic activity and the ESSP identifies it as one of the main drivers of Rwanda's growth in the next decades. To ensure the efficient development of the power system, a **Least Cost Development Plan** (LCDP) and **Master Plan** for the sector has been developed by REG.

Reducing reliance on firewood, and in doing so improving health, developing economic opportunities by reducing the time spent collecting wood, and preserving the country's forests is a priority for the GoR. Advanced biomass fuels such as pellets and briquettes are proposed by the GoR as alternatives to displace firewood and charcoal, particularly in rural areas. Biomass accounts for 85% of all energy consumed. Biomass is largely consumed for cooking, with wood used by rural households and charcoal by urban households. The biomass subsector is being informed by the development of the **Biomass Energy Strategy**[3] (BEST) (2018) which sets out a strategy to reduce reliance on wood and charcoal (as well as making their use more sustainable). Under the **National Strategy for Transformation**[4] (NST), the sector objective is to halve the number of households using traditional cooking technologies to achieve a balance between supply and demand of biomass through promotion of energy efficient technologies. Under the Nationally Determined Contribution (NDC) framework, the GoR have also committed to disseminating modern efficient cook stoves to 80% of the rural population and 50% of the urban population by 2030.

Modern fuels such as LPG or biogas are also regarded by the GoR as cleaner alternatives for cooking. Biogas has been widely promoted among institutional facilities and households under the **National Domestic Biogas Programme** since 2008, reaching 3,700 households, 86 schools and prisons across the country to date. However, the high upfront costs, technical maintenance requirements and availability of waste have hampered wider adoption. LPG has started to gain traction as an alternative fuel for cooking, and it is currently regarded as one of the fastest solutions to curb biomass demand in Rwanda. However, its presence is mostly limited to urban areas and high-income households to date. The GoR, under the coordination of MININFRA, created a national **LPG Master Plan** to set the policies and actions required to achieve the national LPG use target.

Clean cooking and electrification are largely treated as two separate problems calling for different policy interventions. There is a need to connect clean cooking and electrification policies through evidence-based advocacy and stakeholder engagement on the advantages in doing so. Evidence base on the advantages of scaling up eCooking is still limited. Evidence generated through current and upcoming pilot projects and the work carried out by E4I with the support from MECS, will be critical in changing the narrative and will present better opportunities for influencing future policies and interventions.

There are no specific policies that actively constrain the development of an eCooking market. However, import tariffs and certification requirements can be burdensome and hinder the availability of eCooking appliances in the country. Likewise, there are currently no policies which actively support the development of an eCooking market. However, cooking with electricity is among the alternatives needed to reduce the heavy reliance on

[2] https://www.reg.rw/fileadmin/user_upload/Final_ESSP.pdf
[3] See https://www.reg.rw/fileadmin/user_upload/Final_ESSP.pdf for details
[4] https://www.nirda.gov.rw/uploads/tx_dce/National_Strategy_For_Trsansformation_-NST1-min.pdf

biomass. The need to spark higher electricity consumption should additionally work in favour of eCooking market developments in the future, with opportunities for electricity tariff breaks for households adopting eCooking and reduced or removed import taxes on eCooking appliances to boost supply and make products more affordable.

National clean cooking and electrification targets

The target electrification rate is **100% by 2024**. This will see 52% of households connected through on-grid and 48% connected through off-grid solutions at Tier 2 and above (predominantly SHS and solar mini-grids). In order to achieve the ambitious targets for the electricity sector, the ESSP estimates that a target cumulative generation capacity of 556 MW will be needed. As of December 2020, Rwanda had a cumulative installed generation capacity of 238 MW. Consumption of on-grid electricity is split between households (51%), industry (42%) and the public sector (7%).

Biomass consumption remains high. At 85%, biomass energy is the most important source of energy in Rwanda. Households use 91% of biomass, with the remaining consumption shared between industry (4%), non-energy usage (2%) and commercial and the public sector (both 1%). Industrial use is largely in tea industries and small-scale brick making, with biomass used for drying.

The GoR has set a goal to reduce the number of households using wood and other biomass fuels from 83% in 2017 to 42% by 2024. It hopes to achieve universal clean cooking access by 2030. The policy target for LPG adoption was set at 40% of the population (across residential, institutional, and industrial sectors) by 2024. In addition to LPG, other promoted alternatives to meet the overall 42% target include biogas, electricity, and improved high-efficiency biomass cookstoves (including pellet- and briquette-burning stoves). There is no specific (and separate) target for eCooking.

Appendix B: Consumer Demand

The very limited uptake of eCooking has primarily taken place in urban, grid-connected areas among middle- and high-income households. This involves mainly electric cooking appliances such as kettles, microwaves, toasters, rice cookers etc. The use of electric hot plates is limited although gas stoves with included electric plates are available. Local distributors and retailers dominate the supply of electric cooking appliances in Rwanda. The following brands/distributors are present in the country: (Von) Hotpoint, Mika, Black and Decker, Femas, Smifer, and Bosch, among others. These brands are imported from Dubai, China and Europe via Dubai, and distributed through local retail stores.

The EICV5[5] shows that 53% of the households set up their stoves in a separate dwelling indoors, while 20% of the households install their stoves outdoors and 5% in the same dwelling in a sleeping area (NISR, 2018). In 2017 the three-stone stove was the most commonly used stove by households in Rwanda, with 53% of households. 16% of the households use other traditionally manufactured stoves. This results in almost 70% of Rwandan population using low efficiency stoves that emit high levels of pollutants. Charcoal and fire stoves are used by 16.2% of households across Rwanda, and efficient cookstoves by 13.5%. Stove stacking (i.e., use of multiple cookstoves) is common in 6.6% of households, and more common in urban areas (10.7%) than in rural areas (5.6%)[6]. For majority of households using various cookstoves, the additional or secondary stoves are lower performing than the primary stove. For instance, most households that use an ICS as their primary stove use a three-stone stove as a secondary stove, while the households using clean stoves as their primary stove continue

[5] The Fifth Integrated Household Living Conditions Survey, conducted in 2017 among Rwandan households.
[6] ESMAP (2018). Beyond Connections: Country Diagnostic Rwanda. Online: https://openknowledge.worldbank.org/bitstream/handle/10986/30101/129101-ESM-P156666-PUBLIC-MTF-Energy-Access-Country-Diagnostic-Report-Rwanda-6-2018.pdf?sequence=1&isAllowed=y

relying on ICS as secondary stoves (World Bank, 2018). LPG stoves are available but still used by a small proportion of the population. Only 5.6% of households report using LPG as a primary cooking fuel in 2020[7].

Table B1. Market cost for different cooking fuels in Rwanda. Source: Market assessment conducted by E4I.

Type of cooking fuel	Market price (RWF)	Market price (USD $)
Firewood (7kg) in Kigali / Provinces	1,200 / 800	1.2/0.80
Charcoal (1kg pan) in Kigali / Provinces	300 / 250	0.3/0.25
Charcoal (35kg bag) in Kigali / Provinces	11,000 / 9,500	11/9.5
Pellets (1kg / 30 kg / 40 kg / 60 kg)	250 / 4,000 / 6,000 / 8,000	0.25/4/6/8
Briquettes (1kg)	200	0.2
LPG empty cylinder (6 kg / 12 kg / 15 kg)	20,000 / 30,000 / 45,000	20/30/45
LPG refilling cost per cylinder (6 kg / 12 kg / 15 kg)	7,000 / 13,500 / 17,000	7/13.5/17

According to the World Bank, average monthly consumption of charcoal is 36 kg for households with an ICS, compared to 50 kg for households using a traditional stove. This translates to RWF10,000-15,000/month ($10-15/month) on charcoal at current market prices and contrasts with a monthly average expenditure of RWF1,930/month ($1.9/month) by households using firewood (often collected at no cost) (REG, 2021). REG estimate that the average household uses around 1.8 tonnes of firewood each year to satisfy cooking needs with a traditional stove, equivalent to 150 kg of firewood per month or 5 kg/day (MININFRA, 2021). Despite the lower cost of firewood compared to charcoal, if it is not collected for free and always purchased at market prices, the spend on it can be substantial, at up to RWF11,000/month ($11/month), given the amounts that are needed to satisfy the cooking needs.

Comparison of cooking with popular fuels as compared to eCooking

The evidence is currently extremely limited. Lessons learnt from the ARC Power pilot show that with the current mini-grid tariff, cooking with electricity is not competitive with traditional fuels, such as firewood and charcoal. However, Electrocook's research shows that cooking with electricity can offer savings of USD5-10/month in urban households who currently pay for cooking fuels, particularly charcoal (and in some instances also LPG) and are connected to the national grid.

Key lessons learned from eCooking pilots and activities to date

Key lessons learned through the MECS-E4I research:

- Electricity reliability within Kigali City is quite high, which is favourable for the introduction of eCooking. This has been observed during the ongoing MECS Cooking Diary study being implemented by E4I with participants cooking with electricity without any power cuts.
- Awareness raising campaigns and sensitization for eCooking and energy efficient cooking in general are needed. Significant energy is wasted both on unnecessary overcooking practices (e.g., boiling water for several minutes after it comes to boil), and unnecessary multiple cooking events (e.g., cooking the same food item in small quantities several times a day). The latter, however, might also be a result of lack of cooling options as low-income households cannot afford refrigerators.
- Energy efficient eCooking appliances, such as EPCs, have been found to be compatible with most dishes and existing cooking habits in Rwanda. This has been observed in households using 100% eCooking in Kigali City for continuous 2 weeks using EPCs and infra-red cookstoves.
- An EPC with more than one inner pot would serve households better as some people feel it is time-consuming to empty and clean the pot before cooking the next item. Some foods interfere with the taste of others. E.g., a pot used to fry meat changes the taste of water heated for tea.
- There are small variations in cooking habits that affect the energy consumption and cooking process. E.g., some households prefer soaking beans, while others do not. Others believe cooking with electricity for large number of people is too expensive.

[7] https://www.mininfra.gov.rw/fileadmin/user_upload/Mininfra/Publications/Reports/Energy/E-swap/Backward_Looking_Joint_Energy_Sector_Review_Report_FY_2019-20..pdf

- When households have both an infra-red cooker and an EPC, they tend to use the former more because they are used to placing the pot on a stove and can use most of their existing cooking pots.

Key lessons learned through the ARC Power pilot were:

- The mini-grid tariff makes electric cooking (EPCs and hot plates) non-competitive compared to the cost of existing traditional cooking fuels (mostly firewood and charcoal);
- One cooking pot in an EPC is insufficient to cover all the cooking needs of a rural household;
- The pilot participants found the EPC used in the pilot difficult to operate, partly because all the instructions were in Chinese and there were too many buttons, which made it confusing;
- Heat retention bags can be a good complementary solution for cooking on hot plates, where after bringing the pot to boiling, the rest of the cooking continues in a heat-retention bag;

Key lessons learned through the work of Electrocook to date:

- The public interest in clean cooking in Rwanda is ubiquitous: the GoR is supportive of clean cooking. EDCL indicated their support for the dissemination of EPCs by helping to receive tax exemptions and making EPCs eligible for accessing the World Bank's Clean Cooking Fund RBF.
- Being active in the clean cooking/EPC sector means starting small: much learning is still needed and many hypotheses are to be tested with EPCs (e.g. how much value is added by a second inner pot? How are people integrating the product into their cooking routines?). If EPCs are not introduced correctly, the reputation of, and excitement about, EPCs can be damaged long-term. Cooking with EPCs requires a behavioural change component and therefore it is hard to grow or scale up rapidly.
- Investments in cooking with EPCs are hard to attract: the proof of concept is yet to be illustrated. More pilot studies on the mini-grids and the national grid are needed. Many 'traditional' investors seem to expect a specific return on investment. However, the clean cooking sector offers that to a limited extent hence more impact/angel investors are needed. Without grant funding, Electrocook could never have started as the business risks would be too high. Electrocook now faces the challenge of matching the grant money that is provided by EEP.
- Market for EPCs is slowly developing: with big players like Groupe SEB aiming to tailor EPCs for the African market, investments and knowledge are being attracted. Some organisations are also exploring EPC applications in areas such as institutional cooking with EPCs of 40L-60L size.
- Collaboration is key: making EPCs feasible requires all clean cooking stakeholders to collaborate and it cannot be achieved by one company alone. Sharing specialized knowledge and information is essential, e.g. data collection support for the pilot study or production of know-how for the local manufacturing of inner pots for partners such as the Rwanda Engineering and Manufacturing Corporation (REMCO).

Appendix C: Supply chain & delivery models

Upfront vs consumer financing purchases among different market segments

Urban and peri-urban high-income households will be able to purchase electric cooking appliances up front. Depending on the price point, urban and peri-urban middle-income households might also be able to afford up-front payments. The other segments, inclusive of most rural households, will require financing. Consumer financing models which have reached scale include:

PAYGO models have reached scaled in the off-grid solar sector. PAYGO is the primary method for financing customers in Rwanda, due to the lack of credit histories among the majority of rural customers. PAYGO has significantly impacted on the growth of the off-grid solar sector and has benefited from a strong mobile money sector. Currently, around 3 in 5 (61%) adults use mobile money with more males (68%) having mobile money accounts as compared to women (56%)[8].

Micro-Finance Institutions (MFIs) and **Savings and Credit Cooperatives** (SACCOs) have been targeted through the REF to boost SHS adoption. However, the number of loans has been relatively small. The ability and capacity of MFIs to acquire new customers is also low. As SHS companies offer financing options, they effectively

[8] https://www.bnr.rw/fileadmin/user_upload/Rwanda_Finscope_2020.pdf

compete with MFIs and SACCOs. Though prices are lower through SACCOs, SHS companies have the advantage of requiring no collateral, making them more attractive.

Supply chain and delivery models

The supply chain for eCooking products and services are still in the early stages. However, some work is ongoing to develop these. Although EPCs were previously difficult to acquire in Rwanda, the supply chain looks promising in light of developments such as Neseltec's sourced EPC achieving finalist status in the Global Leap Competition Buyers Guide, meaning that it will qualify for future incentives for supply chain development such as RBF. Electrocook's vision is to assemble EPCs in Rwanda in its quest to address supply chain issues and provide employment. Similarities across East African cuisines mean that companies like BURN Manufacturing, who have achieved economies of scale, can export to other countries in the region.

Delivery models

Pay-as-You-Go (PAYGO) models have reached scale in the off-grid solar sector. Most SHSs sold in Rwanda are sold under a PAYGO model. eCooking has not yet been tested under a PAYGO model although there are plans to run pilots to test this model, as well as to pilot a model under which the price of the eCooking appliance is in-built into the tariff (on a solar mini-grid). PAYGO models have been piloted for cooking with LPG and have demonstrated promising results (Perros et al., 2021)

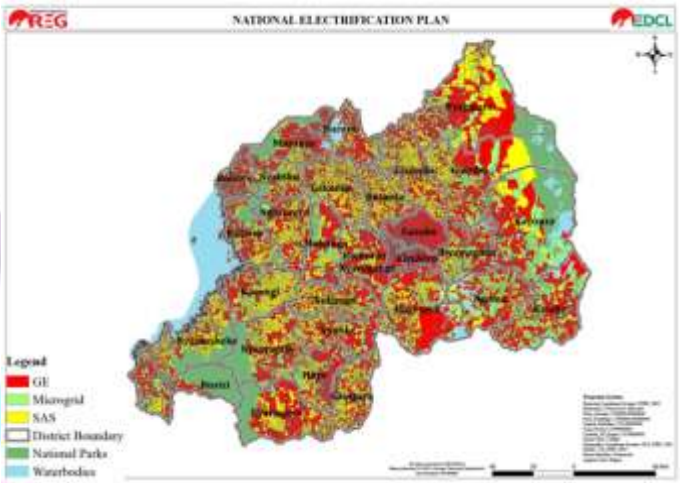
Appliance availability

Apart from commonly stocked appliances such as free-standing electric cookers, electric ovens and microwave ovens, EPCs have entered the Rwandan urban market, also imported for local distribution. Some of the locally available brands include Ewant, Nutricook, and Amier. There are some new-entrant private companies that focus on EPC importation and distribution. No eCooking appliances are currently assembled or manufactured in the country. eCooking appliances are not currently available in rural areas. After-sales services for eCooking appliances are limited through distributors such as Hotpoint do offer warranties (for a limited period of time).

State of the on- & off-grid electricity sectors

To date, 65 % of Rwandan households have access to electricity. 47.2% of households are connected to the national grid whereas 17.8% are connected to off-grid systems (including SHSs which make up the majority of off-grid connections). Urban areas are mostly grid-connected, with some peri-urban areas relying on off-grid solar systems (mini-grids in more densely populated areas and SHSs in other areas). Most villages rely on off-grid systems. Zoning for different modes of electrification according to NEP can be seen in Figure C1.

Figure C1. Geographical distribution of electrification modes under the National Electrification Plan (REG, 2019), including grid extension (GE), microgrids and stand-alone systems (SAS).



National grid and the power generation mix

The total installed generation capacity in Rwanda is currently 235.6 MW, mainly from hydro sources. 11% of the available capacity is imported, the rest is domestically generated. The current mix is as follows: 50.6% hydrological resources, 43.3% thermal sources, and 5% solar sources. The planned generation mix by 2024 is as follows: 50% hydro, 20% methane, 17% peat, 8% solar and 5% diesel[9].

Reliability of grid electricity

In Kigali, grid reliability is high with few and short interruptions per month. In other urban and peri-urban centres, reliability is lower but overall good. The urban SAIDI[10] is 2.8 hrs/year. Table C1 presents the 2017 baseline of the quality of the grid power supply and the planned improvements by 2024.

Table C1. Summary of Rwanda's objectives for the electricity sector under the ESSP: baseline 2017/18 and planned 2023/24. (Source: World Bank (2020). *Rwanda - Energy Access and Quality Improvement Project*).

ESSP Objectives	Baseline (2017)	Target (2023/24)
Achieve universal electrification (Tier 1 or more)	40.7 percent (29.7 percent on-grid, 11 percent off-grid)	100 percent (52 percent on-grid, 48 percent off-grid)
Reserve margin	n.a.	15 percent
Average number of interruptions per year	265	92
Average total duration of interruptions per year	44 hours	14 hours
Reduce transmission and distribution network losses	22 percent	15 percent
Expand electricity access to productive users[a]	72.6 percent	2020/21: 100 percent

The aforementioned initiative to extend access to electricity involves a coordinated effort across all power sector participants to connect new customers, also focusing on powering productive activities by 2022. This is one way of stimulating demand which is currently low, particularly among household customers.

Current tariff system on the national grid

Table C2 shows the current residential electricity tariff structure in Rwanda. A lifeline tariff for electricity consumption below 15 kWh per month was introduced in 2017.

Table C2. Rwandan electricity tariff structure for non-industrial customer by categories (Source: REG (2021)).

Consumption (kWh) / Month	FRW/kWh (excl VAT)	USD $/kWh (excl VAT)
[0-15]	89	0.090
[>15-50]	212	0.21
>50	249	0.25

However, the 15kWh per month under the lifeline tariff is insufficient to support eCooking, given other needs supported by electricity, and particularly not to the extent where a significant proportion of cooking needs would be covered (e.g., a 500W EPC used for 3hrs/day would consume approx. 45kWh/month)[11].

Mini-grids and off-grid systems

Mini-grids have been supported by the GoR as they are part of the NEP and make up a significant proportion of the off-grid electrification strategy. There are 9 private mini-grid developers, including MeshPower (solar), Neseltec (solar), RENERG (solar), Absolute Energy (solar), ECOS (hydro), Ducane Kabrud (hydro), Hobuka Ltd (hydro), Equatorial Power (solar) and ARC Power (solar). Generation capacity ranges between 1kWp to 120kWp.

RURA regulations cover isolated grids below 1 MW and specify that those below 50 kW are exempt from licensing. RURA specify that developers can charge cost-reflective tariffs with a reasonable margin. RURA

[9] https://www.reg.rw/what-we-do/generation/
[10] System Average Interruption Duration Index
[11] https://www.reg.rw/customer-service/tariffs/

maintains the authority to periodically review the tariffs to assess whether they are reasonable. The EnDev RBF provided grants of up to 70% CAPEX for solar or hydropower mini-grids (applicable upon commissioning). Approved projects received technical assistance which included business model development and technical design. REF's third lending window is for mini-grid companies and aims to supply up to 75% of construction costs in Rwandan Francs. The loan can be either a long-term financing or a bridge financing until RBF funds get released upon the commissioning of the mini-grid.

Rate structures used by different mini grid operators include: flat rate; PAYGO with a grid-level tariff; PAYGO with a tariff set by the operator to fit their financial model. Most solar mini-grid operators use a PAYGO with a tariff which works with their financial model. Those tariffs tend to be relatively high as compared to the grid tariff. Examples of tariffs of selected mini-grid providers are below:

1. Ducane Kabrud Ltd: flat rate/hydro (HHs=RWF1500/month ($1.50/month)), milling=RWF15,000/month ($15), tailoring and barbershop=RWF4,000/month ($4))
2. ECOS Ltd: flat rate/hydro (RWF1,000/month ($1))
3. ARC Power: PAYGO/solar (tariff RWF750/kwh ($0.75))
4. MeshPower: PAYGO/solar (tariff RWF350 to RWF400/kwh ($0.3-0.4))
5. Hobuka Ltd: PAYGO/hydro (grid tariff RWF220/kwh ($2.2))

To date, PAYGO SHSs make up the majority of off-grid solar connections in the country. Sales of off-grid solar products in Rwanda between 2014-2018 totalled 811,549. Last year, despite the outbreak of COVID-19, the sales were high at 78,000 units sold between January and June 2020[12]. Small SHSs (3-10Wp) made up 52% of sales in 2018, 0-1.5Wp at 26% of sales, 1.5-3Wp at 15% of sales, 11-20Wp at 4% of sales, and SHSs >20Wp at 3% of sales[13]. The GoR have signed MoUs with over 20 off-grid solar companies. However, there are a few players who have captured most of the market, namely: Ignite - 37%, Bboxx - 32%, One Acre Fund - 12%, Mobisol - 8%, and others - 11%. To date, no eCooking pilots have been conducted on SHSs.

Appendix D: Impact of Scaled Uptake

This section explores the likely costs and benefits for one simple illustrative scenario of scale-up of eCooking in selected key segments. The World Health Organisation (WHO) revised "Benefits of Action to Reduce Household Air Pollution" (BAR-HAP) tool[19] has been applied to quantify the expected financial costs, health and environmental benefits of the scale-up.

The scenario modelled is chosen to reflect the MECS programme's suggested "40, 60, by 2030" goals: a target of 40% for all households connected to grid or off-grid electricity in Low and Middle Income Countries to be using it for cooking by 2030, and a target of 60% of households utilising modern energy for cooking to be utilising energy generated from low carbon sources by 2030 (low carbon interpreted here to include electricity coming from relatively low carbon fuel mix, and excluding fossil-derived LPG). For this illustrative analysis of costs and benefits, the focus is just on the existing 0.7m grid connected households (2.9m people) that are using charcoal for cooking, and not already using any form of MECS. Whilst more households are expected to connect to this existing grid by 2030[20], and grid expansion can be expected, the current scenario is kept to the existing households whose fuel use is known. Reflecting the MECS 40% goal, the scenario assumes 40% of households transition to eCook (so 270,000) by 2030; BAR-HAP models this with a ramp-up of transitioning households over the first 5 years to 2025 and then a further 5 years operation. Details are in the first part of Table D1 below.

BAR-HAP has been implemented here using its policy option of a ban on charcoal use, which comes in gradually from 2020 to 2030. However, the assumption is that transitioning households are fuel stacking, with 20% of cooking still delivered using charcoal. The full costs of the new MECS devices have been assumed to be paid for by the Government, as a convenient simplification for this illustration. Other policy options that could have been modelled

[12] GOGLA (2020) https://www.gogla.org/sites/default/files/resource_docs/global_off_grid_solar_market_report_h1_2020.pdf
[13] ibid.

would see a different distribution of stove and fuel costs and savings between parties. eCook devices are assumed to cost $80 and to have an average efficiency of 75% (MJ input to MJ useful heat output). eCooking is assumed to save 30% of the typical 4 hours cooking per day. Rwanda's grid electricity generation mix comprises 50% hydro, 43% thermal (mix of gas and oil) and 5% solar.

The lower part of Table D1 shows the outputs of BAR-HAP for the modelled scenario. Figure D1 shows the structure of costs and benefits.

Table D1. Targets and BAR-HAP modelled scenario.

Grid connections projections and eCook target		Population (millions)	households (millions)	% grid connected			
National population, 2020		12.9	3.0				
Grid connections, 2020		4.5	1.1	35%			
Of which, using charcoal		2.9	0.7				
Scenario modelled		Population (millions)	households (millions)	% of grid connected			
MECS "40%" target for eCooking by those connected		1.2	0.27	26%			
Other MECS		0.0	0.00	0%			
Not transitioning (the remainder)		3.3	0.78	74%			
Costing (costs are -ve, benefits are +ve)				$/yr	$/yr per household transitioning	$M total	$total per household
Total present value (ie net social benefits of the transition)				52,670,359	195	527	1948
Total costs of transition, government+private				16,725,992	62	167	619
Private cost to housholds: total				19,398,697	72	194	718
Stove				-543,150	-2	-5	-20
Fuel				20,337,054	75	203	752
Maintenance				-395,207	-1	-4	-15
Costs to government: total				-2,672,705	-10	-27	-99
Stove				-1,901,026	-7	-19	-70
Fuel				0	0		
Admin+Programme				-771,679	-3	-8	-29
Health, Time, and Environmental Benefits: total		Physical: change/yr	Physical: % of national cooking total	35,944,367	133	359	1330
Health impacts total: DALYs avoided	DALYs	669		3,817,434	14	38	141
Mortality reduction	*YLL*	*397*	0.2%	3,039,651	11	30	112
Mortality reduction	*Lives*	*34*	0.4%				
Morbidity reduction	*YLD*	*272*	0.6%	777,783	3	8	29
Morbidity reduction	*Cases*	*1,344*	0.6%				
Time savings	Hours	107,444,982	6.0%	22,107,731	82	221	818
Time savings per adopting household	*Hours/HH*	*191*					
Electricity use	*MWh*	*236,493*					
CO2-eq reduction (CO2,CH4,N2O)	Tonnes	541,831	4.5%	8,273,039	31	83	306
Unsustainable wood harvest reduction	Tonnes	210,772	3.7%	1,746,162	6	17	65

Note: costs are discounted across programme period.
Totals are Net Present values; costs/year are NPV divided by the ten years of the programme

The table shows that while this transition would cost government some $100 per household for equipment and programme costs, it would save households 7 times that in reduced energy bills over the ten years of the program: the charcoal prices are high, at an assumed $0.44/kg. Furthermore, health benefits would include more than 30 lives saved per year. Some 3% of current unsustainable wood harvesting would be avoided and greenhouse gas emissions from the national cooking sector would be reduced by more than 4%. These impacts may seem modest but this scenario is targeting less than 10% of the total population.

Figure D1. Breakdown of total costs and benefits.

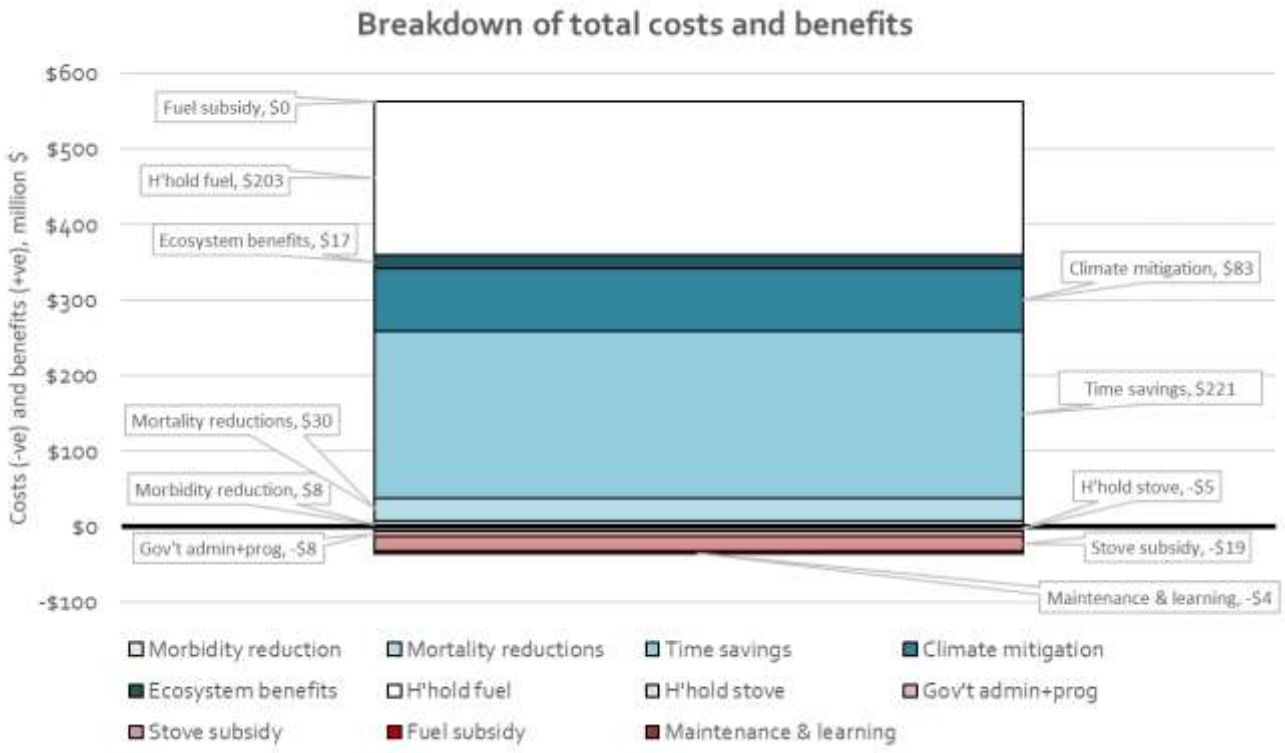


Figure E1 summaries the various physical and financial impacts of the transition in monetary terms. Rwanda's electricity mix is >55% renewables and hence the greenhouse gas emission benefits of switch from charcoal to electricity are positive. However, the social benefits from avoided time spent cooking are much larger, reflecting mainly time savings using an EPC, and the opportunity cost for peoples' time, as used in BAR-HAP. The benefit reduced fuel costs to households is also significant. Post-Covid charcoal prices in urban areas are very high at around $0.44/kg and BAR-HAP estimates charcoal users are spending $70 per month on fuel. Despite the relatively high electricity tariff of around $0.21/kWh, cooking energy savings from use of more efficient stoves lead households to save $6 per month with eCooking. The largest element of cost is for the purchase of modern stoves by government; households are assumed to benefit further by avoiding the need to pay for their traditional charcoal stoves. This is an impact analysis for one simple scenario for just one particular segment (grid connected charcoal users) of Rwanda's population. However, it demonstrates very significant net benefits that could be achieved, based on the WHO's physical impact and impact monetisation methodologies.

Estimated market for eCooking devices

We have also attempted to quantify the size of the markets for electric cooking devices across MECS target countries, as they relate to the aims to enable all households to transition to modern energy cooking (i.e., not including those that may wish to upgrade/replace existing MEC devices). The numbers for Rwanda are as follows:

1. Number of additional devices to reach 40% target: 354,366
2. Number of households needing devices if all have electricity and cook with it: 2,784,302
3. Number of households needing devices if 100% access and 100% cook with it: 3,810,798