

Photo: Ethiopian Clean Cooking Alliance

# CLEAN COOKING COST BENEFIT ANALYSIS

## THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

SUSTAINABLE ENERGY FOR ALL

Netherlands Enterprise Agency

endev

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# FOREWORD

**Ethiopia recognizes clean cooking as a national development priority and a fundamental component of its energy transition. The launch of the National Clean Cooking Roadmap in 2025, with a target of achieving 75% clean cooking access by 2030, marked an important step towards expanding access to modern cooking solutions. Our ambition, however, extends beyond achieving interim targets. Our ultimate goal is universal access to clean cooking, recognizing that clean cooking is not merely a matter of technology, but a critical driver of economic transformation, public health, social equity, and environmental sustainability.**

While Ethiopia has made significant progress in renewable energy development, hydropower generation, and electricity access, clean cooking remains one of our most pressing energy challenges, with national access still at approximately 11%. Continued reliance on traditional cooking fuels places a substantial burden on public health through household air pollution, disproportionately affects women and girls, accelerates pressure on forest resources, and undermines our climate change mitigation efforts and Green Legacy ambitions. Addressing this challenge requires urgent, coordinated, and sustained action.

The Clean Cooking Cost-Benefit Analysis and Geospatial Analysis Report for Ethiopia provides timely and valuable evidence to guide this national effort. By quantifying the economic, health, social, and environmental benefits of transitioning to cleaner cooking technologies and identifying where different solutions are most suitable, the report offers a practical foundation for evidence-based policymaking, investment prioritization, and geographically targeted implementation. Its findings reinforce the case for accelerating the transition and ensuring that public resources and development investments deliver measurable and lasting results.

The priority now is to translate evidence and policy commitments into concrete action. Government institutions, development partners, the private sector, financial institutions, research institutions, and civil society must align their plans, investments, and implementation efforts with our national clean cooking ambitions. This requires clear institutional responsibilities, coordinated resource mobilization, affordable financing, stronger local manufacturing and distribution systems, reliable energy infrastructure, and robust monitoring and accountability mechanisms. Interventions must be tailored to local conditions and ensure that rural communities, low-income households, women, and other underserved populations are not left behind.

I extend my sincere appreciation to Sustainable Energy for All (SEforALL), the Netherlands Enterprise Agency (RVO), through the Energizing Development (EnDev) programme, and the government institutions, experts, and stakeholders represented in the Technical Working Group for their contributions to this important work.

I call upon all stakeholders to take ownership of this report's findings and recommendations and integrate them into their policies, investment decisions, and programmes. We must move decisively from planning to implementation, from commitments to measurable results, and from expanding access to ensuring sustained use of clean cooking solutions. Through strong leadership, coordinated action, and shared accountability, Ethiopia can accelerate progress towards universal clean cooking access and secure a healthier, more equitable, climate-resilient, and sustainable future for all its citizens.



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Photo: Ethiopian Clean Cooking Alliance

# ABBREVIATIONS

**ALRI** – Acute lower respiratory infections

**BAU** – Business as Usual

**CBA** – Cost Benefit Analysis

**$CH_4$** – Methane

**CO** – Carbon Monoxide

**$CO_2$** – Carbon dioxide

**COPD** – Chronic obstructive pulmonary disease

**CRGE** – Climate-Resilient Green Economy Strategy

**DHS** – Demographic and Health Survey

**EA** – Enumeration area

**ECCA** – Ethiopian Clean Cooking Alliance

**eCooking** – Electric cooking

**EnDev** – Energising Development

**EPC** – Electric Pressure Cooker

**fNRB** – Fraction of non-renewable biomass

**GHG** – Greenhouse Gases

**GIZ** – Deutsche Gesellschaft für Internationale Zusammenarbeit

**GTP** – Growth and Transformation Plan

**ICS** – Improved Cooking Stove

**IDP** – Internally Displaced Person

**IHD** – Ischemic Heart Disease

**ISO** – International Organization for Standardization

**LC** – Lung Cancer

**LPG** – Liquefied Petroleum Gas

**MECS** – Modern Energy Cooking Services

**MoH** – Ministry of Health

**MoNS** – Ministry of National Strategy

**MoWE** – Ministry of Water and Energy

**MTF** – Multi-Tier Framework

**Mton / Mt** – Megatonne

**$N_2O$** – Nitrous oxide

**NCCR** – National Clean Cooking Roadmap

**NDC** – Nationally Determined Contribution

**NEP** – National Electrification Program

**NPV** – Net Present Value

**N-SEDS** – National Sustainable Energy Development Strategy

**PEA** – Petroleum and Energy Authority

**$PM_{2.5}$** – Fine Particulate Matter

**RVO** – Rijksdienst voor Ondernemend Nederland / Netherlands Enterprise Agency

**SEforALL** – Sustainable Energy for All

**SHS** – Solar Home System(s)

**SNV** – Netherlands Development Organisation

**UNDP** – United Nations Development Programme

**UNEP** – United Nations Environment Programme

**UNHCR** – United Nations High Commissioner for Refugees

**USD** – United States Dollars

**VSL** – Value of Statistical Life

**WHO** – World Health Organization

# GLOSSARY

**Clean cooking** – Defined as fuels and stove combinations that fall below the maximum emission limits introduced in the World Health Organization's Air Quality Guidelines.

**Cost-benefit analysis** – A policy assessment tool that estimates the benefits and costs of different policy pathways. The benefits and costs are used to estimate the net benefits (benefits minus costs) and can be used for decision making.

**Cost of Illness** – Used to estimate the economic burden of morbidity associated with a specific disease. These costs are disease-specific and include direct medical costs and indirect costs, such as lost productivity due to illness. Some of these costs are borne by private households, while others are borne by society. The cost of illness as used here is consistent with the classical definition and includes the opportunity costs associated with illness particularly lost earnings and times.

**Opportunity cost** – Used to value the time of cooking and fuel collection which could otherwise have been used for other activities.

**Social Cost of Carbon** – Used to estimate the monetary value of damages connected to anthropogenic greenhouse gas emissions.

**Value of Statistical Life** – Used to estimate the monetary value individuals place on small reductions in their risk of deaths. It is commonly used in cost-benefit analysis to evaluate policies that affect mortality risk. The estimated value can vary based on factors such as income, age, and life expectancy, but as these parameters are difficult to measure consistently and the evidence of their impact is mixed, income is often used as a proxy.



Photo: Ethiopian Clean Cooking Alliance


Photo: Ethiopian Clean Cooking Alliance

# EXECUTIVE SUMMARY

Ethiopia has seen an impressive increase in electricity access during the last 20 years, but access to clean cooking has not kept pace. Lack of access to clean cooking is acknowledged as the largest energy access challenge in the country. Currently, the access rate is ~13% and Ethiopia's ambition is to achieve more than 57% access by 2030. SEforALL's review of the sector has highlighted the need for tailored solutions, taking local constraints in supply and demand into account, robust data-driven estimates helping donors and funders understand their return on investment and increased capacity within key-stakeholders across the sector. In the Ethiopian context, clean cooking should not be treated as a separate issue from other energy access goals and targets in the environmental sector.

Increasing clean cooking access is a complex, multi-stakeholder issue involving multiple actors working toward a common goal. However, barriers such as affordability, availability, and cultural preferences continue to limit the uptake of clean cooking technologies nationwide. Given the societal importance of the issue and the scale of needs, ensuring the efficiency of interventions from actors is crucial for accelerating and sustaining progress on clean cooking access. In this context, robust, data-driven energy planning coordinated by the appropriate government entities plays a key role in accelerating energy access by supporting evidence-based decision making, optimizing and prioritizing resource allocation, facilitating the coordination of implementation strategies and reducing information barriers.



**Ambition.** Today, most of the population in the country cook their meals with either firewood or charcoal stoves, with adverse effects on health, environment and social issues. Most households have at least one cooking and one baking stove. The government aims to achieve higher clean cooking shares by mainly focusing on electric, biogas, solar, and advanced biomass stoves.



**Cost.** Transitioning to clean cooking access and reaching the national goals set by the Government is estimated to cost around 3.4 billion USD according to the National Clean Cooking Energy Sector Investment Plan. Simultaneously, the transition to cleaner cookstoves brings with it several benefits, not least for health, gender equality and environment.



**Potential.** The analysis shows that households using traditional collected or purchased firewood, charcoal and traditional mitad stoves can switch to cleaner options (improved and clean stoves) while having significant benefits even when health, time and climate benefits are valued conservatively.

## Key Results

**Bottom line:** The cost-benefit analysis finds that transitioning from Ethiopia's current cooking fuel mix generates positive net benefits to society in almost every case assessed, and households that buy firewood recover the cost of an electric, solar or pellet stove through fuel savings alone in typically under one year. The conclusion holds up even under deliberately pessimistic valuations of health, time, and environmental benefits. Only ethanol, and to a lesser extent LPG, lose their advantage under the low valuation because of their high fuel costs, which suggests that the overall case for transitioning is robust rather than dependent on optimistic assumptions. The case of electric cooking is strong, and across transitions (including those using "low" valuations) it has the highest net benefits when compared to other clean cooking alternatives.

**Health:** Health gains are the largest category of benefit in almost every transition assessed, reflecting the scale of Ethiopia's household air pollution burden, which is currently linked to an estimated 63,000 premature deaths a year. Moving households that currently rely on collected firewood to the best-performing clean options, electric hobs, biogas, LPG or solar cookers, is estimated to prevent between 11,000 and 12,000 premature deaths annually nationwide, with the associated health benefits valued at up to USD 310 per household per year (electric hob). The equivalent gains are smaller for the smaller populations relying on purchased firewood (2,100 to 2,300 deaths avoided) and traditional charcoal (610 to 690), and smaller again for the mitad-specific switch to mirt or electric mitads (250 and 660 deaths avoided respectively).

**Time and gender:** Time savings are generally the second-largest benefit for households that collect their own firewood. About three hours are saved daily when a switch removes collection entirely, and about one hour a day when some collection continues, such as biogas. This is worth roughly USD 250 and 75 per household per year, respectively. This is time that falls

overwhelmingly to women and girls today and that clean cooking could redirect towards schooling and income generation.

**Environment:** Benefits are considerable and consistent across almost all transitions. Electric hobs and solar cookers cut greenhouse gas emissions the most (around 69 Mton/year at a full national transition from collected firewood), with biogas (67 Mton/year) and ethanol (63 Mton/year) close behind. Valued using the National Clean Cooking Roadmap's social cost of carbon, this is worth between 60 and 180 USD per household per year. Deforestation pressure also falls. Households switching away from firewood or charcoal entirely avoid consuming 1.7 to 3.2 tonnes of wood per household per year, more for those currently using charcoal, while even a switch to a more efficient firewood or charcoal stove avoids 1.0 to 2.5 tonnes.

**Costs and net benefits:** Additional fuel expenditure is generally the largest recurring cost of a transition, highest for ethanol (around 270 USD annually) and lowest for electric cooking (around 40 USD a year), reflecting Ethiopia's currently low electricity tariff, while upfront investment is highest for biogas because of digester costs, offset over the equipment's long lifetime. Weighed against benefits, electric hobs come out ahead in most transitions, with net benefits as high as 710 USD per household per year.

## Key Conclusions and Recommendations

Translating these results into action, seven priorities stand out:

- **Transition to clean cooking -** The positive net benefit finding holds up even under pessimistic assumptions, so the case for transitioning is robust rather than contingent on favorable conditions. Because the analysis excludes the cost of the interventions needed to drive adoption, the net benefit calculated here can be read as an upper bound on what the government and donors could spend on price support, financing or awareness campaigns and still come out ahead.
- **Choice of clean cookstove -** No single technology suits every context. A successful transition will need a mix of these technologies matched to local conditions.
- **Electric cooking -** Ethiopia's electrification progress is a strong foundation for electric cooking, but access does not automatically translate into use. Households often keep cooking with biomass for reasons of affordability, reliability and habit. Appliance financing for electric pressure cookers and electric mitads, targeted subsidies, consumer awareness and demand-side management are needed to turn electrification into realized clean cooking outcomes.
- **Job creation -** The employment gains identified are conditional on a supportive local ecosystem. Manufacturing, distribution, installation and repair capacity, together with training for artisans, technicians and entrepreneurs, all need to be built up for the formal jobs to materialize. At the same time, moving away from charcoal will reduce (mostly) informal livelihoods for many of the 1.3 million people in charcoal trade, so reskilling and transition support for these workers should be built into program design from the outset.
- **Affordability -** Upfront cost is an important barrier to adoption. For many transitions, particularly from purchased firewood or charcoal to electricity, biogas or solar, households

save money on fuel from the outset but may not be able to clear the initial hurdle of buying the stove or system. Targeted subsidies, appliance financing and Pay-As-You-Go models aimed at this upfront cost may be effective tools to overcome this initial hurdle.

- **Behavior change -** Long-term health benefits are real, but many households, especially low-income ones, may not be able to invest based on benefits that come far down the line. Awareness campaigns are therefore likely to be more persuasive if they lead with the immediate, tangible savings in fuel and time that many transitions deliver, rather than health messaging alone.
- **Gender empowerment -** The time savings identified translate directly into potential gains for women and girls, who bear most of the burden of cooking and fuel collection today. Clean cooking policies and programs should be explicitly linked to gender equality objectives, with monitoring frameworks tracking gender-related outcomes so progress on time poverty, education and income generation can be assessed directly rather than assumed.

The transition is expected to shift from expanding access alone towards ensuring clean cooking solutions are affordable, reliable and consistently used, with electric cooking playing a growing role alongside advanced biomass and biogas to reach the roadmap's 58% by 2030 and 76% access by 2035 targets. Realizing this will require sustained investment in electricity infrastructure, appliances, financing and supply chains, and will need to manage risks around grid capacity, fuel stacking and financing constraints while capturing opportunities in local manufacturing, carbon finance and private investment.

## Aims and Objectives

In 2025, Sustainable Energy for All (SEforALL) and the Netherlands Enterprise Agency (RVO) under the umbrella of the Energising Development (EnDev) program initiated a clean cooking intervention with the broader objective of supporting Ethiopia's ambition to achieve a just, equitable and sustainable energy transition aligned with national clean cooking targets and adjacent policies in sectors concerning the environment and energy. Specifically, the sub-components of the project include a clean cooking cost-benefit analysis, a geospatial clean cooking plan, and targeted capacity building efforts related to clean cooking.

The overall objective of the project is to enable data-driven, cost-effective, and context-specific clean cooking interventions and support Ethiopia's ambition to achieve a just, equitable and sustainable energy transition aligned with national clean cooking targets.

This report is one of the outputs of the project. The cost-benefit analysis presented here quantifies the benefits, costs and potential disruptions of transitioning to clean cooking, spanning health, environmental, time-use, gender, and economic impacts, to guide just, inclusive, and well-informed policy, investment, program design, and subsequent geospatial analysis. The report describes the methods employed and results. The results can be used to understand if externalities are one cause for differences between the socially optimum outcomes in Ethiopia's clean cooking sector and the current situation. Simultaneously, it can be used to encourage and de-risk investments.

In addition to the cost-benefit analysis this report also presents geospatial mapping of the scenarios in Ethiopia's National Clean Cooking Roadmap, helping in the decision making concerning where different investments will have the highest impact. If the roadmap targets outline what to invest in, the geospatial analysis here indicates where investments should happen across scenarios in order to maximize benefits while minimizing costs.



Photo: Ethiopian Clean Cooking Alliance

CHAPTER ONE

# INTRODUCTION

## 1.1 Clean Cooking

The definition of clean cooking often takes a health perspective following the World Health Organization's (WHO) Air Quality Guidelines. According to these guidelines, a solution is classified as clean if it prevents concentrations from exceeding an annual average of 5 µg/m³ for fine particulate matter ($PM_{2.5}$) and a 24-hour average of 4 mg/m³ for carbon monoxide (CO)[1]. In addition to these targets, WHO also defines interim targets and recognizes the role of transitional fuels and stoves such as improved cookstoves.

From a broader perspective, the World Bank uses their clean cooking Multi-Tier Framework (MTF) accounting for six metrics to define modern energy cooking services (efficiency, exposure, affordability, availability, convenience, and safety)[2]. A modern energy cooking service is defined as a cooking solution which achieves at least Tier 4 across these six metrics. Box 1 outlines common definitions of clean cooking and categorizes cooking technologies, ranging from traditional options to those that meet established clean cooking guidelines.

In line with global standards, the Government of Ethiopia has set targets for clean cooking fuels and technologies that include advanced biomass stoves, electric, biogas and solar, with Liquified Petroleum Gas (LPG) playing a limited role.

1 World Health Organization - Defining clean fuels and technologies. Available from https://www.who.int/tools/clean-household-energy-solutions-toolkit/module-7-defining-clean. (Accessed 30/10/2026)

2 Energy Sector Management Assistance Program (ESMAP). 2020. The State of Access to Modern Energy Cooking Services. Washington, DC: World Bank. License: Creative Commons Attribution CC BY 3.0 IGO.

### Box 1. Definition of Clean Cooking

The definition of clean cooking may differ between documents and countries. There are, however, a few common characteristics across definitions.

In 2012 a set of voluntary performance targets were agreed upon and later replaced by the ISO/TR 19867-3:2018 standards in 2018 (Table 1). These standards set 6 tiers of performance for stoves, with the lowest tier (Tier 0) indicating the worst performing stove and Tier 5 indicating the best performing. This framework accounts for fuel efficiency (including both thermal efficiencies at high power and specific consumption at low power), total emissions ($PM_{2.5}$ and CO), safety and durability of the stoves.

**Table 1.** ISO cooking tiers

| Tier | Thermal Efficiency % | Emissions | | Safety (Score) | Durability (Score) |
|---|---|---|---|---|---|
| | | CO g/$MJ_d$ | $PM_{2.5}$ mg/$MJ_d$ | | |
| 5 | ≥50 | ≤3.0 | ≤5 | ≥95 | <10 |
| 4 | ≥40 | ≤4.4 | ≤62 | ≥86 | <15 |
| 3 | ≥30 | ≤7.2 | ≤218 | ≥77 | <20 |
| 2 | ≥20 | ≤11.5 | ≤481 | ≥68 | <25 |
| 1 | ≥10 | ≤18.3 | ≤1030 | ≥60 | <35 |
| 0 | <10 | >18.3 | >1030 | <60 | >35 |

WHO also includes limits for concentration of CO and $PM_{2.5}$ for cooking technologies in their latest version of the Indoor Air Quality Guidelines from 2021. They identify targets which are to be reached if a stove is to be considered clean (an annual average of 5 µg/m³ for $PM_{2.5}$ and a 24-hour average of 4 mg/m³ for CO). The guidelines also define interim targets. These targets are not goals in themselves but are instead used as transitional steps towards the final goal. They are typically used in areas and cases where the transition to clean cooking is deemed to be far away. WHO considers solar, electricity, biogas, LPG, natural gas, alcohol fuels, as well as biomass stoves that meet the emission targets from the guidelines as clean. See Table 2 for a comparison between the WHO tiers and the ISO ones.

*(continues on the next page)*

**Table 2.** WHO and ISO tier relation.

| ISO Tier | WHO Category for CO | WHO Category for $PM_{2.5}$ |
|---|---|---|
| 5 | Clean | Clean |
| 4 | Transitional | Clean |
| 3 | Transitional | Transitional |
| 2 | Polluting | Polluting |
| 1 | Polluting | Polluting |
| 0 | Polluting | Polluting |

The World Bank's Multi-Tier Framework (MTF) is also a common definition (Table 3). This definition stems from concerns that previous definitions were binary and too technology focused. The MTF uses six characteristics: exposure, efficiency, convenience, safety, affordability, and fuel availability. Like the ISO-tiers the MTF-tiers include six tiers defined by limits for each one of these characteristics. If a household fulfils a score of Tier 4 or higher for all six attributes, it is regarded as a modern energy cooking service, while a household that scores at least Tier 2 but falls short of Tier 4 for all six parameters is in a transition phase.

**Table 3.** Cooking MTF

| Attribute | Description | Tier 0 | Tier 1 | Tier 2 | Tier 3 | Tier 4 | Tier 5 |
|---|---|---|---|---|---|---|---|
| Exposure | default ventilation: $PM_{2.5}$ ($mg/MJ_d$) CO ($g/MJ_d$) | >1030 / >18.3 | ≤1030 / ≤18.3 | ≤481 / ≤11.5 | ≤218 / ≤7.2 | ≤62 / ≤4 | ≤5 / ≤3.0 |
| Efficiency | Stove efficiency (%) | <10 | ≥10 | ≥20 | ≥30 | ≥40 | ≥50 |
| Convenience | Fuel acquisition & preparation time (hrs/week) | ≥7 | <7 | <3 | <1.5 | <0.5 | |
| | Stove preparation time (min/meal) | ≥10 | | <10 | <6 | <2 | |
| Safety | Severity of accidents caused by the stove over past year | Serious | | Minor | None | | |
| Affordability | Fuel cost as share of household expenditure (%) | ≥10 | | <10 | <5 | | |
| Availability | Ready availability of primary fuel (% of year) | ≤80 | | >80 | >90 | 100 | |

## 1.2 Current Cooking Practices

Cooking practices in Ethiopia are heavily dependent on traditional biomass fuels. According to the 2024-2025 Demographic Health Survey (DHS), 85% of households rely on solid fuels for

cooking[3]. Biomass is the dominant fuel used by approximately 77% of households, particularly in rural areas. The modern fuel currently in use is mainly electricity (Table 4).

In rural Ethiopia, approximately 94% of households use biomass. Clean fuel access in rural areas is extremely limited, at roughly 2%. Improved cookstoves, including mud or concrete stoves such as the mirt stove for injera baking, are used in some households. Biogas systems exist mainly as pilot initiatives in communities with livestock, typically using standardized 4–10 $m^3$ digesters[4]. Solar technologies in rural areas are primarily used for lighting rather than cooking.

Urban areas show more diversification, although firewood use remains high. Biomass use in cities is approximately 43%, partly due to increasing costs of alternative fuels. Electricity is the second most common cooking fuel used by around 34% of urban households, and significantly more in Addis Ababa, where approximately 78% of households rely on clean fuels as their primary cooking method. Urban cooking technologies include electric stoves, LPG and ethanol stoves used mainly by middle- and higher-income households, and improved charcoal stoves which are common in peri-urban areas. However, adoption of LPG and ethanol remains constrained by high fuel costs and supply chain limitations.

**Table 4.** Household cooking fuel by place of residence as reported by the 2024-25 Demographic and Health Survey.

| Source of Fuel for Cooking | National (%) | Rural (%) | Urban (%) |
|---|---|---|---|
| Traditional biomass | 71.9 | 89.2 | 36.8 |
| Improved biomass | 5.1 | 4.7 | 5.7 |
| Traditional charcoal | 4.3 | 2.0 | 9.0 |
| Improved charcoal | 3.8 | 0.7 | 10.1 |
| Electricity | 12.2 | 1.3 | 34.3 |
| Others | 1.0 | 1.0 | 0.8 |

Note that the columns do not add to 100% as there are households who are reported to not cook at all. The breakdown of traditional and improved fuels is based on the modelling conducted for this report.

The national cuisine consists mainly of injera, a large, fermented sourdough flatbread, and wot, thick, slow cooked stews[5]. Because these foods require high heat and long simmering times, cooking methods are specialized and often energy intensive. The most energy-demanding task is baking injera. This requires a large, flat, circular griddle, traditionally about 50 - 58 cm in diameter. In rural areas, injera is baked on a clay griddle known as a mitad, typically placed over a three-stone open fire. In urban households, electric mitads are more common. Electric mitads are high-wattage appliances, ranging from 3.5 kW to 3.9 kW, designed to heat the entire surface

3 Ethiopian Statistical Service (ESS) and ICF. 2026. Ethiopia Demographic and Health Survey 2024–25. Addis Ababa, Ethiopia, and Rockville, Maryland, USA: ESS and ICF.

4 Ministry of Water and Energy – National Clean Cooking Energy Sector Investment Plan of Ethiopia (2025 – 2035), 2025.

5 Neela, S., Fanta et al – Injera (An Ethnic, Traditional Staple Food of Ethiopia): A review on Traditional Practice to Scientific Developments. J. Ethn. Food **7**, 32 (2020).

evenly[6]. Since injera must cook quickly and uniformly at high temperatures, baking can account for roughly 50% of a household's total cooking energy use[7].

Traditionally, many households prepare wots on small, portable charcoal stoves such as the Tikikil. Even in modern urban apartments, charcoal remains popular for stew preparation because it provides steady, controlled heat suited to long simmering. However, electric pressure cookers (EPCs) are becoming more common in cities like Addis Ababa[8]. These appliances significantly reduce cooking time for meat or lentils and are promoted for their energy efficiency[9].

## 1.3 National Clean Cooking Roadmap

In January 2025, Ethiopia published its National Clean Cooking Roadmap (NCCR). This is Ethiopia's first national policy document focused exclusively on increasing clean cooking access. The roadmap takes a multisectoral approach to clean cooking and makes clear connections between clean cooking and other development goals. The document sets four objectives: 1) to model clean cooking adoption pathways stretching from 2025 to 2035 with intermediate results being presented for 2030, 2) set realistic targets for the time frame drawing from policies in other related sectors, 3) identify different context specific barriers and drivers for a wide clean cooking transition and 4) give policy and investment recommendations for the sector based on the findings. The roadmap is national in scale and encompasses the impact of transitioning to clean cooking in related sectors.

The roadmap discusses a Business as Usual (BAU) case for the clean cooking sector (estimating carbon dioxide equivalent reductions of 10 million tonnes by 2035) and compares this to three scenarios. The BAU estimates the distribution of 2.83 million cookstoves by 2035, with 2.07 million of these in rural areas. This is estimated to lead to a national clean cooking access rate of 15.34% by 2035. The first policy scenario is labelled as "conservative" and distributes 21.95 million stoves (16.13 million of these in rural areas) achieving a national clean cooking access rate of 49.86%. Of the distributed stoves, 57.4% will be electric, 40.6% are advanced biomass stoves, 1.7% are biogas and 0.3% solar stoves. The second modelled scenario is labelled "moderate" and is aligned with Ethiopia's Nationally Determined Contributions (NDC) 3.0. This scenario would distribute 36.25 million stoves by 2035, leading to a clean cooking access rate of 75.87%. Electric stoves contribute to 44.6% of the total number of stoves distributed, while advanced biomass, biogas and solar contribute to 51.2, 2.4 and 1.8% respectively. Lastly the roadmap presents an "aggressive" scenario distributing 45.04 million stoves (91.88% clean cooking access) and aligned to Ethiopia's Long-Term Low Emission Development Strategy (LT-LEDS). Electric stoves contribute 55.4% of total number of stoves distributed, while advanced biomass, biogas and solar contribute to 39.9, 3.5 and 1.2% respectively. Based on the costs and benefits of each scenario, the "moderate" scenario is presented by the NCCR as the most feasible way forward for Ethiopia.

6 Momona Ethiopian Journal of Science (MEJS), 9(1), 43-65 - Energy consumption performance analysis of electrical mitad at Mekelle City, 2024. Available from https://journal.mu.edu.et/index.php/mejs/article/view/213. (Accessed 30/10/2026)

7 Michael T & Randall Bluffstone – Do households use improved cook stoves? What are the benefits? An Ethiopian case study, 2016.

8 MECS and EnDev – Ethiopia eCooking Market Assessment, 2022.

9 PowerGen Renewable Energy and CLASP – Electric Pressure Cooking: Accelerating Microgrid E-Cooking Through Business & Delivery Model Innovations, 2020.

Ethiopia has adopted a phased approach under the NCCR to achieve its clean cooking goals between 2025 and 2035. Phase I (2025–2027) focuses on deploying advanced biomass and electric stoves in areas with grid access. Phase II (2028–2030) aims to scale up production capacity and support infrastructure for higher tier stoves. Phase III (2031–2035) prioritizes the widespread adoption of high-efficiency Tier 5 electric stoves, alongside biomass and biogas solutions for both urban and rural households. Table 5 presents the targets for each phase and the stove compositions by tiers.

**Table 5.** Ethiopia NCCR phased approach for Clean cooking adoption in its "moderate" scenario (2025 – 2035)[10,11].

| | Phase I (2025 – 2027) | Phase II (2028 – 2030) | Phase III (2031 – 2035) |
|---|---|---|---|
| **Access Target** | 18% | 57.74% | 75.87% |
| **Access Tier 3 (of total stoves distributed)** | 55.05% | 52.08% | 47.26% |
| **Access Tier 4 (of total stoves distributed)** | 4.09% | 4.17% | 4.31% |
| **Access Tier 5 (of total stoves distributed)** | 40.86% | 43.75% | 48.43% |

Ethiopia aims to ensure that all citizens have access to clean, efficient, and sustainable cooking solutions by 2035. To achieve this, the NCCR outlines the following objectives:

1. Reduce premature deaths from household air pollution by 90% compared to current levels by 2035.
2. Reduce carbon dioxide ($CO_2$) emissions from traditional cooking practices by 75% by 2035, in line with Ethiopia's climate commitments.
3. Lower the economic burden of traditional cooking to less than 5% of national health expenditure by 2035.
4. Provide clean cooking access to 75.87% of households by 2035 (90% of urban and 60% of rural households).
5. Upgrade at least 50% of cooking appliances to Tier 3 or higher by 2035, emphasizing efficiency and low emissions.
6. Empower 2 million women by 2035 through training, employment, and leadership opportunities in the clean cooking sector.
7. Fully integrate clean cooking into national energy, health, and environmental policies by 2035.
8. Develop distribution networks for clean cooking fuels and technologies covering at least 80% of regions by 2035.

10 Ministry of Water and Energy & United Nations Development Programme – National Clean Cooking Roadmap, 2025.
11 Ministry of Water and Energy – National Clean Cooking Energy Sector Investment Plan of Ethiopia (2025 – 2035), 2025.

## 1.4 Estimated Cost for Clean Cooking

Ethiopia's National Clean Cooking Energy Sector Investment Plan (2025–2035) estimates that a total of USD 3.38 billion is required to achieve the "moderate" scenario targets by 2035[12]. Of this amount, approximately USD 2.6 billion is allocated to the rollout of clean cooking technologies and financing mechanisms, and USD 780 million is for enabling components such as program management, policy and institutional strengthening. Within the USD 2.6 billion allocated for technology solutions, funding is structured to address affordability and market barriers. About 40% (USD 1.04 billion) is dedicated to microfinance and flexible payment mechanisms to make stoves accessible to low-income households. Carbon project prefinancing accounts for 25% (USD 650 million), providing upfront capital to manufacturers in anticipation of future carbon revenues. Targeted subsidies (15%, USD 390 million) are reserved for the most vulnerable groups, while 10% (USD 260 million) is set aside for a revolving fund to enable continuous stove financing. The remaining 10% supports supply chains and innovation, split evenly between manufacturing infrastructure and a private sector innovation fund.

Investment in cookstove distribution is planned across three phases. Phase 1, with USD 175 million, focuses on building foundations through policy development, pilot programs, and institutional capacity. Phase 2 (USD 1.22 billion) concentrates on scaling up stove distribution and expanding regional coverage while Phase 3 (USD 1.20 billion) focuses on expanding access across the country and ensuring the clean cooking market remains viable over the long term. To finance these investments, Ethiopia plans to move away from its dependence on grants by adopting a more diversified funding mix. Grants are expected to cover 35% of total costs, mainly supporting early-stage activities and low-income households. Carbon finance is projected to contribute 30% through monetized emissions reductions, while concessional loans will provide 20% for large scale infrastructure. The government plans to contribute 10% directly through national budgets, and the remaining 5% is expected from private sector investment, supported by blended finance approaches to encourage entrepreneurship and innovation.

## 1.5 Challenges and Barriers to Clean Cooking

The current household cooking patterns across the country have implications on health, time use and the environment. Regarding health outcomes, traditional stoves and basic mud stoves produce high levels of household air pollution, including $PM_{2.5}$ and CO. Prolonged exposure is linked to respiratory infections, chronic obstructive pulmonary disease, cardiovascular illness, and adverse pregnancy outcomes[13]. Women and young children face the highest exposure because they spend the most time near cooking areas. At the national level, household air pollution contributes to approximately 63,000 premature deaths annually, placing a burden on the public health system and reducing overall productivity[14].

Time burdens are also substantial especially in rural areas, according to the NCCR women and girls often spend two or more hours per day collecting firewood, in addition to long cooking times due to the low efficiency of traditional stoves. This limits opportunities for education, paid work,

12 Ministry of Water and Energy – National Clean Cooking Energy Sector Investment Plan of Ethiopia (2025 – 2035), 2025.
13 World Health Organization - WHO guidelines for indoor air quality: household fuel combustion, 2014.
14 Ministry of Water and Energy & United Nations Development Programme – National Clean Cooking Roadmap, 2025.

rest, and community participation. The time poverty associated with biomass cooking reinforces gender inequality and constrains broader economic development. Where clean cooking solutions are adopted, time savings can be redirected toward schooling, income generation, and other productive activities.

Environmental impacts have been linked to fuel use patterns[15]. Heavy dependence on firewood and charcoal contributes to deforestation and forest degradation. Unsustainable harvesting reduces biodiversity and weakens ecosystem resilience. In addition, inefficient biomass combustion releases greenhouse gases and black carbon, contributing to climate change. Continued reliance on traditional fuels therefore undermines both national climate commitments and long-term natural resource sustainability.

In terms of the barriers, Ethiopia's clean cooking sector faces interlinked barriers that have limited progress despite strong policy commitments and investment plans. A major challenge is economic and financial constraints which account for 30% of adoption challenges[16]. High upfront costs for cleaner technologies, limited availability of affordable consumer financing, and the perception that traditional fuels are 'free' all slow adoption. This affordability gap puts quality cookstoves and modern fuels out of reach for many households, especially in areas where incomes are low, such as displaced settlements[17].

The Ethiopia Energy Access Survey shows a connection between household expenditure and the type of cooking technology used. Among households in the lowest expenditure quintile, 83% rely on open-fire stoves (Figure 1). This share gradually declines across the higher expenditure quintiles, reaching around 51% among households in the highest expenditure quintile[18]. This indicates that household purchasing power influences the type of cooking technology adopted and underscores affordability as an important factor in the transition to clean cooking.

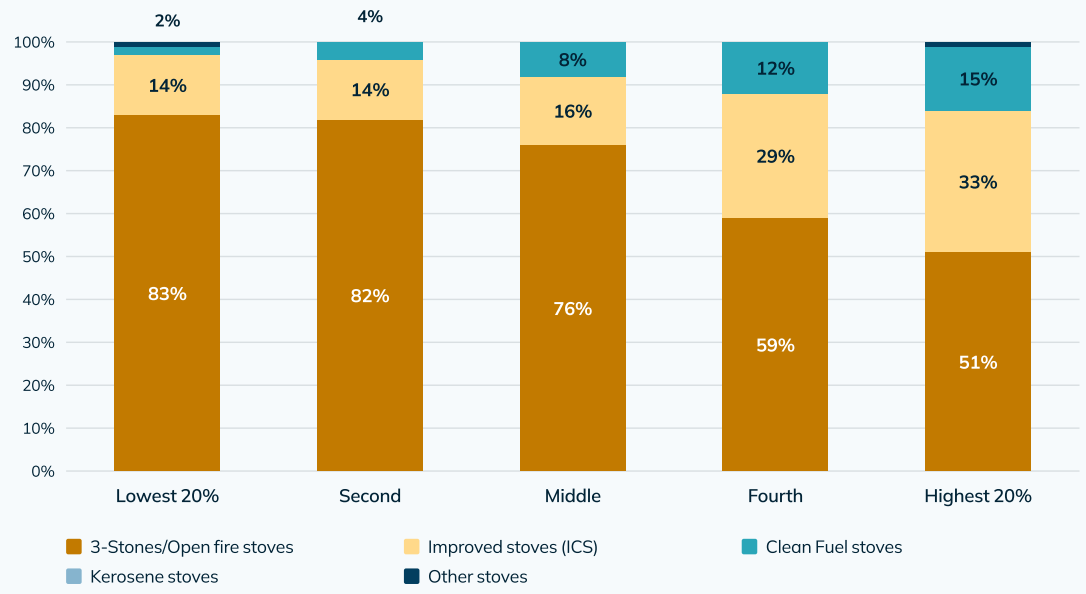
15 Yalew, A.W. Environmental and economic accounting for biomass energy in Ethiopia. Energ Sustain Soc 12, 30 (2022). Available from https://doi.org/10.1186/s13705-022-00356-2. (Accessed 30/10/2026)

16 Ministry of Water and Energy & United Nations Development Programme – National Clean Cooking Roadmap, 2025.

17 UNHCR – Ethiopia: multidimensional poverty of refugees in and out of camps, relative to host communities, 2025.

18 Ethiopia Energy Access Survey - Insights into the energy access situation in Ethiopia based on the Multi-Tier Framework, 2026.

**Figure 1.** Distribution of Households Primary Cookstove by Expenditure Quintiles[19]




Awareness and behavioral factors also influence the adoption of clean cooking technologies. Many households continue to use traditional cooking methods because of familiarity, perceived food quality, taste, and established cooking practices. Fuel stacking, where households combine two or more cooking technologies, is also common and can reduce the incentive to fully transition to cleaner options. For example, despite relatively high levels of grid connectivity in urban regions, the use of electric cooking remains limited. From the Energy Access Survey, close to 90% of urban households were connected to the national grid, yet only around 34% reported using electric cookstoves[20]. This may also reflect the suitability of available appliances for local cooking practices. There is therefore a need to promote appliances and cooking solutions that are compatible with local cuisines and household preferences, while demonstrating how traditional foods can be prepared efficiently using cleaner technologies.

Infrastructure and supply chain gaps further limit clean cooking uptake. Electricity access remains limited, with approximately 56% of the population lacking access to basic electricity services[21], and supply is often unreliable in rural areas. Frequent power outages and voltage fluctuations hinder the potential for electric cooking solutions. Clean fuel supply chains are underdeveloped, with inconsistent availability of fuels, spare parts, and after-sales services, especially outside urban centers. Biogas systems face additional limitations, as they require sufficient livestock and consistent feedstock, which many households do not have.

19 Ethiopia Energy Access Survey - Insights into the energy access situation in Ethiopia based on the Multi-Tier Framework, 2026.

20 Ethiopian Statistical Service (ESS) and ICF. 2026. Ethiopia Demographic and Health Survey 2024–25. Addis Ababa, Ethiopia, and Rockville, Maryland, USA: ESS and ICF.

21 Energy Compact for The Federal Democratic Republic of Ethiopia, 2025.

Institutional and policy coordination issues are another barrier. The responsibility for clean cooking is spread across multiple ministries and agencies, leading to fragmented efforts, duplicated work, and weaknesses in long term planning and accountability[22]. Monitoring has largely focused on counting stoves distributed rather than tracking sustained use or long-term impact, reducing opportunities for learning and improvement. Also previously, clean cooking has received a small fraction (2.3%) of energy sector investment compared with electricity infrastructure which slows down progress.

22 The Reporter Ethiopia – Kitchens of Smoke, Summit of Promises: Ethiopia's Climate Contradiction, 2025. Available from https://www.thereporterethiopia.com/46832/. (Accessed 30/10/2026)


Photo: Ethiopian Clean Cooking Alliance

CHAPTER TWO

# CLEAN COOKING MARKET

## 2.1 Availability of fuel and technology

While firewood remains the dominant cooking fuel in Ethiopia the country is actively promoting the transition to cleaner and emerging cooking fuels as part of its efforts to expand access to modern energy. Bioethanol is being supported using sugar industry by-products, while biogas expansion is advancing under programs such as the National Biogas Program. LPG use is growing in urban centers, although its expansion is restrained by import costs and distribution infrastructure. With the ongoing efforts to transition from traditional biomass to higher-tier clean cooking technologies, electric cooking represents a major opportunity for the country. Ethiopia has relatively low electricity tariffs, averaging around USD 0.033 per kilowatt-hour as of July 2026, and high urban grid connectivity, exceeding 90 percent in cities such as Addis Ababa. This has supported the uptake of electric mitads for baking injera, along with electric pressure cookers in urban areas. However, planned tariff increases, with nominal rates projected to rise significantly by 2028, may influence future affordability and adoption. In rural areas, improved biomass stoves remain the most widely available transitional technology.

## 2.2 Role of the Government, Private Sector and development partners

### Government Institutions

The Government of Ethiopia has endeavored to coordinate the clean cooking sector. Government ministries play roles in supporting different parts of the sector. At the center of this coordination is the Ministry of Water and Energy (MoWE). MoWE holds the mandate for the energy sector and has led the development of the NCCR and the National Clean Cooking Energy Sector Investment Plan. As part of the roadmap, the ministry has proposed follow-up actions to strengthen coordination across institutions. One of these actions is the establishment of a Clean Cooking Coordination Unit, which is intended to support implementation of the roadmap and help align activities across the different government agencies involved in the clean cooking sector.

The Petroleum and Energy Authority (PEA) established under Proclamation No. 1263/2021, serves as the regulatory body for Ethiopia's energy and petroleum sectors. In the clean cooking sector, the PEA is responsible for setting technical standards and regulatory guidance on energy efficiency. The authority has developed documentation and standards for locally manufactured cookstoves, including design guidelines, prototype specifications, and training manuals for manufacturers. It has also carried out tests on high-efficiency electric cooking technologies and supports standardized labelling systems for cooking appliances.

The Ministry of National Strategy (formerly Ministry of Planning and Development) (MoNS) is the government institution responsible for national planning and development in Ethiopia. As part of this role, MoNS has published Ethiopia's National Carbon Market Strategy, which outlines how the country plans to participate in global carbon markets. The strategy identifies priority sectors for carbon market engagement based on Ethiopia's NDC, including the clean cooking sector, renewable energy, and forestry. Under the Clean Development Mechanism, the country hosts project activities focused on improved cookstoves, biomass energy, and solar lighting technologies. These projects have collectively issued approximately 1.1 million Certified Emission Reductions[23]. Through these initiatives, MoNS can support the clean cooking sector by linking it to international climate finance opportunities.

The Ministry of Health (MoH) has created a national plan to address climate change and its adverse health impacts. An aspect of this plan is household air pollution, which is largely attributed to the use of traditional fuels for cooking. MoH highlights that this form of pollution contributes to respiratory illnesses and premature deaths and is closely linked to the types of fuel used at the household level. To address this, the Government of Ethiopia, in partnership with development agencies, have produced the Investment Case for Air Pollution Reduction in Ethiopia. This outlines interventions, including supporting a transition from traditional biomass stoves to electric cooking solutions, alongside proposed subsidies of up to 70% to make the transition accessible for households[24].

23 Ministry of Planning and Development of the Federal Democratic Republic of Ethiopia - Ethiopia's National Carbon Market Strategy (2025 – 2035), 2025.

24 UNDP, Ethiopia Environmental Protection Agency and Ethiopia Ministry of Health. Investment Case Study for Air Pollution Reduction in Ethiopia. United Nations Development Programme; 2024. Licence: CC BY-NC-SA 3.0 IGO.

While government bodies are advancing the clean cooking agenda nationally, these institutions often operate in isolation. Currently, their efforts are fragmented, functioning in silos rather than through a unified framework. Moving forward, a cross-sectoral partnership is essential. By aligning their respective mandates and pooling technical capacity and resources, these agencies could move beyond individual projects to achieve their collective objectives.

### Box 2. Upcoming electricity tariff adjustment and potential impacts on the clean cooking sector

To ensure that Ethiopia's electricity tariff is cost reflective an increase of between 200 and 300% is expected to be carried out up until 2028 (Table 6). This increase will be across the board in the residential sector regardless of consumption levels, as well as in the commercial sector. This will increase the costs for households in cases where more efficient appliances cannot be acquired and risks reducing the financial competitiveness of electric cooking.

Simultaneously, Ethiopia is aiming for a large share of electric cooking. However, none of the related policy documents account for the increasing tariffs. This can potentially have serious implications, especially as the co-benefits of electric cooking are sometimes poorly valued and the costs overestimated. In addition, the NCCR already highlights affordability as the most salient barrier to a wider uptake of clean cooking.

UNDP's value chain analysis of Ethiopia's clean cooking sector highlights that the tariff increase will have a considerable impact on electricity expenditure, but that more efficient appliances can help in reducing the costs by between 40 to 60% as the tariffs increase. However, in cases where these more efficient appliances cannot be attained, there might be a shift back to biomass or alternative less clean fuels. The similar increase across consumption groups also risks leaving low-income households behind and hindering them from obtaining electric cooking.

**Table 6.** Schedule for tariff adjustments (ETB/kWh)

| Usage | 2024/2025 | | | | 2025/2026 | | | | 2026/2027 | | | | 2027/2028 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kWh/Month | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| 51-100 | 0.95 | 1.13 | 1.31 | 1.49 | 1.67 | 1.85 | 2.03 | 2.21 | 2.39 | 2.57 | 2.76 | 2.94 | 3.12 | 3.3 | 3.48 | 3.66 |
| 101-200 | 1.89 | 2.15 | 2.41 | 2.67 | 2.93 | 3.19 | 3.45 | 3.72 | 3.98 | 4.24 | 4.5 | 4.76 | 5.02 | 5.28 | 5.55 | 5.81 |
| 201-300 | 2.46 | 2.92 | 3.38 | 3.84 | 4.3 | 4.76 | 5.22 | 5.68 | 6.14 | 6.6 | 7.06 | 7.52 | 7.98 | 8.44 | 8.89 | 9.35 |
| 301-400 | 2.66 | 3.12 | 3.57 | 4.03 | 4.49 | 4.95 | 5.41 | 5.86 | 6.32 | 6.78 | 7.24 | 7.7 | 8.15 | 8.61 | 9.07 | 9.53 |
| 401-500 | 2.85 | 3.29 | 3.73 | 4.17 | 4.62 | 5.06 | 5.5 | 5.94 | 6.39 | 6.83 | 7.27 | 7.71 | 8.16 | 8.6 | 9.04 | 9.48 |
| >500 | 2.92 | 3.35 | 3.79 | 4.23 | 4.66 | 5.1 | 5.54 | 5.97 | 6.41 | 6.84 | 7.28 | 7.72 | 8.15 | 8.59 | 9.03 | 9.46 |

Given the aggressive increase in electricity tariff coupled with the ambitious goals for electric cooking and these dynamics not having been assessed together before, there is a clear need for understanding exactly how the net benefit and competitiveness of electric cooking change.

## Private Sector

The private sector in Ethiopia's clean cooking market comprises local manufacturers, technology developers and energy retailers. The market actors offer solutions which include electric cooking, ethanol, LPG and improved biomass stoves. Beyond local stove makers, there are multinational companies that specialize in biodigesters. These partner with local organizations and farmers to install biogas systems on-site. The goal is to improve the quality of life for families by providing a clean energy source for household cooking. Companies like Sistema.bio are already operating and partnering with development organisations to scale biogas in Ethiopia[25].

Ethiopia has significant potential for scaling electric cooking, with recent National Electrification Program (NEP) 3.0 data indicating that approximately 94% of the urban population and 43% of the rural population have access to electricity. In the 1970s Ethiopian Electric Light and Power Authority started to promote electric injera stove use to reduce reliance on traditional biomass fuels. As such, the electric mitad stove used to bake injera became widely adopted, especially in Addis Ababa. Most of the producers are very small artisans, resulting in a well-established but fragmented market. The 2022 MECS market assessment found substantial local manufacturing of electric stoves in Addis Ababa's Merkato area and reported that electric mitads used in Ethiopia are almost exclusively manufactured domestically. At the same time, Ethiopia's electric cooking market is gradually diversifying beyond traditional clay electric mitads toward more efficient, modern, and convenient appliances.

An example of this is the induction stoves assembled by Green Scene PLC entering the market alongside electric hobs and imported infrared stoves, induction cookers, and electric pressure cookers (EPCs). Induction cooking has emerged as a new market segment. Through its Green Cook Ethiopia initiative, Green Scene PLC uses a Pay-As-You-Cook model to make induction cooking more affordable and promotes both grid-connected and solar-powered applications for households, businesses, and institutions. Interest in EPCs is also growing, especially for foods that require longer cooking times, such as legumes, stews, and wot. This interest is foreseen to increase as the increasing electricity tariff can be expected to push people further towards more efficient appliances.

While the NCCR places LPG at a lower priority, the fuel does make up a modest share of the market. A supply chain exists with companies operating in the country, with most of these services being centered around Addis Ababa. Players include FYA Gas, Ghion Gas PLC, and Allied Energy, along with several major oil companies. These suppliers provide LPG in cylinders ranging from 3kg to 50kg for households. For larger clients, they offer bulk supplies between 500kg and 60,000kg. In some cases, they install metered systems for housing development or large facilities that use central storage.

Within the private sector, the Ethiopian Clean Cooking Alliance (ECCA) takes on a coordinating role to support and accelerate the adoption of clean and efficient cooking technologies. It is a platform that brings together private companies, government institutions, and development partners working in the clean cooking sector. ECCA focuses on strengthening the overall ecosystem by supporting coordination across stakeholders, advocating for enabling policies, and raising public

25 Sistema.bio - Scaling Biogas in Ethiopia, 2026. Available from https://sistema.bio/blog/scaling-biogas-in-ethiopia/. (Accessed 29/10/2026)

awareness. It also works with stove producers and distributors to improve their capacity to reach last-mile users and expand access to clean cooking solutions.

### Development Partners

International development partners have been actively supporting Ethiopia's clean cooking sector by advancing policy frameworks and increasing access to cleaner fuels. Among them, the United Nations Development Programme (UNDP) played an important role in developing the NCCR by providing technical and analytical support for modelling and analyzing the value chain[26]. This work aligns with UNDP's broader focus on health, gender equality, and climate action.

Working in coordination with MoWE, partners such as GIZ, SNV, and EnDev have implemented long-standing programs to build a sustainable market for clean fuels. EnDev Ethiopia has supported over 1.4 million households in gaining access to improved cooking technologies as of late 2023[27]. Meanwhile, SNV, through its SEE-CC (Strengthening Enabling Environment for Clean Cooking Sector) program, focused on institutional capacity and the development of national standards to ensure long-term sector stability.

A summary of clean cooking programs and interventions in Ethiopia is provided in Appendix D (Table 40). These initiatives reflect coordinated efforts between development partners and government institutions to expand access to clean cooking solutions across the country. Many programs have focused on stove distribution, especially in displaced communities or regions experiencing severe environmental or energy access challenges. Concurrently, other interventions have aimed to promote higher-tier cooking technologies in urban areas.

## 2.3 Existing programs and policies

Clean cooking programs in Ethiopia have contributed to important structural progress within the sector. Over time, clean cooking has become more visible as a national development and climate priority. This is reflected in policy frameworks such as the Climate Resilient Green Economy (CRGE), the Growth and Transformation Plans (GTP I and II), and more recent policies and strategies, like the National Sustainable Energy Development Strategy, the NCCR and National Energy Compact. These frameworks integrate clean cooking across energy, forestry, health, and gender agendas, indicating government recognition of its importance. A summary of policies is provided in Table 39, Appendix D. However, further efforts are still needed to translate these commitments into implementation at scale.

Donor-supported programs have also played a role in testing and demonstrating different delivery and financing models. These include approaches such as pay-as-you-go systems, carbon-financed stove distribution, and results-based financing. Such initiatives have helped move the sector beyond fully subsidized distribution models and explore more sustainable market-based approaches. They have also supported the development of local stove manufacturing in some segments, contributing to job creation and reducing reliance on imports. At the same time,

26 United Nations Development Programme (UNDP) - From Firewood to the Future, 2025. Available from https://www.undp.org/ethiopia/blog/firewood-future-1. (Accessed 29/10/2026)

27 Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH - Energising Development (EnDev) Ethiopia, 2024

challenges remain in enforcing quality standards and supporting local producers to consistently meet them.

The policy framework has evolved over time. Earlier strategies, such as the CRGE (2011), positioned clean cooking mainly in terms of climate mitigation and forest conservation, with a focus on improved biomass stoves. Subsequent plans, including GTP I and II, expanded the focus to include energy access, economic development, and private sector participation. More recent strategies place greater emphasis on electrification, a mix of clean fuels, and clearer financing approaches. Across these policies, inefficient biomass use is consistently identified as a driver of deforestation and greenhouse gas emissions, reinforcing the role of clean cooking as an environmental and development priority. Despite that, improved biomass stoves remain part of the near-term strategy, especially in rural areas where access to alternative fuels is limited.

Overall, there is general alignment across policy frameworks, though some tensions may emerge. For example, recent strategies promote electric cooking, but this ambition may exceed current grid and mini-grid capacity in certain areas. Furthermore, clean cooking continues to rely heavily on donor funding and carbon finance, with relatively limited allocation from domestic energy sector investment.



Photo: Ethiopian Clean Cooking Alliance



CHAPTER THREE

# METHODOLOGY

## 3.1 Cost-benefit analysis

A Cost-Benefit Analysis (CBA) is employed to quantify different transitions to cleaner cook stoves. CBA is a powerful decision-making tool when the benefits and costs of a policy action need to be quantified and compared to justify a policy. A CBA assesses whether a policy is likely to generate greater overall benefits than costs and allows donors and governments to measure the impact of their investments, leading to more informed decisions. In practice, a CBA adds all the expected benefits of a policy and compares them to all expected costs. To allow for this, all benefits are first translated to monetary values that can be interpreted as each benefit's weight in the equation. The analysis adopts a societal viewpoint unless otherwise stated, meaning it evaluates costs and benefits from the perspective of Ethiopia as a whole, rather than from that of individual households or specific stakeholders.

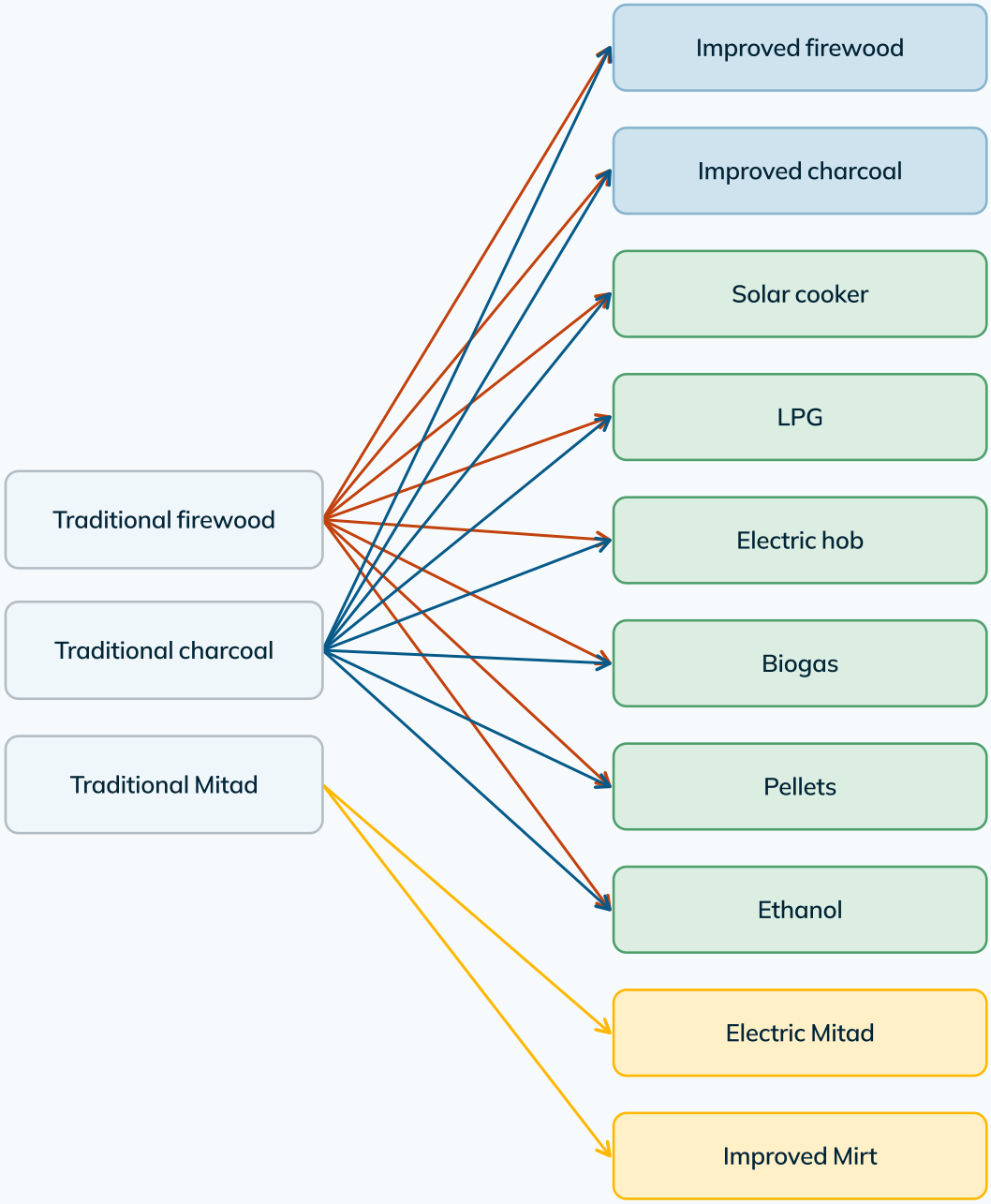
In the analysis traditional firewood, traditional mitad and traditional charcoal stoves are used as the baseline stoves as these are the most widely used stoves currently in the Ethiopian context. The benefits and costs of the transition are calculated for transitioning from each one of these baseline stoves to a set of cleaner cookstoves. The stoves that are being compared to the baseline stoves in terms of benefits and costs are; improved mirt and electric mitad (when transitioning away from traditional mitad), firewood ICS, charcoal ICS, pellet stoves, electric hobs, LPG, ethanol, biogas and solar cookers (see Figure 2). For each transition, the assessed benefits are gender and age disaggregated health benefits, job benefits as well as time and environmental benefits (specifically emissions of GHG pollutants). On the cost side, the transitions will be evaluated based on the investment, fuel, operation and maintenance costs necessary for the transition.

The CBA accounts for fuel stacking, recognizing that most households rely on more than one stove to meet their cooking needs. It assumes that each household uses a primary cooking stove (typically fueled by firewood or charcoal) for general cooking, alongside a secondary stove, a traditional mitad used for baking injera. The analysis therefore computes the costs and benefits of switching the primary cooking stove from traditional fuels to a cleaner alternative, as illustrated in Figure 2, and replacing the traditional mitad with more efficient options such as a mirt or an electric mitad.

All benefits are shadow priced to reflect their estimated economic value to society. This requires the use of Costs of Illness (CoI) to translate reduced morbidity (reduced cases of disease) to monetary values, Value of Statistical Life (VSL) to translate reduced mortality (reduced deaths caused by each disease) to monetary values, a shadow value of time and the wage rate for time savings and the social cost of carbon to translate the reduction of greenhouse gas emissions. These parameters are well-documented and widely used in CBA studies. They do however carry uncertainty as these parameters can be expected to differ individually. To overcome this uncertainty as much as possible and align the analysis to the Ethiopian context, a literature review of widely used values for these parameters has been conducted and the inputs have been discussed with a Technical Working Group consisting of Ethiopian clean cooking partners. Further, scenarios are created based on the most important of these valuation metrics to capture what may happen to the costs and benefits as factors change.

Please refer to Appendix A for detailed calculations and Appendix B for the input data used in the analysis.

**Figure 2.** Transitions assessed as part of the CBA




## 3.2 Geospatial analysis

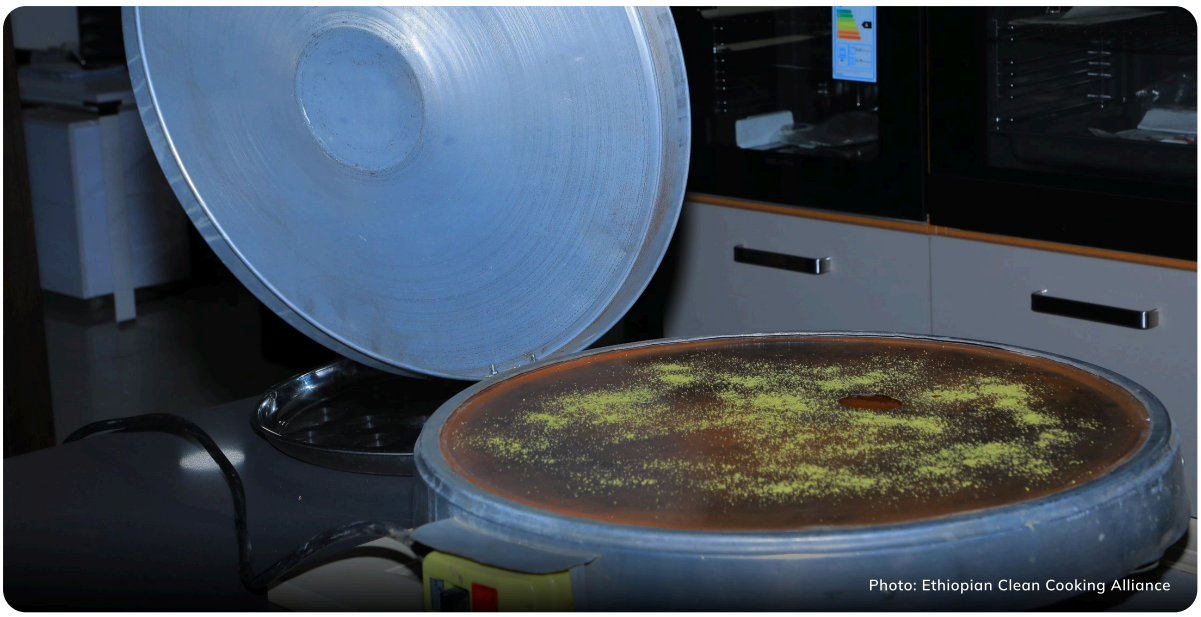
Cooking is highly contextual and what works in certain regions, towns and villages may not work in other parts of the country. While Ethiopia's clean cooking policies and ambitions are far-reaching, the incorporation of context specific data and planning is important in ensuring that

no-one is left behind in the transition and that funders entering the market with bankable projects can get a clearer picture of what their return on investment may be.

In this analysis, the scenarios outlined in the NCCR are used. The underlying cost-benefit calculations of the geospatial analysis help maximize the benefits of the transition while minimizing costs and reaching last-mile populations. The governing equations are like those employed in the CBA described above with certain modifications (See Appendix A and B). The modifications are employed to ensure that the costs and benefits can be accounted for geospatially. As part of these modifications, employment and deforestation benefits are removed from the analysis in the geospatial scenarios due to the spatial distribution of their benefits and associated costs being uncertain. Unlike the CBA, the geospatial analysis assumes that households that switch cook only on their new stoves, so its health results are comparable to the non-stacked results in Box 3. In addition to the NCCR, the analysis is linked to NEP 3.0. This can help foster adoption of electric cooking highlighted as important by partners on the ground and by various existing policy documents. The tool employed (OnStove) calculates the benefits and costs of transitioning to cleaner cook stoves, determines the net benefits for all available stoves, and identifies the stove providing the highest net benefit per square kilometer. The scope of the geospatial analysis is to identify where different clean cooking options are most suitable based on local barriers, enablers, and fuel availability. This will enable an understanding of where the different shares presented in the NCCR should be targeted.

## Geospatial electrification analysis

The potential for electric cooking is strongly linked to electricity access, and an integrated approach that considers electrification and clean cooking planning simultaneously has several benefits. By incorporating electric cooking demand into the electricity sector, integrated planning favors centralized options (grid and mini-grids) as they benefit from economies of scale. For the clean cooking sector, understanding where gridded electrification technologies are planned informs the share of the population for whom an electric option can provide the highest net benefit. With this background, the geospatial clean cooking analysis is linked to the NEP 3.0. The NEP 3.0 geospatial electrification results are used to identify areas where there is currently access from grid- or mini-grid connections, as well as areas targeted for grid-extension and mini-grid deployment in the near future. This supports the identification of areas where these technologies can supply electricity for electric cooking. In this study, electric cooking is assumed to be available in settlements where electricity is supplied by the centralized grid or mini-grids. Solar Home Systems (SHS) are assumed not to be able to provide electricity at the capacities required for electric cooking.


Photo: Ethiopian Clean Cooking Alliance

CHAPTER FOUR

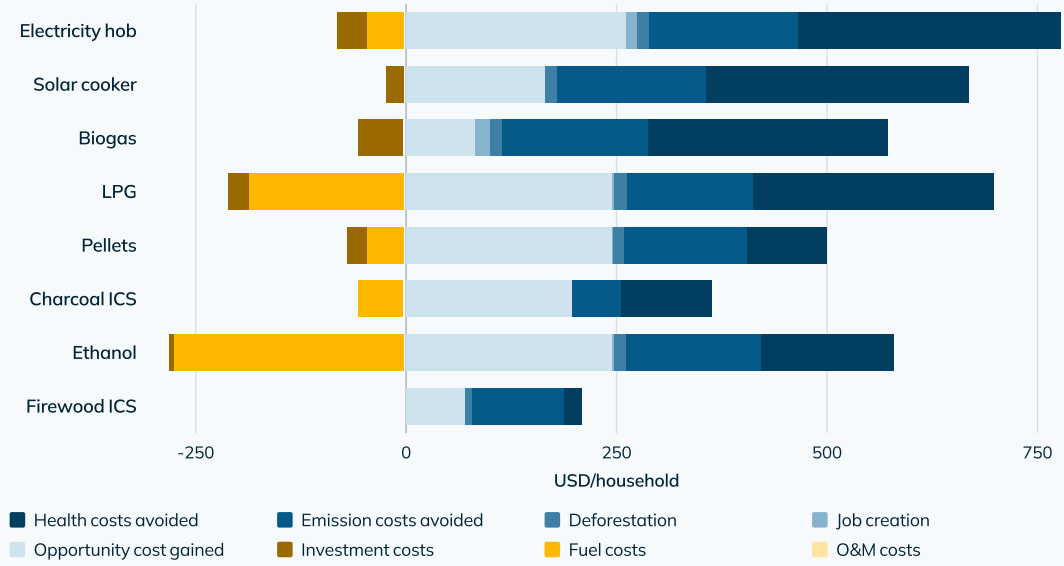
# RESULTS

## 4.1 Cost-benefit analysis

### Transition from collected traditional firewood

When assessing a transition from firewood collected by the households themselves rather than purchased from a vendor, the net benefits across all transitions are positive, highlighting that a switch to improved or clean cookstoves generates societal gains (Figure 3). These gains are connected to improved health outcomes, time savings, and environmental benefits. While the transition also comes at higher costs compared to the current baseline technologies, the monetized benefits outweigh these additional costs in all cases. As a result, the Net Present Value (NPV) of the transition is positive, and benefit-cost ratios exceed 1. These costs and benefits are calculated assuming that those who use collected firewood as their cooking fuel switch to cleaner options but retain their secondary baking stove.

**Figure 3.** NPV of different transitions to cleaner cookstoves per household when switching from collected firewood.




When transitioning away from collected firewood, the largest NPV can be seen while adopting either electric, solar, biogas or LPG stoves (see Figure 3). The largest category of benefits is generally health with the numbers of deaths and cases avoided being large drivers of societal benefits. The total value of health gains given a transition range between USD 21 (for a transition to improved firewood) and USD 310 (for a transition to electric hobs) per household and year. The largest health benefits are seen by switching to either electricity, solar cookers, biogas, or LPG options. The deaths avoided would be between 11,000 and 12,000 per year when switching to these stoves, assuming all those who use free firewood switch but retain their traditional mitad. These health benefits capture the reduction of cases and deaths due to $PM_{2.5}$-caused stroke, ischemic heart disease (IHD), lung cancer (LC), chronic obstructive pulmonary disease (COPD), and acute lower respiratory infections (ALRI). These diseases are selected as the evidence base connecting their prevalence to $PM_{2.5}$ concentrations is well-established. It is important to mention that the health benefits are most likely larger than what is documented here due to connections of household air pollution to additional diseases such as diabetes and tuberculosis, as well as more immediate physical impacts such as soreness of eyes. The five included diseases across genders and age groups are visualized in Figure 4 and Figure 5. For all transitions, age groups, diseases, and both gender groups, deaths are avoided due to traditional firewood leading to the highest concentration of $PM_{2.5}$.

**Figure 4.** Total deaths avoided per year amongst men given a transition from collected traditional firewood to different fuels.

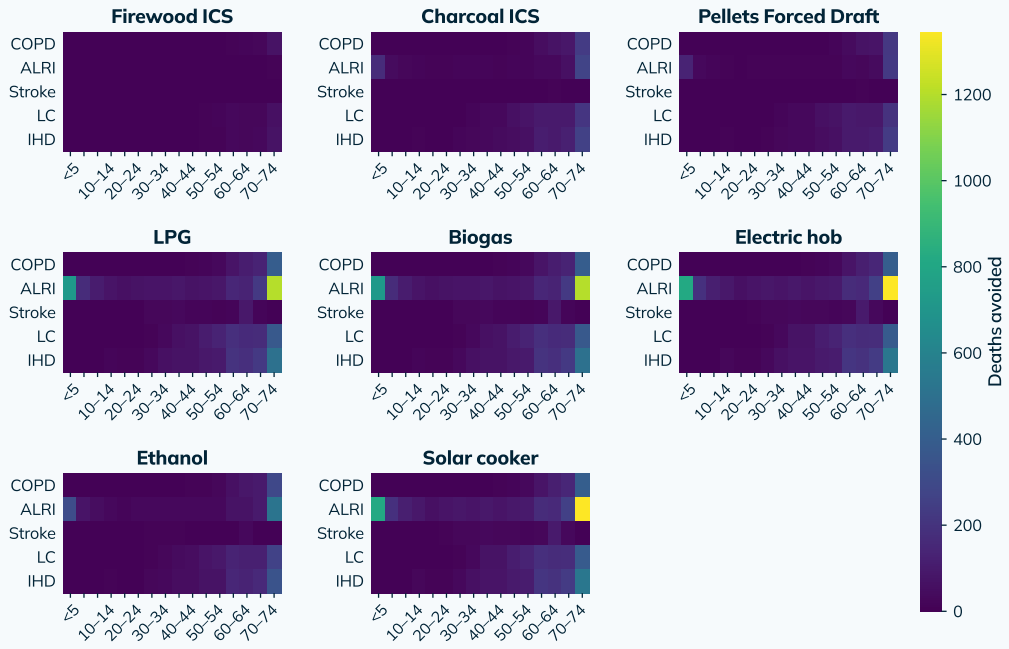
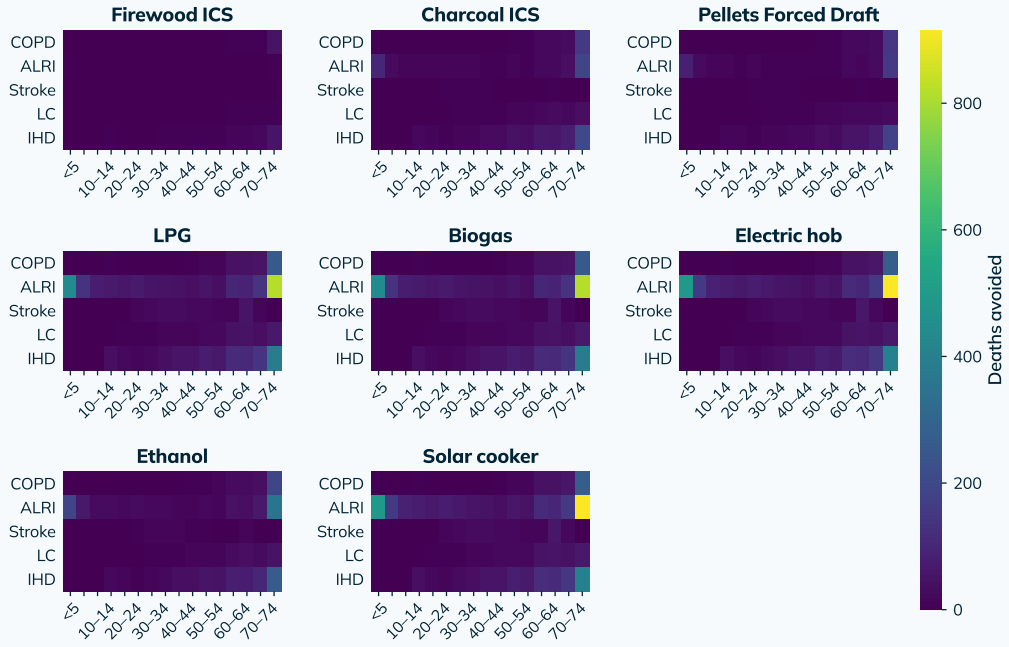
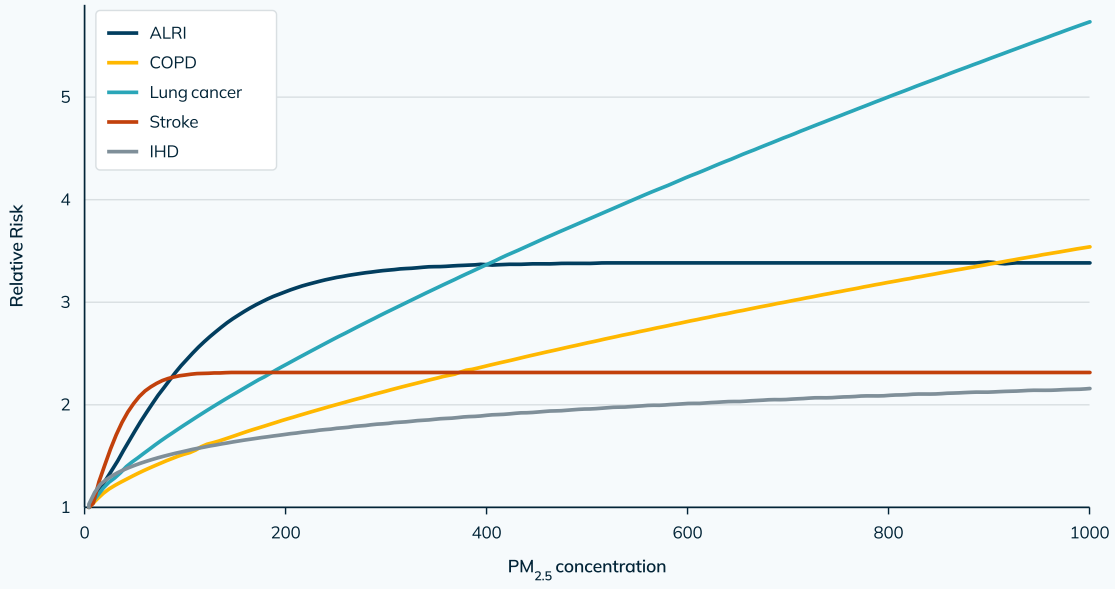



**Figure 5.** Total deaths avoided per year amongst women given a transition from collected traditional firewood to different fuels.



While women have a higher exposure to cooking related $PM_{2.5}$ this does not translate directly to higher deaths and cases avoided in the Ethiopian case. The reasons for this are twofold. First, the relationship between $PM_{2.5}$ exposure and disease risk is nonlinear. Relative risk increases sharply at lower concentrations of $PM_{2.5}$ and then levels off at higher concentrations. As a result, differences in exposure between men and women lead to only small differences in relative risk for several diseases (Figure 6).

**Figure 6.** Relationship between $PM_{2.5}$ concentration and relative risk of different diseases based on data from Burnett et al.[28]




Second, men in Ethiopia have higher baseline rates of mortality and morbidity across the diseases considered[29]. When similar relative risks are applied to these higher baseline rates, the result is a greater number of avoided cases and deaths among men compared to women. This is also in line with the wider data from the Global Burden of Disease database and the gender specific mortality data published by WHO across most sub-Saharan Africa.

Opportunity cost is generally the second largest category of benefits for stoves that do not require active fuel collection. Stoves where the fuel is directly purchased avoid around 3 hours per day and household in comparison to collected firewood options. In cases where fuel must still be collected (biogas or improved firewood options), the average household avoids approximately an hour per day and household. This translates to a yearly opportunity cost of around USD 250 and 75 respectively. In addition, all transitions come with additional job creation. For every biogas stove deployed, 0.08 additional jobs are expected to be created across the import, production,

28 R. T. Burnett et al., "An Integrated Risk Function for Estimating the Global Burden of Disease Attributable to Ambient Fine Particulate Matter Exposure," Environ. Health Perspect., vol. 122, no. 4, pp. 397–403, Apr. 2014, doi: 10.1289/ehp.1307049.

29 Institute for Health Metrics and Evaluation (IHME). Ethiopia profile. Seattle, WA: IHME, University of Washington, 2025. Available from http://www.healthdata.org/Ethiopia. (Accessed 26/08/2026)

distribution, retailing and repair of stoves. This signifies the largest increase in job creation for an individual stove type.

Environmental benefits following the reduction of greenhouse gas (GHG) emissions are considerable across transitions. These benefits are measured by accounting for the reduction of $CO_2$, CO, $CH_4$, $N_2O$, organic carbon, and black carbon. The stoves that cause the largest decrease in GHG are electric hobs and solar cookers (69 Mton/year), biogas (67 Mton/year) and ethanol (63 Mton/year). LPG is also generally close to these three stoves. It is important to note that while the emissions account for production emissions, it omits any transport emissions that may come from transporting fuels from supply points to households. The large environmental benefit for electric cooking is a consequence of the large share of renewables in the electricity generation mix (almost fully renewable). Assuming a social cost of carbon of USD 50 per MT and a social discount rate of 11.7% as outlined in the NCCR these GHG emissions lead to a valuation of between USD 60 and 180 per household across transitions and year. In addition to GHG reductions, the changes in deforestation are important to account for when discussing environmental benefits of the clean cooking transition. When switching away from firewood to a stove that does not use either firewood or charcoal, a total of 1.7 tonnes of firewood is saved per household (assuming useful energy needed to cook amounts to 15.3 MJ per day and an average efficiency of 10% for these traditional stoves). When switching to more efficient firewood options, the reduction of firewood use per household is still around 1.0 tonnes.

While benefits have positive net-present values, all transitions also come with higher costs. Generally, the largest category of costs is additional fuel costs. This highlights the need for policies alleviating these additional re-occurring costs to ensure a sustainable transition minimizing fuel stacking with unclean fuels which would otherwise considerably decrease the benefits. The highest additional fuel cost is estimated for ethanol stoves (USD ~270 per year) while the lowest additional fuel cost is for a transition to electric hobs (USD ~40 per year). The low additional cost for electricity is due to the high efficiency of these stoves and the currently low electricity tariff in the country. Note that a transition to improved firewood stoves, biogas or solar cookers does not come with additional fuel costs as these stoves rely on fuels that are not purchased by the households themselves. Investment costs are also significant across transitions. The largest additional investment cost comes from a transition to biogas stoves, mostly due to the cost of the digestor needed. It is important to note that this cost is offset by the long lifetime of these digesters. Investment costs are also significant for the transition to solar cookers (USD ~120), electric hobs (USD ~60), LPG and pellets stoves (both USD ~80), but the total investment cost of the three later stoves include 56, 20 and 17% of infrastructure costs respectively. These infrastructure costs would be necessary for deploying the different stoves and ensuring their sustained use, but it would not be carried by the households themselves. In the case of electricity, the infrastructure cost includes the cost of adding capacity to the grid necessary to meet the additional electricity demand given a transition. It is important to note that the added electricity capacity can be used for other end-uses separate from cooking and to account for this a coincidence factor of 0.5 consistent with the broader literature is used and the capacity that Ethiopia has committed to expanding either way (4,147 MW) has been removed[30]. The investment costs in Figure 3 have a salvage cost netted for the investment costs to represent yearly values. Combining all costs before netting out the salvage, the most expensive stoves are biogas stoves (USD 540 additional per year), ethanol

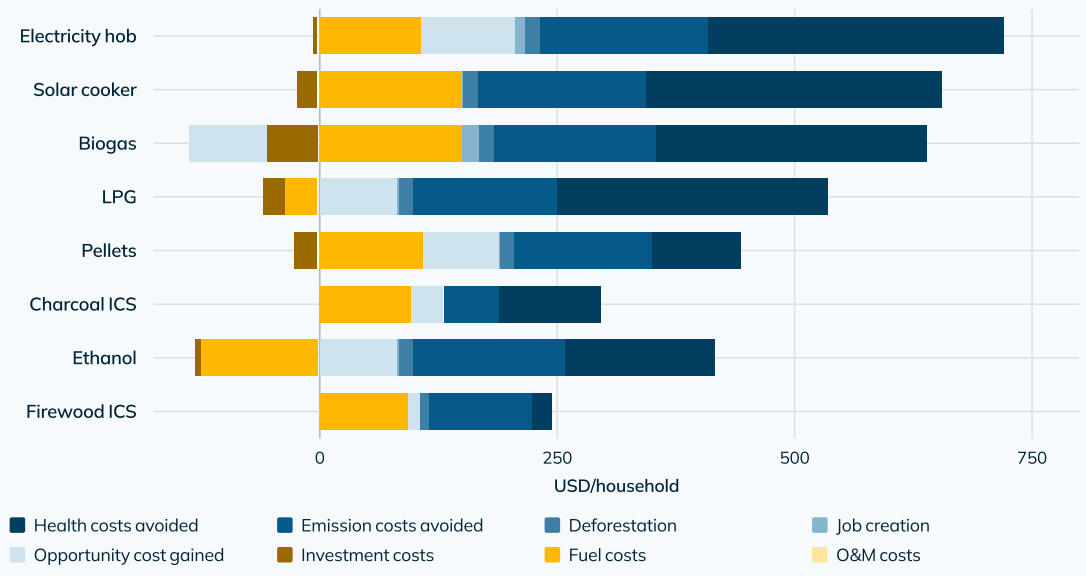
30 Energy Compact for The Federal Democratic Republic of Ethiopia, 2025.

stoves (USD 280 per year), and LPG stoves (USD 260 per year). The stove with the highest overall benefits, electric hobs, has costs of around USD 100 per year. Taking all together, the highest net benefits are given by transitioning to electric hobs, solar cookers, biogas and LPG. These transitions would lead to net benefits of USD 695, 645, 515 and 490 per year respectively. This value is dependent on how the different non-monetary benefits are valued, see Appendix B for the values used in the main analysis.

## Transition from purchased traditional firewood

The 2024-25 Demographic and Health Survey does not explicitly state the share of people collecting firewood. Here it has been estimated that this share is consistent with the data from the 2021 Labour Force and Migration Survey. It is therefore estimated that 11% of the population rely on purchased firewood for cooking. The firewood price is estimated to be around USD 0.096 per kg based on data collected with partners from MoWE. As a trade-off to the additional fuel cost, the collection time is assumed to be negligible for these firewood users. Overall, this leads to lower net benefits across transitions (Figure 7).

**Figure 7.** NPV of different transitions to cleaner cookstoves per household when switching from purchased firewood.




The most significant differences are opportunity and fuel costs. Across all transitions, except for the case of firewood ICS, the gains in opportunity costs are reduced. In the case of biogas, the opportunity costs become negative as the feedstock for biogas production is assumed to still be collected by households. The average time saved across stoves is now an hour per day and household. For the average biogas household, an additional hour in comparison to the baseline needs to be spent on fuel collection. Across all transitions, the added fuel costs are a smaller burden for these households in comparison to their counterparts relying on collected firewood. For

electricity, solar, biogas, pellets and the improved cookstoves (both charcoal and firewood), the cost of fuel is net-saving for the households. In the case of biogas this is due to fuel not being purchased, in the case of electricity and pellets it is due to a combination of low fuel prices currently and higher efficiencies, and in the case of the improved stoves due to higher efficiencies. Compared with their baseline, a household shifting from purchased firewood to biogas, solar cookers, electricity or pellets would save between USD 110 and 150 per year in fuel costs. This would be enough to offset the cost of the stoves without accounting for the benefits (except for the biogas option) within a year of use.

While these households constitute a small share of the population, the transition from purchased firewood to cleaner cookstoves would carry with it significant health and environmental benefits. In total, when these households shift, the deaths avoided per year are between 2,100 and 2,300 for transitions to electricity, solar cookers, biogas or LPG. For emissions, stoves that do not rely on either firewood or charcoal would carry GHG reductions of between 10 and 13 Mton total per year.

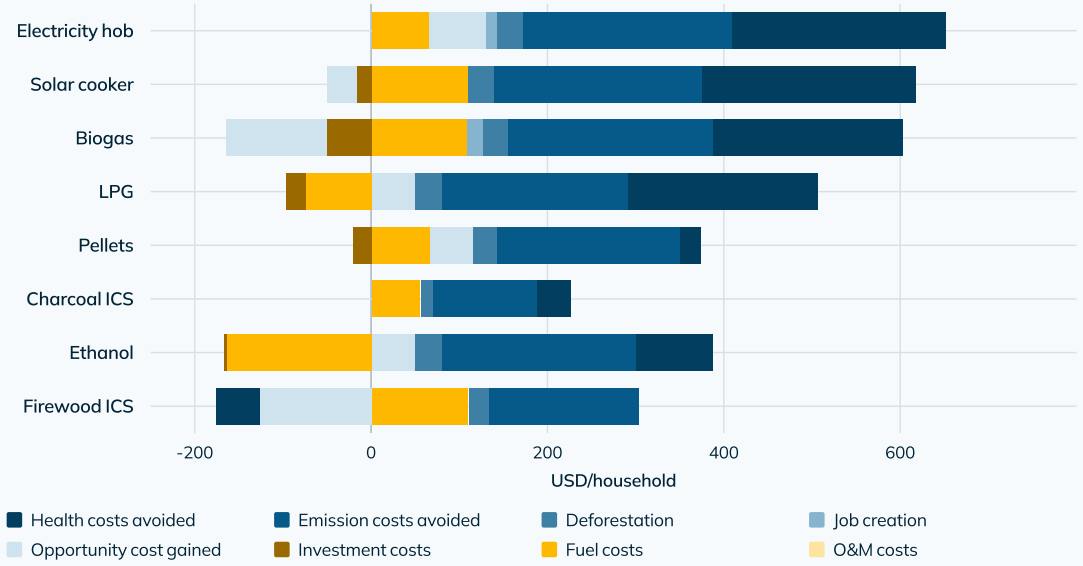
## Transition from traditional charcoal

Charcoal is an important cooking fuel in Ethiopia, especially in urban areas and the country is considered the second largest charcoal producer in the world[31]. Overall, less than 5% of the population is estimated to cook with traditional charcoal stoves. Charcoal, while cleaner than firewood from a health perspective, still has a considerable negative effect on the health of those who rely on it for cooking and a significant environmental impact due to the production of charcoal being carried out in low-efficiency earth kilns. In this analysis, following discussions with partners in the Technical Working Group, an efficiency of 17% was assumed for these kilns.

The net benefits of the different transitions are positive when switching away from traditional charcoal largely driven by positive environmental benefits and, in the case of electric hobs, solar cookers, biogas and LPG, health gains (Figure 8). When switching to either one of these four stoves, a total of between 610 and 690 deaths are expected to be avoided per year. The largest net benefits can still be seen in the case of a transition to electric stoves, followed by solar cookers, biogas and LPG. The range of health benefits across transitions translates to between USD 240 (for a household switching to either an electric hob or a solar cooker) and USD -50 (for a household switching to an improved firewood stove) per year.

31 Biruk Belay, Dawit Guta, Feyera Senbeta - Determinants of participation in charcoal production and its distributive impact on household welfare in rural Ethiopia, Social Sciences & Humanities Open, 2024. Available from https://doi.org/10.1016/j.ssaho.2024.101187. (Accessed 29/10/2026)

**Figure 8.** NPV of different transitions to cleaner cookstoves per household when switching from traditional charcoal.




The negative health benefits for a transition to improved firewood stoves indicate that the improved firewood stove leads to higher concentrations of $PM_{2.5}$ on average in comparison to a traditional charcoal stove (Figure 9 and Figure 10). The additional deaths would come from mainly cases of ALRI in the lowest and highest age groups.

**Figure 9.** Total deaths avoided per year amongst men given a transition from traditional charcoal to different fuels.

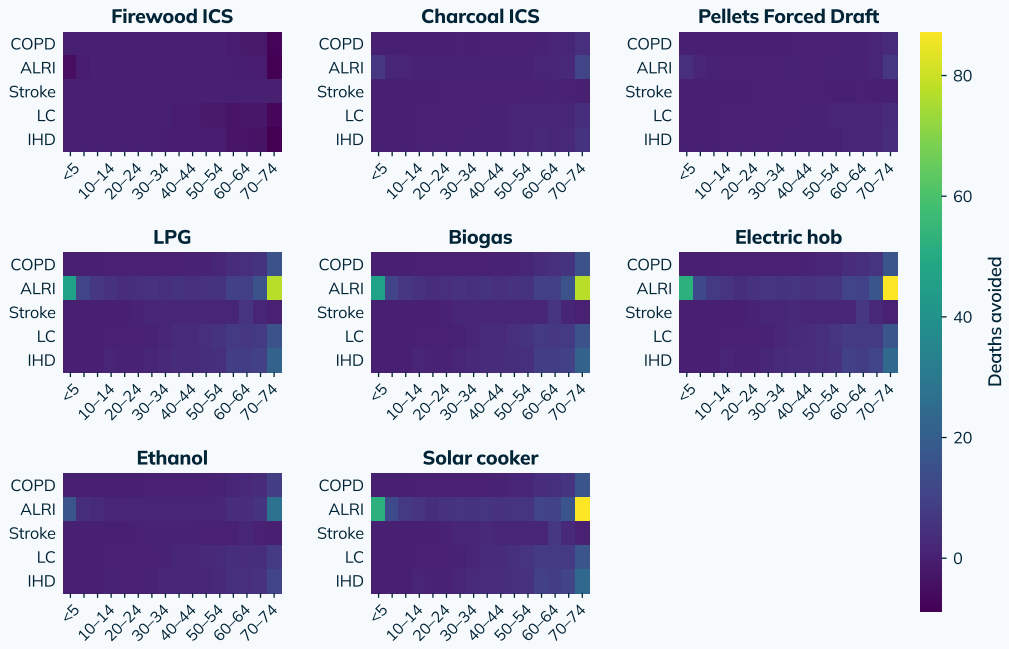
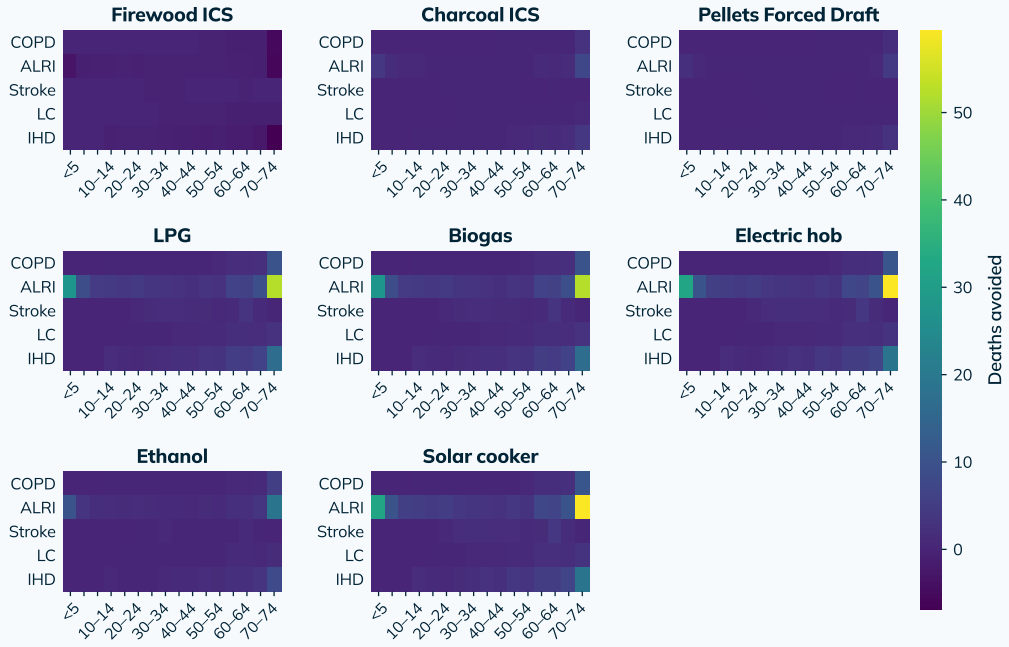



**Figure 10.** Total deaths avoided per year amongst women given a transition from traditional charcoal to different fuels.



The per-household gains in environmental benefits increase by almost a third in comparison to those who transition away from firewood. The monetized carbon emission reductions range from around USD 240 (when transitioning to a solar cooker) to around USD 120 (when transitioning to a more efficient improved charcoal stove). In total, the households currently relying on traditional charcoal have the potential to reduce total emissions by between 6 and 7 Mton/year, assuming the shift is to solar cookers, electricity, biogas, ethanol, LPG or pellet stoves. The households that switch to stoves without either firewood or charcoal avoid the indirect use of 3.2 tonnes of firewood yearly. Switching to an improved firewood or charcoal stove avoids around 2.5 tonnes or 1.6 tonnes respectively. Time saving is also a considerable benefit. When switching to either an electric, LPG, pellet or ethanol stove around 45 minutes are saved per day due to quicker cooking times, but when switching to a stove that requires collection time (biogas or improved firewood stove) around one and a half hours are lost daily. For solar cookers almost half an hour is lost daily due to slower cooking times.

The United Nations Environment Programme (UNEP) estimates that 1.3 million people are employed in the Ethiopian charcoal sector and it is a considerable source of income for the households involved in the sector[32]. Therefore, a move away from charcoal as a cooking fuel may impact many of these households negatively and to ensure this is not a hidden cost of the transition, this impact needs to be quantified. Regardless, the CBA shows positive net gains in employment for most transitions. The discrepancy stems from many of the 1.3 million jobs identified by the UNEP which include a large portion of informal employment opportunities, while the analysis here looks at formal employment only[33]. The UNEP report highlights that a reduction in charcoal consumption would most likely switch informal employment towards other solid biomass (e.g., firewood) instead and this means that the employment benefits of the transition from charcoal to alternative cooking fuels include major uncertainties (especially as the employment included are largely formal).

Accounting for the current price of charcoal in the country, all transitions, except for LPG and ethanol, lead to net fuel savings. The average household that switches to biogas or solar cookers avoids USD 110 per year on fuel costs, assuming the feedstock for biogas is collected by the households themselves. A switch to either electric hobs or pellets would avoid a fuel cost of around USD 60 per year, while a switch to a more efficient improved charcoal stove would avoid around USD 50 per year. Switching to LPG or ethanol would bring additional fuel costs of USD 80 and 160 per year respectively. When switching to an improved firewood stove with collected fuel the benefits match the ones seen for a biogas switch, but assuming purchased firewood the fuel costs would be around USD 40 per year higher than before transition. The additional fuel cost of purchasing firewood comes in return to avoiding more than an hour per day in fuel collection.

### Transition from the mitad stove

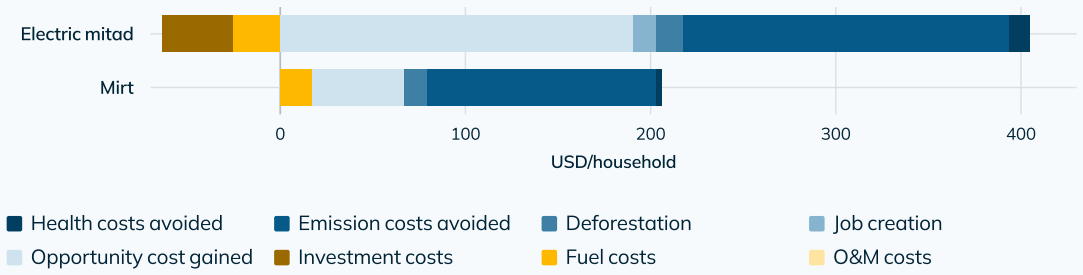
Most households in Ethiopia bake injera in addition to cooking on their primary stove. Baking injera is typically done on traditional mitads using firewood as fuel and it is estimated that half of the total

32 United Nations Environment Programme (UNEP) - Sustainability of Biogas and Solid Biomass Value Chains in Ethiopia: Results and recommendations from implementation of the Global Bioenergy Partnership Indicators, 2019.

33 United Nations Environment Programme (UNEP) - Sustainability of Biogas and Solid Biomass Value Chains in Ethiopia, 2019.

cooking energy is used for baking[34]. Therefore, the changes from different fuels above account for a partial switch from the cooking stove while leaving the traditional mitad untouched. This section outlines the costs and benefits of switching the mitad, while leaving the primary cooking stove. The most widely used improved baking stoves are currently the mirt and the electric mitad. The analysis examines a transition from the traditional mitad to these two. The net benefits across these transitions are positive, highlighting that a switch to a mirt or electric mitad generates societal gains. In addition, the monetized benefits outweigh additional costs in both cases (Figure 11).

**Figure 11.** NPV of different transitions to cleaner baking stoves per household when switching from traditional mitad




The largest category of benefits are time and emission reductions. For time reductions an average of about 1.8 hours per week is saved by switching to the more efficient mirt (but assuming that firewood is still collected for those who collect presently and purchased for those who purchase) and around two hours for the electric mitad per week. Time is saved because these stoves are more efficient and can cook food faster than a traditional mitad. The emission reductions are considerable due to the large energy consumption for baking events in the country and the low efficiency of the mitad. A total of 1.4 tonnes of firewood can be avoided by switching to the more efficient mirt and 1.7 tonnes when switching to the electric mitad. Health benefits are small for both transitions, with a transition to mirt avoiding around 250 deaths yearly and the electric mitad around 660 deaths.

On the cost side the total costs are offset by the benefits within the first year of use of the mirt and the electric mitad. Fuel costs are negative for mirt, indicating net savings. Note that this includes the assumption that those who purchase firewood for their main stove also purchase firewood for their mitad and mirt stove, while the rest collect. The fuel cost savings are therefore the avoided cost of adopting a more efficient stove for the portion of the population purchasing firewood. Investment costs are significant for the electric mitad, estimated to be USD 65 higher per household than the traditional mitad. This indicates that there is a need for policies to alleviate these costs to spur adoption.

34 Ministry of Water and Energy & United Nations Development Programme (UNDP) - Report on Clean Cooking Solutions Value Chain Analysis and Market Performance Study, 2025.

## Impact of stacking

It is known that when households stack different cooking stoves often due to necessity following affordability or reliability of supply constraints, the overall net benefits of the transition are lowered. This is because by using more than one stove, one stove is always going to drive the costs up, bring the benefits down or both. This is a known fact for the health case especially. When using a stove that is clean in conjunction with a non-clean one, the 24-hour average $PM_{2.5}$ concentration increases in the household which quickly increases the relative risk of different diseases (Figure 6). This is the main reason why the deaths avoided presented in the previous sections fall well below the deaths caused by traditional cooking in Ethiopia. See Box 3 below for more details and a calculation of what happens to deaths avoided assuming both stoves are switched simultaneously to cleaner options.

### Box 3. Stove stacking and health impacts

The deaths avoided estimated for these transitions are considerably lower than the household air pollution attributable deaths estimated by the WHO for Ethiopia (61,800, latest data from 2021) and the NCCR (63,000). Reasons for this are 1) the stoves here are assumed to be stacked and 2) even the cleanest stove in this analysis does not eliminate the concentrations of $PM_{2.5}$ as it has been highlighted in literature previously.

If it is assumed that stove used for cooking is the only active stove in the household, deaths avoided would increase as outlined in Table 7 below (results with the cooking-baking stack are given in brackets):

**Table 7.** Deaths avoided when comparing transitions that are stacked and non-stacked.

| Deaths avoided | | | |
|---|---|---|---|
| Transition | From collected traditional firewood (61% of population) | From purchased traditional firewood (11% of population) | From traditional charcoal (4% of population) |
| To firewood ICS | 1,400 [890] | 260 [160] | -330 [-150] |
| To charcoal ICS | 10,300 [4,400] | 1,900 [800] | 310 [110] |
| To pellets | 8,600 [3,900] | 1,600 [710] | 190 [70] |
| To LPG | 46,000 [11,000] | 8,400 [2,100] | 2,900 [610] |
| To Biogas | 46,000 [11,000] | 8,400 [2,100] | 2,900 [610] |
| To Electric hob | 55,000 [12,000] | 10,000 [2,300] | 3,500 [690] |
| To Ethanol | 17,000 [6,400] | 3,200 [1,200] | 830 [250] |
| To Solar cooker | 55,000 [12,000] | 10,000 [2,300] | 3,500 [690] |

## Scenario analysis

The result of a CBA is highly dependent on the valuation of non-monetary benefits. The transitions outlined show that the most important components from the CBA are non-monetary benefits such as health, emission reductions and time saved. To assess how the valuation of these parameters may impact the net benefit of different fuel-stove combinations, three different scenarios are presented: low, medium and high. The medium scenario has already been presented, and the results are highlighted above. For this scenario, the valuations from the NCCR have been used when available and when not (for costs of illness), discussions have been held with the Technical Working Group and on-the-ground experts to collect data. The low and high scenarios are aimed at exploring how the conclusion of the medium scenario holds up if important valuation parameters are to change through different policies or unforeseen events. In addition to assessing valuation methods here, the fuel costs of LPG and electricity will also be assessed as tipping points. LPG is currently not widespread in the country, but there are some policies and plans in place that may impact this moving forward. For electricity, a tariff increase has been advertised and started, and this is expected to lead to significantly higher electricity costs for consumers (see Table 6). The parameters used for the different scenarios are listed in Table 8 and for details on how each parameter is used in the calculations, see Appendix A.

**Table 8.** Scenario parameters.

| Parameter | Low | Medium | High |
|---|---|---|---|
| **Value of Statistical Life (USD/life)**[35] | **94,000** | **500,000** | **1,270,000** |
| **Cost of Illness (USD/case)** | Each value decreased by 50% | IHD: **220**<br>ALRI: **40**<br>LC: **527**<br>Stroke: **309**<br>COPD: **125** | Each value increased by 50% |
| **Social Cost of Carbon (USD/MT)** | **5** (World Bank - Exploring Carbon Pricing in Developing Countries: A Macroeconomic Analysis in Ethiopia)[36] | **50** | **100** |
| **Wage rate (USD/hour)** | **0.31**[37] | **0.5** | **1.04** (2021 Labour Force and Migration Survey) |
| **LPG price (USD/kg)** | **0.6** (average east Africa price beginning of 2026) | **1.9** | **3.2** (based on IEA estimates for the impact of recent geopolitical events on LPG price)[38] |
| **Electricity Tariff (USD/kWh)** | **0.015** (tariff in 2024) | **0.033** (tariff at the time of writing) | **0.059** (expected tariff in 2028) |

35 The different values indicate different elasticities between value of statistical life and income.

36 Telaye, Andualem; Benitez, Pablo; Tamru, Seneshaw; Medhin, Haileselassie; Toman, Michael. 2019. Exploring Carbon Pricing in Developing Countries: A Macroeconomic Analysis in Ethiopia. Policy Research Working Paper;No. 8860. © World Bank.

37 Eversheds Sutherland - Ministry of Labour and Skills — New Deposit and Banking Directive for overseas employment agencies, 2026. Available from https://ezine.eversheds-sutherland.com/managing-a-global-workforce/ethiopia. (Accessed 29/10/2026)

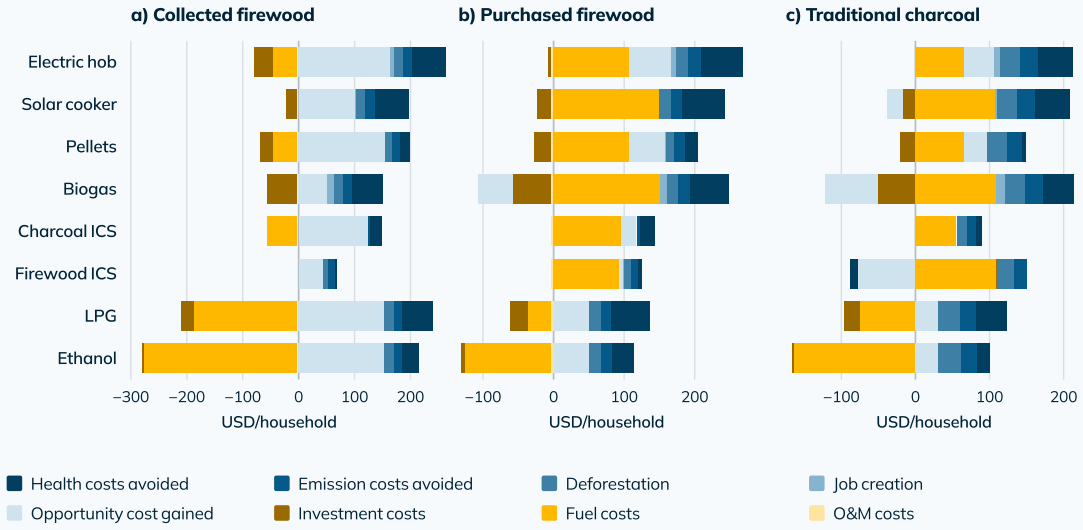
38 International Energy Agency - Liquefied Petroleum Gas import prices in selected regions, 2025-April 2026. Available from https://www.iea.org/data-and-statistics/charts/liquefied-petroleum-gas-import-prices-in-selected-regions-2025-april-2026. (Accessed 29/10/2026)

## Lower valuation

Figure 12 shows the net benefits for each transition away from the different modalities of cooking in the baseline when accounting for lower valuations of benefits. The most significant change is the order of technologies when ranked based on net benefits. With lower valuations, LPG and ethanol are the worst options from a net benefit perspective. In the case of ethanol, the high fuel cost results in negative overall net benefits for all transitions, regardless of the higher benefits in comparison to traditional fuels. LPG is also very close to having negative net benefits especially in the transitions from biomass which is collected and traditional charcoal. The lower valuation also allows pellets to overtake cleaner fuels such as biogas, LPG and ethanol, and improved charcoal stoves to overtake LPG and ethanol and draw almost level with biogas.

Ethiopia currently imports its LPG, and the low net benefits are mostly due to the high cost of LPG. If Ethiopia were to decrease its LPG price to match the average east-African price in the beginning of 2026, LPG would move up to being the stove option with the third highest net benefit after electric hobs and solar cookers. In a transition from traditional charcoal, this decrease in price would lead to net savings in fuel costs. In the case of electricity, a higher tariff is expected in 2028. Regardless of this increase, the net benefit of a transition to electric hobs is expected to produce the highest net benefits from all stoves except for collected traditional biomass (for which a transition to solar cookers would give higher net benefits). In the case of a transition from charcoal, electric hobs would still produce net fuel savings even at the higher fuel costs foreseen in 2028.

**Figure 12.** Benefits and costs when transitioning to different cooking stoves from a) collected firewood, b) purchased firewood and c) traditional charcoal assuming lower valuations of benefits.

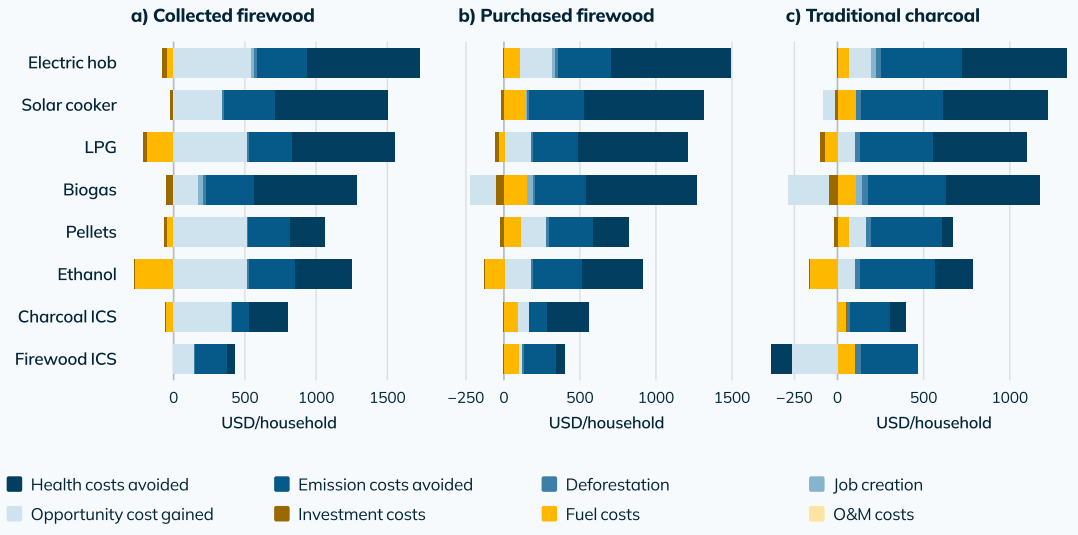



## Higher valuation

With a higher valuation of benefits, no transition produces negative net benefits (Figure 13). The order of technologies ranked by highest net benefits changes with ethanol overtaking the ICS

options and LPG overtaking biogas due to the higher valuation of time saved. A transition from traditional charcoal to improved firewood stoves causes lower net benefits in general as the higher valuation of health and time savings creates higher negative values for the losses in health.

**Figure 13.** Benefits and costs when transitioning to different cooking stoves from a) collected firewood, b) purchased firewood and c) traditional charcoal assuming higher valuations of benefits.




## Electricity access and e-cooking adoption

A critical factor in Ethiopia's clean cooking transition is the gap between electricity access and the capacity to support electric cooking. According to the CBA results, electric cooking consistently delivers some of the highest net benefits across the assessed transitions. This is also reflected in the National Clean Cooking Energy Sector Investment Plan of Ethiopia, where electric cooking is a major component of the transition. However, electricity access alone does not guarantee that households have the capacity, reliability, affordability, or quality of supply required to adopt and sustain e-cooking.

According to the 2026 energy access survey, 56% of households remain at a lower electricity access tier, with limited electricity consumption and capacity to support higher-power appliances and only 7% have tiers 4 or 5 access[39]. While the MTF framework does not define a specific tier at which e-cooking becomes viable, it indicates that Tier 3 (≥200 W capacity) can support medium-power appliances, and Tier 4 (≥800 W) can support higher-power appliances. Therefore, although e-cooking feasibility depends on factors such as appliance power requirements, affordability and availability, Tier 3 or above can be considered a reasonable minimum for supporting e-cooking applications.

39 Ethiopia Energy Access Survey - Insights into the energy access situation in Ethiopia based on the Multi-Tier Framework, 2026.

In addition, data from the NEP 3.0 categorizes households based on electricity demand. As shown in Table 9, 59% of households are classified as low-demand users, with a daily peak consumption of approximately 10 W, which falls within Tier 1[40]. This level of electricity service cannot support most e-cooking appliances. This suggests that while households may have access to electricity for basic uses such as lighting and phone charging, it is not yet widely accessible for cooking, which generally requires substantially higher levels of electricity consumption, especially for baking injera using an electric mitad. This indicates that existing electricity access may not be fully utilized for higher-energy household applications and could constrain the widespread adoption of e-cooking. The relatively low consumption levels may reflect household efforts to limit electricity expenditure, inadequate or unreliable supply, or existing patterns of electricity use, among other factors. In terms of affordability, 99.7% of households from the energy access survey report spending less than 5% of household income on a basic electricity package, implying that affordability of basic electricity access may not be the primary constraint, although the cost of increased electricity consumption for electric cooking may still present a barrier. Therefore, achieving Ethiopia's electric cooking targets will require planning that considers electricity connectivity, including the adequacy and affordability of electricity supply for household cooking needs.

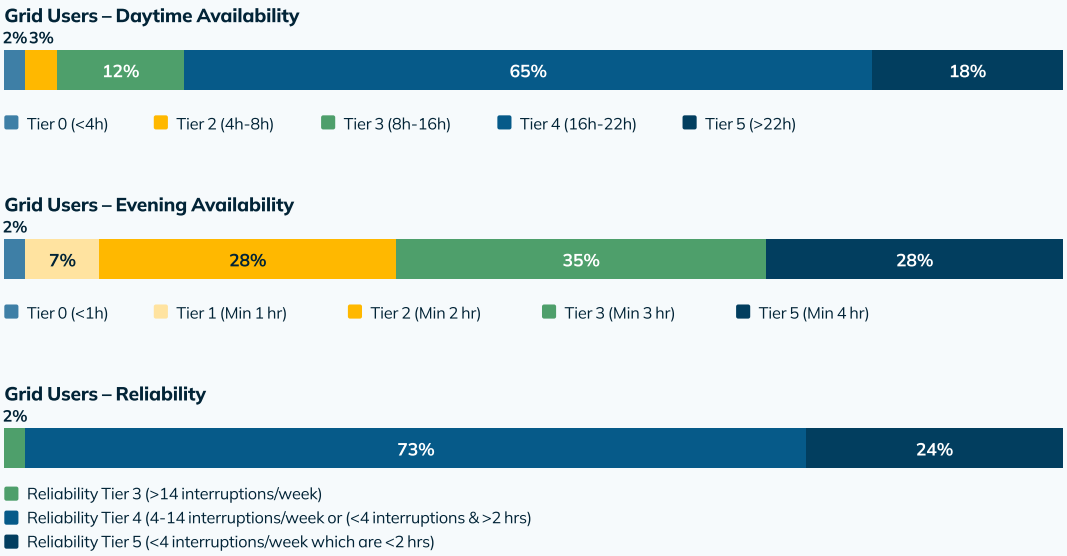
**Table 9.** Domestic categories according to current consumptions.

| Consumer category | Consumption levels | Average yearly consumption (kWh) | Average monthly consumption (kWh) | Average daily consumption (Wh) | Daily Peak (W) | Tier equivalence | Share of households |
|---|---|---|---|---|---|---|---|
| Low demand | <6 kWh/month | 37 | 3 | 100 | 10 | Tier 1 | 59% |
| Medium demand | 6 – 30 kWh/month | 220 | 18 | 600 | 39 | Tier 2 | 19% |
| High demand | >30 kWh/month | 805 | 67 | 2200 | 142 | Tier 3 and more | 22% |

For households connected to the grid, electricity availability is relatively high, but reliability is the concern. According to the energy access survey (Figure 14), a combined 83% of users report having electricity available for at least 16 hours per day, while at least 63% report having a minimum of three hours of electricity available during the evening. However, around three-quarters of users report reliability issues, experiencing more than 4 interruptions per week or long interruptions. These interruptions can disrupt household cooking routines, as users may be uncertain whether electricity will be available when they need to prepare a meal or whether the supply will remain stable long enough to complete cooking. This inconsistency may therefore discourage households from relying on electric cooking, even if they have a grid connection.

40 Innovation Energie Développement - National Electrification Program update (NEP 3.0), 2026.

**Figure 14.** Grid users' daytime and evening availability and reliability[41].




This also contributes to stove and fuel stacking, which the survey highlights as a common practice among households. Three quarters of the population use two cooking stoves, in addition to the stove used for injera baking. This practice is observed in both urban and rural households and may reflect established cooking preferences, the suitability of different stoves for specific foods, or the need for a backup option when a particular fuel or technology is unavailable.

## 4.2 Geospatial analysis

The CBA outlines the costs and benefits of singular households switching their primary and secondary stoves. However, oftentimes a transition to a stove with the highest benefits and lowest overall costs may not be feasible. Governments must therefore weigh costs and benefits against how reasonable different transitions are. This has been done in Ethiopia's NCCR which presents three separate scenarios and identifies one as the most reasonable. Here, the analysis in the NCCR is complemented with a geospatial analysis describing where different stoves could be deployed to reach the targets of the three scenarios described in the NCCR while minimizing the costs.

### Electricity modelling

In parallel to the developments in the clean cooking sector, Ethiopia has also outlined ambitious targets for the electricity sector in their NEP 3.0. The current electricity access rate nationally sits around 65% (reduced to approximately 44% if accounting only for households where current electricity supply meets Tier 1 requirements at the minimum), with a lower electricity access rate in rural areas. In the NEP 3.0, a roadmap to achieve universal electricity access by 2035 through a mix of grid, mini-grid and Solar Home Systems (SHS) is outlined. Two scenarios are presented in the

41 Ethiopia Energy Access Survey - Insights into the energy access situation in Ethiopia based on the Multi-Tier Framework, 2026.

NEP 3.0, differing only in the number of people assumed to live in the country. Scenario 1 uses the population estimates from the United Nations Population Division and the World Bank (133 million in 2025), while scenario 2 uses the number from the Ethiopian Statistical Service (111 million in 2025). For this clean cooking analysis, the latter has been used based on discussions in the Technical Working Group and its alignment with the NCCR. According to this projection, the estimated population by 2035 will have grown to 127 million people.

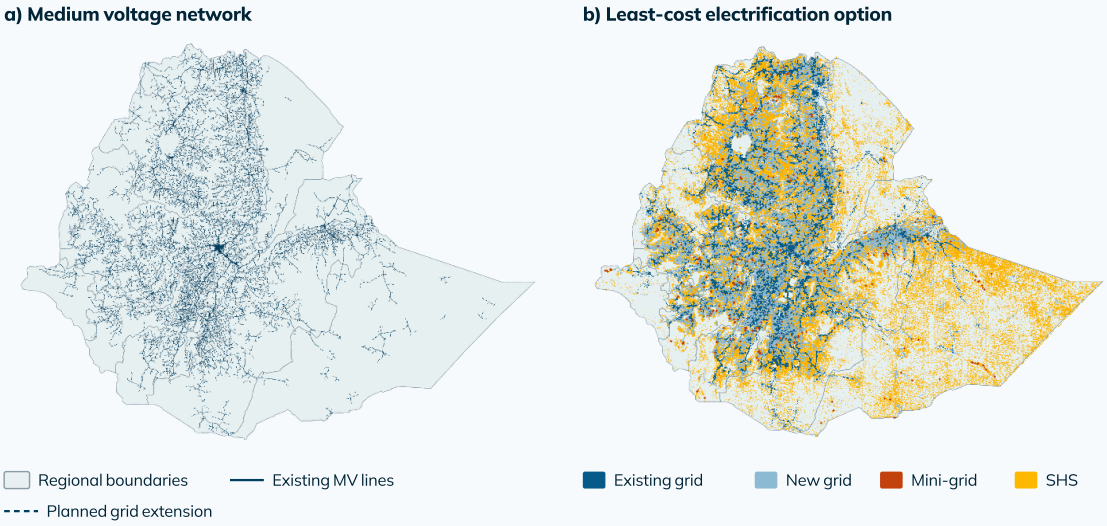
Access to electricity, especially through grid or mini-grid connections, enables a greater uptake of electric cooking. It is therefore important to understand how the electricity sector develops alongside clean cooking. For this, the geospatial electrification pathway from the NEP 3.0 is utilized. These electrification results are fed into the clean cooking analysis to understand where electric cooking is possible. Settlements identified for grid-connection or mini-grids in the NEP 3.0 are assumed to be able to meet potential electric cooking loads, whereas settlements served by SHS are assumed unable to support electric cooking at the moment. Table 10 outlines the population distribution across categories of electrification technologies, by overlaying the areas identified for grid-connection or mini-grids in the NEP with the specific population dataset used for the clean cooking analysis. Note that there is a slight difference between the shares of each category in the NEP 3.0 and the analysis outlined here. This is due to the difference in population data used in the two studies, where the gridded population data required for the clean cooking analysis is distributed over a larger area compared to the settlement data used for the NEP 3.0 electrification analysis, covering also dispersed households located outside of the settlements used for NEP 3.0. Almost one-fifth of the population would be electrified using SHS, excluding them from the potential for electric cooking. This essentially sets the upper boundary for the maximum share of the population that could use electric cooking. As the upper limits are significantly higher than the electric cooking share targeted in the NCCR, this is not expected to have a significant effect on clean cooking results.

**Table 10.** Population by electrification technology in 2035, calculated by overlaying the geospatial analysis from the NEP 3.0 with the gridded population data used for the clean cooking modelling in this report. These categories are model inputs and do not vary between the clean cooking scenarios presented in this report.

| Electrification category | Share of national population (NEP 3.0 - gridded population overlay) | Share of population (NEP 3.0) |
|---|---|---|
| Grid | 79.3% | 87.0% |
| Mini-grid | 0.8% | 1.1% |
| SHS | 19.9% | 11.8% |

Figure 15 shows the spatial distribution of electrification technologies by 2035 as identified by the geospatial analysis of the NEP 3.0. Grids are typically centered around larger, high-density urban areas, where economies of scale ensure grid-extension is the lowest-cost option to provide electricity access. In rural areas where the population density is lower and the centralized infrastructure is less widely available, SHS becomes more prevalent.

**Figure 15.** (panel a) The medium-voltage lines, (panel b) Spatial distribution of least-cost electrification options, based on geospatial analysis from the NEP 3.0 overlaid by gridded population data.




## Clean cooking business as usual

To estimate cooking shares for 2035 in business-as-usual (BAU) case, household cooking-fuel data from six Ethiopian DHS rounds (2000, 2005, 2011, 2016, 2019 and 2024–25) were extrapolated separately for urban and rural areas. The DHS was preferred over the BAU scenario of the NCCR as the NCCR predates the latest DHS and reports BAU only as a national clean-cooking access rate and a cumulative number of stoves, with no breakdown by technology or by urban and rural areas. Shares were projected for seven fuel groups (electricity, LPG/gas/biogas (aggregated in the DHS), kerosene, charcoal, wood, other biomass, and other fuels). The fuel groups were then disaggregated into the same categories used in the NCCR holding the latest proportions constant to 2035. These proportions are the share of wood and charcoal users cooking on a manufactured stove (improved biomass and improved charcoal), the split between LPG and biogas, the share of solar within other fuels, and the share of dung within the other biomass group. Households that do not cook, and a small number of people using alcohol, gasoline or waste, were excluded, and the remaining shares were rescaled to 100%. The stove shares in urban and rural areas in the BAU scenario are outlined in Table 11.

**Table 11.** BAU stove shares across urban and rural settlements based on DHS projections.

| Fuel | BAU | |
|---|---|---|
| | Urban share (%) | Rural share (%) |
| Electricity | 41.0 | 4.5 |
| Biogas | 0 | 0.4 |
| LPG | 0 | 0.3 |
| Solar | 0.7 | 0.7 |
| Advanced biomass | 4.5 | 3.9 |
| Charcoal ICS | 13.8 | 1.4 |
| Traditional stoves | 40.0 | 88.8 |

## Access to clean cooking

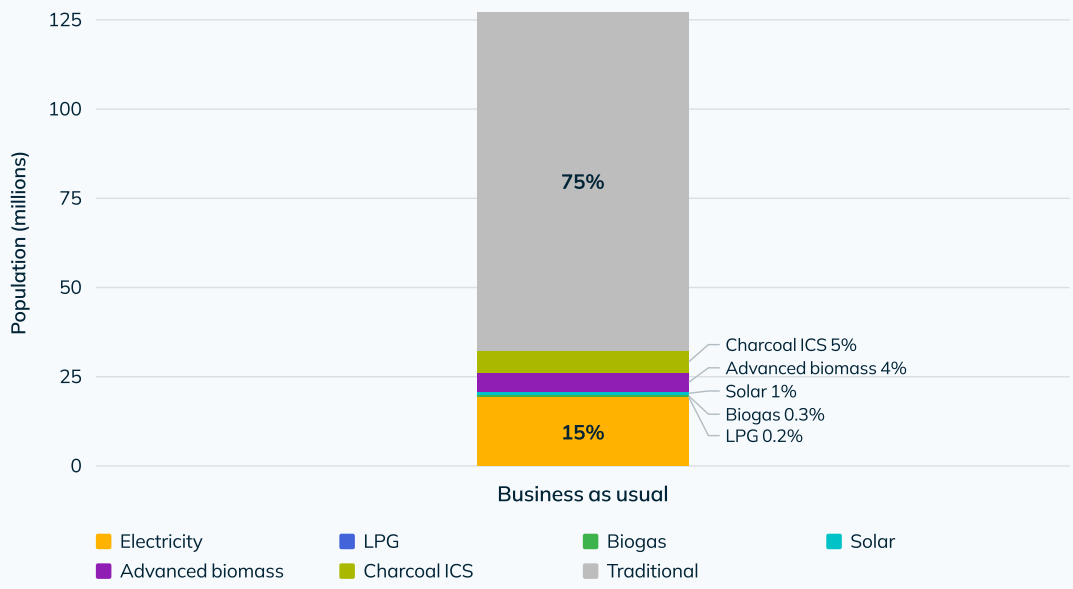
If development in the clean cooking sector continues as it has historically, 1.4 million households (or approximately 5.2 million people) will switch stoves by 2035 (Table 12). Around a quarter of the population in Ethiopia will have access to clean or improved cookstoves (32.4 million people) and population left without a clean stove reach 95.1 million.

**Table 12.** Population reached by clean cooking solutions by 2035 in BAU.

| Indicator | Business as Usual |
|---|---|
| Population with clean or improved stoves | 32 million |
| Share of national population | 25% |
| Population left without | 95 million |

The largest shares of stoves that people use are electric stoves (used by 19.2 million people), improved charcoal stoves (6.4 million) and advanced biomass stoves (5.2 million). Figure 16 shows the number and share of people receiving each stove. The population using a stove in 2035 includes households already cooking with that fuel in the base year, as well as the additional adopters.

**Figure 16.** Population split between stoves in BAU by 2035.




## Health, time and climate outcomes

While the BAU scenario carries benefits in terms of time saved and GHG emissions reductions in comparison to the current situation, they are mostly small. Around 600 premature deaths are avoided yearly once the transition is complete. The avoided deaths are far lower than what the NCCR and the WHO attribute to the use of traditional cooking in Ethiopia currently due to the share of the population remaining on traditional and improved cookstoves in the end-year. BAU avoids 3.3 Mt of $CO_2e$, and the average household who switches saves up to 50 minutes per day in reducing fuel collection and cooking times (Table 13).

**Table 13.** Health, time, and climate outcomes in 2035 for BAU.

| Outcome | BAU |
|---|---|
| Premature deaths avoided per year | 600 |
| Emissions avoided (Mt $CO_2e$) | 3.3 |
| Time saved per household in minutes (only accounting for those who switch) | 50 |

## Costs and cost-effectiveness

BAU returns higher benefits than costs, with a benefit-cost ratio of 11.1 (Table 14). The high ratio reflects the small investment, not an efficient program. The analysis assumes that the few households that switch are in the settlements where the highest net benefit would occur.

**Table 14.** Costs, benefits and benefit-cost ratios in BAU.

| Indicator | BAU |
|---|---|
| Total costs (million USD) | 44 |
| Total benefits (million USD) | 488 |
| Benefit-cost ratio | 11.1 |

## Geospatial cooking results (BAU)

Under BAU, the stove mix barely changes from the current split. Electric cooking stays in grid-connected and mostly urban settlements. Nationally the number of people cooking with electricity rises by only 0.12 million (from 19.1 to 19.2 million). Almost all electric cooking happens on grid connections, and mini-grids are negligible (Table 15), as the mini-grid tariff (about USD 0.3 per kWh) is far above the expected grid tariff (USD 0.059 per kWh). Somali, where many rely on stand-alone systems according to the NEP 3.0, has the largest change in clean cooking shares.

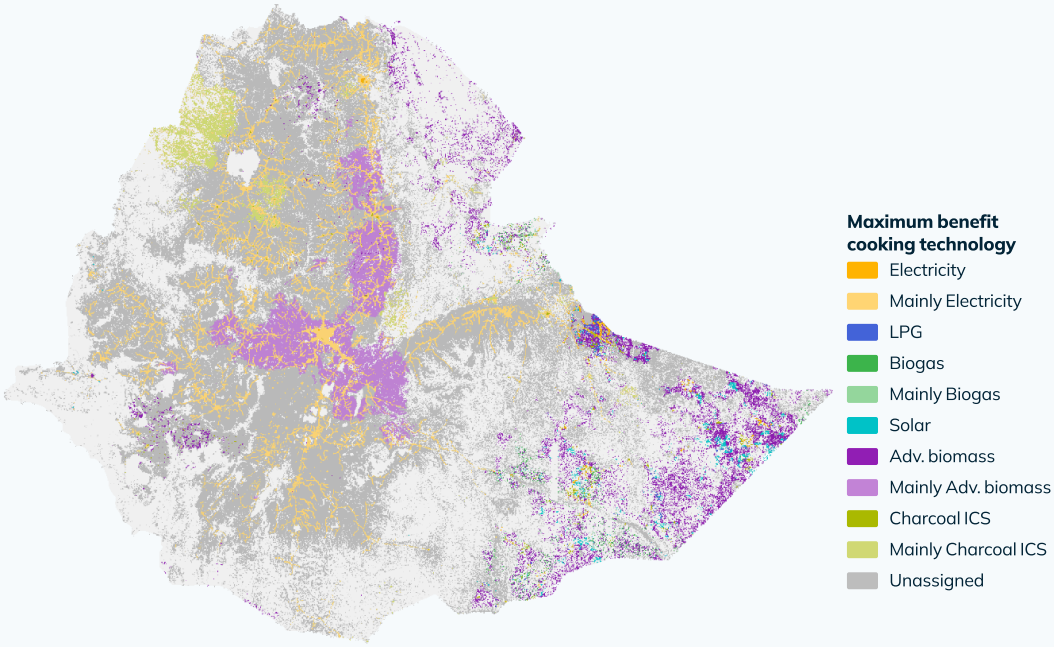
**Table 15.** The number of people cooking with electricity across different least-cost electrification classes.

| Least-cost electrification technology | BAU (Million people) |
|---|---|
| Existing grid | 16.1 |
| Grid extension | 3.2 |
| Mini-grid | 0 |
| SHS | 0 |
| Total | 19.2 |

Totals may not add up due to rounding.

The population relying on charcoal ICS more than doubles from 3.0 to 6.4 million (mostly urban, 5.1 million) and advanced biomass stoves rise from 3.7 to 5.2 million. Together they take 91% of the households who switch. Solar cookstoves rise from 0.7 to 0.9 million. See Figure 17 for the spatial distribution of stoves in the BAU.

**Figure 17.** The stoves from the BAU scenario are distributed across the country to maximize net benefits. "Mainly X" marks settlements where X is the main stove, but part of the population also use another stove. Grey marks settlements where most people remain on traditional fuels.




The population left on current fuels is highly concentrated (Table 16) in specific regions. Five regions account for 83% of the 95 million people remaining on traditional fuels. Most of them live in Oromia, and its settlements rank low on the net benefit per household that switches, because the modelled benefits per household are lower there while costs are similar to elsewhere. The results in Oromia and the other regions in Table 16 reflect where the national targets deliver the largest total net benefit, not where need is greatest. A lower ranking does not mean that clean cooking is a poor investment, for example electric cooking in Oromia would still return around USD 2.5 in benefits for every dollar spent, it just produces a higher return elsewhere in the country.

**Table 16.** Regions ranked by population remaining on traditional fuels with the technology mix indicated under the BAU scenario.

| Region | BAU: Remaining on traditional fuels (million) | BAU: electric cooking (%) | BAU: advanced biomass (%) |
|---|---|---|---|
| Oromia | 39.8 | 11.2 | 5.8 |
| Amhara | 18.4 | 12.2 | 14.5 |
| Central Ethiopia | 9.0 | 4.7 | 2.6 |
| South Ethiopia | 7.0 | 3.6 | 2.1 |
| Somali | 4.8 | 6.6 | 25.4 |
| Other nine regions | 16.2 | - | - |

## National Clean Cooking Roadmap scenarios

The first modelled scenario in the NCCR, labelled "conservative", is developed in line with the National Sustainable Energy Development Strategy (N-SEDS). This scenario distributes 21.95 million stoves, with 16.13 million in rural areas. Of the distributed stoves, 57.4% will be electric, 40.6% are advanced biomass stoves, 1.7% are biogas and 0.3% solar stoves. To reach these goals, it is assumed that the clean cooking sector is supported with policy frameworks, measures to improve resource efficiency and stakeholder alignment. According to the NCCR, the conservative scenario leads to emission reductions of 48.75 million tonnes of $CO_2$ equivalents aligned with the N-SEDS. The second scenario is classified as "moderate" and is aligned with Ethiopia's NDC. It targets 75.87% clean cooking access, reaching approximately 18.12 million households by 2035. Under this scenario, 36.25 million clean cookstoves would be distributed, with a focus on Tier 3 and Tier 5 technologies. Of the total distribution, 44.6% would be electric stoves, 51.2% advanced biomass cookstoves, 2.4% biogas and 1.8% solar solutions. The scenario also aims to reduce emissions by 75 million tonnes of $CO_2$ equivalent by 2035. The estimated cost of implementation is USD 2.6 billion for cookstove distribution according to the NCCR. Based on a CBA, the NCCR identifies this as the main pathway forward. The most ambitious scenario in the NCCR is the "aggressive" one, which aims to achieve 91.88% clean cooking access by 2035. The scenario aligns with Ethiopia's LT-LEDS, which targets a reduction of 100 million tonnes of $CO_2$ equivalent by 2035. For this scenario, the transition would require the distribution of 45.04 million cookstoves, reaching 22.52 million households. The projected investment required for stove distribution alone is USD 3.14 billion. The proposed distribution mix includes 55.4% electric cooking, 39.9% advanced biomass cookstoves, 3.5% biogas and 1.2% solar cooking technologies. Note that while the NCCR does not state a number of LPG stoves distributed it does mention that the goal is for LPG to increase slightly and this has been reflected in the scenarios modelled.

Based on the latest cooking statistics described in the 2024-25 DHS and the stove distribution outlined in the NCCR for each scenario, the final shares are presented in Table 17 (see the full data behind these calculations from the NCCR in Appendix C). Note that the resulting clean cooking shares are slightly different from what is outlined in the different scenarios of NCCR. The reason for

this is that the latest cooking data for the country puts the current clean cooking access at around 13% in comparison to the 8.8% in the NCCR.

**Table 17.** Shares of stoves by 2035 in the different scenarios in the roadmap

| Fuel | Conservative | | Moderate | | Aggressive | |
|---|---|---|---|---|---|---|
| | Urban share (%) | Rural share (%) | Urban share (%) | Rural share (%) | Urban share (%) | Rural share (%) |
| Electricity | 43 | 25 | 48 | 32 | 59 | 49 |
| Biogas | 1 | 1 | 1 | 2 | 2 | 3 |
| LPG | 2 | 1 | 2 | 1 | 2 | 1 |
| Solar | 0 | 1 | 1 | 2 | 1 | 2 |
| Advanced biomass | 24 | 22 | 37 | 40 | 36 | 39 |
| Traditional stoves | 30 | 50 | 11 | 23 | 0 | 6 |

## Access to clean cooking

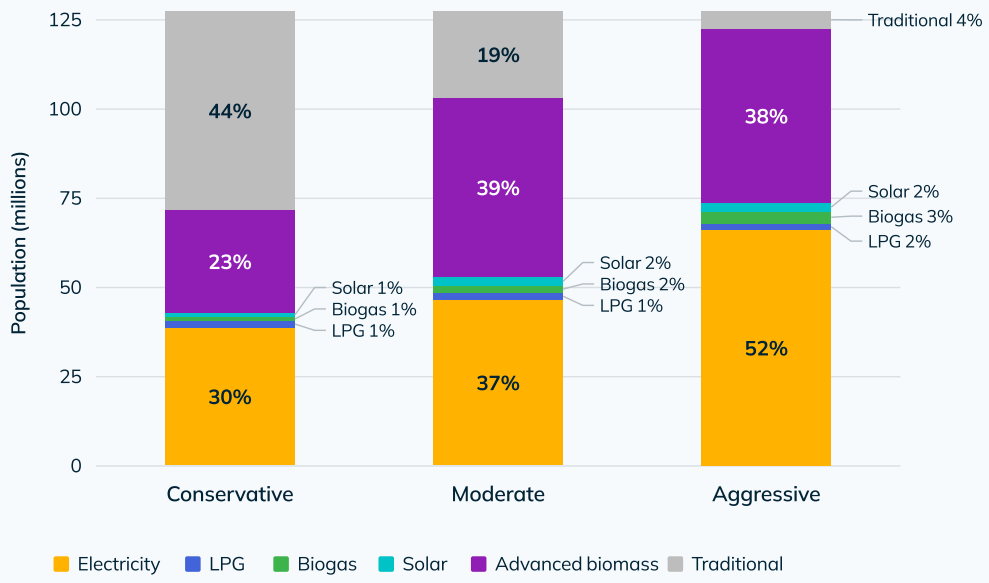
Access to clean or improved cooking rises from today's share to around 56% of the population under the conservative scenario, 81% under the moderate scenario, and 96% under the aggressive scenario. The population left without a clean stove range between 56 and 5 million across the scenarios modelled (Table 18).

**Table 18.** Population reached by clean cooking solutions by 2035.

| Indicator | Conservative | Moderate | Aggressive |
|---|---|---|---|
| Population with clean or improved stoves | 72 million | 103 million | 122 million |
| Share of national population | 56% | 81% | 96% |
| Population left without | 56 million | 24 million | 5 million |

Figure 18 below outlines the estimated number and share of people receiving each stove across scenarios by 2035. Note that the population using a stove in 2035 includes households already cooking with that fuel in the base year, as well as the additional number of people who would adopt. 24.2 million people currently rely on the stoves the NCCR is aiming to increase shares based on the DHS. Across scenarios, electricity and advanced biomass are the most important stoves.

**Figure 18.** Population split between stoves across scenarios.




## Health, time and climate outcomes

Benefits scale broadly with access (Table 19). Avoided premature deaths rise from 11,000 to 23,400 per year, avoided emissions from 33.6 to 72.1 million tonnes of $CO_2e$, and the average household that switches saves from around 55 to 65 minutes per day. The benefits of each transition are valued against a weighted average of the fuels currently used in each settlement rather than against each household's actual fuel, because the model does not track which fuel a switching household leave. However, the results estimate this. For approximately 60% of the people who switch, everyone in their settlement using traditional fuels switches, so the fuel they leave is known exactly, and elsewhere collected firewood makes up most of the fuels that can be displaced. Assuming instead that switchers leave the highest- or lowest-impact fuels first changes deaths avoided, emissions and time saved by 0.3% or less. Again, the avoided deaths are far lower in each scenario than what the NCCR and the WHO attributes to the use of traditional cooking in Ethiopia currently. This is due to the importance of advanced biomass stoves in all scenarios. While they reduce $PM_{2.5}$ concentrations in comparison to the current base levels, these reductions are not large enough to translate into a major reduction of relative risk of different diseases.

**Table 19.** Health, time and climate outcomes in 2035 by scenario.

| Outcome | Conservative | Moderate | Aggressive |
|---|---|---|---|
| Premature deaths avoided per year | 11,000 | 15,600 | 23,400 |
| Emissions avoided per year (Mt $CO_2e$) | 33.6 | 54.9 | 72.1 |
| Hours saved per household and day (total country) | 0.38 | 0.58 | 0.81 |
| Hours saved per household and day (only accounting for those who switch) | 1.05 | 0.95 | 1.08 |

## Costs and cost-effectiveness

All three scenarios return higher benefits than costs (Table 20). The benefit-cost ratio is highest under the moderate scenario (4.6), compared with 4.4 under the conservative and 3.9 under the aggressive scenario. The difference is driven mainly by the technology mix. Most of the additional households reached under the moderate scenario adopt advanced biomass stoves, which require very little investment per household, while the additional households under the aggressive scenario adopt electric cooking and biogas, which are considerably more capital-intensive. Net benefits do however rise with ambition. The NCCR's choice of the moderate scenario as its main scenario is supported with the aim of highest return per USD invested.

**Table 20.** Costs, benefits and benefit-cost ratios by scenario.

| Indicator | Conservative | Moderate | Aggressive |
|---|---|---|---|
| Total costs (USD million) | 1,600 | 2,300 | 3,800 |
| Total benefits (USD million) | 7,100 | 10,500 | 15,100 |
| Net benefit (USD million) | 5,500 | 8,200 | 11,300 |
| Benefit-cost ratio | 4.4 | 4.6 | 3.9 |

Beyond the annual costs in Table 20, the scenarios require substantial upfront capital. The one-off, undiscounted investment needed is about USD 9.8, 14.1 and 24.2 billion under the conservative, moderate and aggressive scenarios, or roughly USD 930, 790 and 1,100 per household that switches stoves. Around 97% of this is new generation capacity to supply electric cooking. The stoves themselves account for USD 0.3, 0.5 and 0.8 billion, most of it on biogas digesters and electric stoves. These are not annual costs as stoves and power plants last for many years, so only the share of the investment used up in 2035 enters the annual costs in Table 20, and the upfront figures should not be compared directly with the annual benefits. The generation capacity estimate assumes that every household switching to electric cooking requires 1.1 kW of new generation capacity, costed at about USD 2,000 per kW based on the current generation mix, and gives no credit for existing or planned surplus capacity. It should therefore be read as an upper bound. This required capacity cannot be only attributed to clean cooking. A grid or mini-grid connection is not a single-purpose asset built for the stove. Once a household is electrified, cooking

is one of several benefits that people might have alongside lighting, refrigeration, cooling, etc. Costing the full 1.1 kW/household increment against cooking benefits understates the true benefits-cost ratio. A more complete accounting, although out of scope for this study, would distribute the shared generation and network capacity across all the end-uses it enables.

Table 20 understates the difference between the scenarios, because each one includes everything the previous one achieves. Table 21 expresses each step as its additional cost and additional outcomes. Reaching the 71 million people that the moderate scenario adds beyond BAU costs about USD 31 per person, while the final 19 million (aggressive scenario) costs USD 83 per person. The marginal cost of avoided $CO_2e$ nearly triples over the same step, from USD 31 to 93 per tonne.

**Table 21.** Additional cost and additional outcomes of each successive step in ambition.

| Step | Additional cost (USD million) | Additional people reached (million) | USD per person | Additional deaths avoided | USD per death avoided | Additional Mt $CO_2e$ | USD per tonne $CO_2e$ |
|---|---|---|---|---|---|---|---|
| BAU to conservative | 1,600 | 39.3 | 40 | 10,400 | 150,500 | 30.3 | 52 |
| Conservative to moderate | 700 | 31.5 | 21 | 4,600 | 141,900 | 21.3 | 31 |
| Moderate to aggressive | 1,600 | 19.3 | 83 | 7,800 | 205,000 | 17.2 | 93 |

## Geospatial cooking results

Figure 19 shows the cooking technology with the highest net benefit in each settlement under the three scenarios. Across these scenarios all input remains constant, except for the shares of different stoves being targeted for distribution (see Table 17). These targets are distributed solely based on national targets and any regional distribution following this is only a result of net benefits being higher in certain regions. Colors show the dominant technology in each settlement with paler shades marking settlements where most use a specific stove. Gray areas indicate areas where traditional fuels are dominant.

Electric cooking is most often selected in the northern regions and in areas already served by the grid. Amhara, Tigray and Southwest Ethiopia already reach high electric shares under the conservative scenario (59–64%). Addis Ababa and Harari start from high existing use, but their electric shares barely rise with ambition (77% and 75–79% respectively), because other urban areas offer higher net benefits per household switching. In Addis Ababa, charcoal is the predominant fuel among households still using traditional stoves, and over half of charcoal users rely on improved charcoal stoves. These stoves generally produce lower emissions than traditional firewood stoves, resulting in smaller incremental health benefits when households switch to electricity as compared with urban areas where households primarily rely on firewood. Mini-grid connected households are a very small share of those with electric cooking and instead almost all electric cooking happens on grid connections for the same reasons as raised for the BAU scenario. Table 22 shows the distribution of electric cooking across the least-cost technologies as outlined by the NEP 3.0.

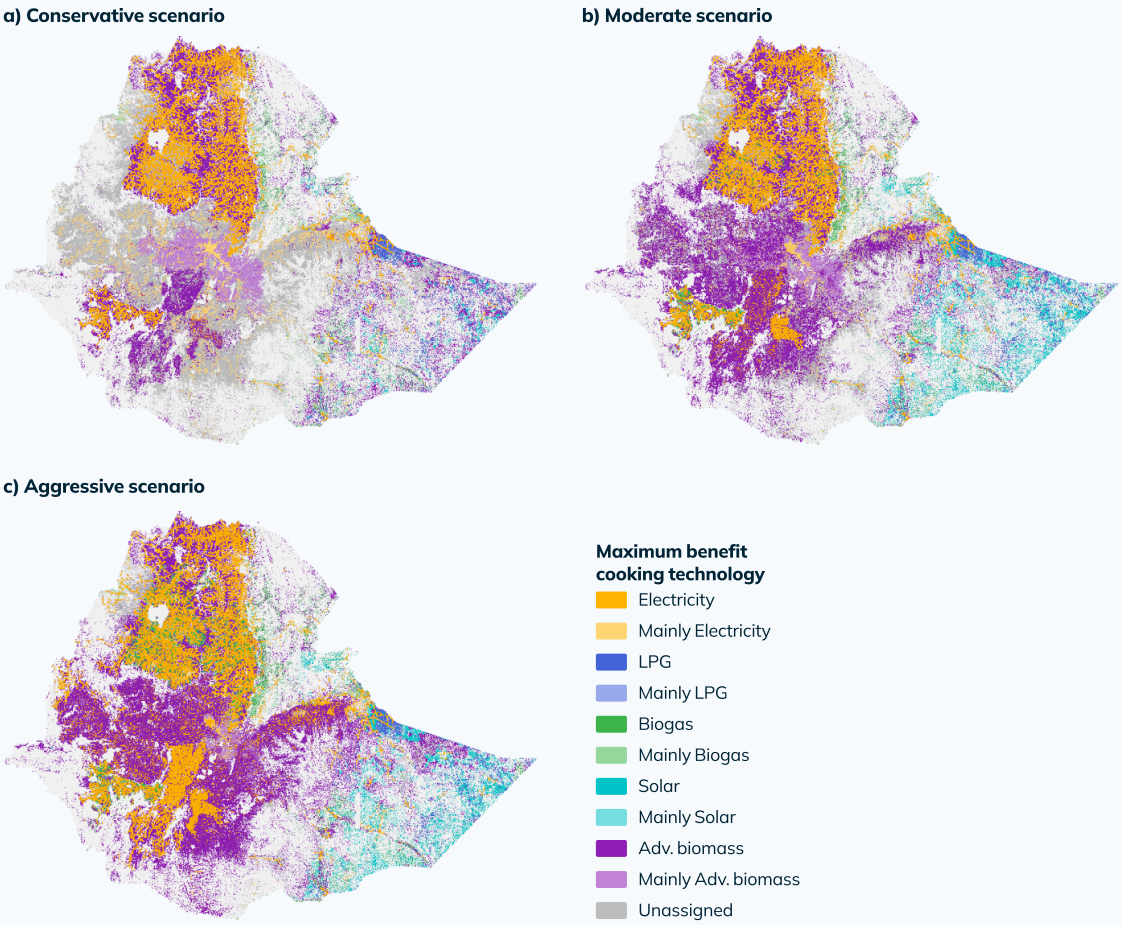
**Table 22.** The number of people cooking with electricity across different least-cost electrification classes in the different scenarios.

| Least-cost electrification technology | Conservative (Million people) | Moderate (Million people) | Aggressive (Million people) |
|---|---|---|---|
| Existing grid | 23.3 | 26.5 | 34.7 |
| Grid extension | 15.3 | 20.0 | 31.1 |
| Mini-grid | 0.2 | 0.2 | 0.3 |
| Solar Home Systems | 0 | 0 | 0 |
| Total | 38.9 | 46.7 | 66.1 |

Advanced biomass cookstoves dominate the central, southern and western parts of the country. Under the moderate scenario they reach 91% of the population in Gambela, 81% of the population in South Ethiopia, 76% in Central Ethiopia and 52% in Oromia. In the aggressive scenario, electricity takes over much of this area, with Gambela (92% on advanced biomass stoves, electricity only around 4%) and Oromia (71% on advanced biomass stoves) the exceptions.

The other stoves in the NCCR (solar, biogas and LPG) are small but highly concentrated if net benefits are to be maximized. Solar cooking becomes common in the Somali region, where it reaches 22% of the population under the moderate scenario, and Somali also holds the largest share of LPG users (11% to 13% of its population). Biogas appears mainly in Afar (15% to 22%) in every scenario, in Southwest Ethiopia (11%) from the moderate scenario onwards, and in Amhara under the aggressive scenario, where it reaches 7% of the population and 58% of all biogas users nationally. Note that in the case of biogas, the model cannot reach the stated moderate target in urban areas as these targets are higher than what is considered feasible based on biogas availability. This gap gets worse as the target increases in the aggressive scenario. In these cases, the shares are equally redistributed across the other urban stoves.

**Figure 19.** The stoves from the three scenarios distributed across the country to maximize net benefits. "Mainly X" marks settlements where X is the main stove, but part of the population also use another stove. Grey marks settlements where most people remain on traditional fuels.




The population still without a clean cooking solution is highly concentrated and becomes more so as ambition rises (Table 23). The five regions in Table 23 account for 82% of the population remaining on traditional fuels under the conservative scenario, 94% under the moderate scenario and 95% under the aggressive scenario. More than a third of Ethiopia's population lives in the Oromia region and the largest number of people who remain on traditional fuels in every scenario live here. Similar to the case of the BAU, settlements in this region rank low on the net benefit of electric cooking per household that switches, because the modelled benefits per household are lower there while costs are similar to elsewhere. This is mainly due to the region's lower baseline mortality rate, that is 71.3 deaths per 100,000 people, compared with 92.3 nationally and 105.8 in Amhara[42]. As avoided deaths account for a significant share of the modelled health benefits, the lower mortality rate reduces the estimated benefits of transitioning to clean cooking in this region.

42 Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2023 (GBD 2023). Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2025.

The model therefore reaches Oromia mainly with advanced biomass cookstoves (12%, 52% and 71% of the population across the three scenarios) and with electricity only at the highest level of ambition (23%). Under the aggressive scenario, the 4.9 million people still using traditional fuels are concentrated in Oromia (2.7 million) and Somali (1.3 million). Because the allocation does not consider how benefits are distributed, following it strictly would leave the region with the largest number of people on traditional fuels to be reached last. Implementation should therefore ensure that Oromia is not left behind, for example through regional targets or by earmarking part of the program for the region. Targeted subsidies or results-based financing could lower the upfront cost of improved stoves and connections for poorer households and support uptake. They would not change the modelled net benefit, which already counts costs for society as a whole, but they address the affordability barriers that the model does not represent and that are likely to be most binding where incomes are lowest.

**Table 23.** Regions ranked by population remaining on traditional fuels with the technology mix indicated under the moderate scenario.

| Region | Population (million) | Remaining on traditional fuels: | | | Moderate: electric cooking | Moderate: advanced biomass |
|---|---|---|---|---|---|---|
| | | Conservative (million) | Moderate (million) | Aggressive (million) | | |
| Oromia | 48.5 | 36.5 | 17.0 | 2.7 | 11.2% | 52.4% |
| Amhara | 25.4 | 4.2 | 1.8 | 0.6 | 64.4% | 22.9% |
| Addis Ababa | 8.5 | 1.7 | 1.7 | 0.0 | 77.0% | 1.2% |
| Somali | 7.6 | 2.2 | 1.7 | 1.3 | 35.2% | 6.9% |
| Benishangul-Gumuz | 1.4 | 1.3 | 0.7 | 0.0 | 3.8% | 47.2% |
| Other nine regions | 36.1 | 9.9 | 1.4 | 0.3 | - | - |

While the end targets are clearly defined and the spatial distribution is a result of the optimization in OnStove ensuring that the targets are reached at the minimum cost, what people move away from is not directly modelled in OnStove. The net benefits are, as outlined previously, in comparison to the fuel people cook with today. This comparison is done based on a composite including all stoves in use in each settlement currently and therefore keeping track of who leaves a specific fuel is not possible. However, it is possible to estimate this number of people and give indicative results. Table 24 outlines the current state of non-target fuels in Ethiopia and the estimated population moved away from each.

**Table 24.** Base year population for the stoves that currently are in use but do not have indicated targets in the NCCR and the estimated population moving away from each stove.

| Fuel left | Base year population (millions) | Switching away (million people) |
|---|---|---|
| Traditional firewood | 91.20 | 71.51 [71.43 - 71.53] |
| Traditional charcoal | 6.38 | 4.41 [4.39 - 4.47] |
| Charcoal ICS | 3.02 | 1.18 [1.17 - 1.20] |
| Dung | 2.10 | 1.64 [1.63 - 1.65] |
| Kerosene | 0.57 | 0.33 [0.33 - 0.34] |

This is an estimation and a range of possible values is given within brackets. Base year population applies each stove's base-year share to the 2035 population. These results are for the moderate scenario.

## Distribution of outcomes across wealth groups

Every wealth group is targeted under every scenario, but the poorest are reached last in all three (Table 25). Under the conservative scenario the poorest fifth of the population is 2.3 times more likely to be left without a clean stove than the richest fifth and under the aggressive scenario the richest fifth is almost fully served while about one in ten of the poorest remains without. The moderate scenario is not strictly ordered as the richest fifth (14%) is left without more often than the third and fourth fifths, reflecting urban households that stay on traditional fuels, almost half of them in Addis Ababa. Under the aggressive scenario, more than half of the remaining shortfall falls to the poorest fifth (55%), while the gap between the poorest and richest fifths narrows in absolute terms, from 31 to 10 percentage points.

**Table 25.** Share of each wealth quintile left without a clean cooking solution by 2035.

| Wealth quintile | Conservative | Moderate | Aggressive |
|---|---|---|---|
| Poorest | 55.6% | 35.3% | 10.6% |
| Second | 53.2% | 24.8% | 4.2% |
| Third | 48.2% | 13.9% | 2.5% |
| Fourth | 37.1% | 6.7% | 1.6% |
| Richest | 24.6% | 14.3% | 0.4% |
| Gap, poorest minus richest (percentage points) | 31.0 | 21.0 | 10.2 |



Photo: Ethiopian Clean Cooking Alliance

CHAPTER FIVE

# CONCLUSIONS AND RECOMMENDATIONS

## → Transition to clean cooking

The cost-benefit analysis indicates that most transitions to cleaner cookstoves have positive net benefits for society. This also holds true under pessimistic valuations of benefits, implying that the cost (while significant) is still smaller than the potential benefits of the transition. The scenario analysis shows that even with higher electricity tariff and LPG costs, clean cooking is still preferable in comparison to the majority's status quo. To ensure the transition is successful and the adoption sustained, there is a need to support households through different interventions to overcome expected price increases. The net benefit here is calculated in the absence of the costs of these interventions. This means that the net benefit here can be interpreted as the upper-bound of these intervention costs if a positive net benefit is to be achieved. Furthermore, excluding intervention costs avoids making assumptions about the effectiveness of these interventions. These numbers also assume households fully transition to their new clean cookstove. However, households tend to continue using their clean stoves alongside their traditional option (fuel stacking) typically for reasons of affordability or fuel reliability. This reduces much of the benefit, particularly for health. Interventions aimed at sustaining adoption should therefore also address this risk directly, for example by pairing new stoves with a reliable fuel supply or target clean(er) stacks, rather than treating distribution alone as sufficient.

### → Leaving no one behind

All three scenarios outlined in the NCCR stop short of universal access. The geospatial analysis uses these targets to allocate net benefits across the country with the aim of maximizing benefits while minimizing costs. This leads to, across all scenarios, people to be left behind in the transition. The geospatial analysis highlights the regions worst affected if a minimum-cost approach is taken. Prioritizing net benefits leaves mostly rural and poor households behind. Reaching them requires deliberate measures such as regional targets or earmarked funding, cooking tariffs, or appliance financing. Off-grid areas, where a fifth of the population and almost half of the poorest are expected to live in 2035, need a dedicated pathway, and the poorest households should be supported through existing social protection programs. Progress should be tracked by region and wealth groups, not only by national shares.

### → Clean cooking for displaced populations

In line with the leaving no one behind agenda, coordination between organizations mandated to support humanitarian settings and clean cooking programs should be strengthened to address the needs of refugees and internally displaced persons (IDPs). These populations often face barriers to accessing affordable cooking fuels and technologies due to limited income and fuel availability in refugee camps. Interventions could prioritize displaced settlements through consumer financing schemes for cooking fuels and partnerships with humanitarian organizations who serve in these communities. National energy planning should also account for displaced households' needs, including their living conditions, cooking practices and access to electricity, to ensure that clean cooking solutions are accessible and utilized.

### → Risk of missing targets

The transition scenarios presented in the geospatial section are dependent on the roadmap. The targets set how many households adopt each stove by 2035. OnStove then decides where each stove goes with the target to maximize net benefits. The national totals (deaths avoided, emission cuts, investment needs and net benefits) therefore show what happens if the targets are reached. The model does not test whether the targets can be reached. For this, additional factors such as levels of affordability, supply chains, and the pace of roll-out, which are outside its scope, would need to be considered. However, three sets of results do not depend on the targets being met. Firstly, the model calculates the costs and benefits of each stove for every settlement before it applies to the targets. These values change little across different scenarios and targets. Secondly, the order in which to act stays. Every household that switches to electric cooking in the conservative scenario also switches in moderate and aggressive scenarios. Likewise, every household that gets any improved or clean stove in the conservative scenario also gets one in the more ambitious scenarios. If progress stalls, the places to reach first are the same. Lastly, the way that benefits scale with partial progress remains. Almost no switch in any scenario costs more than it delivers. A shortfall therefore removes switches that are worth making, not poor ones. Average returns fall only slightly as ambition rises (benefit-cost ratio 4.6 to 3.9), although the last step costs more per person reached.

### → Choice of clean cookstove

While electric, solar, LPG and biogas stoves are typically amongst the stoves with the higher net benefits, it is important to note that their deployment would be impacted by certain limitations and competing loads that are not included in the modelling. Electric cooking has the highest net benefit

across transitions, and it is worth noting that while this is true, costs connected to the stove can behave as a major limitation. Additionally, electric cooking is dependent on the reliability of the electricity grid. The full benefits of the transition can only be realized where these enabling conditions are in place. Biogas, while being clean both from a health and environmental standpoint, requires considerable land area, water usage and upfront costs. In the current cooking landscape, LPG is only used by a small share of the population due to high costs of imported LPG. To increase this import dependence may be problematic. Solar cookers have benefits in cases where access to either feedstock fuel for biogas digestors is lacking or where access to infrastructure is poor. Solar cookers may face adoption challenges due to their longer cooking times, lack of consumer acceptance, limited practicality for everyday cooking, dependence on suitable weather conditions, and relatively high upfront costs. A successful transition to cleaner cookstoves would need to utilize a mix of stove technologies, where stoves are distributed based on their individual suitability.

### → Electric cooking

Ethiopia's progress in electrification provides an important foundation for expanding electric cooking, with transition benefits reaching 710 USD per household per year. However, the consumption data shows that electricity access does not automatically translate into its use for cooking. Households may continue to rely on biomass due to affordability, reliability and established cooking practices, specifically for foods such as injera and wot. The dominance of lower electricity consumption blocks also suggests that increased electricity use for cooking could raise household bills as consumers move into higher tariff blocks. To address these barriers, complementary measures such as appliance financing for technologies like electric pressure cookers and electric mitads, targeted subsidies, consumer awareness campaigns and demand-side management should be considered. These measures can help reduce the upfront and running costs of electric cooking, encourage households to shift cooking to suitable periods of electricity availability, and ensure that expanded electricity access translates into meaningful clean cooking outcomes.

### → Integrate electric cooking demand into electrification planning

Electric cooking demand should be incorporated into national electricity and infrastructure planning. The cost-benefit analysis shows that electric cooking delivers the highest net benefits of the options assessed, and the spatial analysis indicates that e-cooking is most viable in areas already served by the grid or a mini-grid or earmarked for grid extension. Factoring electric cooking demand into planning could therefore strengthen the case for accelerating grid expansion in these areas. Such expansion would also deliver benefits beyond cooking, including improved access to electricity for households, businesses, and public services.

### → Use geospatial analysis to guide stove deployment

The geospatial analysis maps where each stove technology is most feasible and where its deployment would generate the highest net benefits. This mapping should be used to guide stove distribution. For example, the moderate and aggressive scenarios in the NCCR allocate biogas stoves for distribution, yet some of the targeted areas may lack the conditions needed to sustain biogas use, such as ready access to feedstock or the agricultural and livestock activities that supply it. Geospatial mapping can help avoid discrepancies by showing where each stove type is viable, and what constraints may limit its uptake. However, as noted earlier, an approach driven by net

benefits tends to overlook the least financially capable households. This should be addressed through targeted programs designed for the regions where these households are concentrated.

### → Job creation

For a clean cooking transition to create job opportunities, enabling local ecosystems is essential. The employment benefits of the transition are greatest where local industries are established to support clean cooking technologies. This includes opportunities in manufacturing, assembly, distribution, retail, installation, maintenance, and repair services. Developing these value chains strengthens the long-term sustainability of a clean cooking transition. The CBA accounts for formal work which changes the nature of employment. As households move away from traditional charcoal and firewood, there is a shift from informal and low-skilled jobs toward more formal and skilled employment within the clean cooking value chain. While this can lead to improved income opportunities and better working conditions, it also results in livelihood losses for those currently dependent on traditional charcoal trade. These impacts highlight the need for initiatives that support reskilling of about 1.3 million affected workers so that the economic benefits of clean cooking are shared equitably. Further, local capacity for stove production, distribution, and maintenance should be strengthened. Training programs for artisans, technicians, and entrepreneurs will create jobs and ensure sustainability of clean cooking interventions.

### → Affordability

Cost is a major barrier to clean cooking adoption. However, the results of the cost-benefit analysis suggest that the situation is more nuanced. For many clean cooking transitions, specifically when households switch from purchased firewood or traditional charcoal to electricity, solar cookstoves, or biogas, the analysis shows that households experience fuel cost savings ranging between USD 110 and 150 per year. That said, the analysis also confirms that the upfront investment cost remains a significant barrier. Although households can save money on fuel after switching, the initial cost of purchasing a clean stove or system can be prohibitive. Governments, working alongside the private sector, cookstove companies, and development partners, could implement targeted subsidies, appliance financing mechanisms, or Pay-As-You-Go models to reduce the upfront purchase cost. Once households overcome this initial investment barrier, the ongoing savings from lower fuel and maintenance costs can help offset and effectively pay back the initial investment over time.

### → Behavior change

The difference between the CBA results and local conditions suggests a disconnect between perceptions of affordability and the actual economic realities faced by households. The findings from the CBA should therefore be incorporated into behavior change and consumer awareness initiatives. While long-term health benefits have a greater impact on livelihoods, this is often difficult for households to observe immediately. Messaging should also emphasize the tangible and immediate financial benefits of lower running fuel costs. Highlighting immediate benefits, such as fuel and time savings, could provide a stronger incentive for households to adopt clean cooking technologies.

### → Demand side management

Given that electric cooking delivers some of the highest net benefits across the assessed transitions, it is important to consider the availability, capacity, and reliability of the electricity grid when planning for its wider adoption. As highlighted in the results section, there is a gap between

electricity access and actual household usage. To address this, demand-side management measures should be implemented alongside behavior change initiatives to encourage households to shift electricity-intensive activities, such as cooking, to periods when supply is more available. Time-of-use tariffs could further encourage this shift by offering lower electricity costs during off-peak periods, helping households manage expenditure while supporting greater adoption of electric cooking.

### → Monitoring and evaluations

It is essential to acknowledge that Ethiopia has implemented several incentive and subsidy programs combined with cookstove distribution initiatives, over the years. These have been supported by development partners across regions, as summarized in Appendix D. However, while many stoves have been distributed, there has been relatively little evidence of their long-term impact. We still have limited understanding of whether households continue to use the stoves over time, how these interventions have influenced communities, and whether the expected health, economic, and environmental benefits have been realized. While scaling up or introducing new initiatives, there should be systematic follow-ups to assess how households respond to the intervention, whether uptake is sustained over time, and whether the anticipated fuel cost savings and other benefits are being realized in practice. Understanding why households continue to use (or stop using) a particular stove is as vital as making the technology available. Indicators such as "electricity used for cooking" and "percentage of households adopting Tier 4+ technologies" should be tracked alongside electrification rates. This will provide a more accurate picture of progress and ensure accountability. The feedback generated through these evaluations would not only help improve future policy and program design but would also provide insights to cookstove manufacturers and distributors. This creates a continuous learning process, allowing both policymakers and stove companies to refine technologies and delivery models so that they better meet the needs of the communities they are intended to serve. Following the implementation of a monitoring and evaluation framework, effective data management should be established as a key component of the clean cooking program. Various initiatives, including market assessments, pilot projects, and clean cooking programs in displacement settings, generate valuable data that is currently held separately by different partner institutions. Consolidating this information into a centralized data repository would make it easier to track completed and ongoing initiatives, document lessons learned, identify data gaps, and inform the design of future interventions. MoWE could lead this process, given its mandate within the energy sector, with a dedicated component for clean cooking data management. Establishing clear protocols for data sharing, updating, and access would also help ensure that government and development partners can draw on a common evidence base when planning and implementing clean cooking interventions in Ethiopia.

### → Gender empowerment

When a transition eliminates fuel collection entirely, households save around three hours per day and one hour per day when some collection is still required, as in the case of biogas. This is worth roughly USD 250 and 75 per household per year, respectively. Based on the time savings computed, transitioning to clean cooking has the potential to improve gender equality and women's economic and social wellbeing. Since women and girls often bear an uneven share of household cooking and fuel collection responsibilities, the adoption of clean cooking can reduce the time and physical burden associated with these activities. Policies and programs should therefore

link clean cooking initiatives with gender equality objectives, with particular attention to reducing time poverty and creating opportunities for women and girls to pursue education, income-generating activities, and other productive activities. Monitoring frameworks should also track gender-related outcomes to assess whether clean cooking interventions are contributing to tangible improvements in the lives of women and girls.

Beyond 2030, Ethiopia's clean-cooking transition is expected to move increasingly towards more efficient technologies, with electric cooking playing a growing role alongside advanced biomass and biogas. The National Clean Cooking Roadmap targets approximately 75.9% access by 2035, with electric stoves expected to make a significant contribution during 2031–2035. Achieving this ambition will require continued investment in reliable electricity infrastructure, affordable appliances, consumer financing, supply chains and after-sales services. Key risks include high upfront costs, unreliable electricity supply, limited grid capacity, continued fuel stacking, regional disparities, financing constraints and climate-related pressures on power generation. At the same time, the transition offers opportunities for local appliance manufacturing, carbon finance, innovative payment and greater private-sector investment. Improved spatial data and planning further helps identify the most appropriate solutions as it considers electricity access, cooking practices, population, income and settlement characteristics. Overall, the period to 2035 is likely to mark a shift from expanding access alone towards establishing the institutional structures and systems needed to support and sustain the transition.

APPENDIX A

# CALCULATIONS

## Valuing health benefits

To value the health benefits, both morbidity and mortality reductions are included in the analysis. The starting point is the concentration of $PM_{2.5}$. As the concentration of gases will depend on the size of the room, the emission rate of the stoves and ventilation, the values in Table 28 in Appendix B are therefore to be used as average concentrations following normal stove use.

The concentration of $PM_{2.5}$ has been strongly linked to the prevalence and incidence of diseases such as ALRI, COPD, IHD, LC and stroke. Using the concentration of these particles, the Relative Risk (RR) of each disease can be determined using the following system of equations:

$$\begin{cases} if\ \varepsilon * 24 - \text{h PM2.5 concentration} < z_{rf},\ RR = 1 \\ if\ \varepsilon * 24 - \text{h PM2.5 concentration} \geq z_{rf},\ RR = 1 + \alpha * \left(1 - e^{\left(-\beta * (\varepsilon * 24 - \text{h PM2.5 concentration} - z_{rf})^{\delta}\right)}\right) \end{cases} \quad (1)$$

Where:

- RR is the relative risk associated with each disease
- $\alpha, \beta, \delta$ and $z_{rf}$ are disease-specific constants, previously determined experimentally,
- $\varepsilon$ is the exposure-adjustment factor accounting for potential changes in behavior due to lower smoke emissions from cleaner cookstoves.

The RR can be used to estimate the share of the total mortality and morbidity by all causes attributable to the use of traditional cooking methods:

$$PAF_i = \frac{sfu * (RR_k - 1)}{sfu * (RR_k - 1) + 1} \quad (2)$$

Where:

- *PAF* is the Population Attributable Fraction for each stove *i*
- *sfu* is the fraction of population using non-clean stoves, and
- *RR* is the relative risk of each disease *k* as calculated in equation 1

Using the PAF values calculated with equation 2 and combining it with overall morbidity and mortality rates of each disease and the population, the expected reduction of deaths and cases caused by the disease following stove switch can be estimated using equations 3 and 4.

$$Morb_{k,j} = Population * (PAF_0 - PAF_i) * IR_{k,j} \quad (3)$$

$$Mort_{k,j} = Population * (PAF_0 - PAF_i) * MR_{k,j} \quad (4)$$

Where:

- Where $Morb_{k,j}$ and $Mort_{k,j}$ are cases and deaths due to cooking related $PM_{2.5}$ concentrations for disease *k* respectively.
- *Population* is the population being studied
- *PAF* is the Population Attributable Fraction at the initial phase (*0*) and of each stove (*i*)
- *IR* is the incidence rate of each disease *k* disaggregated by *j* indicating different age-gender subgroups
- *MR* is the mortality rate of each disease *k* disaggregated by *j* indicating different age-gender subgroups

Lastly, $Morb_{k,j}$ and $Mort_{k,j}$ can be translated into monetary values using equations 5 and 6 respectively.

$$Morb = \sum_k \left( \sum_{j=1}^{J} \varphi_j \sum_{t=1}^{5} CL_{kt} * COI_k * \frac{Morb_{k,j}}{(1+\delta)^{t-1}} \right) \quad (5)$$

$$Mort = \sum_k \left( \sum_{j=1}^{J} \varphi_j \sum_{t=1}^{5} CL_{kt} * VSL * \frac{Mort_{k,j}}{(1+\delta)^{t-1}} \right) \quad (6)$$

Where:

- *Morb* and *Mort* are the monetized values of total morbidity and mortality respectively across all five diseases in USD
- *j* is the subgroups of the population (based on age and gender)
- $\varphi_j$ is the share of the population in subgroup *j*
- *CL* is the cessation lag of each disease *k* across year *t*
- *COI* is the cost of illness of each disease *k* in USD/case
- *VSL* is the Value of Statistical Life in USD/life
- $\delta$ is the discount rate

## Valuing time savings

Different stoves require different cooking times, and some, especially in cases where either firewood is used, have collection times. Switching to a stove that has either a faster cooking time, a lower collection time, or both will lead to time savings. To monetize these time savings, the time difference between stoves is translated into opportunity costs using the wage rate. See Appendix B for time estimates for each stove and the wage rate used.

## Changes in emissions

In the CBA, changes in GHG emissions caused directly by stove-switch will be estimated. As a starting point, the amount of fuel used for cooking a meal is determined using equation 7.

$$f = \frac{E * \frac{meals}{day} * 365}{eff} \quad (7)$$

Where:

- E is the energy required for cooking a meal
- eff is the efficiency of the stove.

Once fuel use is determined, the reduction in emissions is calculated using equation 8.

$$Reduced\ emissions = f_0 * \gamma_0 - f_i * \gamma_i \quad (8)$$

Where:

- γ is the carbon intensity of the fuel for the current situation *(0)* and the stove switched to *(i)* and
- *f* is the amount of fuel used for the current situation *(0)* and the stove switched to *(i)*

γ is fuel-specific and accounts for emissions of $CH_4$, $N_2O$, $CO_2$, CO, organic carbon and black carbon and their respective 100-year Global Warming Potentials according to equation 9.

$$\gamma_i = \sum_j \varepsilon_{i,j} * GWP_j \quad (9)$$

Where:

- *ε* is the emission factor of stove *i* with regards to pollutant *j*
- *GWP* is the 100-year global warming potential of each pollutant.

Certain stoves have fuel specific emissions. For electricity and charcoal, production emissions are added to the emissions caused by direct stove use. For LPG, transportation emissions are included in the geospatial analysis. For all firewood and charcoal options, the emissions connected to national fraction of non-renewable harvest of firewood is included. Therefore, for firewood and charcoal, equation 9 is modified in the case of $CO_2$:

$$\gamma_i = \sum_j \varepsilon_{i,j} * GWP_j * \psi \quad (10)$$

Where:

- *ψ* is the fraction of non-renewable biomass.

The reduced emissions are monetized and discounted using the social cost of carbon (equation 11):

$$Carb = c^{CO_2} * Reduced\ emissions * \frac{1}{(1+\delta)^{t-1}} \quad (11)$$

## Deforestation

The use of firewood and charcoal for cooking puts strains on forest resources and a decrease in these types of cooking fuels can be expected to significantly reduce the consumption of non-renewable harvest of biomass. To account for this, we estimate the amount of fuel wood consumed with the help of equation 7 above for both the original stove and the stove which people switch to. Some stoves will completely displace firewood, while others (firewood and charcoal ICS) will reduce the consumption due to higher efficiency. The reduction of firewood is monetized using the cost of tree replacement.

## Employment impacts

The employment implications of traditional versus clean cooking solutions can be incorporated into the CBA by explicitly accounting for labor as part of the overall costs of different cooking alternatives. Labor represents an important input to stove and fuel production and distribution, and changes in employment may have value beyond cost considerations. However, tracking enhanced employment is still important as it may be measured in increased productivity which has the possibility of reducing idleness and potential crime while, in cases where unemployment is high, workers can get higher compensation for their work and the government to collect additional tax revenue.

To quantify labor requirements, employment needs for each stove–fuel combination i can be estimated using the following equation:

$$Emp_i = Fixed + \frac{(Pop_i \cdot \mu) \cdot (\vartheta_i^f + \vartheta_i^i)}{hhsize} \tag{12}$$

Where:

- $\vartheta_i^f$ represent a per household full-time employment requirement for supplying stove-fuel combination i
- $\vartheta_i^i$ represent a per household part-time employment requirement for supplying stove-fuel combination i
- *Fixed* is a number of fixed jobs required no matter the number of stoves distributed simply due to the existence of the value chain

These parameters represent a per household full-time and part-time employment requirement, respectively, for supplying stove-fuel combination i. These are measured in terms of people employed per household using a stove-fuel combination, and the number of employed people is so tracked. This includes employment in fuels value chains (if applicable) and in stove supply value chains.

Next, employment benefits are estimated:

$$Emp = \sum_{i=1}^{I} \left[ Emp_i \cdot (W_i - W \cdot \kappa^l) \right] \tag{13}$$

Where:

- $W_i$ is the average wage for workers in the supply chain for technology *i*
- $\kappa^l$ is the shadow cost of labor expressed as a fraction of the informal sector wage

If wage data by value chains are unavailable, all $W_i$ can be estimated using the informal sector wage, simplifying the expression to:

$$Emp = \sum_{i=1}^{I} \left[ Emp_i \cdot W \cdot (1 - \kappa^l) \right] \quad (14)$$

This allows for capturing surplus generated for workers supporting an energy transition, as well as the surplus lost when employment in displaced technologies decline.

## Costs

Three categories of costs are accounted for: capital costs (with a netted salvage cost to adjust for the varying lifespan of different stoves), fuel costs (when relevant) and operation and maintenance costs.

APPENDIX B

# INPUT DATA

## Techno-economic data

**Table 26.** Investment, fuel cost and stove life span

| Stove | Investment Cost (USD) | Fuel Cost (USD/kg or USD/kWh) | O&M Cost (USD/year) | Tech life (Year) |
|---|---|---|---|---|
| Biogas | 597 | 0 | 3.7 | 10 |
| Firewood ICS | 2.2 | 0.096 (when purchased), 0 (if collected) | 3.7 | 4 |
| Charcoal ICS | 7 | 0.22 | 3.7 | 4 |
| Traditional firewood | 0 | 0.096 (when purchased), 0 (if collected) | 0 | 1 |
| Electric hob | 28 | 0.033 | 3.7 | 6 |
| Electric mitad | 70 | 0.033 | 3.7 | 5 |
| Ethanol | 1.9 | 1.6 | 3.7 | 8 |
| LPG | 70 | 1.9 | 3.7 | 7 |
| Mirt | 6.4 | 0.096 (when purchased), 0 (if collected) | 0 | 7 |
| Pellets | 73 | 0.16 | 3.7 | 6 |
| Solar | 137 | 0 | 3.7 | 6 |
| Traditional charcoal | 5.4 | 0.22 | 3.7 | 2 |
| Traditional mitad | 4.8 | 0.096 (when purchased), 0 (if collected) | 0 | 10 |

**Table 27.** Time spent on fuel collection, cooking and fuel efficiency

| Stove | Collection Time (Hours/Day) | Cooking Time (Hours) | Efficiency (%) |
|---|---|---|---|
| Biogas | 2 | 2 | 50 |
| Firewood ICS | 1.3 | 2.85 | 26 |
| Charcoal ICS | 0 | 2.6 | 34 |
| Traditional firewood | 2 | 3 | 10 |
| Electric hob | 0 | 1.8 | 53 |
| Electric mitad | 0 | 2* | 51 |
| Ethanol | 0 | 2 | 55 |
| LPG | 0 | 2 | 57 |
| Mirt | 2 | 2* | 33 |
| Pellets | 0 | 2 | 59 |
| Solar | 0 | 3 | 25 |
| Traditional charcoal | 0 | 2.6 | 17 |
| Traditional mitad | 2 | 2.6* | 10 |

* Injera is assumed to be baked on average 3 times per week.

**Table 28.** 24-h average $PM_{2.5}$ concentrations from stove use.

| Stove | 24-h average concentration of $PM_{2.5}$ (µg/m³) |
|---|---|
| Biogas | 43 |
| Firewood ICS | 450 |
| Charcoal ICS | 185 |
| Traditional firewood | 855 |
| Electric hob | 32 |
| Electric mitad | 48 |
| Ethanol | 125 |
| LPG | 43 |
| Mirt | 100.5 |
| Pellets | 207 |
| Solar | 32 |
| Traditional charcoal | 256 |
| Traditional mitad | 190.5 |

Note these values would be highly dependent on ventilation and the size of the room.

## Age and gender disaggregated health data

**Table 29.** Morbidity amongst men (cases per 100,000 people) in COPD, IHD, ALRI, stroke and LC.

| Age | COPD | IHD | ALRI | STROKE | LC |
|---|---|---|---|---|---|
| <5 | 0 | 0 | 9129.418 | 39.90359 | 0 |
| 05 – 09 | 0 | 0 | 3343.715 | 103.0492 | 0 |
| 10 – 14 | 0 | 0 | 1677.394 | 153.9389 | 0 |
| 15 – 19 | 166.4697 | 46.01547 | 1292.693 | 205.7452 | 0.389 |
| 20 – 24 | 226.5714 | 120.3867 | 1245.507 | 262.5529 | 0.507 |
| 25 – 29 | 298.9678 | 221.678 | 1537.105 | 331.6807 | 1.115 |
| 30 – 34 | 385.6416 | 349.0026 | 1826.282 | 420.026 | 3.440 |
| 35 – 39 | 495.7651 | 504.0117 | 2121.681 | 542.591 | 6.424 |
| 40 – 44 | 636.5121 | 692.8299 | 2894.667 | 708.8592 | 11.992 |
| 45 – 49 | 822.25 | 953.2177 | 4155.546 | 939.9005 | 17.193 |
| 50 – 54 | 1060.883 | 1309.33 | 5445.646 | 1253.368 | 34.784 |
| 55 – 59 | 1337.197 | 1824 | 6725.204 | 1706.579 | 52.640 |
| 60 – 64 | 1630.717 | 2446.8 | 10364.89 | 2290.316 | 64.388 |
| 65 – 69 | 1915.713 | 3034.996 | 16366.11 | 2979.58 | 71.582 |
| 70 – 74 | 2226.172 | 3568.265 | 22409.63 | 3787.062 | 77.989 |
| 75+ | 3119.969 | 4797.8 | 41725.99 | 5785.965 | 57.714 |

**Table 30.** Mortality amongst men (deaths per 100,000 people) in COPD, IHD, ALRI, stroke and LC.

| Age | COPD | IHD | ALRI | STROKE | LC |
|---|---|---|---|---|---|
| <5 | 0 | 0 | 105.0066 | 0.502548 | 0 |
| 05 – 09 | 0 | 0 | 23.19566 | 0.26378 | 0 |
| 10 – 14 | 0 | 0 | 15.01738 | 0.366595 | 0 |
| 15 – 19 | 0.088288 | 2.872085 | 14.51405 | 4.011432 | 0.392551 |
| 20 – 24 | 0.10901 | 3.143453 | 14.29924 | 4.475849 | 0.48238 |
| 25 – 29 | 0.138974 | 4.031725 | 18.35705 | 3.713887 | 0.606945 |
| 30 – 34 | 0.45743 | 10.57188 | 25.98854 | 11.4074 | 1.604138 |
| 35 – 39 | 0.396496 | 15.64518 | 24.64286 | 12.53923 | 3.679248 |
| 40 – 44 | 0.982988 | 28.00866 | 35.91499 | 27.99302 | 8.085987 |

| Age | COPD | IHD | ALRI | STROKE | LC |
|---|---|---|---|---|---|
| 45 – 49 | 3.056303 | 33.30846 | 37.315 | 36.76719 | 11.11427 |
| 50 – 54 | 5.049014 | 56.5988 | 59.07191 | 67.84299 | 24.36087 |
| 55 – 59 | 12.01251 | 91.83072 | 85.37746 | 119.2496 | 40.47844 |
| 60 – 64 | 28.804 | 200.4747 | 160.5973 | 250.5609 | 59.86825 |
| 65 – 69 | 56.39455 | 271.3339 | 207.8618 | 417.5623 | 76.95745 |
| 70 – 74 | 84.89643 | 429.3454 | 417.2064 | 566.9567 | 96.17296 |
| 75+ | 134.8678 | 687.1973 | 1202.205 | 993.9433 | 115.2343 |

**Table 31.** Morbidity amongst women (cases per 100,000 people) in COPD, IHD, ALRI, stroke and LC.

| Age | COPD | IHD | ALRI | STROKE | LC |
|---|---|---|---|---|---|
| <5 | 0 | 0 | 8520.429975 | 39.03970384 | 0 |
| 05 – 09 | 0 | 0 | 3368.765285 | 99.78837459 | 0 |
| 10 – 14 | 0 | 0 | 1851.75789 | 147.9355679 | 0 |
| 15 – 19 | 152.0246162 | 81.43289494 | 1552.382384 | 195.9221273 | 0.064058063 |
| 20 – 24 | 201.5518247 | 205.8563734 | 1425.491774 | 247.2739391 | 0.323209803 |
| 25 – 29 | 261.7295555 | 349.2452134 | 1483.653569 | 309.2688267 | 0.560047074 |
| 30 – 34 | 333.5460052 | 505.3940528 | 1544.565686 | 387.6707264 | 2.063816996 |
| 35 – 39 | 421.4432716 | 679.0938088 | 1603.620193 | 493.9320754 | 2.460964143 |
| 40 – 44 | 527.52482 | 878.3309279 | 2080.532354 | 635.7071269 | 3.824523466 |
| 45 – 49 | 662.4882861 | 1132.897202 | 2971.5377 | 832.8405597 | 5.747916094 |
| 50 – 54 | 832.8948929 | 1451.691148 | 3846.009314 | 1091.26447 | 8.283594079 |
| 55 – 59 | 1033.998902 | 1846.789167 | 4700.225533 | 1432.177045 | 10.47618391 |
| 60 – 64 | 1265.43934 | 2319.425131 | 8007.170091 | 1858.461786 | 16.70288639 |
| 65 – 69 | 1519.936866 | 2886.255175 | 13749.05893 | 2369.851173 | 23.71399901 |
| 70 – 74 | 1829.510998 | 3486.737186 | 19491.00345 | 2972.552707 | 23.74977157 |
| 75+ | 2596.794764 | 4453.786751 | 37290.56566 | 4180.82714 | 11.81618863 |

**Table 32.** Mortality amongst women (deaths per 100,000 people) in COPD, IHD, ALRI, stroke and LC.

| Age | COPD | IHD | ALRI | STROKE | LC |
|---|---|---|---|---|---|
| <5 | 0 | 0 | 67.87508 | 0.499751 | 0 |
| 05 – 09 | 0 | 0 | 20.03282 | 0.34739 | 0 |
| 10 – 14 | 0 | 0 | 11.5815 | 0.468454 | 0 |
| 15 – 19 | 0.281349 | 5.026068 | 13.37313 | 4.052028 | 0.058298 |
| 20 – 24 | 0.235912 | 4.007758 | 13.65565 | 3.263795 | 0.285645 |
| 25 – 29 | 0.279483 | 3.239345 | 15.58214 | 3.472054 | 0.289944 |
| 30 – 34 | 0.314322 | 7.511231 | 16.54068 | 10.32544 | 0.914936 |
| 35 – 39 | 0.328474 | 9.229183 | 14.27228 | 13.07787 | 1.296075 |
| 40 – 44 | 0.566018 | 23.08912 | 20.56741 | 26.63759 | 2.314762 |
| 45 – 49 | 1.23874 | 26.67502 | 22.6833 | 39.09085 | 3.598477 |
| 50 – 54 | 3.396326 | 49.93226 | 38.75744 | 70.36447 | 5.592593 |
| 55 – 59 | 6.162934 | 65.04242 | 45.0721 | 99.99776 | 7.957329 |
| 60 – 64 | 15.97404 | 114.4422 | 111.9384 | 188.2843 | 15.13046 |
| 65 – 69 | 24.30191 | 176.7152 | 159.2996 | 267.743 | 24.92634 |
| 70 – 74 | 42.90501 | 347.0708 | 332.9099 | 503.9934 | 28.51171 |
| 75+ | 111.4042 | 654.1588 | 1008.493 | 950.5865 | 23.14876 |

## Social-economic data

**Table 33.** Social-economic parameters

| Parameter | Value | Unit |
|---|---|---|
| Population 2025 | 111,450,000 | People |
| Population 2035 (Projected) | 127,000,000 | People |
| Urban Population 2035 (Projected) | 0.29 | Ratio |
| Rural Household size | 4.7 | People/household |
| Urban Household size | 3.7 | People/household |
| Urban fNRB | 0.52 | Ratio |
| Rural fNRB | 0.32 | Ratio |
| Cost of illness ALRI | 40 | USD/case |
| Cost of illness COPD | 125 | USD/case |

| Parameter | Value | Unit |
|---|---|---|
| Cost of illness IHD | 220 | USD/case |
| Cost of illness LC | 527 | USD/case |
| Cost of illness stroke | 309 | USD/case |
| Social cost of carbon | 50 | USD/MT |
| Discount rate | 0.117 | Ratio |
| Wage rate | 0.5 | USD/hour |
| Value of Statistical Life | 500,000 | USD/life |

## Displaced Settlement Data

**Table 34.** Population and stove shares (%) in refugee camps with GIS data availability.

| Camp | Population | Firewood | Charcoal | Briquettes | Electricity | Other |
|---|---|---|---|---|---|---|
| Aw-barre | 13,952 | 0.30 | 0.70 | 0.00 | 0.00 | 0.00 |
| Aysaitya | 31,555 | 0.85 | 0.04 | 0.03 | 0.08 | 0.00 |
| Bambasi | 21,222 | 0.99 | 0.00 | 0.00 | 0.01 | 0.00 |
| Berahle | 33,239 | 0.75 | 0.15 | 0.00 | 0.10 | 0.00 |
| Bokolmanyo | 33,560 | 0.95 | 0.05 | 0.00 | 0.00 | 0.00 |
| Buramino | 49,748 | 0.96 | 0.04 | 0.00 | 0.00 | 0.00 |
| Helaweyn | 52,636 | 0.98 | 0.02 | 0.00 | 0.00 | 0.00 |
| Jewi | 67,843 | 0.94 | 0.05 | 0.00 | 0.00 | 0.01 |
| Kebribeyah | 23,618 | 0.25 | 0.75 | 0.00 | 0.00 | 0.00 |
| Kobe | 37,169 | 0.99 | 0.01 | 0.00 | 0.00 | 0.00 |
| Kule | 55,408 | 0.93 | 0.06 | 0.00 | 0.00 | 0.01 |
| Melkadida | 44,429 | 0.99 | 0.01 | 0.00 | 0.00 | 0.00 |
| Nguenyiel | 112,483 | 0.94 | 0.05 | 0.00 | 0.00 | 0.01 |
| Okugo | 12,577 | 0.91 | 0.07 | 0.00 | 0.00 | 0.01 |
| Pugnido 1 | 52,920 | 0.94 | 0.05 | 0.00 | 0.00 | 0.01 |
| Pugnido 2 | 7,062 | 0.93 | 0.06 | 0.00 | 0.00 | 0.01 |
| Sheder | 15,697 | 0.45 | 0.40 | 0.00 | 0.15 | 0.00 |
| Sherkole | 16,504 | 0.89 | 0.04 | 0.00 | 0.07 | 0.00 |
| Tierkidi | 74,222 | 0.93 | 0.06 | 0.00 | 0.00 | 0.01 |
| Tsore | 40,891 | 0.95 | 0.05 | 0.00 | 0.00 | 0.00 |
| Ura | 12,077 | 0.95 | 0.00 | 0.00 | 0.05 | 0.00 |

Data from UNHCR.

# APPENDIX C

## Context of the DHS data

Ethiopia Demographic and Health Survey (DHS) 2024–25 provides a detailed breakdown of the demographic and health landscape of the country, based on a regionally representative sample of 21,241 households. The primary goal of the survey is to equip policymakers, researchers, and program managers with the evidence needed to drive Ethiopia's development. The report covers a wide range of critical indicators, including the usage of cooking fuels.

The sampling framework used for the DHS is based on the Population and Housing Census conducted in 2019, by the Ethiopian Statistical Service. Administratively, Ethiopia is divided into 12 regions and two city administrations. Each region is subdivided into zones, each zone into woredas, and each woreda into kebeles. In Ethiopia, there are 127 zones, 1,101 woredas, and 19,460 kebeles. In addition to these administrative units, each kebele was subdivided into enumeration areas (EAs), which served as counting units for the population census. An EA is a geographical area, usually a neighborhood in urban areas and a village or a part of a large village in rural areas, consisting of an adequate number of households for counting purposes.

DHS is a stratified sample selected in two stages from the sampling frame. Stratification was achieved by separating each region into urban and rural areas. The survey was successfully carried out in 797 clusters after eight clusters in the Amhara region (one in urban and seven in rural areas) were dropped due to security concerns during the fieldwork. The DHS is designed to be nationally and sub-nationally representative. This sample across the country also allows geospatial interpolation to have an estimate of the usage of cooking shares at the granularity that OnStove requires.

## Methods

### Data processing

The DHS survey data was obtained from the official website. The data has two parts, a Stata Data File that contains the variables from the survey and a shapefile that includes offset GPS coordinates of the points where the surveys were conducted and the region where the interview was conducted. The offset coordinates are meant to protect the household's identity that took part in the sample.

Three representative variables from the survey: number of households (hv005), cooking fuel (hv226) and type of cooking stove (hv222) were joined to the GPS coordinates by using a common IDs. Posteriorly, the data was processed to get the shares for ten widely used stove types: electric cooking, improved charcoal stoves, traditional charcoal stoves, improved biomass stoves, traditional biomass stoves, LPG, biogas, solar, animal dung and kerosene. The biomass group

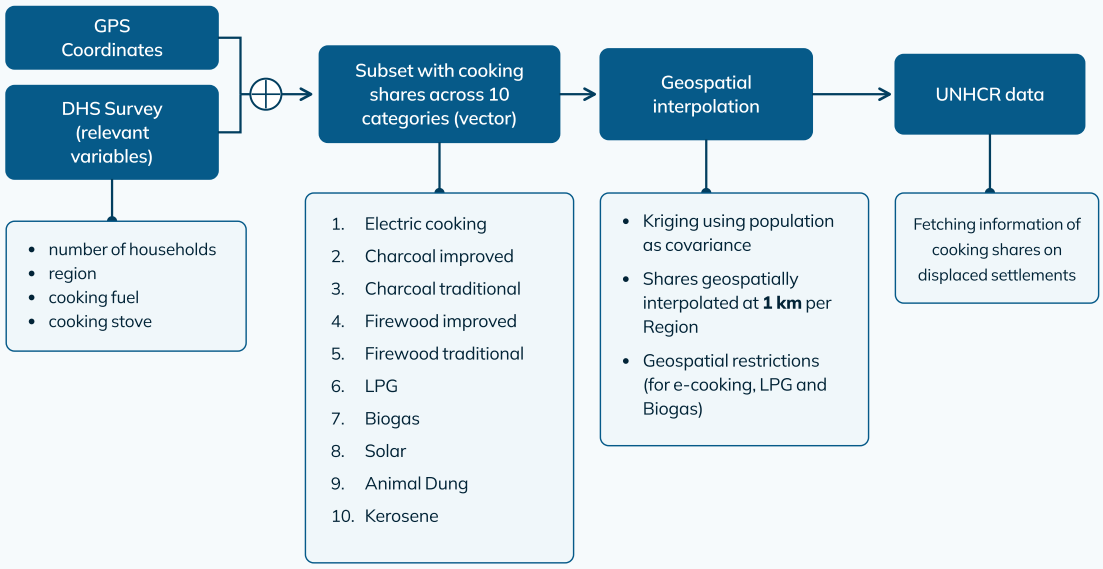
combines wood, processed biomass (pellets)/woodchips, agricultural crop residue, straw/shrubs/grass, and sawdust, while the charcoal and electricity stoves were a single category. These two groups were then split by type of cooking stove: a household is classified as using Improved Cooking Stove (ICS) if the answer refers to a manufactured solid fuel stove, and a traditional type for those were not.

A similar procedure, using only the type of cooking fuel, is applied to the other 6 categories using only the cooking fuel data. A handful of categories were discarded from the survey (no food cooked, garbage/plastic, gasoline/diesel, alcohol/ethanol, or an unspecified "other"). Finally, every remaining household was weighed by the DHS household sample weight (hv005), so the percentages are population-representative shares of all cooking households.

### Geospatial interpolation

Kriging, a standard spatial-statistics method, was used to estimate values between the survey points at a granularity of 1 km². This technique is not applied directly to the raw percentages, but relative to a reference category (traditional biomass, the largest national category). That transform guarantees the result adds up to exactly 100% everywhere.

**Figure 20.** High-level description of the geospatial interpolation using the DHS data and UNHCR data




The model also uses the population layer, first as a covariate in the per-region trend, since fuel use tends to shift with population density (more charcoal and electricity in denser areas, more firewood in sparser ones) and then reused as the weighting layer when aggregating and calibrating regional estimates. Furthermore, each of Ethiopia's 14 regions is modelled separately, so a pattern found in one region does not leak into another. Once predictions are deducted, a softmax conversion turns the log-ratios back into percentages.

Each region's totals are nudged slightly until they match figures recalculated directly from the DHS household data, using this same ten-category grouping. This calibration is only applied to the categories with a large enough surveyed sample in every region to support it. A last step is done for some displaced settlements where information for cooking shares was updated based on UNHCR reports and geospatial information.

## Output and validations

The results are ten rasters at 1km² resolution (see Figure 21). Each raster is independently tested region by region against the survey numbers. Table 35 shows the interpolated shares per region for five representative stoves: biomass traditional and improved, charcoal traditional and improved and electricity. The numbers for biomass groups are not only wood, but also processed biomass (pellets) or woodchips, agricultural crops, straw/shrubs/grass, and sawdust. Charcoal and electricity values are directly taken from the DHS. Some small gaps remain mostly explained by a population-vs-household weighting difference, and the geospatial restrictions applied which are tighter for grid infrastructure for electric cooking and LPG.

**Figure 21.** Cooking shares in Ethiopia at 1km² derived from the DHS dataset

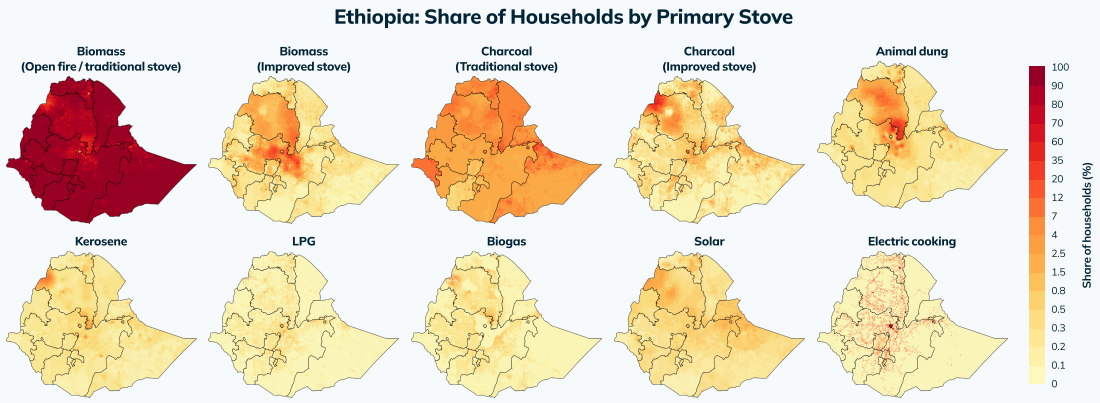



**Table 35.** Comparison of Kriging interpolation method per region against the DHS data for Charcoal, Biomass and Electricity.

| Region | Charcoal | | | Biomass | | | Electricity | |
|---|---|---|---|---|---|---|---|---|
| | Kriging(Traditional stove) | Kriging (Improved stove) | DHS | Kriging(Traditional stove) | Kriging (Improved stove) | DHS | Kriging | DHS |
| Afar | 11.27 | 3.46 | 18.55 | 79.65 | 0.75 | 77.66 | 2.76 | 2.69 |
| Amhara | 5.22 | 2.96 | 10.61 | 72.45 | 3.01 | 65.18 | 9.38 | 9.37 |
| Oromia | 2.73 | 0.75 | 4.48 | 80.86 | 4.48 | 83.33 | 8.55 | 8.57 |
| Somali | 16.85 | 3.01 | 2.59 | 73.66 | 0.65 | 71.17 | 3.61 | 3.60 |
| Benishangul-Gumuz | 4.39 | 2.91 | 11.92 | 87.31 | 0.98 | 84.51 | 2.94 | 2.91 |

| Region | Charcoal | | | Biomass | | | Electricity | |
|---|---|---|---|---|---|---|---|---|
| Central Ethiopia | 1.05 | 0.51 | 1.64 | 91.84 | 1.51 | 94.02 | 3.58 | 3.58 |
| South Ethiopia | 1.6 | 1.1 | 7.94 | 92.26 | 0.55 | 88.88 | 3.11 | 3.06 |
| Southwest Ethiopia | 2.32 | 1 | 2.94 | 93.52 | 0.33 | 95.07 | 1.43 | 1.43 |
| Gambela | 22.64 | 0.34 | 23.26 | 72.09 | 0.31 | 73.06 | 3.3 | 3.29 |
| Harari | 13.38 | 1.44 | 17.07 | 44.28 | 0.55 | 43.43 | 36.81 | 36.46 |
| Addis Ababa | 6.11 | 10.4 | 16.41 | 1.68 | 1.11 | 5.84 | 76.92 | 77.08 |
| Dire Dawa | 13.11 | 20.91 | 31.74 | 26.47 | 0.94 | 31.39 | 33.96 | 34.2 |
| Sidama | 1.45 | 0.36 | 1.74 | 88.51 | 0.49 | 90.2 | 7.81 | 7.92 |
| Tigray | 8.39 | 1.97 | 13.08 | 69.59 | 0.54 | 66.80 | 17.12 | 17.13 |

## Limitations

DHS data was collected between August 2024 and April 2025 and therefore represents a single snapshot of primary cooking fuels during that window. Given this cross-sectional nature, the data cannot capture seasonal variation in cooking fuel use, for example, households that switch fuels between wet and dry seasons, or during periods of local fuel scarcity, nor can it capture how adoption is trending over time.

Stoves tied to infrastructure (electricity, LPG, and biogas) are geospatially restricted to areas where infrastructure is currently available, based on the feasibility layers used in the model. This means the results are only as current as those layers and if the underlying infrastructure changes, or new infrastructure becomes available, the geospatial pattern of these fuels' shares would need to be updated accordingly, and until then the model would understate adoption in newly served areas.

DHS data fills a gap in understanding the types of stoves Ethiopians use at the national and subnational level. However, the spatial pattern shown in this section is built from a limited number of survey locations distributed across the country for representativeness. The method interpolates across these sparse points using a spatial statistical model. This helps to visualize and map likely stove use at a given location, which OnStove then uses as a starting point. The results should be understood as a modeled estimate of likely fuel use, not as directly observed data.

## Data for share calculations

**Table 36.** Cumulative distributions of stoves as outlined by the NCCR in the conservative scenario. It is assumed that two stoves are distributed per household.

| | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Advanced biomass (Urban) | 179,095 | 388,910 | 585,932 | 818,942 | 1,036,056 | 1,293,774 | 1,363,279 | 1,504,693 | 1,720,416 | 2,012,851 | 2,384,399 |
| Advanced biomass (Rural) | 558,650 | 1,196,778 | 1,781,219 | 2,455,567 | 3,068,780 | 3,779,344 | 3,966,468 | 4,338,315 | 4,892,481 | 5,626,566 | 6,538,167 |
| Electric Stove (Urban) | 257,326 | 559,202 | 907,128 | 1,307,736 | 1,757,482 | 2,268,509 | 2,451,867 | 2,647,721 | 2,856,860 | 3,080,124 | 3,318,402 |
| Electric Stove (Rural) | 802,674 | 1,720,798 | 2,752,872 | 3,912,264 | 5,182,518 | 6,591,491 | 7,085,133 | 7,600,129 | 8,137,382 | 8,697,831 | 9,282,450 |
| Biogas (Urban) | 1,457 | 4,261 | 8,547 | 14,368 | 21,776 | 30,737 | 41,480 | 53,971 | 68,261 | 84,404 | 102,453 |
| Biogas (Rural) | 4,543 | 13,072 | 25,786 | 42,632 | 63,557 | 88,263 | 117,187 | 150,029 | 186,739 | 227,263 | 271,547 |
| Solar Powered (Urban) | 938 | 1,905 | 2,903 | 3,931 | 4,990 | 6,546 | 8,159 | 9,829 | 11,559 | 13,349 | 15,200 |
| Solar Powered (Rural) | 2,925 | 5,868 | 8,827 | 11,803 | 14,795 | 19,084 | 23,425 | 27,819 | 32,262 | 36,755 | 41,296 |

**Table 37.** Cumulative distributions of stoves as outlined by the NCCR in the moderate scenario. It is assumed that two stoves are distributed per household.

| | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Advanced biomass (Urban) | 34,680 | 172,539 | 548,919 | 1,227,604 | 2,236,170 | 3,367,350 | 3,531,789 | 3,759,093 | 4,047,298 | 4,457,322 | 4,953,711 |
| Advanced biomass (Rural) | 108,177 | 527,461 | 1,643,939 | 3,608,110 | 6,456,687 | 9,575,507 | 10,018,211 | 10,615,907 | 11,356,273 | 12,385,535 | 13,603,432 |
| Electric Stove (Urban) | 23,843 | 122,819 | 405,103 | 937,046 | 1,763,509 | 2,733,092 | 2,880,603 | 3,094,131 | 3,377,834 | 3,801,084 | 4,338,838 |
| Electric Stove (Rural) | 74,372 | 375,396 | 1,212,754 | 2,752,240 | 5,086,491 | 7,759,765 | 8,156,897 | 8,718,369 | 9,447,166 | 10,509,630 | 11,829,019 |
| Biogas (Urban) | 1,379 | 7,003 | 22,760 | 51,942 | 96,513 | 147,930 | 155,624 | 166,583 | 180,911 | 201,953 | 228,277 |
| Biogas (Rural) | 4,302 | 21,406 | 68,149 | 152,603 | 278,487 | 420,252 | 440,967 | 469,781 | 506,589 | 559,410 | 623,996 |
| Solar Powered (Urban) | 1,084 | 5,502 | 17,883 | 40,812 | 75,831 | 116,231 | 122,276 | 130,886 | 142,144 | 158,678 | 179,360 |
| Solar Powered (Rural) | 3,381 | 16,819 | 53,545 | 119,902 | 218,811 | 330,198 | 346,474 | 369,114 | 398,034 | 439,537 | 490,282 |

**Table 38.** Cumulative distributions of stoves as outlined by the NCCR in the aggressive scenario. It is assumed that two stoves are distributed per household.

| | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Advanced biomass (Urban) | 26,010 | 205,404 | 709,644 | 1,551,581 | 2,522,793 | 3,663,478 | 3,802,767 | 3,983,823 | 4,203,981 | 4,460,373 | 4,749,933 |
| Advanced biomass (Rural) | 81,133 | 626,739 | 2,122,499 | 4,559,133 | 7,302,207 | 10,447,236 | 10,822,233 | 11,298,319 | 11,863,877 | 12,507,485 | 13,217,925 |
| Electric Stove (Urban) | 28,178 | 232,316 | 835,603 | 1,895,820 | 3,184,543 | 4,781,503 | 4,987,535 | 5,270,927 | 5,636,187 | 6,087,926 | 6,630,851 |
| Electric Stove (Rural) | 87,894 | 708,756 | 2,498,326 | 5,566,680 | 9,206,529 | 13,609,569 | 14,164,251 | 14,909,431 | 15,847,741 | 16,981,717 | 18,313,792 |
| Biogas (Urban) | 1,931 | 15,709 | 55,819 | 125,272 | 208,470 | 310,095 | 323,021 | 340,554 | 362,843 | 390,036 | 422,282 |
| Biogas (Rural) | 6,024 | 47,927 | 166,908 | 367,910 | 602,894 | 883,087 | 917,888 | 963,991 | 1,021,248 | 1,089,510 | 1,168,627 |
| Solar Powered (Urban) | 650 | 5,290 | 18,796 | 42,183 | 70,199 | 104,420 | 108,772 | 114,676 | 122,182 | 131,339 | 142,197 |
| Solar Powered (Rural) | 2,028 | 16,139 | 56,204 | 123,888 | 203,015 | 297,366 | 309,085 | 324,609 | 343,890 | 366,876 | 393,517 |

## APPENDIX D

# SELECTED IMPORTANT SECTOR POLICIES

**Table 39.** Summary of Clean Cooking Policies

| Year | Name | Clean Cooking Relevance |
|---|---|---|
| 2011 | The Climate-Resilient Green Economy | Highlights clean cooking as a major pathway for emissions reduction, noting that nearly 40% of national abatement potential from the forestry sector could come from shifting to efficient or alternative-fuel stoves. It identifies advanced cooking stoves as a fast-track initiative due to their significant climate, health, gender, and economic co-benefits, while also acknowledging financing barriers to scaling their adoption. |
| 2016 | The Second Growth and Transformation Plan | Reinforces clean cooking as a national priority by setting large-scale deployment targets for improved biomass, biogas, and solar cookstoves to expand rural energy access and reduce reliance on traditional fuels. Its emphasis on modern energy technologies positions clean cooking as a key contributor to environmental sustainability, health improvements, and Ethiopia's broader economic transformation goals. |
| 2018 | National REDD+ Strategy | Identifies unsustainable fuelwood use as a major driver of deforestation and promoting improved, electric, solar, and biogas cookstoves as key mitigation measures. By prioritizing efficient cooking technologies, it positions clean cooking as an essential tool for reducing pressure on forests and achieving national emissions-reduction goals. |
| 2023 | Long-Term Low Emission Development Strategy | Highlights clean cooking as an important mitigation pathway by targeting improved cooking efficiency and promoting efficient, biogas, and other low-emission stoves as part of Ethiopia's 2050 decarbonization strategy. By aiming to curb fuel use and reduce deforestation, it positions clean cooking technologies as essential to achieving long-term low-emission development. The aggressive transformation scenario in the national clean cooking roadmap is also aligned with the emission reductions proposed in this strategy. |

| Year | Name | Clean Cooking Relevance |
|---|---|---|
| 2024 | National Sustainable Energy Development Strategy | Positions clean cooking as a core element of achieving universal access to modern energy services by 2030, emphasizing R&D, value-chain strengthening, and behavior change to expand adoption of efficient and clean fuels and technologies. Its explicit 2030 access targets for electricity, biogas, and improved cookstoves underscore the central role of clean cooking in Ethiopia's sustainable energy transition. The conservative scenario in the national clean cooking road map is aligned to this strategy. |
| 2025 | National Clean Cooking Roadmap | Guiding document presenting different pathways for achieving clean cooking goals. The roadmap presents three scenarios aligned with different policies mainly related to reduction of emissions. |
| 2025 | National Clean Cooking Energy Sector Investment Plan | The investment plan accompanying the national clean cooking roadmap. Discusses the financial needs for the goals set out in the roadmap and recommendations for acquiring necessary funding. |
| 2025 | National Carbon Market Strategy | Identifies clean cooking as a priority sector for generating high-quality carbon credits, positioning improved cookstove and clean-fuel programs as key avenues for mobilizing climate finance. Ethiopia's existing carbon market participation already centers heavily on cookstove and biomass energy PoAs, underscoring clean cooking's importance in meeting NDC targets and attracting private investment. |
| 2025 | Nationally Determined Contribution 3.0 | Underscores clean cooking as a major mitigation priority because biomass use for cooking and baking is identified as the largest source of LUCF emissions. By targeting substantial emission reductions and relying on external finance, including carbon markets, the NDC reinforces the need to scale clean and efficient cooking solutions as part of Ethiopia's core climate strategy. The moderate intervention scenario in the national clean cooking roadmap is also aligned with the emission reductions proposed in this strategy. |
| 2025 | National Energy Compact | Places clean cooking at the center of Ethiopia's energy transition, reiterates the goals set out by the Clean Cooking Roadmap and commits 1 Bn USD to scale electric cooking, improved biomass stoves, and cleaner fuels. It highlights clean cooking as a critical energy-access gap and outlines concrete actions, such as standards enforcement, private-sector incentives, and consumer financing, to transform the market and deliver major emission reductions. |

**Table 40.** Summary of Clean Cooking Programs and Interventions

| Year | Program | Funding | Outcomes |
|---|---|---|---|
| 2005 - Present | Gaia Association (Ethanol Cooking) | Not specified | Ethanol stove pilots; refugee camp rollouts; feasibility studies; evidence of ethanol cost-competitiveness |
| 2005 - 2025 | EnDev Ethiopia | EUR 52 million | 2,017,400 access to modern cooking energy; 1,268,900 access to electricity; Benefited 4,955 social institutions and 15,775 enterprises |
| 2012 - 2016 | Energy Efficient Cookstoves Project (World Vision) | Not specified | 100,000 Tikikil & Mirt stoves distributed; 50,149 households reached; 320 cooperatives formed; 795,000 tCO2 reduced; USD 1.8 million carbon trading |
| 2013 - 2020 | National Improved Cookstove Program (NICP) | USD 5.5 million | Support institutional capacity building, entrepreneurship development and carbon finance |
| 2014 - 2019 | Fuel-Efficient Stoves PoA (WFP) | Not specified | 200,000 stoves distributed; 80% subsidy on stoves; reached rural households in 4 regions; carbon credits targeted |
| 2014 - 2022 | National Biogas Programme (NBPE II & NBPE+) | EUR 20.85 million (EU) + EUR 2 million (GoE) | 25,000+ biodigesters installed nationwide; built private sector capacity |
| 2015 - 2023 | UNDP Rural Energy Technologies Project | Not specified | 600,000 people reached with ICS; national stove standards; testing equipment; 2.56 MtCO2 avoided |
| 2015 - present | Fairtrade Carbon Partnership Project | Not specified | 40,000 cleaner stoves planned, 13,000 distributed; 8 local workshops setup; 400,000 farming families potential reach |
| 2017 - 2019 | Strengthening Enabling Environment for Clean Cooking Sector (SNV/RVO) | Not specified | Creation of ECCA; cookstove standards; testing facility support; policy reviews |
| 2019 - 2021 | Biogas, Biomass & Solar Trilateral Cooperation | USD 2 million | 3 institutional PV systems (127 kW total); 300 m³ biogas plant; 500+ officers trained; ~10,000 households benefited |
| 2019 - 2022 | Energy Solutions for Displacement Settings (ESDS) | Not specified | Briquette plant (350 kg/hr); energy kiosk; 3 health centers electrified; >140,000 refugees reached; contribution to National Multi-Actor Cooking Energy Strategy; 13,200 institutional stove beneficiaries |

| Year | Program | Funding | Outcomes |
|---|---|---|---|
| 2019 - present | Modern Energy Cooking Services (MECS) | Not specified | eCooking market assessment; MTF analysis; stove testing; urban adoption surveys; pilots for electric cooking |
| 2020 - 2021 | COVID-19 Relief Fund for Cooking Energy & Off-Grid Solar (EnDev) | EUR 40.8 million (within EnDev) | ~60 SMEs supported; grants EUR 5k–25k each; 97,200 ICS and 13,920 solar systems deployed; ~480,600 people reached; support to 11 industry associations |
| 2023 - 2026 | Strengthening Entrepreneurial Ecosystem (RVO HTCC) | EUR 1.8 million | 100,000 people targeted in Ethiopia; 10 SMEs targeted; 500 jobs to be created; Tier 3+ stove promotion |
| 2023 - 2030 | Vita SNNPR Improved Cookstoves Project | Not specified | 515,000 people reached with improved cookstoves; 300 jobs created; EUR 600,000 revenue generated, 105 million labor hours saved |
| 2024 | E-cooking market assessment for Sheder refugee camp | Not Specified | Commissioned 254kWp mini grid in Sheder camp; connected 1,100 households |



Photo: Ethiopian Clean Cooking Alliance

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Sustainable Energy for All has a global mandate to accelerate progress on the energy transition in emerging and developing countries. Hosted by UNOPS, we work at the intersection of energy, climate and development, partnering with governments and organizations worldwide to end energy poverty, double energy efficiency, significantly expand renewable energy and combat climate change.

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