Ethiopia

eCooking Market Assessment

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This version is intended for public disclosure

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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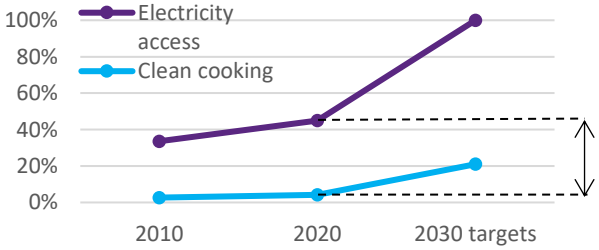
Executive Summary

Electric cooking (eCooking) has been a feature of Ethiopian cooking practices since the 1970s when government programmes promoted eCooking appliances (particularly electric injera stoves) to create demand for surplus power and reduce the environmental impacts of biomass consumption. Yet, the majority (96%) of Ethiopia's population of 115 million (22% urban) still relies on polluting fuels for their cooking needs, with firewood most used (82%). Over the last decade, there has been a rapid increase in the use of electricity for cooking in urban areas and given the very low Ethiopian electricity prices and ongoing support from government programmes for eCooking, it is perhaps surprising that only 4.1% of all households use electricity as their primary cooking fuel. The ambitious plans to increase electricity access from the current 45% to 100% by 2025 offer further opportunities for eCooking going forward. To increase uptake and unlock the potential for eCooking in Ethiopia, measures are required to address electricity coverage and reliability issues while policy needs to better integrate electrification and clean cooking. Improved access to finance and payment plans could increase the affordability of electric stoves.

Ethiopia data snapshot from MECS eCooking Global Market Assessment:

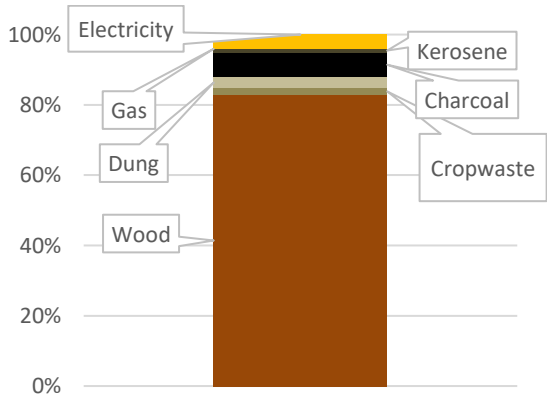


41% now connected to electricity, but still primarily cooking with polluting fuels. However, an estimated 6-15% are tier 1 connections which cannot support electric cooking.

Cooking energy

Primary fuel use:

4% cook primarily with electricity



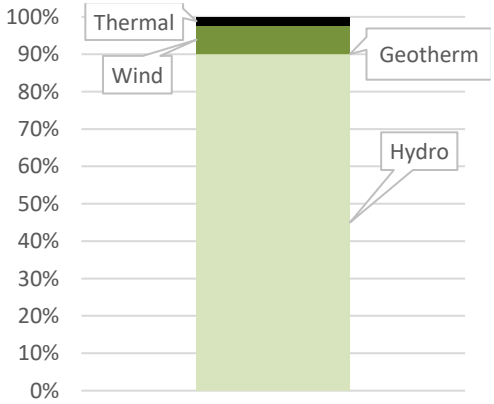
8% cook primarily with commercialized polluting fuels (charcoal)

95% cook primarily with polluting fuels

Electricity generation

On-grid:

98% renewable



27% surplus power generation but major deficits (up to a 44% shortfall) when hydropower water levels are low

Low reliability: 81% power availability (SAIDI*SAIFI=1634hrs/yr)

Off-grid:

Mini-grid & off-grid sectors: 15,000 mini-grid customers, 14 mini-grid developers, 7.6m off-grid lighting/appliance customers

eCooking GMA viability scores/rankings

Overall:	On-grid eCooking:	Mini-grid eCooking:	Off-grid eCooking:
79th/130	**0.47 – 91st/130**	**0.32 – 109th/130**	**0.43 – 43rd/130**

Key opportunities

- Electricity tariffs are among the lowest in sub-Saharan Africa
- Declining availability and increasing price of biomass and LPG
- Significant increases in grid generation capacity projected
- Significant local manufacturing base for electric cooking appliances and maintenance

Key challenges

- Unreliable grid electricity service and lack of coverage in many areas
- Off-grid access is predominantly tier 1 which cannot support eCooking [1].
- Affordability of electric cooking appliances. Firewood freely available in many rural areas.
- Traditional attachment to biomass fuels and limited awareness of alternatives

Potential impacts of scaled uptake in most viable market segment

If 40% of Ethiopia's grid-connected charcoal users (4.2m ppl, 0.9m HHs) switched to eCooking, the WHO's BAR-HAP tool suggests that:

- 903 DALYs/yr avoided
- 2.2m tonnes/yr CO2eq emissions reduced
- 0.4m tonnes/yr reduction in unsustainable wood harvest
- 132m hrs/yr of women's time saved (147 hrs/HH/yr)
- 14 months payback for eCooking appliances ($100/HH upfront cost, $90/HH/yr savings on fuel energy costs)
- 517 GWh demand for electricity stimulated

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

1 Introduction

Clean cooking and electricity access in Ethiopia

Ethiopia faces a considerable clean cooking challenge: the majority of the population (96%) still relies on polluting fuels for their cooking needs, with firewood predominant as the primary cooking fuel for 82% of the population. Continued use of these fuels has led to an array of interlinked development challenges: there are 63,000 deaths each year in Ethiopia caused by in-door household air pollution (HAP) while the daily drudgery of collecting fuel and lighting/tending fires results in missed educational and economic opportunities [1]. These impacts disproportionately affect women and girls. Deforestation and environmental degradation are also major issues affected by the use of biomass and solid fuels for cooking.

Fuel stacking in Ethiopian households is a major coping practice in response to fuel price fluctuation and availability of cooking fuels and there has been a significant increase in eCooking in the last decade which has led to reduced firewood usage. 4.1% of all households use eCooking (half exclusively) and electricity has become the second most used cooking fuel in urban areas, with 65% of households in the capital Addis Ababa owning electric appliances [2] and 63% using it as their primary cooking stove [7]. Given electricity access stands at 45% and the per unit cost of grid electricity very low, there is clear untapped potential to increase uptake of eCooking. In particular, 41% of the population appear to have an electricity connection but not use it for the majority of their cooking needs although an estimated 6-15% of the population have tier 1 connections which cannot support electric cooking[1]. Opportunities for eCooking are likely to be greater in urban areas where existing usage is much higher (15.3%) compared to rural households (0.9%) due largely to greater access to grid electricity (urban: 96.2%, rural: 12.2%) [3].

[1] 6-15% estimate based on ESMAP (2020) data and discussions with EnDev/GIZ Ethiopia. See table 4 in Narrative Report for full ESMAP (2020) breakdown of types of off-grid access.

2 Enabling environment

eCooking policy outlook: Policy embraces a range of clean cooking solutions including eCooking although there is still considerable emphasis on improved biomass cookstoves. Electricity access is a clear priority area for the national government but a clear integrated planning framework connecting cooking and electrification policy.

Key policy stakeholders: Government: Ministry of Water, Irrigation and Energy (MOWIE); Ethiopian Electric Power (EEP); Ethiopian Electric Utility (EEU); Ethiopian Energy Authority (EEA); Energy Study and Development Follow-Up Directorate (ESD); Alternative Energy Technology Development and Promotion Directorate (AETDPD); Ministry of Mines and Petroleum (MOMP); Environment, Forest, and Climate Change Commission (EFCCC); and regional level offices of MOWIE, MOMP and EFCCC. **Development Partners:** World Bank, African Development Bank, GIZ, MECS

RISE (Regulatory Indicators for Sustainable Energy) scores:

78%	69%	43%	29%
Electricity Access	Clean Cooking	Renewable Energy	Energy Efficiency

Targets:

Electricity access	Clean cooking
100% electricity access by 2025 (65% grid/35% off-grid) 96% grid/4% off-grid electricity by 2030	33% clean cooking access by 2030 (includes ICS) 21% modern energy cooking access by 2030 main energy sector contributor to Ethiopia's Nationally Determined Contributions (NDCs)

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

- **The National Electrification Program 2.0 (2019)** targets universal electrification by 2025 through grid (65%) and off-grid (35%) connections as a stepping stone to 96% grid/4% off-grid access by 2030.
- **Growth and Transformation Plan (Phases I-IV)** is the overarching economic and social development strategy. Energy is seen as a core enabler and the plan incorporates a massive expansion of hydropower resources and electrification drive.
- **Reducing Emissions from Deforestation and Forest Degradation Strategy (REDD+, 2016)** sets 2030 cookstove distribution targets of: 3m ICS, 0.8m biogas plants, 1m other stoves (electric, LPG & solar).
- **National Hygiene and Environmental Health Strategy: 2016 – 2020 (2016)** recommends measures to mitigate the impacts of HAP from biomass cooking (e.g. chimneys, separate kitchen area).
- **Ethiopian Power System Expansion Master Plan Study (2014)** assumes 95% of households will be grid connected by 2037 and that a large share will (in the long run) use electric cooking. A household scenario is envisioned of *"a 1000 W electrical cooker operating for 1.2 hours per day for 365 days*".
- **Energy Policy (Draft 2013)** promotes a range of cooking fuels and technologies, namely electricity (specifically electric injera mitads in both urban and rural areas), biogas, biofuels, solar, and kerosene.
- **Biomass Energy Strategy (2013)** has a range of recommendation including: efficiency improvements for biomass cooking; using electricity and other renewable fuels as substitutes for biomass cooking; and providing credit for stove producers.
- **National Improved Cookstoves investment program (NICSP, 2013)** aimed to distribute 9 million improved cookstoves (ICS) in 4.5 million households by 2018 (aligned to CRGE strategy of reducing biomass cooking GHGs).

- **Climate Resilient Green Economy strategy (2011)** states clean cooking as the largest energy sector contributor of greenhouse gas (GHG) to Ethiopia's Nationally Determined Contributions (NDCs) and aims to distribute 5 million electric stoves.
- **Public-Private Partnership (PPP) Proclamation and Legal Framework** (**2010)** has opened vast opportunities for private investment in the energy sector as the government seeks to accelerate the transition to modern energy services while reducing its financial burden.
- **Biofuel Development Strategy (2007**) recommended ethanol for cooking fuel.

Key barriers/drivers in the enabling environment:

- Electricity access is a major priority area for the national government
- Clean cooking access is also a priority for the government as evidenced by the sector's prominent place in meeting Ethiopia's Nationally Determined Contributions (NDCs)
- Recent stakeholder insights indicate key government actors are pushing for eCooking in light of surplus power coming on line from prestige projects such as the Grand Renaissance Dam
- No clear integrated planning framework connecting cooking and electrification policy: the NEP2.0 does not provide plans or estimates on electricity use by consumer groups or end uses (such as cooking).
- The policy framework embraces a range of clean cooking solutions including electricity but still places considerable emphasis on improved (biomass) cookstoves (ICS).

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

3 Consumer demand

What's on the menu?

In an average week, a typical Ethiopian cook might prepare:

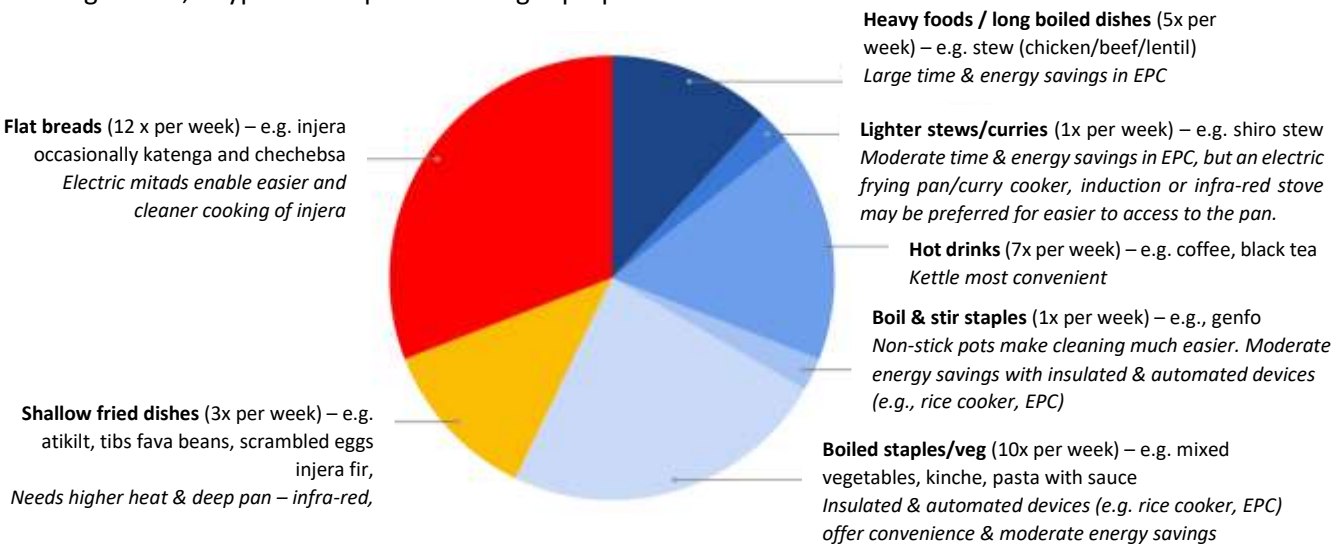


Figure 1: Visualisation of the results of a culinary analysis carried out during this market assessment by asking local team members to map out the dishes that a typical Ethiopian household might prepare in an average week and assessing their compatibility with modern energy-efficient appliances.

The main types of Ethiopian food include:

- Injera is a a fluffy thin pan-cake type bread baked on a 'mitad' – a large circular griddle plate either made of clay and used over a fire or made of metal as part of an 'electric mitad'.
- Sauce ('wot') is the most common dish in Ethiopia and is eaten with injera. Wot can be made with various ingredients including legumes, vegetables and meat and involves both frying (e.g. for onions) and boiling processes.
- Boiled meat is either boiled separately before adding to a sauce, or boiled with spices and onion as a dish on its own ('kikil').
- Vegetables: spinach, round cabbage, potato, cassava and other roots, and onions are the common vegetables in the Ethiopian diet. These are mostly boiled or cooked as stew with other ingredients.
- Fried meat ('tibs') can be eaten alone but is usually fried with onion, green chilli and spices in flat frying pans.
- Stiff porridge ('genfo') is prepared in almost all parts of Ethiopia and typically made from barely, maize or wheat flours. it is a staple food in Bale, almost all of Gambella, and the Borena Zones in Oromia.
- Rice and pasta have increasingly become one of the most frequently cooked dishes in urban households, and the main dish cooked in both urban and rural areas of Somali, Harari and Afar regions.

Most Ethiopian cooking cultures involve cooking more than one dish at a time (particularly in urban households) and require multiple stoves. Energy efficient EPCs, which are sometimes marketed as one pot solutions, would therefore likely need other appliances to cater for the multiple dishes eaten as part of Ethiopian meals, while a separate mitad stove would also generally be required to prepare injera.

Most viable energy-efficient appliances: electric mitad, single and double electric cookstove (either induction, infra-red, or less efficient hot plate), kettles, electric pressure cookers (EPCs), rice cookers.

Key marketing messages: very low tariffs mean eCooking is clearly the cheapest way to cook in Ethiopia. Energy-efficient appliances further increase cost savings, while also offering substantial time savings and enable multi-tasking. EPCs are the cheapest and most convenient way to cook heavy foods.

Key demand side barriers/drivers:

- Electricity tariffs are among the lowest in sub-Saharan Africa
- Declining availability and increasing price of biomass and LPG
- Widespread recognition of the inconvenience of firewood for cooking (including from wood users)
- Firewood remains freely available in many rural areas.
- Traditional attachment to biomass fuels and limited awareness of alternatives
- Affordability of more reliable electric cooking appliances

Key demand creation programmes:

- Several government policies have significant electric stove distribution targets.
- The flagship electrification project, the Grand Ethiopian Renaissance Dam is now being positioned politically as the means to transition women away from cooking with biomass although this push for eCooking not been incorporated into a formal policy.
- Several development agencies interested to engage in the sector: DRC, UNDP, UNHCR [7]

Key market segments:

- *Urban and peri-urban areas* – urban and peri-urban areas have seen a rapid uptake of eCooking over the last decade. In particular in Addis Ababa, where 65% of households use electric cooking. The expansion of the electricity network is also likely to facilitate a greater shift to electrical cooking [4].
- *Charcoal users (particularly in urban areas)* – 8 million Ethiopians use charcoal as their primary fuel and many more use it as part of their fuel stack. Approximately half live in urban areas and are connected to the national grid. Unlike firewood, charcoal is almost always purchased, creating an attractive existing expenditure to convert into electricity units.
- *Urban female-headed households (FHHs)* – FHHs are more likely to own a clean fuel stove (electricity, LPG or biogas) than male-headed households (MHHs) - 8.3% compared to 3.2%. Similarly, fewer FHHs (43%) use a three-stone fire for cooking than MHHs (63%) [3]. These differences are mostly due to a higher concentration of female-headed households in electrified urban areas. A higher proportion of women who cook exclusively with electricity are engaged in income generation which suggests that cooking exclusively with electricity may liberates time for women to engage in income generating activities or that they can afford the capex on the electric stoves [5].

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

4 Supply chain

Key domestic eCooking appliance manufacturers: Significant local manufacture (almost entirely in the informal sector) of single/double electric stoves centred in Merkato (Addis Ababa), involving traditional potters, metal artisans, and electric component suppliers. Electric mitads used locally are almost all made in Ethiopia [7]

- Leggio Aluminium – best known local electric mitad manufacturer. Sales volume unavailable.
- A and H Development Solutions PLC: well-organized local electric stove manufacturer. Average electric stove production: 10,000 units/year. Production capacity for electric stoves: 30,000 units/year [7].
- Other electric mitad manufacturers: Wub and Wass Electronics.

Key eCooking appliance distributors:

- Mekerez Engineering Service: based in Addis Ababa supplying mainly locally manufactured stoves, but also imported stoves from China and Turkey. Sales: approximately 60 electric stove and 45 mitads per month (locally manufactured models).

Innovative eCooking pilot projects:

- GIZ formed an eCooking Community of Practice in 2021, which includes plans to implement eCooking projects (also in 2021).
- MECS have produced several reports providing situational analysis of the eCooking and clean cooking sectors in Ethiopia, which could support eCooking pilot projects
- 1970s government programme promoted eCooking to create demand for surplus power, facilitate sales of government produced electric stoves, and reduce the environmental impact of biomass consumption. The programme led to high adoption of electric injera baking stoves in grid connected (and almost always urban) households but low uptake of other electric cookstoves.

Key supply side barriers/drivers:

- Significant increases in grid generation capacity and electricity access projected
- Significant local manufacturing base for electric cooking appliances and maintenance
- Current grid electricity network lacks coverage and the service has considerable reliability issues
- Tariff system may be unsustainable long term and can deter low electricity users from adopting eCooking
- Off-grid access is predominantly tier 1 (mostly solar lanterns) which cannot support eCooking. There are also very few mini-grids. Barriers to expanding to larger off-grid systems and offering flexible payment options need to be analysed and addressed [3].
- The more rudimentary local production methods cannot cater for the increasing demand for eCooking appliances. Imports of appliances have increased as a result but tend to be cheaper, poorer quality devices requiring frequent repair [4].

Popular appliances in Ethiopia today:

- Stove ownership has increased significantly over the last decade from 300,000 households owning at least one electric stove in 2011 to an estimated 1.8m in 2017 [2, 4].
- Electric mitads for baking injera have been common in grid connected urban households since the 1970s
- Uptake of single and double electric cookstoves (mainly hotplates or spiral rings) has increased over the last decade as kerosene, LPG and charcoal prices have risen [4].

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

Appliance	Sales volumes	Typical retail price [5]
Oven/cooker (elec & elec/gas)		8000-15000 ETB (170-320 USD)
Single Hotplate		350-470 ETB (7-10 USD)
Double hotplate		650-1500 ETB (14-32 USD)
Rice Cooker		
Kettle		
Electric Pressure Cooker (EPC)		
Microwave		
Induction/infra-red stoves		2000-3000 ETB (43-64USD)

The authors were unable to source appliance specific sales data to complete table 1. In terms of aggregated annual sales data, estimates range from that 200,000 [7] to 2.1m [4] locally manufactured electric stoves sold.

Relative cost of eCooking vs. popular cooking fuels:

- The heavily subsidized electricity prices mean cooking on electricity is nearly always the cheapest way to cook (except for collected firewood).
- Cooking all your food with grid electricity (on band 2[2]) on energy efficient appliances is 1.6 times cheaper than kerosene, 1.8 times cheaper than purchased firewood, 4.5 times cheaper than LPG, and 6 times cheaper than charcoal (Figure 1).
- When using non-efficient appliances[3], cooking exclusively on grid electricity (on band 2) is still cheaper than all other fuels: 1.2 times cheaper than kerosene, 1.4 times cheaper than firewood, 3.6 times cheaper than LPG, and 5 times cheaper than charcoal.

Grid electricity tariffs:

- **Band 2: 0.6644 ETB/kWh** (0.014 USD/kWh) **51-100kWh/mnth + service charge 42 ETB** (0.89 USD)
- **Band 1: 0.2730 ETB/kWh** (0.006 USD/kWh) **< 50kWh/mnth + service charge 10 ETB** (0.21 USD)

Mini-grid tariffs:

- National legislation governing mini-grid tariffs under development by EEA
- Data could not be sourced on Private sector avg

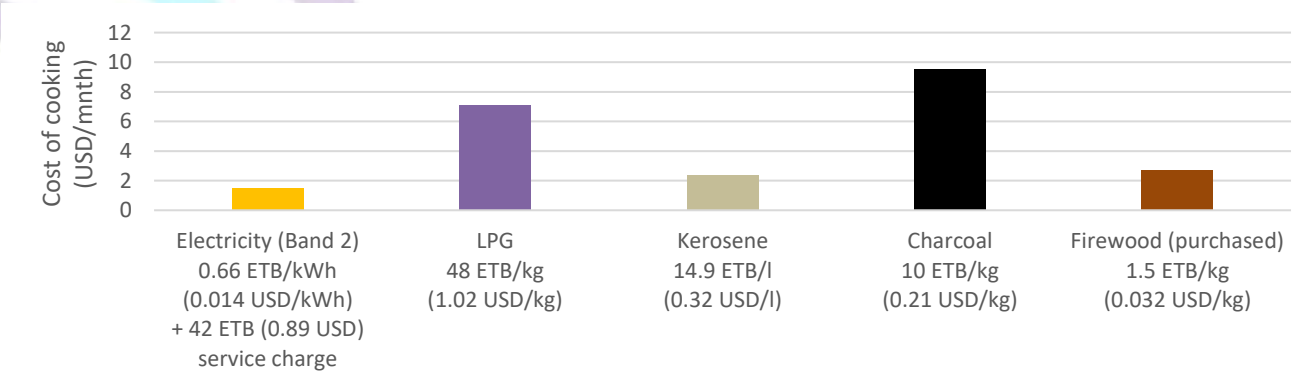


Figure 2: Cost comparison of different cooking fuels based on international averages for cooking energy demand from ESMAP (2020) and local electricity/fuel prices obtained during this market analysis.

[2] The Ethiopian electricity tariff system consists of seven bands: each one allowing a greater amount of monthly electricity consumption and increasing incrementally in price/kWh.
[3] Cooking exclusively on electricity with non-efficient appliances is assumed to use 75kWh a month [5]. Cooking exclusively with energy efficient appliances is assumed to use 44kWh a month [1].

For further detail, please see *Appendix D: 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**	▪ Very low tariffs – key enabler ▪ Heavily subsidised tariffs may be unsustainable long term. Jumps in per kWh price and service charge between bands 1-2 and 2-3 may deter low electricity users from adopting eCooking.	▪ Review tariff system to explore whether tariff bands and their relevant service charges can be adjusted to incentivise eCooking – in particular bands 2 and 3. ▪ Review tariff system to better understand mechanisms to introduce cost reflective tariffs to ensure long term sustainability of grid electricity.
	Mini-grid	▪ Only 0.1% of population use mini-grids [3] ▪ Government policy: huge emphasis and subsidies on grid and intention to decrease off-grid electricity between 2025-2030 disincentivises and hinders mini-grid/off-grid investment	▪ See off-grid (SHS) point below
	Off-grid (SHS)	▪ 31.6% of rural households use off-grid solutions but mostly tier 1 devices that cannot support eCooking.	▪ Analyse barriers to expanding to larger off-grid systems including scope for offering flexible payment options
TToC dimensions	**Supply chain**	▪ Low availability, quality, and reliability of grid electricity	▪ **Improve the availability (especially in the evening), reliability, and quality of grid-electricity - likely to increase eCook uptake as it already makes economic sense.** ▪ Investigate feasibility of battery supported grid cooking to enable cooking during outages (e.g. payback periods, customer profiles)
	Consumer demand	▪ Affordability challenges with the upfront costs of eCooking appliances ▪ Availability of better quality energy-efficient stoves is lacking ▪ Lack of awareness of the benefits of eCooking (e.g. health) ▪ Buildings with multiple single room tenants often forbidden by landlords to use eCooking as shared meter does not allow disaggregated bills.	▪ Introduce financing mechanisms to increase affordability of eCooking stoves (e.g. payment plans). Gender-targeted mechanisms may be required to incentivize female-headed households (a key market segment). ▪ Raise awareness and advocate for the health benefits of eCooking ▪ Advocate for policy/regulatory change to address issues of shared meters
	Enabling environment	▪ Lack of distinct eCooking policy focus (i.e. many clean cooking fuels are promoted) and lack of integrated eCooking/electrification planning.	▪ Create intersectoral working group to integrate & coordinate electrification and clean cooking. Platform created by CCA and Electrical Appliances Manufacturers Association could be used to advocate for this group.

6 References

[1] Will Coley, Aran Eales, Simon Batchelor, Jon Leary, Stuart Galloway (2021) Global Market Assessment for Electric Cooking, University of Strathclyde, MECS. Available from: Global-Market-Assessment-for-Electric-Cooking.pdf (mecs.org.uk)

[2] Central Statistical Agency (CSA) Ethiopia (2011 & 2016) Welfare Monitoring Survey 2011 & 2016.

[3] Padam G, Rysankova D, Portale E, Bonsuk Koo B, Keller S, Fleurantin G, (2018) ETHIOPIA Energy Access Diagnostic Report Based on the Multi-Tier Framework, The World Bank (ESMAP) with external contributions SE4All, SREP. Available from: https://openknowledge.worldbank.org/bitstream/handle/10986/30102/129100.pdf?sequence=5&isAllowed=y

[4] Tesema H.L, Tesfaye G, Paulos M, Tesfamichael M, Mulugetta Y, (2020) Situational and Context Assessment: Ethiopia. Ethio Resource Group & UCL. MECS.

[5] Scott N, Jones T, Batchelor S, (2020) Ethiopia; Cooking transitions - An analysis of Multi-Tier Framework Data for insights into transitions to modern energy cooking. Gamos. MECS. Available from: https://mecs.org.uk/wp-content/uploads/2020/04/Ethiopia-Cooking-transitions-31032020.pdf

[6] World Bank database at https://databank.worldbank.org/source/world-development-indicators

[7] GFA Consulting Group & GIZ (2021) Assessment of Electric Cooking (e-cooking) status in Ethiopia & Possible Support Potentials – Interim report (unpublished).

7 Appendices

Figures showing trends in primary fuel use and access to electricity in Ethiopian households to be added

Appendix B: Enabling Environment

Electricity access is a priority area for the national government. As part of its plan to attain middle-income country status by 2025, the government has set ambitious targets to reach universal coverage of electricity by 2025 and become a power hub for East Africa by 2030. The National Electrification Program (NEP 2.0, 2019) targets universal electrification by 2025 through grid (65%) and off-grid (25%) connections as a stepping stone to universal grid access by 2030. To achieve these aims, the national electrification expansion strategy (which falls under the Growth and Transformation Plan II (GTP-II)) government sees energy generating capacity increase from the current 4,300 megawatts (MW) to 25,000MW by 2030 (22,000MW hydro, 2,000MW wind and 1,000MW geothermal)[4]. This huge expansion of hydropower has assumed political prestige and importance due to the scale (e.g., the 6.5GW Grand Renaissance Dam will be the largest African hydro plant and 7th largest globally) and because of geopolitical tensions over the impacts on downstream countries.

[4] Tafesse M., Mezgebu M., Wabi E. (2020) Electricity regulation in Ethiopia: overview. Thompson Reuters Practical Law. UK.

Clean cooking access is also a priority area for the government as evidenced by the sector's prominent place in the 2011 Climate Resilient Green Economy (CRGE) strategy, in which clean cooking is the largest energy sector contributor of greenhouse gas (GHG) to Ethiopia's Nationally Determined Contributions (NDCs) and which aims to distribute 5 million electric stoves. Clean cooking has also been incorporated into policy and strategy documents for various sectors (energy, health, environment, agriculture, and gender). Despite these intersections there is no clear integrated planning framework connecting cooking and electrification policy. Notably, the NEP2.0 does not provide plans or estimates on electricity use by consumer groups or end uses (such as cooking). There is also a lack of policy/regulation on e-waste. Overall, the policy framework embraces a range of clean cooking solutions but still places considerable emphasis on improved (biomass) cookstoves (ICS). A list of key policy documents pertaining to electrification and electric cooking is provided in the annex.

Standards. The Ethiopian Standards Authority (ESA) and EEA established standards for locally produced electric injera baking stoves (known as 'mitads') and electric cookstoves (ES ISO 04090:2016). A voluntary Minimum Energy Performance Standards (MEPS) for the injera stove was published in 2020 with one for electric cookstoves under way. These standards are not yet applied to imported electric stoves or locally produced stoves with different specifications. The 2019 Ethiopian standard "Clean Cook Stove and Clean Cooking Solution, Performance Requirements and Test Methods (ES 6085: 2019)" aligns with international clean cooking standard ISO19867-1, covering domestic, small scale enterprise and institutional electric cooking appliances of less than 20kW and less than 150l volume.

Key stakeholders: Government

Several federal government institutions are key in shaping the electricity and clean cooking sectors in Ethiopia. The Ministry of Water, Irrigation and Energy (MOWIE) is responsible for energy policy and oversees state companies: Ethiopian Electric Power (EEP), responsible for generation and transmission; Ethiopian Electric Utility (EEU) who manage distribution and retail; and energy regulator Ethiopian Energy Authority (EEA). Within MOWIE, the Energy Study and Development Follow-Up Directorate (ESD) and Alternative Energy Technology Development and Promotion Directorate (AETDPD) promote and support non-public sector energy actions including off-grid electrification and alternative energy technology promotion.

Other relevant government institutions include: the Ministry of Mines and Petroleum (MOMP), responsible for the exploration, development, and regulation of downstream operations for fossil fuels and biofuels; the Environment, Forest and Climate Change Commission (EFCCC) which guides environment and forestry activities including promotion of improved cook stoves; the Ministry of Finance (MOF), in charge of financing public sector energy projects and their fiscal and monetary regulation; and the National Planning Commission (NPC) which plans, monitors and evaluates federal agencies. MOWIE, MOMP and EFCCC all have regional level counterparts that implement projects and programs at the regional and local level.

Key stakeholders: Development Partners

Multilateral Development Finance Institutions (DFIs) – especially the World Bank and the African Development Bank – and bilateral non-governmental organisations (NGOs) – notably GIZ and SNV – have been key in providing energy project financing and technical assistance. GIZ and SNV have been particularly active in the Ethiopian clean cooking sector: GIZ supported the development of the 2013 Biomass Energy Strategy and formed in 2021 an eCooking Community of Practice with plans to implement eCooking projects in 2021. SNV helped form the Ethiopian Clean Cooking Alliance (ECCA), a platform for clean cooking advocacy. MECS have been particularly prominent in developing a suite of eCooking research outputs (Table 1). Private enterprises have an important role in the supply of off-grid electrification technologies for rural households as well as fuels and stoves for cooking in both urban and rural areas.

Table 1: Research outputs pertaining to eCooking

Organisation	Research output
MECS	Situational and Context Assessment: Ethiopia (worked with Ethio-Resource Group) (2020)
	Working Paper: Electric Stove Use in Ethiopia and Policy Recommendations
	Working Paper: Cooking with electricity in Ethiopian cities
	Working Paper: Ethiopia - current and future excess grid electricity capacity (2019)
	Report: Ethiopia; Cooking transitions. An analysis of Multi-Tier Framework Data for insights into transitions to modern energy cooking (2020)
SNV	Review of Policies and Strategies Related to the Clean Cooking Sector in Ethiopia (2018)
UCL	ERSS Journal article: Counting the cost: Coping with tariff increases amidst power supply shortfalls in urban households in Ethiopia (2021).
MEGEN Power Ltd	Impacts of Rising Petroleum Prices on Ethiopia's Economy (2008)
Addis Ababa university	Liquefied Petroleum Gas Supply Chain Management Challenges in Ethiopia (2019 PhD thesis)

Appendix C: Consumer Demand

Electricity has been used for cooking/baking in Ethiopia, particularly Addis Ababa, since the 1970s when government programmes promoted eCooking to create demand for surplus power, facilitate sales of government produced electric stoves, and reduce the environmental impact of biomass consumption. This led to high adoption of electric injera baking stoves ('mitads') in grid connected (and almost always urban) households but very low uptake of other electric cookstoves. It seems convenience and cleanliness over firewood rather than price drove the initial adoption of electric mitads, while low uptake of other electric cookstoves may have been due to limited availability of these appliances in the market and low awareness levels of the benefits of eCooking (e.g. HAP). However, consumer price sensitivity seems to have increased. As kerosene, LPG and charcoal prices have risen over the last decade, uptake of electric cookstoves has exceeded electric mitads. Overall, given the very low Ethiopian electricity prices, it is perhaps surprising that only 4.1% of households use electricity as their primary cooking fuel.

Key market segments

Key market segments for eCooking are urban and peri-urban areas which have seen a rapid uptake of electrical cooking. In particular in Addis Ababa, where 65% of households use electric cooking[5]. The expansion of the electricity network is likely to facilitate a greater shift to electrical cooking[6].

Gender dimensions are also relevant. Female-headed households (FHHs) are more likely to own a clean fuel stove (electricity, LPG or biogas) than male-headed households (MHHs) - 8.3% compared to 3.2%. Similarly, fewer FHHs (43%) use a three-stone fire for cooking than MHHs (63%)[7]. These differences are mostly due to a higher concentration of female-headed households in electrified urban areas. The gender gap disappears when female- and male-headed households are compared in urban and rural areas separately. A higher proportion of women who cook exclusively with electricity are engaged in income generation and women who are earners cook less often and spend less time cooking. This suggests that cooking exclusively with electricity may liberates

[5] Central Statistical Agency Ethiopia
[6] Tesema et al., 2020.
[7] Padam et al. (2018)

time for women to engage in income generating activities or that they can afford the capex on the electric stoves[8].

Local cuisine

Ethiopian cuisine is culturally diverse reflecting the 80+ ethnic groups within the country. The varying cooking practices and diets are shaped by the agro-ecologies where different communities live. In warm climates, food is served immediately after cooking as temperature could spoil the food (unless refrigerated) and so cooking meals several times a day is a common practice. In cool climates, batch cooking and re-heating food is common and households usually cook once or twice a day. Densely populated areas are located mainly in the central and northern highlands and midlands and have cool humid or sub-humid agro-ecologies; these areas have influenced the main types of dishes cooked in urban areas across Ethiopia. The main types of Ethiopian food include:

Most Ethiopian cooking cultures involve cooking more than one dish at a time (particularly in urban households) and therefore require multiple stoves. Usually, the main sauce is cooked in one pot with at least one separate side dish (usually vegetables) cooked with a smaller stove and pan[9]. Most Ethiopian cooking centres on boiling and simmering, with some frying (mainly onions). A separate larger, higher intensity stove called a mitad with a clay plate of diameter 40-60cm is used for injera cooking. Some cooking cultures where the bread is smaller and thicker may use the same flat baking pan for both cooking and baking. A one pot solution like an EPC would need other appliances to cater for the multiple dishes eaten in Ethiopian cuisines and to prepare injera.

The national cooking energy mix of Ethiopia

Firewood dominates the Ethiopian cooking fuel landscape and is the primary fuel of 82% of the population, including 54% of the urban population. Despite some regional variations, heavy household reliance on solid biomass cooking fuels can be seen nationwide (Figure 1). Fuel stacking in Ethiopian households is a major coping practice in response to fuel price fluctuation and availability of cooking fuels. More than a quarter (27.2%) of 4,317 households sampled in a World Bank survey used multiple cooking fuels. 63.3% of households use a three-stone stove as their primary cooking solution: 51.5% exclusively with 11.8% stacking with another fuel/stove[10]. Table 2 highlights the characteristics of exclusive users of different cooking fuels.

There has been a significant increase in eCooking in the last decade which has led to reduced firewood usage. 4.1% of all households use eCooking (half exclusively) and electricity has become the second most used cooking fuel in urban areas. Usage is much higher in urban households (15.3%), particularly Addis Ababa (65%), than rural households (0.9%) due largely to greater grid coverage. Charcoal is also prevalent in urban areas (16.6%) while primary use of kerosene has reduced from 5% to just over 1%. Further uptake of eCooking is limited by the quantity and quality of electricity supply: only 28.5% of all grid connected households are in tiers 3-5 which can support eCooking, while 74.5% of rural grid-connected households only own tier 1 appliances[11].

[8] MECS (Scott et al.) (2020)
[9] Kifleyesus, A. (2007) Food Familiarity and Novelty in a Condition of Socio-economic Transformation in North-Central Ethiopia. Journal of Eastern African Studies, 1(3), 449–465. https://doi.org/10.1080/17531050701625417
[10] MECS (2020)
[11] Padam et al. (2018)

Figure 1: Cooking fuels used in Ethiopia by region[12]

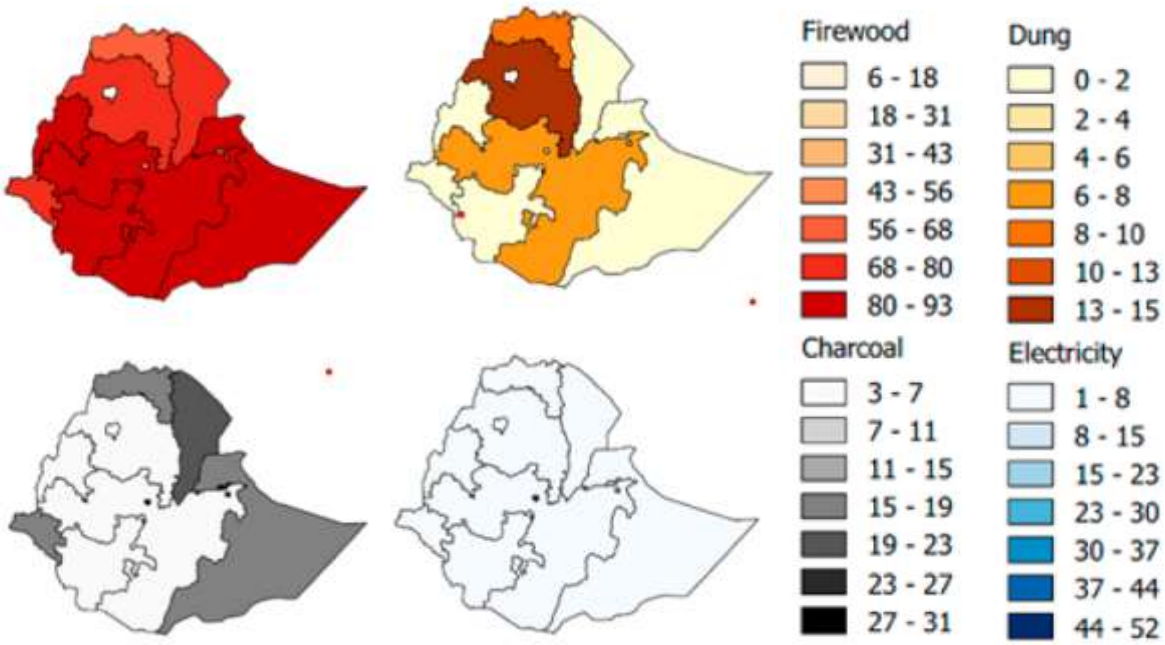


Table 2: Characteristics of exclusive users of cooking fuels[13]

Cooking fuel used	User profile	Urban/rural	Home	Household size	Employment	Financial inclusion	Education & income
Exclusively use collected wood	lowest status group, relatively homogeneous group of rural farmers	Almost all live in rural areas	97% own their own home	largest household sizes (mean=5.2)	Predominantly self-employed agricultural workers	Largely excluded (10% have bank account)	Poorly educated with lowest income
Exclusively use charcoal	less well-off mix of urban dwellers, including high proportion of self-employed workers:	Almost all live in an urban settlement	54% rent their home	Small household sizes (mean of 3.7	Mix of small businesses and waged workers, and elderly	65% financially included (have bank account)	Well educated with high incomes
Exclusively use purchased wood	heterogeneous mix of urban dwellers, including high proportion of elderly	Split equally between rural and urban areas	68% own their own home	Average household sizes (mean of 4.4)	Mix of small businesses and farmers, as well as unemployed	35% financially included (have bank account)	Average levels of education and incomes

[12] WHO (2018) Opportunities for transition to clean household energy in Ethiopia. Application of the WHO Household Energy Assessment Rapid Tool (HEART) at https://www.who.int/tools/household-energy-assessment-rapid-tool-templates

[13] MECS (2020)

	and some highly educated elites.						
Exclusively use electricity	highest status group; heterogeneous mix of urban dwellers, including high proportion of elderly and some highly educated elites.	Almost all live in an urban settlement	66% rent their home	smallest household sizes (mean of 3.5)	Predominantly waged workers mixed with pensioners and small businesses	70% financially included (have bank account)	Highest levels of education and highest incomes

Typical prices for popular cooking fuels and subsidies

Electricity in Ethiopia is heavily subsidised and tariffs are among the lowest in sub-Saharan Africa (Table 3). Lifeline tariff post-paid electricity domestic consumers pay 0.2730 ETB/kWh with a 10ETB service charge. Grid electricity is therefore affordable for most households: 99.5% of connected households spend less than 5% of their total household expenditure on basic electricity services. Among households using off-grid solutions, 96.1% are willing to pay for a grid connection, and 79.8% are willing to pay for a solar home system capable of powering a television (and potentially eCooking), either up-front or with a payment plan.

Electricity subsidies are generous but regressive: the most affluent quintile in Addis Ababa receive 37% of the total, the poorest receive 7% (Cardenas and Whittington, 2019)[14]. The government has been implementing a series of more cost reflective tariffs, in an effort to create a more financially viable operation. These tariff revisions have been considered "punitive" as a customer using one more unit per month than the upper limit of the lifeline tariff would see monthly costs more than treble[15] (Tesfamichael et al., 2021). This could disincentivise eCooking uptake among low income households as eCooking is likely to mean moving out of the lifeline tariff.

Table 3: Ethiopian domestic electricity tariffs

Consumption per month	Tariff/kWh (ETB)				
	Before Dec 18	Dec 18	Dec 19	Dec 20	Dec 21
Up to 50kWh	0.2730	0.2730	0.2730	0.2730	0.2730
Up to 100kWh	0.3564	0.4591	0.5617	0.6644	0.7670
Up to 200kWh	0.4993	0.7807	1.0622	1.3436	1.6250
Up to 300kWh	0.5500	0.9125	1.2750	1.6375	2.0000
Up to 400kWh	0.5666	0.9750	1.3833	1.7917	2.2000
Up to 500kWh	0.5880	1.0423	1.4965	1.9508	2.4050
Over 500kWh	0.6943	1.1410	1.5870	2.0343	2.4810
Service charge. Post-paid: 0-50kWh = 10ETB; 50+kWh = 42 ETB. Pre-paid: 0-50kWh = 3.50ETB; 50+kWh =14.70					

Households that cook exclusively with electricity spend much less on fuel than households cooking exclusively with charcoal or purchased wood. MECS (2020) assume an electrical cooking load of around 2.5kWh/day (using conventional rather than efficient cooking devices) for cooking exclusively on electricity. Under the current tariff system, this load would equate to monthly electricity cooking costs of 91.8ETB on the current Dec 20 tariff (post-paid), rising to 99.5ETB from Dec 21[16]. In comparison, households cooking exclusively with charcoal spend

[14] Cardenas H., Whittington D (2019) The consequences of increasing block tariffs on the distribution of residential electricity subsidies in Addis Ababa, Ethiopia. At https://doi.org/10.1016/j.enpol.2019.01.033

[15] Tesfamichael M., Mulugetta Y., Beyene A.D. & Sebsibie S. (2021) Counting the Cost: Coping with tariff increases amidst power supply shortfalls in urban households in Ethiopia. Energy Research & Social Science, 7

[16] NB other electrical loads in addition to those for eCooking may result in a total monthly usage which falls into a higher tariff band. Where this is the case, the assumed 75kWh/month for eCooking would be charged at the higher rate.

189ETB on charcoal per month while those exclusively using purchased firewood spend 237ETB on firewood per month[17]. Although these figures are for all uses of these fuels, cooking is by far the largest share. In addition, exclusive users of charcoal and firewood spend more on other fuels as part of their fuel stack: spending an additional 46ETB and 22ETB respectively on other fuels while electricity users only spend an additional 12ETB.

The split between those who collect and those who pay for firewood is approximately even. Households collecting wood are far more likely to use it exclusively for cooking than those which pay (44% compared to 12%)[18]. Wood prices seem likely to increase as the proportion of non-renewably harvested biomass is very high at an estimated 62%[19]. LPG is expensive as it is imported and Ethiopia is land locked. A 12kg cylinder costs 420-595 ETB. The fuel is not eligible for income tax exemption and international price volatility is also a risk; a 2007 hike in petroleum prices in 2007 led to widespread substitution from kerosene and LPG to charcoal and firewood, but also created conditions for the electric stove market to develop.

Affordability and consumer financing needs

The ESMAP Multi-Tier Framework (MTF)[20] data shows that clean fuel stoves (mainly electric) are owned predominantly by the top income quintile of the urban population. Ownership declines markedly in urban areas as household income reduces: 10.7% of households in the top spending quintile use a clean fuel stove as their primary stove; 2.7% of households in the 4th spending quintile; and 0.4% of households in the bottom quintile. This suggests the upfront cost of purchasing an electric stove may be a barrier for most households. In rural areas, three-stone fires dominate most income quintiles. Even in the top rural income quintile, 50% of households use a three-stone fire as their primary stove. Very few rural households use a clean fuel stove, regardless of spending quintile.

MTF data on willingness to pay reveals instalments may enable more uptake of cleaner stoves. 62.2% of households are willing to pay full price (175 ETB) upfront for an improved charcoal stove, with an additional 28% of households willing to pay this price with a 6-24 month payment plan. Ability to pay for energy services is a bigger issue for FHHs: 37.5% of female-headed households (FHHs) are willing to pay upfront for a grid connection compared to 60.1% of MHHs. For solar devices, almost 50% of MHHs will pay upfront, compared to 28% of FHHs. The data indicates allowing households to pay in instalments could be an effective way to increase affordability of clean fuel stoves without upfront cost subsidies, which often suffer from lack of sustainability. The gender gap in WTP suggest gender-targeted awareness efforts and financing mechanisms may be required to incentivize female-headed households to obtain a grid connection or move to a higher tier solar device.

Appendix D: Supply chain & delivery models

Key supply side barriers/enablers for eCooking

Among urban households, 93% of those who cook excessively with charcoal and 87% of those who cook exclusively with purchased wood are grid connected but do not cook with electricity. This suggests other barriers, beside price and grid access, influence choice of cooking fuels[21]. In particular, lack of awareness of clean

[17] MECS (2020)
[18] MECS (2020)
[19] Drigo R, Bailis R, Ghilardi A, Masera O, et al. Pan-tropical analysis of wood fuel supply, demand and sustainability. Tier 1: final report. Wisdom and beyond 2015 (www.wisdomprojects.net/pdf/?file=Tier_I_Final_report_rev_May2015.pdf).
[20] Padam et al. (2018)
[21] MECS (2020)

cooking solutions and electricity supply unreliability are key barriers, while the growing gap between the supply of and demand for biomass fuels may be a push factor for increased eCooking uptake[22].

Business models piloted or reached scale in the clean cooking and electrification sectors

The Rural Electrification Fund (REF) was established in 2003 by MOWIE to make financing available to developers, suppliers, and consumers of off-grid Renewable Energy Technology (RET) products. Through the fund, several thousand off-grid solar products have been commercially distributed. Financing to consumers was arranged through MFIs with interest rates between 15% and 20%. More recently, the REF financing approach has been successful in addressing the financing constraints of off-grid solar product importers and consumers. Supported by the World Bank and the Development Bank of Ethiopia (DBE), this facility has succeeded in distributing around 2 million solar lanterns and solar home systems since 2013. The allocation of a risk guarantee fund by the World Bank reduced the collateral requirements for loans, enabling smaller business to benefit from the finance facility and leading to improved availability of off-grid solar products in the market. Interest rates for loan from the DBE is 12%.

In the electrification sector, government and development partner financing for renewable energy technologies (RETs) has increased in the past decade, helping to accelerate the development of the sector and uptake of RETs. Due to growing demand for RETs in rural areas and from consumers seeking to move to higher quality (tier) off-grid energy products, demand for financing continues to grow and finance institutions (banks and MFIs) seek increased availability of funds for lending and increased coverage of risk from borrowers.

Mobile banking and payment systems such as Pay-As-You-Go for off-grid solar products are still at an early stage, with only a few solar companies piloting PAYG models. A lack of clear regulation for mobile banking and support platforms for PAYG systems have impeded wider implementation.

Appliance availability

Electric cooking appliances widely available in the current Ethiopian market include injera baking stoves, single hot plate stoves (1000W, 350-470 ETB), double hot plate stoves (1200W, 650-1500 ETB; and hobs/ovens (8000-15000 ETB). Induction stoves and infrared stoves and rarely available and cost between 2000-3000 ETB. eCooking appliances on the market are both imported and locally manufactured. Most imports are cheap (below 1000ETB) single/double stoves of inferior quality and need frequent repair. These issues created a market (almost entirely in the informal sector) for locally manufactured and maintained single/double electric stoves. Manufacturing is centred in Merkato (Addis Ababa), using traditional potters, metal artisans, and electric component suppliers. Rising prices in LPG, kerosene, and charcoal have seen imports increase to meet the demand that rudimentary local production methods cannot cater for. Most imports are cheap (300-700ETB) single and double stoves and the aforementioned quality issues remain[23].

Electric stove ownership has increased significantly over the last decade from 300,000 households owning at least one electric stove in 2011 to an estimated 1.8m in 2017 (CSA). The annual number of imported and locally produced stoves has increased from 400,000 in 2011 to 2.7m in 2017 (of which 2.1m are locally produced), meaning in 2017 the number of new stoves added to the market was 1.5 times more than the number of electric stove owning households. Such a large quantity of supply is primarily because of the large number of replacement stoves bought to replace the inferior quality stoves most commonly bought[24].

Access to electricity

[22] WHO (2018)
[23] Tesema et al. (2020)
[24] Tesema et al. (2020)

45% of the population has access to electricity: 33% via the grid and 12% via off-grid solutions. ESMAP (2018) state overall access at 57% of households when including tier 1 solar lanterns (Table 4). Many other off-grid solutions used are tier 1 which cannot support electric cooking while grid reliability issues mean many grid connections can also be classified as tier 1. Only 44% of households have access to an electricity supply that provides at least the basic tier 1 energy service (available at least 4 hours a day, including 1 hour in the evening with capacity to light the house and charge phones). The use of off-grid solar solutions as a primary electricity source is a recent trend: 82% of such households acquired their first solar device in the last three years. Mini-grids and other off-grid technologies are rarely used in Ethiopia. The government plans to phase out off-grid solutions by 2030, leaving only 4% of the population in deep rural areas to be served by off-grid means.

A marked urban/rural divide exists in terms of electricity access. 96.2% of urban households but only 12.2% of rural households have access to the grid. 82.9% of urban households and 10.3% of rural households are in Tier 3 or above for access to electricity, with the average 3.2 for urban households and 0.6 for rural households.

Table 4: Breakdown of off-grid electricity access

Off grid technology	% of population using as primary source of electricity	MTF tier
Solar lantern	12.8%	Tier 0-1
Solar Lighting System (SLS)	5.8%	Tier 1
Solar Home System (SHS)	4.9%	Tier 1-3
Rechargeable batteries	0.2%	Tier 2
Mini-grid	0.1%	Tier 1-4
Generator	0.1%	Tier 3

National grid

Ethiopia has an installed grid capacity of 4244MW powered 98% by renewable sources (hydro 90% wind 7.6% geothermal 0.1%) and 2.3% by diesel[25]. Grid electricity is characterized by frequent interruptions and voltage fluctuations. The transmission and distribution (T&D) are significant, standing at 18.5% of output, (in the bottom 20% globally)[26] and the T&D infrastructure lacks adequate reach and sufficient capacity to cater for rapidly increasing demand without scheduled maintenance. The reliance on hydro power also leaves the country vulnerable to seasonal variations in water levels and climate change.

Reliability of supply is poor. Only 20% of households have electricity available 23 hours a day, 7 days a week, most (50%) receive at least 8 hours service a day, while 5.2% receive less than 4 hours of service per day. 57.6% of grid-connected households face 4–14 disruptions a week, 2.8% have more than 14 disruptions per week. 15.8% of households face voltage issues. The situation worsens in rural areas where only 9.6% of households have electricity available 23 hours a day, while 60.1% receive less than 8 hours a day. Despite these issues, most households (80.1%) are satisfied with their grid electricity service although reliability of supply may hinder eCooking uptake. Households may be disincentivized from moving to a higher tier for access to electricity to support eCooking while voltage issues can damage appliances and limit their use. EEU plans to adjust the grid tariff to be cost reflective by introducing tariff revisions in four phases introduced yearly between 2018-2020. The third and current phase was implemented in December 2020, with the last scheduled for December 2021.

Future outlook

[25] EEP (2019)

[26] Leary, J. & Batchelor, S. (2018) "eCook Global Market Assessment (GMA) database". Available from: https://elstove.com/open-access-resources/ [Accessed 02/10/2019].

Grid densification plans could connect many unelectrified households as many are located within 7 kilometers of the national grid although there is a need to address both supply-side barriers (in particular, administrative barriers to connect) and demand-side barriers (providing a mechanism to pay the connection fee over time or simplifying the complex application process).

Electricity demand is projected to grow rapidly by over 12% a year to 2030[27] and there is a recognised need to increase, and diversity energy generating capacity. While government plans predominantly focus on a massive expansion of hydropower, Ethiopia also has a reserve of 300 million tons of coal and 253 million tons of oil shale that is yet to be exploited[28]. The Power System Expansion Master Plan envisions electric cooking accounting for half of electricity consumption for residential customers that have been on the grid for more than five years. However, pricing of different cooking fuels, grid reliability, growth in demand and access to technologies are likely to interact in dynamic ways raising levels of uncertainty over future outcomes.

Mini-grid and off-grid

Mini-grids are rarely used in Ethiopia (0.1% of households) with off-grid solar solutions far more common (24% of households) (Section 4.3). Most households are satisfied with their off-grid systems (73%). Among households that use off-grid solar solutions, satisfaction increases with system size with availability and capacity the main issues cited. Promoting higher capacity off-grid solar systems and/or batteries could help address these issues.

Most off-grid devices (80%) used in Ethiopia are tier 1 (mostly solar lanterns) and MTF data reveals there is high willingness to pay (WTP) for both tier 1 and tier 2 devices. 20% of off-grid devices are solar home systems which could potentially support electric cooking as there are PV cooking options that could be introduced to the Ethiopian market. To help support uptake of larger off-grid systems that can cater for eCooking, business models are required that allow users to pay for the system over time should be prioritized while barriers to offering flexible payment options should also be analysed and addressed.

Appendix E: Impact of Scaled Uptake

Household air pollution (HAP) is associated with four of the main causes of death in Ethiopia: Chronic Obstructive Pulmonary Disease (COPD), ischemic heart disease (IHD), Stroke, and Accurate Lower Respiratory Infections (ALRI). WHO estimated that in 2018, more than 65,000 Ethiopians died, including children aged five years or younger, from HAP-related illnesses. More than 31 million disability-adjusted life years (DALYs) could be avoided in the next decade by eliminating exposure to HAP in their homes.[29]

Scale-up cost-benefit analysis

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[30] has been applied to quantify the expected financial costs, health and environmental benefits of the scale-up.

The scenario modelled for MECS country market assessments reflects 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

[27] Res4Africa (2016) "De-risking Renewable Energy Investments Addressing risks for a better market design". Available from: https://www.res4med.org/wp-content/uploads/2019/07/Position-Paper-BOOK-2.pdf [Accessed 11/10/19]
[28] World Energy Outlook (2020)
[29] WHO (2018)
[30] https://www.who.int/tools/benefits-of-action-to-reduce-household-air-pollution-tool

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). The scenario for the MECS Ethiopia market assessment differs slightly in that it centres specifically on the key market segment for eCooking identified by this study, namely the 50% of Ethiopia's 8m charcoal users who live in urban areas. Thus, for this illustrative analysis of costs and benefits, the focus is just on these existing 0.9m grid connected households (4.2m people) in urban areas that are estimated to be using charcoal as their primary fuel for cooking - . Whilst more households are expected to connect to this existing grid by 2030[31], and grid expansion can be expected, the current scenario is kept to the existing households whose fuel use is known. The scenario assumes that all these households transition to eCook 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 5 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 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 2.6 hours cooking per day. Ethiopia's grid electricity generation mix comprises 95% hydro,3.5% wind and only a very small share of oil-fired generation.

The lower part of the table shows the outputs of BAR-HAP for the modelled scenario. The figure shows the structure of costs and benefits.

[31] https://electrifynow.energydata.info/explore/rw-2

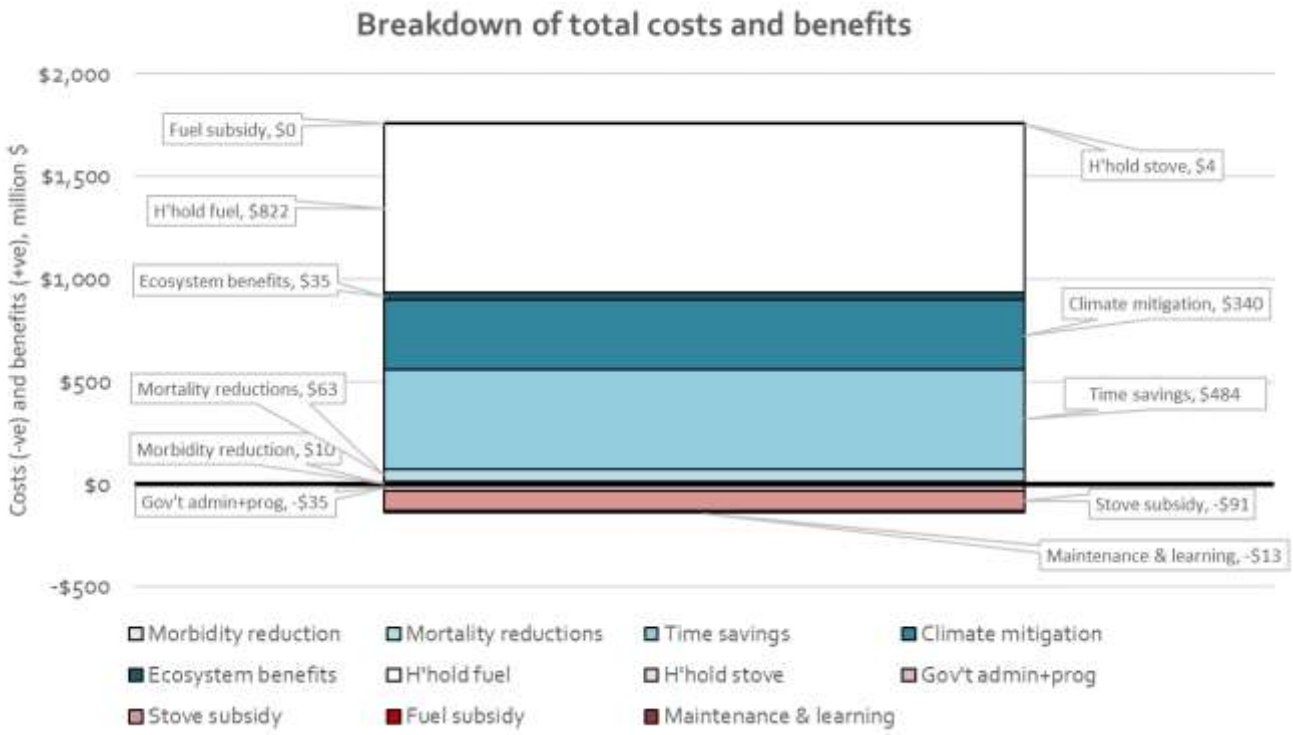
Grid connections projections and eCook target		Population (millions)	housholds (millions)	% grid connected
National population, 2020		114.5	24.8	
Grid connections, 2020		51.7	11.2	45%
Of which, using charcoal		8.6	1.9	
Scenario modelled		Population	housholds	% of grid connected
50% of households using charcoal as primary cooking fuel		4.2	0.91	8%

Cooking transitions: model outputs		Due to programme	In baseline year	Total post programme
Households transitioning to MECS	Housholds	910,202		
Households transitioning to MECS	% of national total	3.7%		
Households transitioning to eCook	Housholds	910,202		
Households transitioning to other MECS	Housholds	0		
Households transitioning to MECS, low Carbon	Housholds	910,202	5,540,051.48	6,450,254
Households transitioning to MECS, low Carbon	% of total transitioning	100.0%	22.81%	122.8%

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)				161,794,582	178	1,618	1778
Total costs of transition, government+private				68,579,290	75	686	753
Private cost to housholds: total				81,194,230	89	812	892
Stove				*365,745*	0	4	4
Fuel				*82,159,103*	90	822	903
Maintenance				*-1,330,617*	-1	-13	-15
Costs to government: total				-12,614,940	-14	-126	-139
Stove				*-9,143,619*	-10	-91	-100
Fuel				*0*	0		
Admin+Programme				*-3,471,320*	-4	-35	-38
Health, Time, and Environmental Benefits: total		Physical: change/yr	Physical: % of national cooking total	93,215,292	102	932	1024
Health impacts total: DALYs avoided	DALYs	903		7,329,811	8	73	81
Mortality reduction	*YLL*	*612*	0.0%	*6,338,670*	7	*63*	70
Mortality reduction	*Lives*	*53*	0.1%				
Morbidity reduction	*YLD*	*291*	0.1%	*991,141*	1	*10*	11
Morbidity reduction	*Cases*	*1,502*	0.1%				
Time savings	Hours	235,140,649	2.2%	48,382,215	53	484	532
Time savings per adopting household	*Hours/HH*	*132*					
Electricity use	*MWh*	*517,558*					
CO2-eq reduction (CO2,CH4,N2O)	Tonnes	2,224,512	4.2%	33,965,339	37	340	373
Unsustainable wood harvest reduction	Tonnes	427,049	1.5%	3,537,926	4	35	39

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 $140 per household for equipment and programme costs, it would save households 15 times that in reduced energy bills over the ten years of the program. Furthermore, health benefits would include more than 50 lives saved per year. Greenhouse gas emissions from the national cooking sector would be reduced by more than 4%, for this scenario that affects less than 4% of total Ethiopian households.



The figure summaries the various physical and financial impacts of the transition in monetary terms. Ethiopia's electricity mix is >98% renewable 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 larger, reflecting mainly time savings using an EPC, and the opportunity cost for peoples' time, as used in BAR-HAP. The largest benefit though comes from reduced fuel costs to households. The assumed charcoal prices in urban areas are relatively low at $0.21/kg and the electricity tariff of around $0.016/kWh (second tier, for use of 51-100kWh/month) is very low; combining the benefits of this fuel switch with the savings from use of more efficient stoves lead households to considerable energy cost savings 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 Ethiopia's population. However, it demonstrates very significant net benefits that could be achieved, based on the WHO's physical impact and impact monetisation methodologies.