ውሃና ኢነርጂ ሚኒስቴር
MINISTRY OF WATER AND ENERGY
የኢትዮጵያ ፌዴራላዊ ዲሞክራሲያዊ ሪፐብሊክ | Federal Democratic Republic of Ethiopia

# National Clean Cooking Road Map

January, 2025

Addis Ababa, Ethiopia

# Table of Contents

## List of Table



## List of Figures

## Key Terms in Clean Cooking

### Assessment Frameworks

- **Multi-Tier Framework (MTF) for Access to Cooking**: A comprehensive assessment method developed by ESMAP at the World Bank to measure access to modern energy cooking services. It categorizes cooking access across six key attributes: **exposure to harmful pollutants, energy efficiency, convenience, safety, fuel availability, and affordability**, with each attribute ranging from Tier 0 to Tier 5.

### Concepts and Practices

- **Clean Cooking**: Cooking systems meeting international emissions standards at the point of use, encompassing energy-efficient or modern technologies such as electric cooking, LPG, ethanol stoves, and advanced biomass stoves.
- **Carbon Markets for Clean Cooking:** Initiatives that leverage carbon financing to expand access to clean cooking solutions. By quantifying and monetizing the reduction in greenhouse gas emissions achieved through the adoption of clean cookstoves, these markets provide financial incentives for both producers and users.
- **Energy Ladder**: A conceptual model describing how households move from traditional biomass fuels to more efficient and cleaner energy sources as their income increases. The progression typically starts with dung and wood, moving to charcoal, then to kerosene, and finally to electricity or gas.
- **Fuel Stacking:** Fuel stacking refers to the practice where households utilize multiple fuels or cooking solutions concurrently. This often involves using a combination of traditional biomass fuels (like wood or charcoal) alongside cleaner options (such as LPG, electricity, or biogas).

### Cooking Technologies

- **Traditional Cooking Systems**: Simple stoves like open fires or mud stoves using biomass fuels like firewood and charcoal, typically characterized by high emissions, low efficiency, but often the cheapest and most accessible option.
- **Advanced Biomass Stoves**: Stoves meeting Tier 3 or higher across MTF attributes, utilizing fuels like pellets or processed biomass, designed for high efficiency and low emissions, often incorporating technologies like gasifiers, forced draft stove, or solar-powered fans.
- **Improved Cookstoves (ICS):** Stoves offering advantages over traditional stoves but may not reach higher access tiers, using various biomass fuels, generally more affordable and produced locally or imported.
- **LPG Stoves**: Clean cooking systems powered by LPG canisters, providing high-tier cooking solutions with low emissions, but often associated with high upfront costs and reliance on robust LPG supply chains.
- **Electric Stoves**: Cooking appliances using electricity to generate heat, typically through resistance heating elements or electromagnetic induction.
- **Solar Power Cooking**: Cooking systems utilizing solar energy, including solar thermal cooking and solar photovoltaic (PV) cooking, with options like thermal storage systems, battery storage, or direct sunlight use.
- **Ethanol Stoves**: Cooking systems using ethanol as a clean fuel, offering lower emissions compared to traditional biomass fuels.

- **Biogas Stoves**: Cooking systems powered by biogas, a clean and renewable energy source produced from cattle dung, organic waste and agricultural residues.

### Health and Social Considerations

- **Cultural Barriers to Adoption of Clean Cooking:** Socio-cultural factors that impede the acceptance and use of clean cooking technologies. These may include traditional cooking practices, taste preferences, and resistance to change, all of which can influence the effectiveness of clean cooking interventions.
- **Cost of Inaction**: The economic and social costs associated with not transitioning to clean cooking solutions. These costs include healthcare expenses due to illnesses caused by household air pollution, lost productivity from time spent collecting fuel, and environmental degradation from unsustainable fuel us
- **Gender Equality in Clean Cooking:** This recognizes the disproportionate burden of traditional cooking on women and girls, leading to health issues, time poverty, and limited opportunities. It emphasizes the need for clean cooking solutions to be designed and implemented with a focus on women's needs and empowerment, including their involvement in decision-making, access to information, and ownership of clean cooking technologies.
- **Household Air Pollution (HAP)**: Indoor air pollution resulting from the use of traditional cooking methods and fuels, such as wood, charcoal, or dung, leading to health issues like respiratory infections and chronic diseases. Transitioning to clean cooking solutions can significantly reduce HAP.

### Acronyms

- **BLEENS**: An acronym representing modern clean cooking solutions: Biogas, Liquefied Petroleum Gas (LPG), Electricity, Ethanol, Natural Gas, and Solar. These fuels and technologies are considered clean as they produce lower emissions compared to traditional biomass fuels.

### Climate and Energy Goals

- **Sustainable Development Goal 7 (SDG 7):** One of the 17 UN Sustainable Development Goals, aiming to "ensure access to affordable, reliable, sustainable, and modern energy for all" by 2030.
- **National Sustainable Energy Development Strategies (NSEDS): Comprehensive national plans integrating policies and actions to promote sustainable energy development, ensuring energy security, supporting economic growth, and addressing environmental concerns.**
- **National Sustainable Energy Development Strategy (N-SEDS) of Ethiopia:** Ethiopia's N-SEDS 2024 - 2030, launched by the Ministry of Water and Energy on April 12, 2024, aims to guide actions toward a sustainable and inclusive energy future. The strategy focuses on achieving energy access and social equity, economic growth and competitiveness, energy efficiency and conservation, energy security and resilience, and environmental sustainability.
- **Nationally Determined Contributions (NDCs):** Climate action plans submitted by countries under the Paris Agreement, detailing their efforts to reduce greenhouse gas emissions and adapt to climate change impacts.
- **Long-Term Low Emission Development Strategies (LT-LEDS):** Voluntary national strategies outlining planned pathways toward low-emission, climate-resilient development over the long term, typically up to 2050.

## Executive Summary

Ethiopia faces significant challenges in adopting clean cooking technologies. Despite the country's large population, over 100 million people continue to depend on traditional biomass fuels, which contribute to health hazards, environmental degradation, and economic inefficiencies. While efforts to promote clean cooking solutions have been made, progress has not kept pace with population growth, resulting in a considerable gap in access. By 2022, only 8.8% of the population had access to clean cooking, and without substantial interventions, improvements are expected to be limited. The urban-rural divide is pronounced, with urban access at 28.6% compared to just 0.6% in rural areas. Rising fuel prices have prompted many households to adopt fuel stacking, while eCooking is gaining traction as a promising alternative.

Currently, 4.1% of households utilize electric cooking, particularly in urban areas where access to electricity is more prevalent. However, challenges remain, including the need for improved infrastructure and consumer awareness of the benefits of clean cooking technologies. Without significant interventions, projections indicate that the national access rate will remain below 10% through 2024.

Based on international best practices, local experience, and literature on clean cooking, the critical factors influencing adoption of clean cooking solutions in Ethiopia, in general, are affordability (approximately 30%), awareness of risks and benefits (approximately 18%), enabling policies and regulations (approximately 15%), and fuel availability (approximately 14%). Other factors, such as inclusive participation, attitude toward technology, social and cultural influences, and research and development, play a complementary role in supporting adoption efforts. Addressing these factors and creating an enabling environment with tailored solutions for each factor will pave the way for a long-lasting impact and wider adoption of clean cooking. Other factors, such as inclusive participation, attitude toward technology, social and cultural influences, and research and development, play a complementary role in supporting adoption efforts. Prioritizing these critical and complementary areas is essential to achieving sustainable and inclusive progress.

The Ethiopian government aims to reduce greenhouse gas emissions by 68.8% by 2030, aligning with national policies that seek to encourage the adoption of clean cooking solutions. The transition from traditional cooking methods to cleaner technologies is critical for meeting both health and environmental objectives. National policies emphasize reducing reliance on traditional fuels and enhancing access to modern energy sources. By the end of 2023, 20.3 million improved cookstoves had been distributed, with a target of 31 million by 2030.

The modeling exercise has been performed considering three scenarios, as it is essential for developing a structured and evidence-based approach to increasing access to clean cooking energy in Ethiopia from 2025 to 2035. This process aims to identify realistic access targets by analyzing barriers and drivers, projecting adoption rates under different scenarios, and evaluating policy, investment, and technology options, as well as cooking culture, availability of fuel, population growth, and economic and social factors. The effort aligns with Ethiopia's commitments under SDG 7, the updated NDC, and the Long-Term Low Emission Development Strategy (LT-LEDS). Furthermore, it integrates socio-cultural and regional considerations, supporting the achievement of clean cooking goals while contributing to broader climate resilience and sustainable development objectives.

The modelling exercise employed a Multi-Tier Framework (MTF) to analyze clean cooking access, incorporating data from various sources including the World Bank, IEA, WHO, and Ethiopia's Ministry of Water and Energy. This framework evaluates access across multiple dimensions (efficiency, exposure, affordability, fuel availability, convenience, and safety), enabling a nuanced understanding of the challenges and opportunities in transitioning to cleaner cooking solutions.

Three distinct adoption scenarios are modeled: Conservative Growth, Moderate Intervention, and Aggressive Transformation, each projecting different adoption rates and associated costs. The three Adoption Scenarios considered were

**Conservative Growth (N-SEDS Aligned)**: This scenario was designed to increase the penetration of electric stoves to 25.4 %, improved cookstoves to 25.73 %, and biogas to 0.54 % of households by 2030, achieving an overall emission reduction of up to 48.75 Mt $CO_2$eq by 2035

**Moderate Intervention (NDC Aligned):** This scenario was performed considering that the emissions reduction of **50 million tons of $CO_2$ equivalent ($MTCO_2eq$) from 2025 - 2030** and an additional **25 million tons of $CO_2$ equivalent ($MTCO_2eq$) from 2031 to 2035** will be achieved in line with the NDC goals. Advanced improved cookstoves with Tier 3 and above contribute 45%, electric stoves account for 50%, while biogas and solar solutions each contribute 2.5%, aiming to achieve the stated target of reducing 75 million tons of $CO_2$ equivalent from 2025 - 2035.

**Aggressive Transformation (LT-LEDS Aligned) :** The scenario aligns with Ethiopia's Long-Term Low Emission Development Strategy, targeting a reduction potential of 100 million tons of $CO_2$ equivalent ($MTCO_2e$) from 2025 to 2035, in support of the country's long-term emission reduction objectives. This will be achieved through $CO_2$ equivalent reduction contributions of 25% from advanced improved cookstoves meeting Tier 3 and above, 70% from the transition to electric cooking, 3.5% from adopting biogas, and 1.5% from utilizing solar, LPG, and ethanol cooking technologies. These efforts significantly advance Ethiopia's ambitious climate goals by promoting clean cooking solutions and fostering sustainable practices nationwide.

### Key Findings and Context

The report identifies key barriers to clean cooking technology adoption, including affordability, awareness, and technological limitations. It emphasizes the importance of a comprehensive, multisectoral strategy that involves government, private sector, civil society, and development partners. Recommendations include establishing a dedicated national clean cooking coordination unit at the Ministry of Water and Energy (MoWE) to unify efforts and stakeholders, making clean cooking a national priority, and implementing flexible payment mechanisms. Addressing affordability through tax exemptions, subsidies, and rigorous implementation of carbon financing is essential, alongside promoting large-scale manufacturing. Raising awareness through community engagement, bridging demand and supply gaps, and fostering behavior change are critical. Additionally, fostering public-private partnerships, enhancing technological standards, and ensuring proper labeling will improve the quality, efficiency, and safety of clean cooking solutions.

The scenarios considered for this analysis reflect varying levels of intervention to achieve clean cooking adoption in Ethiopia: Business-As-Usual (BAU), Conservative Growth, Moderate Intervention, and Aggressive Transformation.

The **Business-As-Usual (BAU)** scenario assumes minimal efforts and limited policy interventions. By 2035, it aims to deploy 2.83 million cookstoves, primarily Tier 2 stoves, serving 7.1 million people and increasing clean cooking access to just 15.34%. Oromia, Amhara, and the Southern Region lead the distribution with the highest allocations of cookstoves. This scenario achieves a modest $CO_2$ reduction of 10 $MtCO_2eq$ by 2035 but fails to meet Ethiopia's clean cooking and climate goals due to limited progress and minimal investment.

The **Conservative Growth scenario**, aligned with the National Sustainable Energy Development Strategy (N-SEDS), envisions deploying 21.95 million cookstoves, including a mix of Tier 2 and Tier 3 stoves, by 2035. This approach benefits 54.9 million people, achieving 49.86% clean cooking access. Oromia, Amhara, and the Southern Region remain the leading beneficiaries. It achieves a $CO_2$ reduction of 50 $MtCO_2eq$ with an estimated cost of $1.60 billion. While it represents a significant improvement over the BAU scenario, its reliance on biomass stoves and limited technological diversity restricts its potential impact.

The **Moderate Intervention scenario**, aligned with Ethiopia's Nationally Determined Contributions (NDC), targets deploying 36.25 million cookstoves by 2035, including Tier 3 and Tier 4 stoves. This scenario benefits 90.6 million people and achieves 75.87% clean cooking access. Oromia, Amhara, and the Southern Region are again dominant regions. It promotes a diverse mix of technologies, including advanced biomass, electric, biogas, and solar stoves, achieving a substantial $CO_2$ reduction of 75 $MtCO_2eq$ from 2025 to 2035. With an estimated cost of $2.60 billion, it balances ambition and feasibility, making it a practical yet transformative choice.

The **Aggressive Transformation scenario**, aligned with the Long-Term Low Emission Development Strategy (LT-LEDS), is the most ambitious. It targets deploying 45.04 million cookstoves by 2035, emphasizing Tier 4 and Tier 5 stoves. This scenario benefits 112.6 million people, achieving 91.88% clean cooking access. Oromia, Amhara, and the Southern Region receive the highest share of cookstoves. It achieves a $CO_2$ reduction of 100 $MtCO_2eq$ but requires $3.14 billion, making it the most resource-intensive scenario with significant implementation challenges.

The **Moderate Intervention scenario** is selected as the optimal pathway due to its balance of ambition and feasibility. It achieves **75.87% clean cooking access** and a $CO_2$ reduction of **75 $MtCO_2eq$ from 2025 to 2035**, serving **90.6 million people** across Ethiopia. With an estimated cost of **$2.60 billion**, it prioritizes urban-rural equity and promotes a mix of technologies suitable for Ethiopia's diverse regions. By addressing key barriers such as affordability, infrastructure, and awareness, the Moderate Intervention scenario provides a robust framework to advance Ethiopia's clean cooking transition while meeting its climate and development goals.

**Findings of the Cost-Benefit Analysis for the Selected Moderate Intervention Scenario:** Even though the selected and optimal scenario requires an overall and cumulative cost of **$2,601,393,262 (2.6 Billion Dollar) (2025 -2035)**, the cost-benefit analysis highlights that the incurred costs will be offset by the long-term benefits. These benefits include **time savings, health improvements, environmental restoration, and conservation gains**, which collectively **repay the investment over time**. This underscores the importance of balancing initial costs with long-term gains to drive the sustainable adoption of clean cooking technologies. It is crucial to note that **LPG and ethanol stoves** face challenges due to their **high long-term fuel costs**, resulting in negative net benefits unless addressed. Major interventions are necessary to incentivize their use through **targeted subsidies for fuel** and efforts to **lower stove costs**, which could significantly improve their long-term viability. During scenario development, careful attention was given to the cost-benefit analysis, ensuring that interventions align with both economic and environmental sustainability objectives. Due to this, **major**

**attention was given to improving the efficiency of advanced biomass stoves**, aiming to elevate them to Tier 3 or above in all six aspects of the Multi-Tier Framework. Efforts also focus on **enhancing the efficiency of electric stoves** through mandatory labeling in the future. Additionally, **biogas technology** is given attention, as it offers net positive benefits in the long term, particularly for rural populations with access to cattle dung, organic waste, and agricultural residues resources readily available alongside water sources.

Solar photovoltaic (PV) systems for cooking, with or without battery storage, have been proven effective in other countries, where they have helped reduce reliance on traditional fuels, improved energy efficiency, and addressed health issues related to indoor air pollution. However, while these systems have been tested successfully in different regions, the specific context in Ethiopia may present challenges in terms of infrastructure, climate conditions, and consumer adoption. Additionally, solar thermal cooking solutions have been tested in Ethiopia, though their effectiveness may be limited due to factors such as inconsistent sunlight and the challenges of meeting local cooking needs. Therefore, while lessons learned from other countries are valuable, the adaptation and scaling of solar PV and thermal cooking solutions in Ethiopia may require careful consideration of local needs, capacity, and resources. Thus, a small percentage is included in the modeling analysis as one option for those living far from the grid with high solar potential.

With these considerations in mind, the scenario development prioritizes these four technologies advanced biomass stoves, electric stoves, biogas, and solar cooking systems - during the projection period **(2025 - 2035).** This Scenario analysis ensures a balance between technological advancement, resource availability, and long-term sustainability and cost-benefit analysis, while also **highlighting the critical need for major interventions to promote LPG and ethanol stoves**, as their long-term benefits remain negative unless supported through targeted measures.

**30%** of the cumulative total cost of cookstoves, amounting to **$780,417,978**, were also considered additionally to run program, advocacy, awareness creation, management, and incentives. These funds cover a range of activities essential for program success, including distribution logistics, installer training, quality control, after-sales service, public awareness campaigns, community outreach, collaboration with local leaders, program management, monitoring and evaluation, reporting, and the provision of financial and non-financial incentives to consumers. This allocation, when added to the overall cost of **$2,601,393,262**, results in a total expenditure of **$ 3,381,811,240 (3.38 Billion Dollar).**

**Key findings for Social and Economic Impacts of Advanced Clean Cooking Technologies: Wood Saving, Job Creation, and Gender Empowerment in the Moderate Intervention Scenario**: For the moderate intervention scenario, social benefit analysis revealed key findings in wood saving, job creation, and gender impact in terms of time saving and economic value. The suggested advanced clean cooking technologies, including **18,557,143 advanced biomass stoves, 16,167,857 electric stoves, 852,273 biogas stoves, and 669,643 solar stoves**, significantly reduce wood consumption, saving a total of **105.3 million tons annually**. This reduction alleviates deforestation pressures and promotes environmental sustainability. Job creation is also notable, with over **335,700 jobs** generated across manufacturing, distribution, and maintenance. Additionally, these clean cooking technologies save substantial time for women and girls, with a total of **13.22 billion hours saved annually**, translating to an economic value of **$6.77 billion**, which enhances economic empowerment and community development.

**A Phased Approach to Clean Cooking Adoption in Ethiopia: Strategies, Milestones, Technologies, and Targets (2025-2035)** : For the moderate scenario, which is optimal and

selected, the suggested strategies, technologies, milestones and targets and activities for the ten-year period (2025-2035) are divided into three phases of implementation.

**Phase 1 (2025 - 2027): Foundations and Early Scaling** focuses on promoting advanced biomass stoves and electric cooking technologies where grid access is available. Pilot programs for biogas systems in livestock-rich rural areas and solar cooking technologies in off-grid regions are also recommended. The overall clean cooking access target for this phase is set at **18%**. **Tier 3 contributes 55.05%** towards this target by utilizing a cumulative **2,050,000 advanced biomass stove** units for urban and rural households. **Tier 4 contributes 4.09% by introducing 152,192 units of biogas and solar-powered stoves** for urban and peri-urban households. **Tier 5 contributes 40.86% by introducing 1,519,643 electric stove units** for urban and rural households to transition to electric and hybrid stoves.

**Phase 2 (2028 - 2030): Expansion and Consolidation** aims to scale up large scale production of Higher Tier Stoves with standardized product t with labeling and expanded production facilities, roll out smart cookstoves with real-time feedback and IoT-enabled features in urban areas. The clean cooking access target for this phase is **57.74%**. **Tier 3** contributes **52.08%** towards this target by utilizing a cumulative **8,107,143** advanced biomass stove units for urban and rural households. **Tier 4** contributes **4.17%** by introducing **649,350 units** of biogas and solar-powered stoves for urban and peri-urban households. Tier 5 contributes **43.75%** by introducing **6,803,571** electric stove units for urban and rural households to transition to electric and hybrid stoves. Besides, in Phase 2, it is highly recommended to focus on infrastructure development for ethanol and LPG distribution, research and development for bioethanol production from biomass to reduce competition with sugar-based ethanol production, the development of incentive mechanisms, and negotiations with sugar industries to reduce the cost of ethanol by linking sugar industries with inactive mechanisms to allocate at least 20% of their production for ethanol stoves.

**Phase 3 (2031 - 2035): Universal Access and Sustainability** focuses on promoting majorly **high-efficiency Tier 5 electric stoves**, High Tier Advanced biomass Stoves and biogas stoves tailored to urban and rural needs, integrating solar-biogas hybrid solutions for off-grid and semi-urban areas, and promoting scalable modular cooking technologies for diverse household sizes. The clean cooking access target for this phase is **75.87%. Tier 3** contributes **47.26%** towards this target by utilizing a **cumulative 5,007,143 advanced biomass stove units** for urban and rural households. **Tier 4** contributes **4.31%** by introducing **456,575 units** of biogas and solar-powered stoves for urban and peri-urban households. **Tier 5** contributes **48.43%** by introducing **5,130,357 electric stove units** for urban and rural households to transition to electric and hybrid stoves. These phases outline a comprehensive approach to achieving clean cooking access targets through the promotion of advanced technologies, strategic interventions, and robust support mechanisms. The focus is on scaling up successful initiatives, leveraging carbon markets, and ensuring regulatory compliance to drive sustainable adoption of clean cooking solutions.

In conclusion, creating widespread access to clean cooking requires a multifaceted approach that includes promoting innovative technologies, improving supply chains, and establishing decentralized distribution networks. Specific strategies will be tailored to Ethiopia's diverse socio-cultural contexts to ensure effective implementation. Furthermore, the report highlights the necessity of urgent action to address the clean cooking access deficit in Ethiopia. By prioritizing clean cooking technologies, the government and its partners can enhance public health, reduce emissions, and contribute to sustainable development goals. Collaboration among stakeholders will be pivotal in realizing the vision of universal access to clean cooking by 2035, ultimately improving the quality of life for millions of Ethiopians

**Technological and Policy Recommendations**

- Promote the adoption of advanced biomass stoves (Tier 3 and above), electric stoves, biogas systems, solar cookers, LPG, and ethanol stoves, tailored to meet regional needs.
- Make clean cooking a national priority and agenda by further integrating it into policies, strategies, and frameworks, engaging leaders to be part of the initiatives, ensuring continuous media coverage, appointing a dedicated champion, mobilizing funds and innovative financing, and embedding it into strategies for poverty reduction, gender equality, and environmental sustainability to achieve universal access to modern energy and contributing to sustainable development.
- Establish a dedicated National Clean Cooking Coordination Unit at the Minster of Water and Energy, and inter-ministerial task force to streamline policy development, resource allocation, and monitoring & evaluation related to clean cooking initiatives.
- Develop robust infrastructure for distribution and maintenance, especially in rural areas.
- Support local private sector production and entrepreneurship capacity for clean cooking, by facilitating public-private linkage, training and knowledge transfer.
- Promote research and innovation to improve stove efficiency and affordability.
- Implement results-based financing schemes to incentivize clean cooking technology adoption while ensuring affordability for end-users
- Introduce subsidies, flexible payment options, and public-private partnerships to improve affordability and access.
- Develop regional hubs and demonstration centres for clean cooking technologies, aligned with cultural preferences.
- Foster public-private partnerships (PPPs) and industry associations to incentivize private sector investment in large-scale manufacturing, technology development, and infrastructure expansion for advanced biomass, electric cooking, biogas, LPG, and ethanol solutions.
- Integrate specific clean cooking goals into broader climate and development strategies, including NDCs and LT-LEDS.
- Prioritize the inclusion of women in the development, distribution, and adoption of clean cooking technologies. This includes targeted financing options, training programs, and promoting women-led enterprises within the clean cooking sector.
- Develop incentives and support mechanisms for local and large scale production of clean cooking stoves and fuels, focusing on creating jobs and reducing reliance on imports. This includes fostering partnerships with SMEs and integrating clean cooking goals into industrial development policies.
- Introduce the concept of higher-tier cookstoves and fuels in the context of locally produced improved stoves by aligning with cultural preferences and focusing on efficiency improvements adapted to modify existing cooking and baking systems, thereby drastically reducing costs.
- Develop and enforce national standards for clean cooking technologies, ensuring quality and safety compliance while encouraging innovation.
- Develop and operationalize a national carbon market framework linked to clean cooking projects by leveraging Ethiopia's potential to generate high-quality carbon credits, streamlining certification processes, building capacity for local stakeholders, and reinvesting carbon revenues into scaling higher-tier clean cookstoves. While the Ministry of Planning and Development is leading the initiative to ensure alignment with Ethiopia's

climate goals while maximizing co-benefits such as improved health, reduced deforestation, and job creation, it is crucial to ensure effective engagement of other sectoral agencies, such as the Ministry of Water and Energy and Petroleum and Energy Authority that have direct stake in promoting cooking-related initiatives

- Create a centralized database to track clean cookstove distribution, the number of households served, time saved, emissions reductions, carbon credits, job creation, and forest savings, integrating community-level data with national monitoring to improve transparency and decision-making.
- Develop a comprehensive stakeholder engagement plan that includes regular consultations, knowledge-sharing workshops, and a joint work plan to ensure coordinated action and resource mobilization across sectors.

# 1. Introduction

## 1.1. Context and Importance of Clean Cooking Technologies in Ethiopia

Ethiopia faces significant challenges in energy access, particularly in clean cooking practices. Over 100 million Ethiopians, mainly in rural areas, rely on traditional biomass fuels for cooking, leading to health risks, deforestation due to excessive wood harvesting, biodiversity loss, greenhouse gas emissions from inefficient burning, economic inefficiencies from high fuel costs and lost productivity, and time burdens on women and children[1,2].

Despite efforts, the expansion of clean cooking access has not kept pace with population growth. Between 2019 and 2024, Ethiopia's population grew by an average of 3 million people annually. However, the annual increase in access to clean cooking solutions has been slower, just below 1 million people per year, leading to a widening gap with an access deficit reaching 108 million people by 2023[3]. Ethiopia remains one of the five countries with the largest clean cooking access deficits globally. As of 2022, only 8.8% of Ethiopia's population, approximately 10.4 million people, had access to clean cooking solutions, with projections estimating an increase to 9.3% in 2023 and 9.8% in 2024, reflecting an annual growth rate of 0.5%[2,3].

The disparity in access between urban and rural populations is significant. In urban areas, clean cooking access stands at 28.6% (2022), while in rural regions, it is just 0.6% (2022). Over the past two decades, the gap has widened, with rural access to clean fuels and cooking technologies increasing marginally from 0.4% in 2000 to just 0.6% in 2022. Urban areas have seen more significant progress, with access rising from 2.3% in 2000 to 28.6% in 2022[3].

To manage fuel price fluctuations, many Ethiopian households practice fuel stacking. However, there has been a notable increase in eCooking, reducing firewood usage. Currently, 4.1% of households use eCooking, with half relying on it exclusively. Electricity has become the second most used cooking fuel in urban areas, particularly in Addis Ababa, where 65% of households own electric appliances and 63% use electricity as their primary cooking method. Despite 54% electricity access nationwide in 2023, significant potential for expanding eCooking remains, especially in urban areas where usage is much higher (15.3%) compared to rural areas (0.9%) due to better grid access (urban: 96.2%, rural: 12.2%)[3,4].

Addressing these issues is vital for Ethiopia's health, environmental, and development goals. Rising costs have pushed households towards firewood, highlighting the need for revised clean cooking strategies and increased consumer awareness of the benefits[4]. Clean cooking technologies are defined in line with WHO guidelines, including electricity, biogas, natural gas, LPG, solar, or alcohol fuels[1].

Ethiopia aims to reduce greenhouse gas emissions by 68.8% by 2030 (NDC targets), with clean cooking playing a crucial role by reducing deforestation and improving health outcomes[5],[6].

[1] World Health Organization (WHO). (2022). Household Air Pollution and Health.
[2] World Bank. (2021). Ethiopia Economic Update: Overcoming the Challenges of Poverty and Inequality.
[3] International Energy Agency (IEA). (2024). Energy Outlook.
[4] Ethiopia Socioeconomic Panel Survey. (2021/22). Survey Report.
[5] Ethiopia. (2021). Nationally Determined Contributions (NDC).
[6] Ethiopia. (2020-2050). Long-Term Low Emission and Climate Resilient Development Strategy.

Clean cooking solutions also support multiple SDGs, notably SDG 7 for affordable and clean energy, SDG 13 for climate action, SDG 3 for health, and SDG 5 for gender equality by reducing time and financial burdens on women and enhancing educational outcomes [7].

By the end of 2023, 20.3 million improved cookstoves were distributed in Ethiopia, with plans to reach 31 million by 2030, targeting both rural and urban areas differently[8]. Achieving universal access requires a comprehensive, multi-sectoral strategy, learning from global best practices, and focusing both on rural areas where the need is greatest.

Achieving universal access to clean cooking in Ethiopia demands a comprehensive, multi-sectoral strategy that embraces lessons from global best practices while concentrating efforts on both urban and rural areas where the need is most acute. These global best practices include employing a multi-fuel approach, offering financial incentives, running educational campaigns, supporting local manufacturing, ensuring gender inclusivity, establishing robust policy frameworks, fostering technological innovation, forming strategic partnerships, implementing adaptive monitoring, and providing maintenance support to boost adoption and effectiveness[8]. From these practices, Ethiopia can glean significant insights, particularly the necessity of customizing strategies to fit local contexts, making clean cooking solutions accessible and both culturally and economically appropriate for its diverse populations.

## 1.2. Objectives and Scope

### Objectives of the Study

- **Model Adoption Pathways**: To develop strategic pathways for increasing the adoption of clean cooking technologies across Ethiopia, focusing on both urban and rural contexts.
- **Set Realistic Targets**: Establish feasible adoption targets for the period 2025-2035, aligning with national policy objectives (N-SEDS, NDC, LT-LEDS) and SDG 7.
- **Identify Barriers and Drivers**: Analyze factors influencing the adoption of clean cooking technologies, including socio-cultural, economic, and policy aspects.
- **Policy and Investment Recommendations**: Suggest policies and investment strategies that can incentivize the transition to clean cooking solutions.

### Geographical and Sectoral Focus

- **National Scale**: The study will cover all regions of Ethiopia, emphasizing areas with the lowest access rates.
- **Sectoral Integration**: Incorporate health, energy, environment, gender, and economic sectors to ensure a holistic approach to clean cooking adoption.

## 1.3. Vision and Strategic Goals

Ethiopia envisions a future where all its citizens have access to clean, efficient, and sustainable cooking solutions by 2035, significantly reducing reliance on biomass and thereby mitigating health risks, environmental degradation, and socio-economic burdens. This vision is grounded

[7] Global Clean Cooking Alliance. (2024). Clean Cooking Definition and Technologies.
[8] Ethiopia. (2024). National Sustainable Energy Development Strategy (N-SEDS, 2024 - 2030).

in Ethiopia's broader sustainable development objectives, emphasizing health, environmental stewardship, and economic empowerment.

## Strategic Goals

### Health Improvement

- **Target**: Reduce premature deaths caused by household air pollution (HAP) by 90% by 2035.
- **Strategy**: Promote the adoption of clean cooking technologies that minimize indoor air pollution, targeting a significant decrease in respiratory and cardiovascular diseases.

### Environmental Sustainability

- **Target**: Achieve a 75 % reduction in $CO_2$ emissions from traditional cooking practices by 2035, aligning with Ethiopia's international commitments.
- **Strategy**: Enhance forest conservation by reducing wood fuel demand through the widespread adoption of alternative cooking technologies like biogas, LPG, electric, and solar cooking solutions.

### Economic Efficiency

- **Target**: Decrease the economic cost associated with traditional cooking methods to less than 5% of the total national health expenditure by 2035.
- **Strategy**: Introduce affordable clean cooking solutions, reducing time spent on fuel collection and cooking, thereby freeing up resources for education and income-generating activities, particularly for women and children.

### Access and Equity

- **Target**: Ensure 75.87% of Ethiopian households have access to clean cooking by 2035, with a focus on equitable distribution between urban (90%) and rural (60%) areas.
- **Strategy**: Develop tailored strategies for urban and rural contexts, leveraging existing infrastructure in urban areas and focusing on decentralized solutions like biogas in rural settings.

### Technological Innovation and Adoption

- **Target**: Elevate at least 50 % of all cooking appliances to Tier 3 or above by 2035, with a focus on energy efficiency and low emissions.
- **Strategy**: Invest in research and development for advanced cooking technologies, promote local manufacturing to reduce costs, and ensure cultural and practical suitability through community engagement.

### Gender Equality

- **Target**: Empower 2 million women through clean cooking initiatives by providing training, employment, and leadership opportunities within the clean cooking sector by 2035.
- **Strategy**: Integrate gender considerations in clean cooking policies, ensuring women's active participation in decision-making and benefiting from time savings and health improvements.

### Policy Integration

- **Target**: Fully integrate clean cooking into national policies, including energy, health, and environmental strategies, by 2035.
- **Strategy**: Advocate for clean cooking as a national priority, establishing a dedicated coordination unit within the Ministry of Water and Energy to streamline policy, resource allocation, and monitoring.

### Infrastructure and Supply Chain

- **Target**: Establish a comprehensive distribution network for clean cooking fuels and technologies, covering at least 80% of Ethiopia's regions by 2035.
- **Strategy**: Develop regional hubs, enhance rural infrastructure, and create public-private partnerships to ensure supply chain efficiency and fuel availability.

## 2. Methodology

Multi-Tier Framework is used as it serves as a foundational tool for modeling and strategic planning aimed at improving access to clean cooking energy in Ethiopia. Unlike traditional binary assessments, the MTF introduces a nuanced, tiered system ranging from Tier 0 to Tier 5, which evaluates access based on several dimensions like cooking efficiency, exposure to harmful emissions, affordability, fuel availability, convenience, and safety. This detailed analysis helps in crafting interventions that are specifically tailored to meet the varied needs of Ethiopia's urban and rural populations.

The framework begins with establishing a baseline assessment of current cooking practices, drawing on data from sources like the World Bank's Ethiopia Report, national statistics, and strategic plans from the Ministry of Water and Energy. This baseline is crucial for setting realistic goals for the decade from 2025 to 2035.

From this baseline, three future scenarios are projected where those scenarios are aligned with Ethiopia's commitments under various international and national frameworks like the NDC, LT-LEDS, N-SEDS, and SDG 7, aiding in forecasting the required distribution and types of cookstoves, household coverage, and tier-level progress.

For data integration and cost estimation, the approach involves using a broad spectrum of data from the World Bank, SDG 7 tracking, IEA projections, WHO insights, and governmental inputs. Costs are analyzed considering inflation, technology costs, and market volatility, tailored to the economic diversity across Ethiopia's regions. This regional customization extends to considering local food practices, fuel availability, and socio-cultural preferences to ensure widespread adoption of clean cooking technologies.

The modeling process includes baseline data utilization, scenario development based on various factors, and rigorous validation through stakeholder engagements and benchmark comparisons. Data from numerous sources like the Ethiopia Statistical Agency, previous studies, and health data from WHO are integrated to form a comprehensive model that supports targeted, effective interventions.

Customization to regional and socio-cultural contexts involves deep research into local cooking habits, economic conditions, and cultural practices to ensure that clean cooking solutions are not only efficient but also culturally acceptable. Data harmonization across different sources, timelines, and formats is essential for accurate modeling, with validation through stakeholder consultations ensuring that the strategies are grounded in real-world applicability and feedback.

Key assumptions in the modeling include using the MTF survey from 2017/18 as the baseline, with scenarios crafted around economic, cultural, and policy factors. Continuous stakeholder engagement helps refine these parameters, making the model dynamic and reflective of both current conditions and future possibilities. This comprehensive approach not only addresses immediate needs but also sets a scalable and adaptable framework for long-term sustainable development in Ethiopia.

## 3. Identifying the Barriers and Drivers of Clean Cooking Technologies

In Ethiopia, the shift towards clean cooking technologies represents a vital step not only towards environmental sustainability but also towards enhancing public health, curbing deforestation, and improving socio-economic conditions. Traditional biomass fuels, predominantly used for cooking, contribute to severe indoor air pollution, exacerbating health conditions like respiratory diseases, and have detrimental environmental impacts such as deforestation and increased carbon emissions. However, the journey to widespread adoption of clean cooking solutions is rife with various obstacles that require strategic, multifaceted approaches to overcome. Here, we explore these barriers and drivers, drawing on international experiences to suggest practical strategies that can guide Ethiopia towards adopting cleaner, healthier cooking methods.

### 3.1. Identifying the Barriers and Drivers of Clean Cooking Technologies

**Affordability and Financial Barriers**: The high costs associated with both the initial purchase and ongoing use of clean cooking technologies pose significant challenges, especially in rural and economically disadvantaged regions. To address this, strategies include introducing flexible payment options like pay-as-you-go models, offering targeted subsidies, and utilizing carbon finance to fund clean cooking projects. Ethiopia could implement subsidy schemes, promote microfinance for easier access, and encourage local manufacturing to leverage economies of scale for cost reduction. The Ministry of Finance (MoF), along with Microfinance Institutions and the Ministry of Water and Energy (MoWE), are pivotal in executing these financial strategies, focusing on both immediate relief and long-term affordability.

**Awareness and Sociocultural Barriers**: The cultural preference for traditional cooking methods alongside a lack of awareness about clean cooking benefits presents significant hurdles. Strategies to overcome these include launching awareness campaigns that respect and integrate with local culture, involving community leaders and influencers, and promoting gender equality in decision-making processes. NGOs, Women Associations, and the Ministry of Women and Social Affairs are key players in these initiatives, aiming to transform cultural attitudes towards clean cooking.

**Technological and Supply Chain Barriers**: The supply of clean cooking technologies often lacks consistency, with high production costs and insufficient diversity of products that align with local needs. Strategies to tackle these issues involve creating decentralized distribution networks, providing financial support to local manufacturers, and investing in research for innovative solutions. Decentralized approach and use of carbon finance for technological innovation provide blueprints for Ethiopia. Here, the Ministry of Trade, alongside the private sector, should work on supply chain logistics, with the Ethiopian Standards Authority and universities ensuring technological standards and advancements.

**Policy and Institutional Barriers**: The lack of a cohesive policy framework and weak regulatory systems impede the adoption of clean cooking technologies. The strategy here includes developing a unified national strategy that aligns clean cooking with broader energy, health, and environmental goals while simplifying regulatory processes. The MoWE, in collaboration with the Environmental Protection Authority, must lead in policy integration and simplification to remove bureaucratic obstacles.

**Community Engagement Barriers**: Without community involvement, the adoption of clean cooking technologies will remain low. Strategies should focus on community education,

mapping local fuel resources, and ensuring that solutions are culturally appropriate. NGOs, community leaders, and Civil Society Organizations (CSOs) are essential in fostering community acceptance and ensuring that clean cooking technologies meet local needs.

**Financing Clean Cooking Initiatives**: The absence of tailored financial incentives can hinder progress in clean cooking technology adoption. Strategies include setting up targeted financing options, offering tax benefits, and integrating clean cooking into broader renewable energy financing mechanisms. Approach to blended finance, combining public and private funds, could be adapted in Ethiopia. The MoF, development banks, and the Revenue Authority are crucial in securing and directing these financial resources to support the widespread adoption of clean cooking technologies across the country.

In conclusion, Ethiopia's path to clean cooking involves addressing a complex array of barriers through coordinated, strategic actions that consider both local context and global best practices. This multifaceted approach is essential for achieving sustainable, health-enhancing, and environmentally friendly cooking practices nationwide.

**Overcoming Barriers in Fuel Availability and Infrastructure for Clean Cooking in Ethiopia** : Ensuring access to reliable and affordable fuels and developing adequate infrastructure are pivotal for the sustainable adoption of clean energy solutions in Ethiopia. Communities face challenges with inconsistent fuel supply, inadequate distribution networks, and insufficient infrastructure to support clean cooking technologies. Addressing these issues is crucial for promoting equitable access, increasing adoption rates, and achieving long-term sustainability.

**Advanced Biomass Stoves**: These stoves are essential for enhancing energy access while minimizing environmental impact over traditional methods. To elevate these stoves to Tier 3 and beyond, key modifications include gasification, secondary combustion for better efficiency and lower emissions, and advanced insulation. Efficiency is maximized through a holistic strategy involving combustion efficiency (40%), heat transfer efficiency (30%), emission reduction (20%), and user practices (10%)[9]. Combustion efficiency can be enhanced by optimizing the air-fuel ratio, refining combustion chamber design, and using pre-processed fuels. Heat transfer improvements involve better heat flow control, high thermal conductivity materials, and optimized stove-pot interaction[10]. Emission reductions are achieved via gasification, catalytic systems, and cleaner fuel types like pellets or briquettes, while user education ensures sustained efficiency.

**Electric Stoves**: These align with Ethiopia's renewable energy resources, but their adoption depends on proximity to the electricity grid. The 2024 World Bank report indicates that within 5 km of the grid, 34 million people and 7.4 million households (26.45% of total) reside, increasing to 87.4 million people and 19 million households within 25 km (67.92%). However, around 10% of households rely on informal electricity sharing due to limited grid access, highlighting affordability and coverage issues, particularly in rural areas. Urban areas are better positioned for electric stove use, but rural regions require infrastructure expansion, off-grid solutions, and affordable access strategies to enable clean cooking transitions.

**Biogas Stoves**: The potential for biogas in Ethiopia, as per the 2023 Policy Development Institute's analysis, is significant. About 14 million households have livestock, with 3.365 million potentially producing biogas and located within 5 km of waterways and owning at least four

[9] Smith, K.R. et al. (2011). Health Impacts of Household Energy and Indoor Air Pollution. Annual Review of Public Health.
[10] MacCarty, N., Still, D., & Ogle, D. (2010). Fuel use and emissions performance of fifty cooking stoves. Biomass and Bioenergy

cattle. This estimate requires further validation, but the potential includes not just cattle dung but also organic and agricultural waste. Large-scale biogas could offer higher efficiency, more energy output, and cost-effectiveness. In 2024, Ethiopia's 8.4 million tons of annual municipal solid waste could generate 120 MW if 30% were converted to biogas, alongside 2,500 MW from 60 million tons of crop residues and 730 MW from 70 million cattle's dung, significantly boosting clean energy access, reducing indoor pollution, and mitigating deforestation. Scaling up these initiatives is key to advancing Ethiopia's renewable energy goals and enhancing energy security.

**Solar Cooking**: Solar cooking represents an advanced clean cooking solution particularly suitable for communities far from the electrical grid. A GIS-based solar suitability map, validated by the Global Solar Atlas, has identified regions across Ethiopia with high solar potential, including Afar, Somali, Oromia, Dire Dawa, Amhara, and parts of Tigray, where annual solar irradiance exceeds 2000 kWh/m² ("Very High Suitability"), 1750-2000 kWh/m² ("High Suitability"), and 1500-1750 kWh/m² ("Moderate Suitability"). These areas are ideal for solar-based cooking technologies, offering a sustainable and practical option for remote and off-grid communities. Solar photovoltaic (PV) systems for cooking, with or without battery storage, have proven effective elsewhere, reducing reliance on traditional fuels, enhancing energy efficiency, and mitigating health issues from indoor air pollution. However, in Ethiopia, challenges like infrastructure, climate conditions, and consumer adoption must be considered. While solar thermal cooking solutions have been tested, their effectiveness can be limited by inconsistent sunlight and the need to adapt to local cooking practices. Lessons from other countries are valuable, but scaling in Ethiopia requires careful consideration of local context, leading to a small percentage being included in modeling analysis for those with high solar potential and living far from the grid.

**LPG Stoves**: Liquefied Petroleum Gas (LPG) penetration in Ethiopia is very small; however, it aligns with modern cooking practices. While the initial cost is low, the ongoing expense of purchasing LPG can be a barrier for low-income households as the cost of LPG is increasing. The government is gradually lifting the incentive, and its availability depends on infrastructure, which may be limited in rural or remote areas. Additionally, as it is a fossil fuel, it is not considered environmentally friendly. Safety concerns are also a major issue in Ethiopia, as there have been previous accidents related to LPG, causing many people to be afraid to use it. To promote LPG, the government must incentivize its use to make it affordable.

**Ethanol Stoves**: Gaia and SNV have done considerable work in promoting and distributing ethanol stoves. One of the biggest challenges is the price, which is increasing at an alarming rate. As of December 2024, the cost of 1 liter directly from the sugar corporation is 169 Ethiopian Birr, while outside the cost is more than twice that amount. Ethanol is highly demanded by the alcohol industry, leading to fierce competition. It is extremely hard to make it affordable for clean cooking stoves unless there is significant government intervention to incentivize at least a portion of that ethanol, like 20%, to go directly to ethanol stoves with high incentives. Besides focusing on sugar-based ethanol, bio-based ethanol production must also be promoted to diversify sources and potentially reduce costs.

In urban areas, LPG and electric stoves are preferred for their convenience and alignment with modern lifestyles, particularly when incentives are available for LPG adoption. In rural areas, advanced biomass stoves and biogas stoves are recommended as they leverage local resources and traditional practices. For low-income households, advanced biomass stoves and

biogas systems offer cost-effective solutions with low operational expenses. In regions with abundant sunlight, solar-powered stoves are ideal, especially when supported by financial models that reduce initial costs. In conclusion, selecting the appropriate clean cooking technology in Ethiopia requires a comprehensive assessment of cultural, financial, and logistical factors to ensure successful adoption and sustained use.

## 3.2. Drivers for Promoting Adoption of Clean Cooking Technologies

### 3.2.1. Policy Incentives and Awareness in Clean Cooking Adoption

Government Initiatives: Ethiopia's experience with the National Improved Cookstove Program (NICS) from 2013 to 2019 provides insights into promoting clean cooking. By distributing improved cookstoves across various governance levels, the program reduced reliance on traditional biomass fuels through financial incentives and market linkages. The establishment of a national clean cooking coordination unit is recommended to manage these efforts effectively. Ethiopia's draft energy policy further supports this by advocating for renewable energy and clean cooking, proposing financial incentives for research and development, national quality standards, and integration into broader health and environmental goals. To implement these initiatives, creating a National Clean Cooking Authority could streamline coordination, policy incentives should include tax exemptions and grants, quality standards must be enforced to build consumer trust, and clean cooking should be integrated into national health and environmental strategies.

**Public Awareness Campaigns**: Educational campaigns are crucial in promoting clean cooking by emphasizing the health, environmental, and economic benefits. Media campaigns across radio, TV, social media, and community events help showcase real-life testimonials and practical demonstrations, thereby increasing public understanding. Training programs for local technicians not only build technical capacity but also create employment opportunities. To enhance these efforts, multi-channel media campaigns should be designed to reach diverse demographics, educational workshops should be launched in various community settings, local influencers should be engaged to advocate for clean cooking, and technical training should be supported to foster job creation. The campaign involves mapping and engaging stakeholders to align efforts, conducting baseline surveys to understand existing practices, advocating for supportive policies, and providing educational outreach through training sessions and workshops. Behavioral interventions use psychological nudges and gamification to encourage adoption. Community mobilization includes setting up demonstration hubs, working with local leaders, and using media and influencers for broader outreach. Financial subsidies and incentives are promoted to enhance accessibility, integrating clean cooking with existing development programs. Continuous monitoring and evaluation should be part of these campaigns to adapt strategies based on feedback and actual outcomes.

### 3.2.2. Technological Advancements

Advancements in technology are essential for the promotion of clean cooking. This includes improving the efficiency and performance of cookstoves through academic collaborations, reducing costs via advanced manufacturing, increasing fuel diversity, and making designs more user-friendly by considering cultural preferences. Integration with modern energy systems like solar power, the use of data through IoT for real-time monitoring, reducing emissions, and

offering scalable, customizable solutions are all pivotal developments. To drive these advancements, there should be investment in research and development, promotion of affordable local manufacturing, development of user-friendly products with community input, and expansion of fuel options to match local sustainability.

### 3.2.3. Economic and Demographic Shifts

The economic landscape, with investments from both domestic and international sources, supports the affordability of clean cooking solutions. Urbanization drives demand as infrastructure and income levels rise, making these technologies more accessible. The demographic challenge involves managing population growth while expanding clean cooking access. Gender dynamics are significant, with women and children benefiting most from reduced exposure to traditional cooking methods. To leverage these shifts, initial focus should be on urban markets, tailored programs should address rural needs, and gender-inclusive programs should empower women through training and roles in the clean cooking sector.

### 3.2.4. International Support and Funding

International support through financial mechanisms like the Clean Cooking Fund is vital. To harness this support, global partnerships should be forged to share knowledge and resources, access to carbon financing should be pursued to fund initiatives, and advocacy for international policies that support clean cooking should be intensified, focusing on technology transfer and financial aid.

### 3.2.5. Community Engagement and Education

Community engagement and education are critical for ensuring that clean cooking technologies meet local needs and gain acceptance. This involves involving communities in technology design, educating them on the benefits, and using culturally sensitive advocacy strategies. To achieve this, community-led design should be practiced, local education campaigns should be tailored to cultural contexts, culturally sensitive advocacy should use local cultural platforms, and there should be a mechanism for ongoing feedback to adapt technologies and strategies to community preferences.

Based on the key findings from the UNDP's previous assignment on "Scoping of Ongoing Clean Cooking Initiatives and Stakeholder Analysis, Existing Policies, Regulations and Institutional Frameworks, and Financing Mechanisms," it is recommended to establish a dedicated national clean cooking coordination unit as shown in Figure 6. This unit should operate across national, regional, zonal, woreda, and Kebele levels, aligning with governance structures at each level to effectively implement clean cooking initiatives. More details can be referred to in the original documents, including detailed stakeholder mapping and analysis, as well as recommendations for institutional frameworks, financing mechanisms, and implementation strategies critical for advancing Ethiopia's Clean Cooking Roadmap.

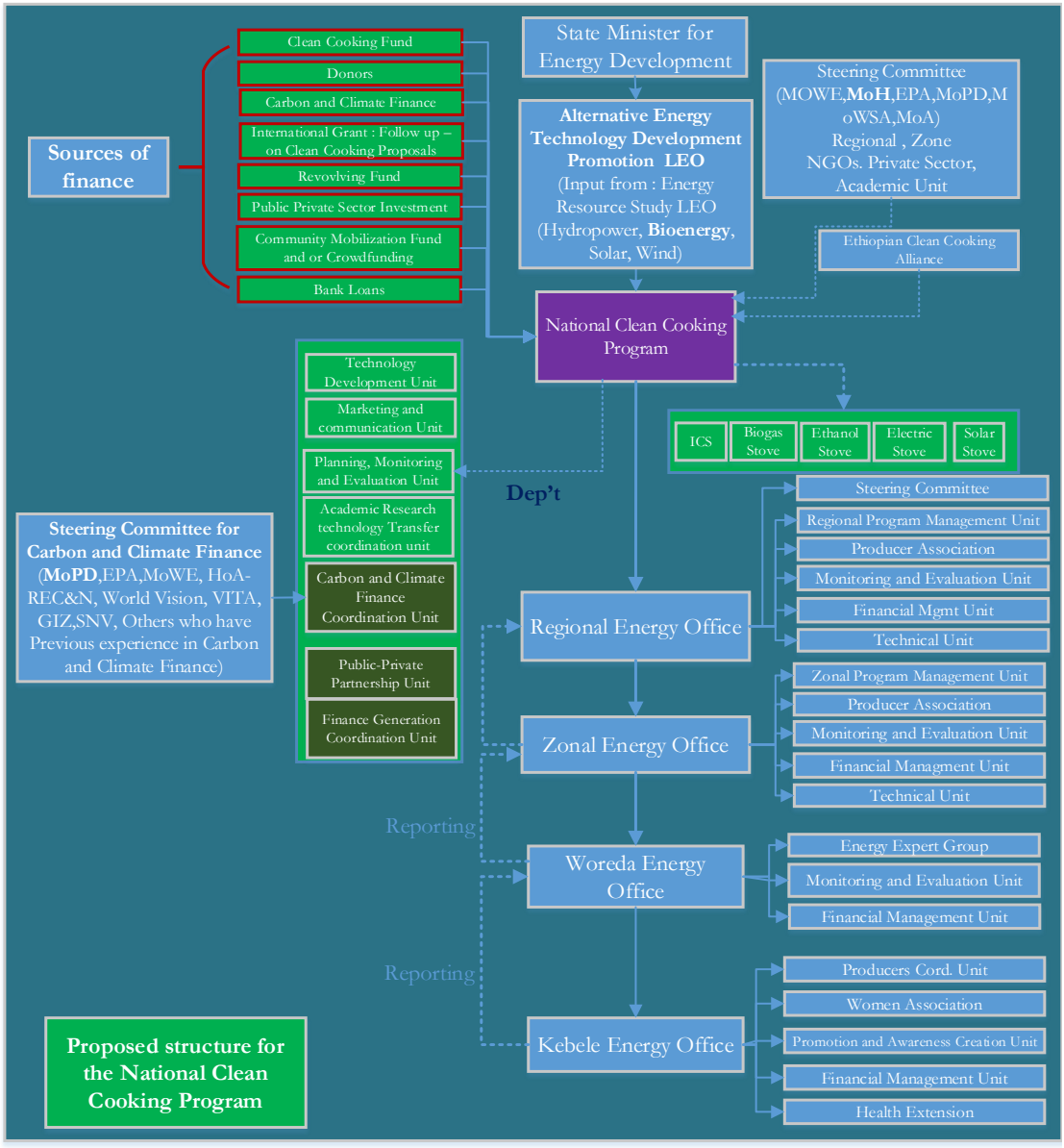



*Figure 1:Proposed Structure for the National Clean Cooking Program*[11]

**Strategies for Raising Awareness and Promoting Clean Cooking Solutions :** To effectively raise awareness and promote behavioral shifts toward clean cooking solutions, a multifaceted approach is essential, encompassing **education, community engagement, and targeted communication** to address the various factors influencing cooking practices. One key strategy is **community engagement** through **peer-led initiatives**, where **local influencers and community leaders** demonstrate the benefits of clean cooking technologies. Peer-led promotion and community cooking demonstrations can effectively encourage adoption. **Workshops and practical training sessions** are also crucial,

[11] Findings of UNDP's previous assignment on "Scoping of Ongoing Clean Cooking Initiatives and Stakeholder Analysis, Existing Policies, Regulations and Institutional Frameworks, and Financing Mechanisms".

providing communities with the knowledge needed to understand the health, environmental, and economic advantages of clean cooking.

In terms of communication, **mass media campaigns, including radio, television, and billboards**, can help reach a broader audience and raise awareness, while social media engagement allows for targeted outreach, especially to younger, digitally connected demographics. To further incentivize adoption, financial incentives such as subsidies or discounts can reduce the initial cost barrier for households, making the transition to clean cooking technologies more accessible. Additionally, **loyalty programs** that reward consistent use can encourage sustained adoption over time.

Collaboration with government stakeholders is also essential for integrating clean cooking solutions into national energy policies, ensuring alignment with broader development goals. **Advocacy** for regulatory support is equally important to promote the production and distribution of clean cooking technologies. Finally, monitoring and evaluating the impact of awareness campaigns and behavioral change initiatives allows stakeholders to assess their effectiveness, while community feedback channels provide insights into user experiences, helping to adapt strategies to better meet local needs.

Thus, by implementing these strategies, stakeholders can create a supportive environment that fosters the adoption of clean cooking solutions, leading to improved health, environmental sustainability, and economic benefits for communities. In conclusion, a **well-rounded approach combining education, communication, incentives, policy support, and continuous feedback** will ensure the widespread adoption of clean cooking solutions, ultimately contributing to the betterment of public health, the environment, and economic well-being.

| Major Activities for Awareness and Behavior Change Campaigns | | |
|---|---|---|
| **Sr. #** | **Major Activities** | **Description** |
| **1** | Stakeholder Mapping and Engagement | • Identify key stakeholders, including local communities, influencers, policymakers, and private sector partners.<br>• Organize stakeholder workshops to ensure alignment and support for awareness campaigns. |
| 2 | Baseline Surveys and Community Assessments | • Conduct surveys to understand current cooking practices, barriers to adoption, and perceptions of clean cooking technologies.<br>• Use insights to tailor campaign messages to specific demographic and cultural contexts. |
| 3 | Advocacy for Policy Support | • Advocate for supportive policies that prioritize clean cooking access, and include campaign messaging that highlights government commitment to sustainable cooking practices. |
| 4 | Stakeholder Engagement | • Conduct workshops and forums with local leaders, community influencers, and policymakers to emphasize the importance of clean cooking solutions.<br>• Collaborate with non-governmental organizations (NGOs), private sector actors, and international partners to amplify campaign reach. |
| 5 | Public Awareness Campaigns | • Introduce hands-on training sessions for households to familiarize them with clean cooking devices.<br>• Share data and case studies on the health benefits of reduced indoor air pollution and environmental sustainability.<br>• Collaborate with healthcare professionals to highlight clean |

| | | |
|---|---|---|
| | | cooking's role in reducing respiratory diseases.<br>• Develop and disseminate multimedia content, including videos, radio programs, and social media posts, highlighting the benefits of clean cooking solutions (e.g., health, time savings, environmental benefits).<br>• Organize roadshows, public demonstrations, and community events to showcase clean cooking technologies in action.<br>• Organize contests or incentives to encourage adoption and consistent use of clean cooking technologies. |
| 6 | Educational Outreach and Campaigns in Schools | • Conduct targeted education programs in schools, women's groups, and community centers to teach the long-term benefits of clean cooking.<br>• Create easy-to-understand infographics, posters, and brochures tailored to different literacy levels.<br>• Integrate clean cooking awareness into school curricula, emphasizing health, environmental, and economic benefits.<br>• Conduct cooking competitions or activities for students to engage families indirectly. |
| 7 | Behavioral Science Interventions | • Use behavioral nudges, such as commitment pledges or incentive programs, to encourage households to adopt clean cooking practices.<br>• Introduce gamified elements (e.g., community competitions) to motivate sustainable behavior changes. |
| 8 | Community Outreach and Mobilization: | • Establish cooking demonstration hubs where households can experience the efficiency and ease of clean cooking technologies.<br>• Provide hands-on training to women and other household members on using and maintaining clean cooking appliances.<br>• Conduct community meetings, cooking demonstrations, and roadshows to showcase the benefits of clean cooking solutions.<br>• Engage local leaders, women's groups, and youth organizations to serve as ambassadors for clean cooking technologies. |
| 9 | Leveraging Media and Influencers | • Develop and disseminate messages via radio, television, and social media platforms to reach a broad audience.<br>• Develop interactive digital tools, such as mobile apps or SMS services, providing tips on clean cooking and maintenance.<br>• Partner with local radio stations and TV channels to air relatable stories and testimonials from early adopters of clean cooking solutions.<br>• Engage community influencers, including local celebrities and faith leaders, to endorse clean cooking practices.<br>• Launch targeted social media campaigns with hashtags, challenges, and influencers to engage younger audiences.<br>• Create culturally relevant content, including stories, testimonials, and drama series, showcasing the benefits of clean cooking solutions. |

| | | |
|---|---|---|
| **10** | Subsidies and Incentive Awareness | • Promote financial programs such as subsidies, RBF models, or microloans that make clean cooking technologies more accessible.<br>• Highlight success stories of individuals or communities that benefited economically and socially from the transition. |
| **11** | Integration with Existing Programs and Partner with Private Sector and NGOs | • Incorporate clean cooking awareness into broader development programs such as health, education, and women empowerment initiatives to leverage existing networks.<br>• Collaborate with manufacturers and distributors to promote and subsidize clean cooking technologies.<br>• Partner with NGOs to amplify outreach and ensure sustained engagement |
| **12** | Monitoring and Feedback Mechanisms | • Deploy surveys and community feedback sessions to gauge public awareness and address concerns or misconceptions about clean cooking.<br>• Use insights to refine and adapt messaging strategies for future campaigns. |

## 4. Adoption Scenarios

The adoption scenarios were proposed considering Ethiopia's national and international commitments and goals up to 2030, including SDG7, NDC targets, and the Long-Term Low-Emission Development Strategy (LT-LEDS), as well as projected data for 2024 from the World Bank and international agency reports on access to clean cooking in Ethiopia, which is estimated to reach 9.8% by 2024. These scenarios integrate Ethiopia's urbanization rate, population growth, regional population variations, and the distinct needs and setups of urban and rural areas. They also account for the diverse cultural preferences and requirements of each region, the availability of clean cooking fuels, and the country's current status regarding access to clean cooking solutions. Insights from the Multi-Tier Framework (MTF) study conducted by the World Bank in 2018 were used as a baseline for evaluating the adoption of clean cooking technologies and setting targets for the roadmap. To ensure practical and achievable outcomes, the scenarios incorporate realistic projections grounded in MTF criteria, evaluating access across dimensions such as stove efficiency, indoor air pollution exposure, safety, affordability, convenience, durability, and reliability.

Besides, these scenarios align with Ethiopia's Clean Cooking Plan, providing a comprehensive pathway to accelerate the transition to higher-tier clean cooking solutions while addressing the unique challenges and opportunities within the Ethiopian context. The scenarios focus on achieving Tier 3 and above, as defined by the Global Alliance for Clean Cooking, representing progressive advancements in cooking technologies and fuels. Starting with Tier 3, these offer significantly higher efficiency and substantial reductions in emissions compared to basic improved stoves. Tier 4 technologies provide advanced clean cooking options with very high efficiency, minimal indoor air pollution, and enhanced safety, often using clean fuels such as LPG, biogas, ethanol, or electricity. At the highest level, Tier 5 technologies deliver optimal clean cooking solutions with near-zero emissions and reliance on renewable energy systems.

The integration of LT-LEDS into these scenarios emphasizes long-term planning for low-emission pathways, ensuring that the transition to clean cooking is sustainable and aligned with Ethiopia's broader climate goals. By prioritizing these tiers, the scenarios emphasize health

improvements, environmental sustainability, and social equity, aligning with Ethiopia's ambition to achieve meaningful and lasting impacts through its clean cooking initiatives.

## 4.1. Scenario Development Methodology - Development of Three Adoption Scenarios Based on Barriers, Drivers, and MTF Criteria

Multi-Tier Framework (MTF), alongside existing barriers and drivers for clean cooking in Ethiopia, was used to comprehensively evaluate cooking technologies. This framework uses six attributes for its evaluation: **exposure, efficiency, convenience, fuel availability, safety, and affordability**[12]. These attributes collectively determine the overall performance and suitability of a stove, assigning them to one of five tiers (1 being the lowest and 5 the highest). The following analysis and table offer an in-depth assessment of various cooking technologies, highlighting their tier classifications based on the MTF design.

## Explanation of Tier Assignment and Technologies Adopted for Ethiopia's Clean Cooking Roadmap

- **Electric Stove**: Performs exceptionally well in exposure, efficiency, convenience, fuel availability, and safety, qualifying as **Tier 5**. Affordability may limit some users, dropping it to **Tier 4** in specific contexts.
- **Biogas Stove**: Strong overall performance, slightly limited by feedstock reliance and moderate affordability, qualifying it as **Tier 4**.
- **Advanced Biomass Stove (Tier 3+):** Meets **Tier 3** requirements with moderate performance across exposure, efficiency, and affordability, but convenience and safety lag behind.
- **Solar Stove**: Safety and zero emissions boost it to **Tier 5** for some attributes, but reliance on sunlight and limited convenience place it between **Tier 3 and 4**.
- **LPG/Ethanol Stoves**: Consistently strong across attributes, especially in convenience, safety, and exposure, qualifying as **Tier 4**.

*Table 1: Tier Classification Adopted for Ethiopian Access to Clean Cooking Roadmap*

| Attribute | Electric Stove (Tier 5) | Biogas Stove (Tier 4) | Advanced Biomass Stove Tier 3+ | Solar Stove (Tier 3-4) | LPG/Ethanol Stoves (Tier 4) |
|---|---|---|---|---|---|
| **Exposure** | **Tier 5**: No emissions. | **Tier 4**: Minimal emissions. | **Tier 3**: Reduced emissions compared to traditional stoves. | **Tier 5**: Zero emissions. | **Tier 4**: Minimal emissions. |
| **Efficiency** | **Tier 5**: High efficiency | **Tier 4**: Good efficiency | **Tier 3**: Moderate efficiency | **Tier 4**: Moderate efficiency (varies by sunlight). | **Tier 4**: Good efficiency |
| **Convenience** | **Tier 5**: Highly convenient. | **Tier 4**: Convenient but requires biogas system upkeep. | **Tier 3**: Moderate convenience (preparation needed). | **Tier 3**: Low convenience (sunlight-dependent). | **Tier 4**: Highly convenient. |
| **Fuel** | **Tier 5**: | **Tier 4**: | **Tier 3**: Biomass | **Tier 3**: | **Tier 4**: |

[12] Multi-Tier Framework for Cooking: A Comprehensive Assessment Method to Measure Access to Modern Energy Cooking Services

| | | | | | |
|---|---|---|---|---|---|
| **Availability** | Reliable with stable electricity. | Dependent on digester feedstock. | availability can vary. | Sunlight availability-dependent. | Reliable in urban and semi-urban areas. |
| **Safety** | **Tier 5**: Very safe with proper installation. | **Tier 4**: Safe with occasional risks (leaks). | **Tier 3**: Moderate safety (fire/burn risks). | **Tier 5**: Extremely safe, no combustion. | **Tier 4**: Safe with minor risks. |
| **Affordability** | **Tier 3-4**: High upfront, variable costs. | **Tier 4**: Moderate upfront and feedstock costs. | **Tier 3**: Low upfront, moderate labor/fuel costs. | **Tier 3**: High upfront, zero operational costs. | **Tier 4**: Moderate upfront, variable fuel costs. |

For scenario development, understanding the existing situation and data related to access to clean cooking is crucial. This analysis is based on reports such as **SDG 7 Tracking**, the **World Health Organization Report** [13], and projections from the **International Energy Agency**[14], the **World Bank Report of 2018 on Ethiopia – Beyond Connections: Energy Access Diagnostic Report Based on the Multi-Tier Framework**[15] provides insights into Ethiopia's clean cooking access rates from 2018 to 2024. The data for 2024, being the most recent, has been considered as the baseline for analysis. The clean cooking access rates over the years are as follows: **2018 - 6.0%, 2019 - 6.6%, 2020 - 7.4%, 2021 - 8.0%, 2022 - 8.8%, 2023 - 9.3%, 2024 - 9.8%**. **Thus, 2024 is used as the baseline, as our scenario development focuses on the period from 2025 to 2030.**

## 4.2. Description of Three Adoption Scenarios

### 4.2.1. BAU Scenario : Business-as-Usual Scenario

To model the Business-as-Usual (BAU) scenario for clean cooking from 2024 to 2035, the baseline year (2024) is established with an estimated access to clean cooking at 9.8 %, based on the International Energy Agency Report (2024)[16]. Over this period, Ethiopia's population is projected to grow substantially, from 109 million in 2024 to 127.15 million by 2035[17]. This growth is characterized by significant urbanization trends, with the share of the urban population increasing from 23.8% in 2024 to 28.95% by 2035. Conversely, the rural population share is expected to decline from 76.2% to 71.05% over the same period. These shifts reflect broader demographic changes that influence household dynamics and access to clean cooking solutions. The total number of households is also projected to grow significantly, from 23.28 million in 2024 to 27.47 million in 2035. Urban households are anticipated to increase from 7.40 million to 10.20 million, reflecting the rising urban population. Meanwhile, rural households will grow at a slower pace, from 15.88 million in 2024 to 17.27 million in 2035. Average household sizes remain constant, with urban households averaging 4.0 persons and rural households 5.0 persons. In this BAU scenario, it is assumed that no new policies or programs will be implemented to accelerate access to clean cooking. The scenario reflects static market

[13] Proportion of population with primary reliance on clean fuels and technologies for cooking (%)
[14] Access to clean cooking – SDG7: Data and Projections – Analysis - IEA
[15] Padam, Gouthami, et al. *Ethiopia–Beyond connections: energy access diagnostic report based on the multi-tier framework*. World Bank, 2018.
[16] Access to clean cooking – SDG7: Data and Projections – Analysis - IEA
[17] National Bank of Eth 2022-23 Annual Report

dynamics, modest income growth, and demographic trends, including urbanization. Given these assumptions, urban households are expected to adopt cleaner cooking fuels more readily than their rural counterparts due to better access to infrastructure and resources.

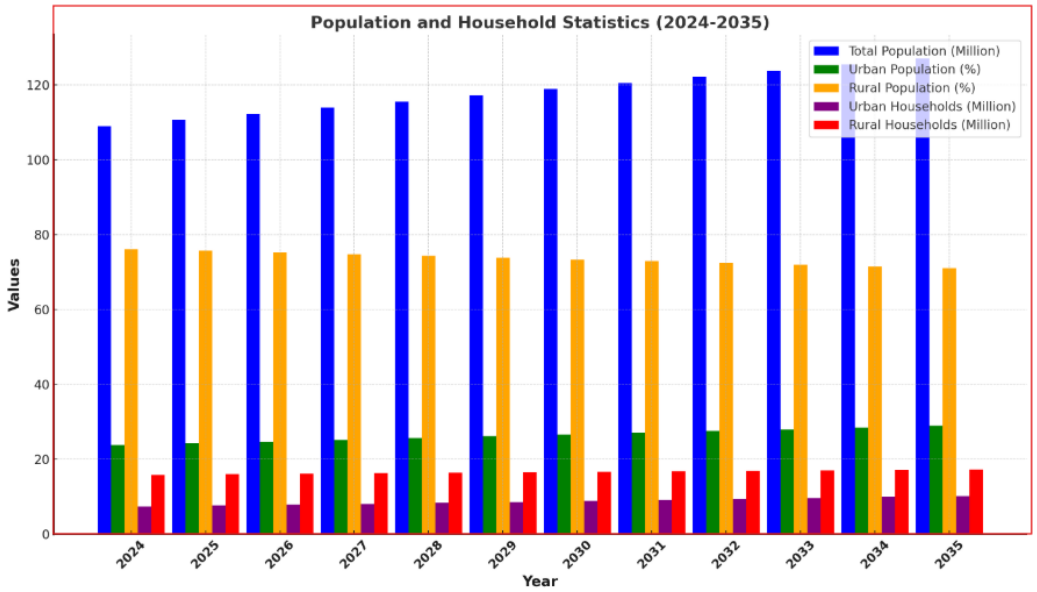



*Figure 2: Population, Household Projections (2024-2035)*[18,19]

### 4.2.2. Scenario 1: Conservative Growth in line with the National Sustainable Energy Development Strategy (N-SEDS) of Ethiopia

This scenario was performed in line with the National Sustainable Energy Development Strategy (N-SEDS) of Ethiopia (2024 - 2030), which outlines an approach to advancing clean cooking technologies. The strategy aims to increase the penetration of electric stoves to 25.4% of the total household population by 2030, up from a baseline of 6.75% in 2022. Similarly, the adoption of improved cookstoves is projected to reach 25.73 % of households, starting from a baseline of 15.68 % in 2022. The biogas goal is set to reach 0.54 % of households by 2030, compared to 0.15 % in 2022, while the share of LPG use is projected to remain at 1 % of households, consistent with the baseline assumption of 1 % for the overall population. Thus, the National Sustainable Energy Development Strategy (N-SEDS) of Ethiopia (2024 - 2030) places a greater focus on the adoption of electric stoves and improved cookstoves. For this assignment, the timeline is extended until 2035 (2025 - 2035). Thus, considering the existing strategy as part of the scenario shows the alignment of this assignment to be in line with the existing national goals, plans, strategy, and international commitments. This Scenarios based on the National Sustainable Energy Development Strategy (N-SEDS) of Ethiopia (2024-2030) assumes that promoting clean cooking technologies will be supported by policy frameworks, resource efficiency, and stakeholder collaboration to enhance affordability, accessibility, gender inclusion, Infrastructure development related to grid connection, environmental goals and environmental sustainability. While developing all these scenarios, several factors were carefully considered, including the existing situation and penetration rate of clean cooking technologies, cooking culture, realistic ground realities, availability of fuels and resources in specific regions,

[18] Ethiopian Central Statistics Agency and World Bank (2024), Number of Household in Rural and Urban Population: Ethiopia
[19] National Bank of Eth 2022-23 Annual Report

urbanization rates, regional population variations, the number of households within a reasonable distance from the grid, access to water and feedstock availability for biogas interventions, and current cooking trends and technologies in use. Additionally, the scenarios are driven by targeted interventions focusing on specific regions or demographics within the 2025 to 2035 timeframe, aligning with the Multi-Tier Framework (MTF), which assesses clean cooking technologies based on six attributes: convenience (ease of use), fuel availability (reliability of supply), safety (risk levels), affordability (cost relative to income), efficiency (fuel-to-heat conversion), and exposure (pollution levels during cooking). The anticipated outcomes of this scenario include **reduced deforestation and carbon emissions, improved air quality, enhanced public health, and better livelihoods** for communities engaged in the production and distribution of clean cooking solutions. It has to be noted that between 2025 and 2035, Ethiopia's population is projected to grow steadily, starting from 110.65 million in 2025 and reaching 127.15 million by 2035, according to data from the Ethiopian Statistical Agency. By 2025, the urban population is expected to account for 24.28% of the total, with the rural population making up 75.72%. By 2035, the urban population is projected to rise to 28.96%, while the rural population will decrease to 71.04%. This demographic shift underscores the importance of promoting clean cooking solutions across both urban and rural areas, ensuring that as urbanization increases, access to efficient and sustainable cooking technologies remains a priority for all populations.

This scenario was designed to increase the penetration of electric stoves to 25.4 %, improved cookstoves to 25.73 %, and biogas to 0.54 % of households by 2030, achieving an overall emission reduction of up to 48.75 Mt $CO_2$-eq by 2035 and reaching approximately 46 % access to clean cooking by 2035. A detailed review of progress after 2030 is essential to guide the path toward 2035, with an overall distribution of approximately 22 million cookstoves.

**Expected outcomes from the Conservative Growth Scenario analysis** include: the distribution of a substantial number of cookstoves, widespread adoption by households, and the provision of clean cooking solutions to a significant portion of the population, resulting in considerable $CO_2$ equivalent reductions. National and regional cookstove distribution targets will be met, with a balanced focus on urban and rural areas, improving the rate of access to clean cooking technologies over the years.

The scenario also anticipates manageable cost implications for the overall cookstove program, with detailed cost sharing among regions tracked annually and cumulatively until 2035. **This cost-effective approach will primarily rely on advanced biomass stoves as a transitional solution paving the way for the adoption of Electric Stoves** followed by other clean cooking technologies, such biogas, solar, LPG, and ethanol, to achieve the majority of clean cooking goals.

### 4.2.3. Scenario 2: Moderate Intervention

This scenario represents a more proactive strategy that is in line with NDC goals of Ethiopia to promote clean cooking, emphasizing increased investment in research and development, expanded access to financing, and the establishment of stronger regulatory frameworks. The primary objective is to accelerate the transition to clean cooking technologies while maintaining a balance between economic and social considerations.

The approach combines market-based solutions with targeted government interventions, fostering a balanced pathway to progress. It focuses on scaling up proven technologies and

encouraging innovation, supported by financial incentives and subsidies designed to boost the adoption of clean cooking solutions.

This scenario was performed considering that the emissions reduction of 50 million tons of $CO_2$ equivalent ($MTCO_2e$) from 2025 - 2030 and an additional 25 million tons of $CO_2$ equivalent ($MTCO_2e$) from 2031 to 2035 will be achieved in line with the NDC goals . Advanced improved cookstoves with Tier 3 and above contribute 45%, electric stoves account for 50%, while biogas and solar solutions each contribute 2.5%, aiming to achieve the stated target of reducing 75 million tons of $CO_2$ equivalent from 2025 - 2035.

Expected outcomes include a significant reduction in air pollution and greenhouse gas emissions, improved health outcomes for millions of people, and stimulated economic growth through job creation in the clean cooking sector. This scenario aligns with Ethiopia's Nationally Determined Contributions (NDC), which aim to reduce $CO_2$ equivalent emissions by 50 million tons between 2025 and 2030. Additionally, there is a target for a further reduction of 25 million tons of $CO_2$ equivalent from 2031 to 2035. This scenario will reduce a total of 75 million tons of $CO_2$ equivalent between 2025 and 2035.

### 4.2.4. Scenario 3: Aggressive Transformation

This scenario was performed by envisioning a radical shift towards universal access to clean cooking, driven by substantial investments in infrastructure, technology, and policy reforms. The primary goal is to rapidly phase out traditional cooking methods and replace them with clean and sustainable solutions.

The approach focuses on rapid transformation through significant investments in research, development, and deployment of clean cooking technologies. A strong policy framework enforces strict regulations to limit the use of polluting fuels and technologies. Innovative financing mechanisms, such as public-private partnerships and blended finance models, are employed to mobilize the resources needed for this ambitious transition.

The scenario aligns with Ethiopia's Long-Term Low Emission Development Strategy, targeting a reduction potential of 100 million tons of $CO_2$ equivalent ($MTCO_2e$) from 2025 to 2035, in support of the country's long-term emission reduction objectives. This will be achieved through $CO_2$ equivalent reduction contributions of 25% from advanced improved cookstoves meeting Tier 3 and above, 70% from the transition to electric cooking, 3.5% from adopting biogas, and 1.5% from utilizing solar, LPG, and ethanol cooking technologies. These efforts significantly advance Ethiopia's ambitious climate goals by promoting clean cooking solutions and fostering sustainable practices nationwide.

The potential outcomes include a drastic reduction in air pollution and climate change impacts, substantial improvements in public health and well-being for Millions of people in Ethiopia both in Urban and rural areas, and significant economic benefits, such as job creation and reduced healthcare costs. However, the scenario also acknowledges challenges, including ensuring equitable access and managing potential social and economic disruptions.

Additional considerations emphasize the importance of contextual factors, tailoring approaches to specific countries or regions based on their economic development, infrastructure, and cultural practices. Stakeholder engagement is critical, requiring active participation from governments, businesses, NGOs, and communities. Monitoring and evaluation are also essential to regularly assess progress, adapt strategies, and ensure accountability.

## 4.3. Regional and Community-Specific Customizations

The three scenarios were performed considering the unique needs and conditions of different regions and communities. The Regional and Community-Specific Customizations in clean cooking technologies focused on tailoring solutions based on several critical factors. These included cultural preferences in cooking, ensuring that the technology aligned with local cooking traditions for greater acceptance. Regional share variation was also considered, where household numbers and energy demands differed, allowing solutions to match the scale of need. Fuel availability played a key role, with technologies adapted to local fuel resources.

For example, in Afar, with its large-scale solar energy potential, livestock population, and existing agricultural production practices, solar stoves, biogas, and biomass charcoal stoves were ideal. Therefore, during the scenario analysis, cultural cooking practices, potential fuel sources, fuel assessments, and preferred cookstove technologies, based on regional practices and future trends, were considered for each region.

The affordability of the clean technology, a crucial factor for the adoption of clean cooking technologies, relative to income levels, ensured it was accessible, while ease of use was prioritized, especially in areas with lower literacy and technical skills.

## 4.4. Alignment with National Targets In Climate (N-SEDS, NDC, LT-LEDS) and SDG 7 Targets

The three adoption scenarios were designed to align with the National Sustainable Energy Development Strategy (N-SEDS) of Ethiopia, Ethiopia's Nationally Determined Contributions (NDC), Long-Term Low-Emission Development Strategy (LT-LEDS), and the Sustainable Development Goal (SDG) 7 targets. These scenarios integrate Ethiopia's demographic trends, such as urbanization and population growth, while addressing regional and cultural variations. They focus on achieving progressive advancements in cooking technologies, emphasizing health, environmental sustainability, and social equity. The scenarios include realistic projections based on the Multi-Tier Framework (MTF), ensuring they address all six attributes: stove efficiency, indoor air pollution exposure, safety, affordability, convenience, and fuel availability. This comprehensive approach ultimately supports Ethiopia's commitment to reducing emissions and expanding clean cooking access. Among the three options, which one we should adopt as a country is closely linked to the cost implications, as will be discussed later.

# 5. Quantifying Potential Adoption Rates

## 5.1. Methodology for Projecting Adoption Targets (2025-2035)

The methodology for projecting adoption targets is based on a scenario-driven approach that integrates Ethiopia's socio-economic context, energy policies, and climate commitments. Using the Multi-Tier Framework (MTF) as the analytical foundation, the modeling incorporates baseline data from the World Bank's 2018 survey, national statistics, and energy access trends. Three adoption scenarios: **Conservative Growth, Moderate Intervention, and Aggressive Transformation** are developed to reflect varying levels of policy and investment efforts. The methodology evaluates factors such as population growth, urbanization, income trends, and the availability of infrastructure and clean fuels. Quantitative projections estimate adoption rates under each scenario, defining the proportion of households transitioning to clean cooking technologies annually. Cost and investment estimates are calculated alongside tier-level progressions, ensuring alignment with Ethiopia's national targets, including the N-SEDS, NDC,

LT-LEDS, and SDG 7. This structured approach provides actionable insights for achieving clean cooking access from 2025 to 2035.

**Key Factors Considered:** The adoption of clean cooking technologies in Ethiopia is influenced by several critical factors, including **affordability, awareness, population growth, and urbanization trends**, which drive faster adoption in urban areas with better access to electricity and infrastructure. **Cultural preferences and previous cooking experiences** significantly shape acceptance, emphasizing the need for user-friendly, culturally appropriate designs. **Access to fuel sources** varies widely, with urban households benefiting from electricity and other modern gases and liquid fuel while rural areas might majorly depend on biomass and to a small extent biogas in the Ethiopian context. Ethiopia's renewable energy strategies and grid extension plans enhance the potential for electric cooking, particularly in peri-urban regions. The increasing number of households, driven by demographic growth and urban expansion, underscores the urgency to scale up clean cooking solutions, aligning with the nation's commitments under frameworks like N-SEDS, NDC, and LT-LEDS to set realistic adoption targets for 2025-2035. Additionally, the health impacts of household air pollution highlight the importance of transitioning to cleaner cooking methods to improve public health outcomes. Gender dynamics also play a role, as studies have shown that women, who are often the primary users of cooking technologies, may have different adoption behaviors influenced by social factors and access to resources.

**Population Growth**: Figure 8 presents the population and household trends from 2024 to 2035, based on data from the Ethiopian Statistical Agency. According to these projections, Ethiopia's population is expected to increase from 109 million in 2024 to 127.15 million by 2035. During this period, the average household size is anticipated to stay at 4.6 persons, with urban households averaging around 4 individuals and rural ones at about 5. The population distribution across regions in Ethiopia, as per the July 2024 projections by the Ethiopian Central Statistical Agency, shows Oromia leading with 37.65%, followed by Amhara at 21.38%, South at 6.99%, Somali at 6.13%, Central at 5.78%, Tigray at 5.38%, Sidama at 4.88%, South West at 3.87%, Addis Ababa at 3.63%, Afar at 1.91%, Benishangul-Gumuz at 1.15%, Dire Dawa at 0.51%, Gambella at 0.48%, and Harari at 0.26%. This population growth significantly increase the demand for clean cooking solutions.

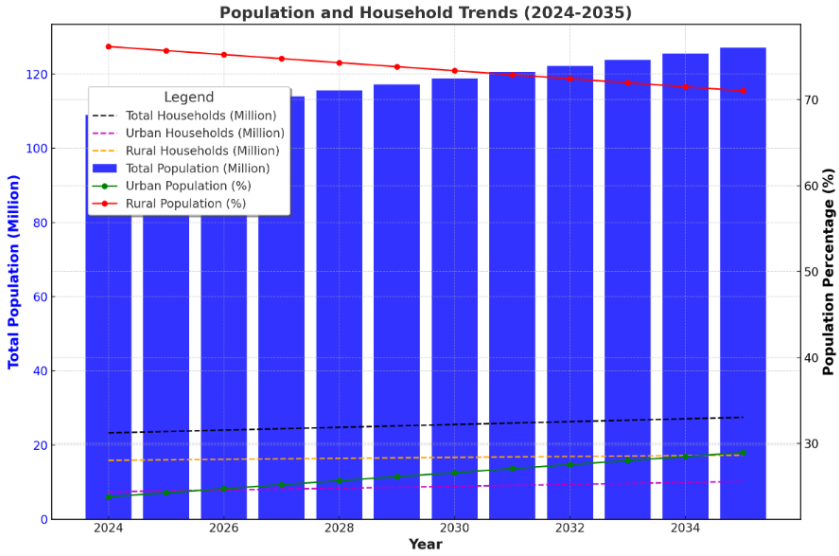



*Figure 3 : Population and Household Trends (2024 - 2025) based on Ethiopian Statistical Agency data.*

**Urbanization Trends**: Ethiopia is witnessing a trend towards urbanization, with the urban population share projected to rise from 23.8% in 2024 to 28.96% by 2035, while the rural population share decreases. This shift will see urban households increase from 7.40 million in 2024 to 10.20 million by 2035. The implications for clean cooking are that urban areas might adopt clean technologies more rapidly due to better infrastructure, higher awareness, and potentially greater financial resources. However, this also means that rural areas will require specific, targeted interventions to ensure equitable access to clean cooking solutions, addressing the unique challenges these areas face.

**Economic Indicators**: Economic forecasts suggest modest growth for Ethiopia, which, coupled with high inflation rates (close to 19% in 2024) and a 7% interest rate, implies a 12% average discount rate for financial analyses. This scenario reduces purchasing power, making imported clean cooking technologies and fuels more expensive. The persistent income disparities between urban and rural populations further complicate the affordability of clean cooking solutions. For clean cooking initiatives to succeed, it's critical to implement subsidies, promote local stove production, and develop affordable financing mechanisms to mitigate these economic barriers, particularly in less affluent rural areas.

**Energy Policies** : Ethiopia's energy policies, including the National Strategy for Energy Development (N-SEDS), Nationally Determined Contributions (NDC), Long-term Low Emission Development Strategy (LT-LEDS), and alignment with Sustainable Development Goal 7 (SDG 7), focus on reducing $CO_2$ emissions and enhancing access to renewable energy solutions. While these policies theoretically support the adoption of clean cooking, practical challenges in implementation remain. For clean cooking to gain traction, it's essential that policy support is not only in place but also effectively implemented. Strengthening policy execution through financial incentives and regulatory frameworks will be key in aligning clean cooking adoption with broader climate and sustainability goals.

## 5.2. Annual Adoption Rate Projections under Each Scenario

This analysis examines Three scenarios and one Business-as-Usual case for scaling access to clean cooking in Ethiopia by 2035 as shown in Table below , starting from a baseline access rate of 9.8% in 2024. These scenarios - Business-As-Usual (BAU), Conservative Growth Based on the **National Sustainable Energy Development Strategy (N-SEDS) of Ethiopia** , Moderate Intervention **(aligned with the Nationally Determined Contributions or NDC)**, and Aggressive Transformation **(aligned with Long-Term Low Emission Development Strategy or LT-LEDS)**, assess the impact of different levels of intervention on clean cooking adoption and greenhouse gas (GHG) emission reductions.

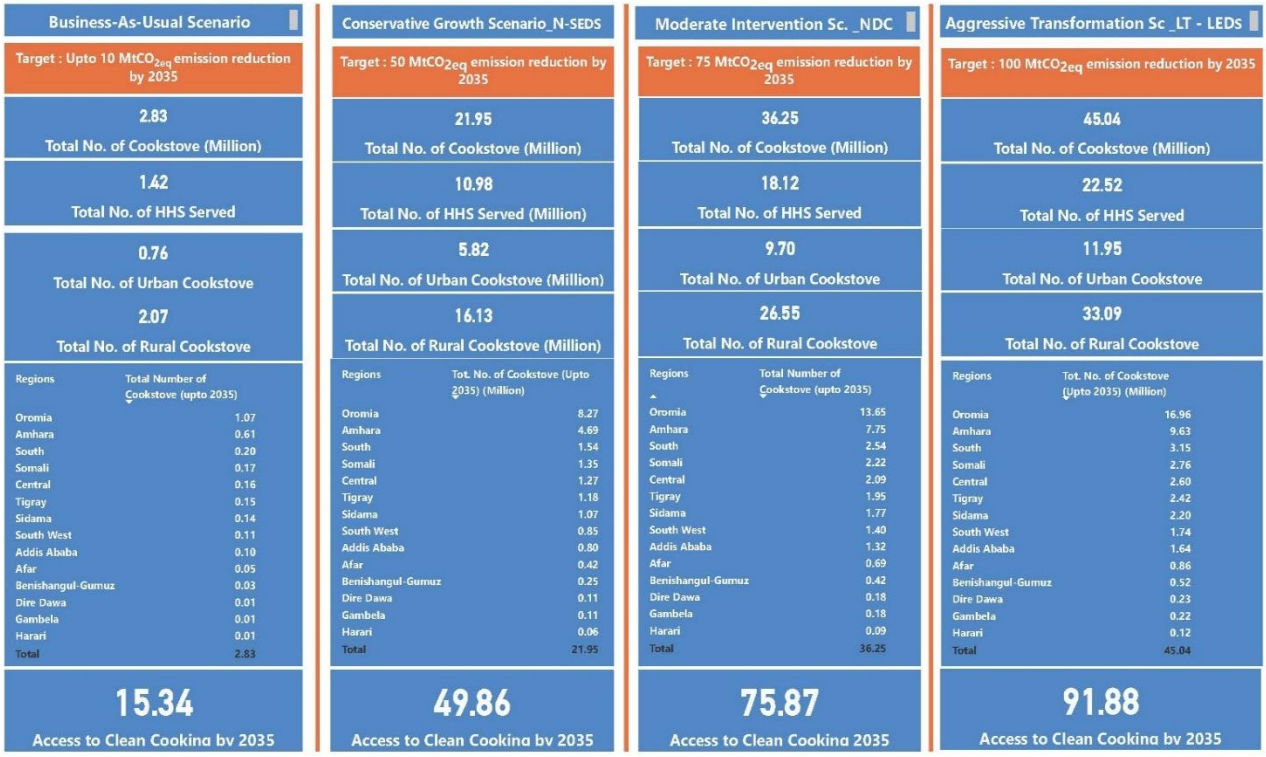
**Business-As-Usual (BAU) Scenario**: The BAU scenario targets a modest $CO_2$ emission reduction of up to **10 $MtCO_2eq$ by 2035**. It involves the deployment of **2.83 million cookstoves, serving 1.42 million households**. Urban areas account for 0.**76 million cookstoves, while rural areas receive 2.07 million**. Regional adoption is led by **Oromia (1.07 million cookstoves) and Amhara (0.61 million)**. **This scenario reflects minimal progress in clean cooking access due to limited interventions, achieving an access rate of 15.34% by 2035.**

**Conservative Growth Scenario (N-SEDS):** Targeting a $CO_2$ emission reduction of 50 $MtCO_2eq$ by 2035, the Conservative Growth scenario based on the National Sustainable Energy Development Strategy (N-SEDS) of Ethiopia envisions the deployment of **21.95 Million cookstoves**, benefiting **10.98 Million** households. Urban areas account for 5.82 million cookstoves, while rural areas receive 16.13 million. Oromia leads with 8.27 million cookstoves, followed by Amhara (4.69 million) and other regions. **This scenario results in significant progress, achieving an access rate of 49.86% by 2035 through moderate policy and financial interventions.**

**Moderate Intervention Scenario (NDC)**: Aligned with Ethiopia's Nationally Determined Contributions, this scenario aims for a $CO_2$ emission reduction of **75 $MtCO_2eq$ by 2035**. It involves the deployment of 36.25 million cookstoves, serving **18.12 million households**. Urban areas receive 9.70 million cookstoves, and rural areas **26.55 million**. Oromia dominates with **13.65 million cookstoves, followed by Amhara (7.75 million) and Southern Regions (2.54 million).** This scenario balances urban and rural efforts, **achieving a clean cooking access rate of 75.87% by 2035.**

**Aggressive Transformation Scenario (LT-LEDS)**: Aligned with the Long-Term Low Emission Development Strategy, this scenario achieves the most ambitious $CO_2$ emission reduction target of **100 $MtCO_2eq$ by 2035**. It involves the deployment of 45.04 million cookstoves, benefiting 22.52 million households. Urban areas account for **11.95 million cookstoves, and rural areas receive 33.09 million**. **Oromia** leads with **16.96 million cookstoves**, followed by **Amhara (9.63 million) and Southern Regions (3.15 million). This scenario achieves an impressive clean cooking access rate of 91.88% by 2035 but requires substantial investment and coordination.**

*Table 2 : Cumulative Projected Access to Clean Cooking in Ethiopia from 2025 to 2035: Scenarios, Emission Reduction Targets, and Regional Distribution*



**Business-As-Usual Scenario**

Target : Upto 10 $MtCO_{2eq}$ emission reduction by 2035

2.83 Total No. of Cookstove (Million)

1.42 Total No. of HHS Served

0.76 Total No. of Urban Cookstove

2.07 Total No. of Rural Cookstove

| Regions | Total Number of Cookstove (upto 2035) |
|---|---|
| Oromia | 1.07 |
| Amhara | 0.61 |
| South | 0.20 |
| Somali | 0.17 |
| Central | 0.16 |
| Tigray | 0.15 |
| Sidama | 0.14 |
| South West | 0.11 |
| Addis Ababa | 0.10 |
| Afar | 0.05 |
| Benishangul-Gumuz | 0.03 |
| Dire Dawa | 0.01 |
| Gambela | 0.01 |
| Harari | 0.01 |
| Total | 2.83 |

15.34 Access to Clean Cooking by 2035

**Conservative Growth Scenario_N-SEDS**

Target : 50 $MtCO_{2eq}$ emission reduction by 2035

21.95 Total No. of Cookstove (Million)

10.98 Total No. of HHS Served (Million)

5.82 Total No. of Urban Cookstove (Million)

16.13 Total No. of Rural Cookstove (Million)

| Regions | Tot. No. of Cookstove (Upto 2035) (Million) |
|---|---|
| Oromia | 8.27 |
| Amhara | 4.69 |
| South | 1.54 |
| Somali | 1.35 |
| Central | 1.27 |
| Tigray | 1.18 |
| Sidama | 1.07 |
| South West | 0.85 |
| Addis Ababa | 0.80 |
| Afar | 0.42 |
| Benishangul-Gumuz | 0.25 |
| Dire Dawa | 0.11 |
| Gambela | 0.11 |
| Harari | 0.06 |
| Total | 21.95 |

49.86 Access to Clean Cooking by 2035

**Moderate Intervention Sc. _NDC**

Target : 75 $MtCO_{2eq}$ emission reduction by 2035

36.25 Total No. of Cookstove (Million)

18.12 Total No. of HHS Served

9.70 Total No. of Urban Cookstove

26.55 Total No. of Rural Cookstove

| Regions | Total Number of Cookstove (upto 2035) |
|---|---|
| Oromia | 13.65 |
| Amhara | 7.75 |
| South | 2.54 |
| Somali | 2.22 |
| Central | 2.09 |
| Tigray | 1.95 |
| Sidama | 1.77 |
| South West | 1.40 |
| Addis Ababa | 1.32 |
| Afar | 0.69 |
| Benishangul-Gumuz | 0.42 |
| Dire Dawa | 0.18 |
| Gambela | 0.18 |
| Harari | 0.09 |
| Total | 36.25 |

75.87 Access to Clean Cooking 2035

**Aggressive Transformation Sc _LT - LEDs**

Target : 100 $MtCO_{2eq}$ emission reduction by 2035

45.04 Total No. of Cookstove (Million)

22.52 Total No. of HHS Served

11.95 Total No. of Urban Cookstove

33.09 Total No. of Rural Cookstove

| Regions | Tot. No. of Cookstove (Upto 2035) (Million) |
|---|---|
| Oromia | 16.96 |
| Amhara | 9.63 |
| South | 3.15 |
| Somali | 2.76 |
| Central | 2.60 |
| Tigray | 2.42 |
| Sidama | 2.20 |
| South West | 1.74 |
| Addis Ababa | 1.64 |
| Afar | 0.86 |
| Benishangul-Gumuz | 0.52 |
| Dire Dawa | 0.23 |
| Gambela | 0.22 |
| Harari | 0.12 |
| Total | 45.04 |

91.88 Access to Clean Cooking by 2035

Starting from a baseline access rate of **9.8% in 2024**, these scenarios demonstrate a clear progression in clean cooking adoption. The **net increase in access** ranges from just 5.54 percentage points under BAU to a **transformative 82.08 percentage points under the Aggressive Transformation scenario**. Oromia, Amhara, and Souther Regions consistently emerge as key regions across all scenarios due to their demographic significance. It has toe be noted taht achieving Ethiopia's clean cooking targets will require balancing urban-rural needs, addressing regional disparities, and mobilizing significant policy and financial resources.

*Table 3 : Summary Table of Projected Access to Clean Cooking in Ethiopia by 2035*

| Scenario | Total Cookstoves (Million) | Households Served (Million) | Urban Cookstoves (Million) | Rural Cookstoves (Million) | Access Rate (%) |
|---|---|---|---|---|---|
| **Business-As-Usual (BAU)** | 2.83 | 1.42 | 0.76 | 2.07 | 15.34 |
| **Conservative Growth (N-SEDS)** | 21.95 | 10.98 | 5.82 | 16.13 | 49.86 |
| **Moderate Intervention (NDC)** | 36.25 | 18.12 | 9.70 | 26.55 | 75.87 |
| **Aggressive Transformation** | 45.04 | 22.52 | 11.95 | 33.09 | 91.88 |

Based on the Scenario analysis, the adoption of advanced biomass improved cookstoves (BICS), electric stoves, biogas stoves, and solar stoves across three scenarios is depicted herewith: **Conservative Growth**, **Moderate Intervention**, and **Aggressive Transformation**, highlighting trends from 2025 to 2035. In the **Conservative Growth Scenario (N-SEDS),** the cumulative adoption of clean cooking technologies under the conservative N-SEDS scenario

reveals distinct trends across various stove categories. As depicted in the figure, Advanced Improved Biomass Cookstoves (IBCS) show a steady and significant increase, growing from **737,746 units to nearly 9 million units by the final stage**. This indicates their pivotal role in clean cooking transitions due to their affordability and compatibility with traditional cooking practices. In this scenario, electric stoves exhibit the fastest growth, **starting at 1,060,000 units and surpassing 12.6 million**, driven by the belief that a strong push towards electrification and grid extension will occur, especially in urbanized, rural, and grid-connected areas. In contrast, biogas stoves experience moderate growth, climbing from **6,000 units to 374,000 units**. This suggests their role remains localized to areas where organic waste resources are available and suitable for biogas production. Similarly, solar-powered stoves, while demonstrating an increase from **3,863 units to 56,496 units**, assumed to have the slowest adoption rate due to high upfront costs, limited awareness, or operational constraints, despite their potential in off-grid regions. Overall, this scenario illustrates a multi-faceted approach, balancing the scaling of proven technologies with the gradual integration of emerging solutions to address diverse needs and challenges in advancing clean cooking access. In the **Moderate Intervention Scenario**, the cumulative adoption of clean cooking technologies from 2025 to 2035, as shown in the data below, highlights significant trends across various stove types. Advanced Improved Biomass Stoves exhibit the highest adoption, starting from **142,857 units in 2025** and reaching **18,557,143 units by 2035**. This consistent growth emphasizes their role as a primary solution, leveraging affordability and widespread acceptance in both rural and urban areas. Electric stoves also demonstrate remarkable growth, increasing from **98,214 units in 2025 to 16,167,857 units in 2035**, reflecting a strong push towards electrification supported by grid expansion efforts in diverse regions. Biogas stoves, while experiencing slower adoption, show steady growth in this scenario, increasing from 5**,682 units in 2025 to 852,273 units in 2035**. This indicates their niche relevance in areas with access to cattle dung, organic waste, agricultural residues, clean water, and biogas infrastructure. Similarly, solar-powered stoves, starting at **4,464 units in 2025 and reaching 669,643 units in 2035**, are assumed to exhibit the slowest growth. Overall, this scenario reflects a comprehensive approach to clean cooking, combining the rapid scale-up of established technologies with the gradual adoption of emerging solutions to address the diverse needs of households over the decade. Finally, in **the Aggressive Transformation Scenario,** the cumulative adoption of clean cooking technologies from 2025 to 2035 reveals distinct trends across various stove types. Advanced Improved Biomass Stoves lead the adoption trajectory, starting with **107,143 units in 2025 and increasing to 17,967,857 units by 2035**. This steady growth underlines their critical role as a cost-effective and accessible solution in addressing clean cooking challenges, especially in rural and peri-urban areas. Electric stoves demonstrate substantial progress, beginning with **116,071 units in 2025 and surging to 24,944,643 units by 2035**. This significant increase reflects the expansion of electrification infrastructure and an active transition toward cleaner energy sources in urban and semi-urban settings. Biogas stoves, although growing at a slower pace, show consistent adoption, increasing from **7,955 units in 2025 to 1,590,909 units in 2035** in the Aggressive Scenario. This trend highlights their utility in specific regions with available biogas feedstocks, such as cattle dung, agricultural residues and organic waste. Similarly, solar-powered stoves experience gradual adoption, starting at **2,679 units in 2025 and reaching 535,714 units by 2035**. Despite their slower uptake, these stoves provide a viable option for regions with high solar energy potential. Overall, this scenario highlights a balanced approach to promoting clean cooking solutions, combining rapid scaling of established technologies like biomass and electric stoves with gradual yet impactful adoption of emerging innovations such as biogas and solar-powered stoves to cater to the diverse needs of households over the decade.

### 5.2.1. Cookstoves Distributed by Regions and Country

Based on the analysis, the number of cookstoves distributed exhibits a substantial increase across the Business-As-Usual Scenario and three scenarios. Under the Business-As-Usual Scenario, **2.83 million cookstoves are distributed cumulatively nationwide by 2035**. This grows significantly in the **Conservative Growth Scenario (N-SEDS) to 21.95 million**, while **the Moderate Intervention Scenario (NDC) expands further to 36.25 million**. The Aggressive Transformation Scenario (LT-LEDS) achieves the highest distribution, with **45.04 million cookstoves**. Regionally, **Oromia consistently receives the highest allocation across all scenarios, culminating in 16.96 million cookstoves under the Aggressive Transformation Scenario, followed by Amhara with 9.63 million.**

### 5.2.2. Households Adopted by Regions and Country

The total number of households adopting clean cookstoves increases significantly across the scenarios from 2025-2035. Under the Business-As-Usual Scenario analysis, only **1.42 million households adopt clean cooking solutions**. This rises to **10.98 million households in the Conservative Growth Scenario (N-SEDS)**, while the **Moderate Intervention Scenario (NDC) achieves 18.12 million households**. The Aggressive Transformation Scenario (LT-LEDS) results in the highest adoption, **reaching 22.52 million households**. These figures underscore the growing impact of clean cooking interventions, with higher levels of investment and policy commitment driving greater adoption rates across the regions.

### 5.2.3. Population Served by Regions and Country

Considering the rural and urban proportions of cookstove dissemination and average household sizes (rural and urban populations served growing cumulatively nationwide by 2035), the total population benefiting from clean cooking solutions increases significantly across scenarios. Under the Business-As-Usual Scenario, **7.10 million people will be served**, with **6.21 million in rural areas and 0.89 million in urban areas based on the scenario analysis.** The Conservative Growth Scenario (N-SEDS) analysis shows **54.90 million people (48.39 million rural and 6.51 million urban) will be served**, while the Moderate Intervention Scenario (NDC) **benefits 90.60 million people (79.65 million rural and 10.95 million urban)**. **The Aggressive Transformation Scenario (LT-LEDS) reaches the largest population, serving 112.60 million people, with 99.27 million in rural areas and 13.33 million in urban areas**. Based on the analyses, it should be noted that increasing access to clean cooking in both urban and rural areas requires substantial investment, with the aggressive scenario requiring higher funding, followed by moderate intervention, then conservative growth, and lastly, business as usual.

### 5.2.4. Progression along the MTF Tiers

**Conservative Growth Scenario**: In this conservative growth scenario, the number of advanced biomass stoves (Tier 3) shows a significant **cumulative increase**, starting from **737,746 in 2025 and reaching 8,922,566 by 2035**. **Electric stoves (Tier 5)** exhibit robust cumulative growth, increasing from **1,060,000 in 2025 to 12,600,852 by 2035**. **Biogas stoves (Tier 4)** see a steady cumulative rise from **6,000 in 2025 to 374,000 by 2035**, reflecting a gradual but persistent uptake. Similarly, **solar-powered stoves (Tier 4) grow from 3,863 in 2025 to 56,496 by 2035**, showing a slow but steady increase. This cumulative number in terms of the number of stoves is depicted in short here: In 2025, the scenario shows the number of stoves will be 737,746 advanced biomass stoves (Tier 3), 9,863 Tier 4 stoves, and 1,060,000 electric

stoves. By 2030, these numbers grow to 968,282, 39,512, and 1,920,000 respectively. Finally, by 2035, the numbers reach 1,283,149 advanced biomass stoves, 68,725 Tier 4 stoves, and 822,898 electric stoves.

**Moderate Integration Scenario**: Under the moderate integration scenario, the number of advanced biomass stoves (Tier 3) shows a substantial cumulative increase, starting from 142,857 in 2025 and reaching 18,557,143 by 2035. Electric stoves (Tier 5) exhibit strong cumulative growth, increasing from 98,214 in 2025 to 16,167,857 by 2035. Biogas stoves (Tier 4) see a steady cumulative rise from 10,146 in 2025 to 1,521,916 by 2035, reflecting a gradual but persistent uptake. Similarly, solar-powered stoves (Tier 4) grow from 5,682 in 2025 to 71,429 by 2035, showing a slow but steady increase. In terms of the number of stoves, the scenario in 2025 shows 142,857 advanced biomass stoves (Tier 3), 15,828 Tier 4 stoves, and 98,214 electric stoves. By 2030, these numbers grow to 12,942,857 advanced biomass stoves, 1,014,610 Tier 4 stoves, and 10,492,857 electric stoves. Finally, by 2035, the numbers reach 18,557,143 advanced biomass stoves, 1,521,916 Tier 4 stoves, and 16,167,857 electric stoves. This scenario outlines the projected growth of various stove types under a moderate intervention strategy, highlighting the significant increases in advanced biomass and electric stoves, with steady growth in biogas and solar-powered stoves.

**Aggressive Transformation Scenario**: Under the aggressive intervention scenario, the number of advanced biomass stoves (Tier 3) shows a dramatic cumulative increase, starting from **107,143 in 2025 and reaching 17,967,857 by 2035**. **Electric stoves (Tier 5)** exhibit even stronger cumulative growth, increasing from **116,071 in 2025 to 24,944,643 by 2035**. Biogas stoves (Tier 4) see a steady cumulative rise from **10,633 in 2025 to 2,126,623 by 2035**, reflecting a significant but consistent uptake. Similarly, **solar-powered stoves (Tier 4) grow from 10,633 in 2025 to 148,864 by 2035**, showing a slow but steady increase. In terms of the number of stoves, the scenario in 2025 shows **107,143 advanced biomass stoves (Tier 3), 10,633 Tier 4 stoves**, and **116,071 electric stoves**. By 2030, these numbers grow to **14,110,714 advanced biomass stoves, 1,594,968 Tier 4 stoves, and 18,391,071 electric stoves**. Finally, by 2035, the numbers reach **17,967,857 advanced biomass stoves, 2,126,623 Tier 4 stoves, and 24,944,643 electric stoves**. The total number of stoves in 2025 is **234,847**, which includes 107,143 advanced biomass stoves, 10,633 Tier 4 stoves, and 116,071 electric stoves. By 2030, the total number of stoves increases to **20,096,753**, comprising 14,110,714 advanced biomass stoves, 1,594,968 Tier 4 stoves, and 18,391,071 electric stoves. By 2035, the total number of stoves reaches **45,039,123**, with **17,967,857** advanced biomass stoves, **2,126,623 Tier 4 stoves**, and **24,944,643** electric stoves. This scenario outlines the projected growth of various stove types under an aggressive intervention strategy, highlighting the significant increases in advanced biomass and electric stoves, with steady growth in biogas and solar-powered stoves.

### 5.2.5. Rate of access Cooking achieved

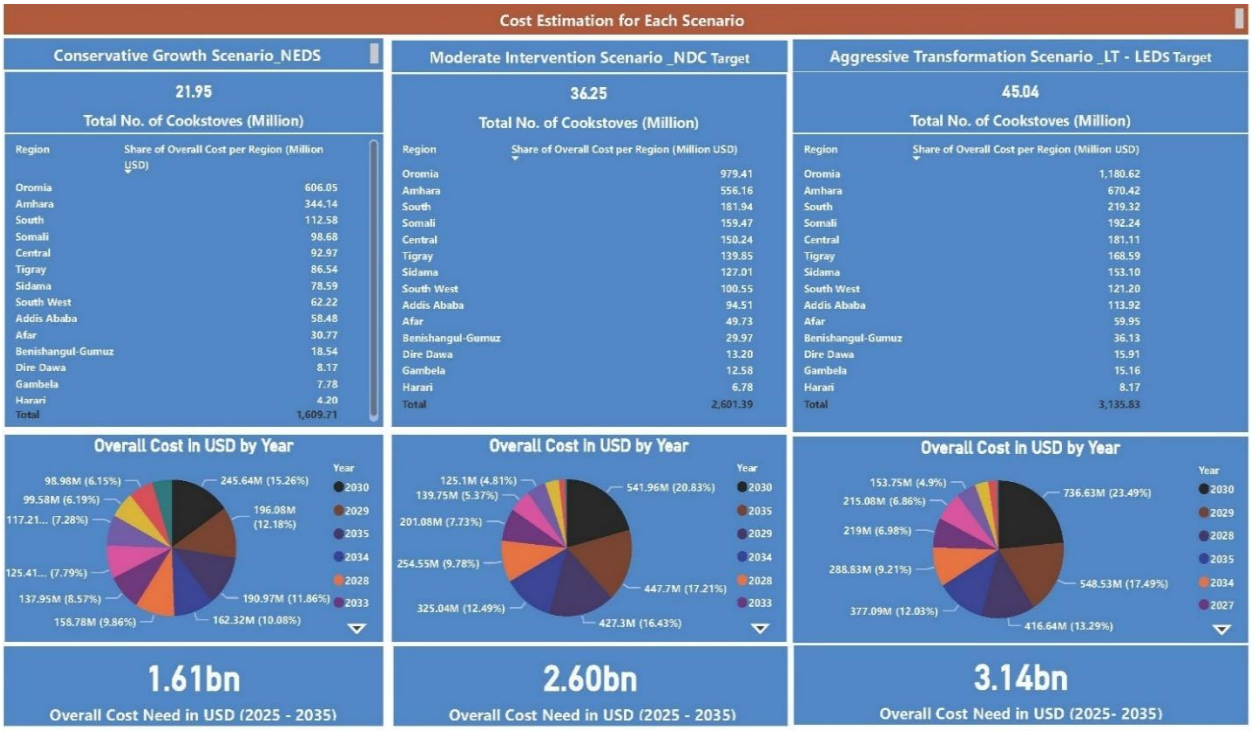
Adjusting for the **baseline of 9.8 % access to clean cooking in 2024**, the cumulative increase in access to clean cooking by 2035 under each scenario is as follows. The Business-As-Usual Scenario **achieves a modest increase of 5.54 %, reaching 15.34% access**. **The Conservative Growth Scenario (N-SEDS)** increases access by **40.06%**, resulting in **49.86%** access by 2035. The **Moderate Intervention Scenario (NDC)** achieves a **66.07% increase**, bringing total access to **75.87%**. Finally, the **Aggressive Transformation Scenario (LT-LEDS)**

demonstrates the highest cumulative increase of **82.08%**, resulting in **91.88% access by 2035**. This underscores the transformative impact of ambitious interventions in scaling up access to clean cooking technologies.

## 5.3. Investment and Budget Estimates for Achieving Targets

The detailed analysis of the cost distribution across regions from 2025 to 2035 under three different growth scenarios: conservative growth, moderate intervention, and aggressive transformation by highlighting the cumulative and yearly costs for each region is discussed below.

*Table 4: Budget Estimates Considering Only Cookstove Costs for Achieving Targets*




**Conservative Growth Scenario: Regional Cost Distribution (2025 - 2035)** : The total estimated cost over this period is **$1,609.71 million**. Oromia holds the largest share, accounting for **67.21%** of the total cost, which amounts to **$606.05 million over eleven years**. Amhara follows with a **38.17%** share, contributing **$344.14 million**. Regions such as Harari, Gambella, and Dire Dawa have the smallest shares, collectively representing less than 2% of the total cost. This analysis highlights both the cumulative costs and the yearly distributions based on each region's share of the overall cost. From 2025 to 2035, the yearly distribution of costs is as follows: In 2025, the overall cost is **$76.79 million**, with Oromia accounting for **$606.05 million**. In 2026, the overall cost is **$98.98 million**, with Amhara accounting for **$344.14 million**. By 2027, the overall cost rises to **$125.41 million**, with the South region accounting for **$112.58** million. In 2028, the overall cost is **$158.78 million**, with Somali accounting for **$98.68 million**. The cost continues to increase in 2029 to **$196.08 million**, with the Central region accounting for $92.97 million. By 2030, the overall cost reaches **$245.64 million**, with Tigray accounting for **$86.54** million. In 2031, the cost is **$99.58 million**, with Sidama accounting for **$78.59 million**. The overall cost in 2032 is **$117.21 million**, with South West accounting for **$62.22 million**. In

2033, the cost is **$137.95 million**, with Addis Ababa accounting for **$58.48 million**. By 2034, the overall cost is **$162.32 million**, with Afar accounting for **$30.77 million**. Finally, in 2035, the overall cost is **$190.97 million**, with Benishangul-Gumuz accounting for **$18.54 million**. This scenario provides a detailed view of the projected costs associated with the low intervention strategy, emphasizing the significant financial contributions required from Oromia and Amhara, while also noting the smaller but important shares from other regions.

**Moderate Intervention Scenario: Regional Cost Distribution (2025–2035)** : Moderate intervention Scenario (NDC Aligned): The overall cost required from 2025 to 2035 for this scenario is **$2,601,393.26 million**. Breaking down the cost analysis, in 2025, the total cost is projected at **$9,080.96 million**, with Oromia being the largest contributor, accounting for **$979.41 million**. By 2026, the cost rises significantly to **$40,648.67 million**, with Amhara contributing **$556.16 million**, reflecting the region's growing importance in implementing NDC-aligned measures. In 2027, the total cost increases further to **$125,098.47 million**, with South Ethiopia contributing **$181.94 million**, demonstrating its emerging role in the medium-term strategy. During 2028, the overall cost reaches **$254,545.54 million**, with Somali contributing **$159.47 million**, reflecting its increasing significance in the financial distribution. In 2029, the cost grows to **$427,300.44 million**, with Central Ethiopia contributing **$150.24 million**, marking its pivotal role in this phase of the strategy. By 2030, the total cost rises to **$541,960.50 million**, with Tigray contributing **$139.85 million**, showcasing its sustained importance in achieving the scenario's goals. In 2031, the overall cost drops to **$89,194.44 million**, with Sidama contributing **$127.01 million**, highlighting its significant share despite the overall reduction. For 2032, the cost slightly increases to $139,746.50 million, with South West Ethiopia contributing **$100.55 million**, reflecting its growing involvement in the intervention. In 2033, the total cost reaches $**201,076.24 million**, with Addis Ababa contributing **$94.51 million**, demonstrating the capital's essential role in this period. By 2034, the cost further increases to $325,039.97 million, with Afar contributing **$49.73** million, marking its sustained participation in the strategy. Finally, in 2035, the total cost peaks at **$447,701.54 million**, with Benishangul-Gumuz contributing **$29.97 million**, alongside smaller contributions from Dire Dawa **($13.20M),** Gambella **($12.58M)**, and Harari **($6.78M).**

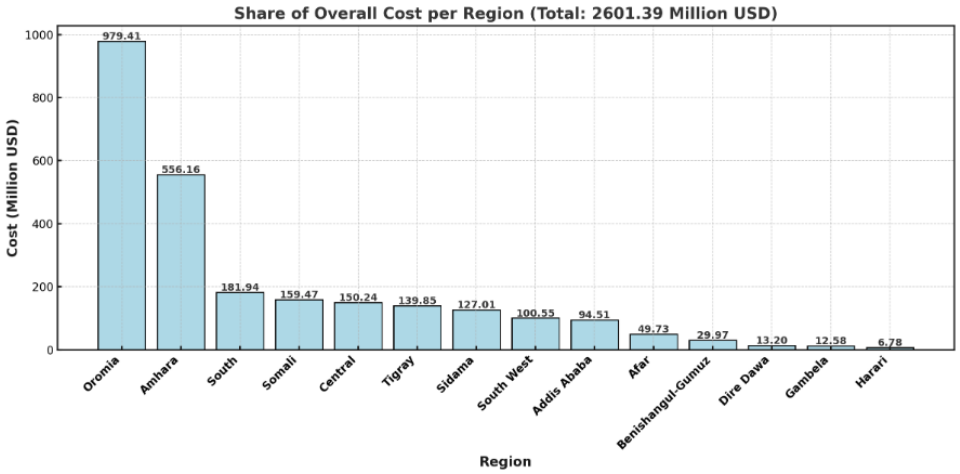



*Figure 4 : Moderate Intervention Scenario : Cumulative Cost Distribution by Region*

**Aggressive Transformation Scenario: Regional Cost Distribution (2025–2035):** The Aggressive Scenario outlines a steadily increasing trend in overall costs from 2025 to 2035,

reflecting the significant investments requirement. With a total projected cost of **$3.14 billion USD** over the period.

Beginning at **$8.74 million USD** in 2025, the costs increases sharply over the decade, reaching **$68.49 million USD** in 2026 and **$219.00 million USD in 2027**. The investment continues to grow exponentially, peaking **at $736.63 million USD in 2030** and **$377.09 million USD by 2035**. These figures underscore the financial magnitude of the ambitious plan and highlight the need for phased implementation and resource mobilization. **Regionally**, the distribution of these costs reveals significant disparities. Oromia leads with the highest share at **$1,180.62 million USD, followed by Amhara at $670.42 million USD**. Regions like the **South Ethiopia, Somali, and Central Ethiopi**a also bear notable costs, ranging from **$181.11 to $219.32 million USD**, reflecting their strategic importance. Meanwhile, smaller regions such as **Harari ($8.17 million USD), Gambella ($15.16 million USD), and Dire Dawa ($15.91 million USD)** have comparatively lower shares, signifying varying levels of intervention needs and resource allocation across the country. Together, these trends highlight both the overall scale and regional complexities of Ethiopia's ambitious pathway toward sustainable development.

In conclusion, the cost distribution analysis for Ethiopia's clean energy initiatives between 2025 and 2035 underscores the critical role of regional prioritization in achieving energy transformation goals. Oromia emerges as the dominant contributor across all scenarios, reflecting its significant demand and resource potential. Meanwhile, regions like Harari, Gambella, and Dire Dawa, although with smaller shares, emphasize the need for tailored strategies to ensure equitable development. The cumulative investments vary dramatically across the conservative, moderate, and aggressive scenarios, highlighting the trade-offs between ambition and resource allocation. Moving forward, a balanced approach is essential to maximize impact while ensuring sustainable and inclusive growth.

## 5.4. Selection of Optimal Scenario

**The Moderate Intervention Scenario, aligned with Ethiopia's Nationally Determined Contributions (NDC)**, is the optimal choice among the clean cooking adoption strategies based on the Scenario Analysis. This scenario targets a reduction of **50 million tons of $CO_2$ equivalent by 2030** and **an additional reduction of 25 million tons from 2031 to 2035, achieving a cumulative reduction of 75 million tons over the 2025 - 2035 period**. By focusing on clean cooking access for **75.87 %** of the population, it benefits approximately **18.12 million households**. The strategy emphasizes advanced biomass stoves, electric stoves, Biogas and solar powered stoves systems, thereby addressing urban and rural disparities while enhancing public health and environmental resilience. In the latter phase of implementation, interventions will include the promotion of LPG, ethanol, and biodiesel stoves. These efforts will involve advancing research and development (R&D), building local capacity, and addressing logistical challenges associated with these fuels. By integrating these options, the scenario aims to diversify fuel sources, improve accessibility, and further enhance emission reductions while fostering innovation in clean cooking technologies.

This scenario requires an estimated investment of **$2.60 billion**, a balanced allocation compared to the **$1.60 billion for the Conservative Growth Scenario** and the **$3.14 billion required for the Aggressive Transformation Scenario**. It leverages carbon finance, subsidies, microfinancing, and contributions from development partners. The deployment plan includes **36.25 million cookstoves**, with a focus on **9.70 million units for urban households and 26.55 million for rural areas, balancing geographical needs**.

The Moderate Intervention Scenario addresses critical shortcomings of the Conservative Growth approach, which focuses primarily on improved biomass stoves and achieves limited $CO_2$ reductions (**50 $MtCO_2$ by 2035)** with an **access rate of 49.86%**. Compared to the Aggressive Transformation Scenario, which seeks universal access but requires **$3.14 billion and poses implementation challenges**, the Moderate Intervention Scenario offers a more pragmatic yet impactful pathway.

To ensure success, this scenario includes robust **carbon finance mechanisms and results-based incentives for manufacturers and users**. **Public-private partnerships** will expand biogas and electric stove infrastructures, while community campaigns will drive behavioral change. Investments in local manufacturing and capacity-building programs will create jobs and ensure sustainability. With its blend of ambitious goals and realistic execution strategies, the Moderate Intervention Scenario represents Ethiopia's best opportunity to achieve its clean cooking and climate commitments while fostering economic and social development.

## 5.5. Cost-Benefit Analysis of Moderate Intervention (NDC Aligned) Scenario

Cost-benefit analysis (CBA) is a systematic approach used to assess the economic, social, and environmental feasibility of clean cooking technologies, focusing on the private costs and benefits to ensure affordability, adoption, and long-term impact. This analysis was applied to a moderate intervention scenario aligned with the Nationally Determined Contributions (NDC), which aims to balance environmental and socioeconomic factors for sustainable clean cooking interventions. The scenario examined various costs including stove purchase, program implementation, learning, operation, maintenance, and fuel expenses. On the benefits side, it considered net fuel savings, time saved from efficient cooking or reduced fuel collection, and health improvements due to decreased exposure to indoor pollutants.

Stoves like the Advanced Biomass, Electric, Biogas, and Solar Powered models showed positive savings, with the Solar stove leading due to its use of free sunlight, whereas LPG and Ethanol stoves presented negative savings because of their high fuel costs as shown in Figure 12. Time savings were also quantified, with benefits ranging from $4.56 to $9.12 annually for different stove types, reflecting their efficiency in reducing cooking time. Social benefits included forest conservation, reduced carbon emissions, and enhanced environmental restoration, with specific values assigned to each stove type based on their impact on land restoration and ecosystem services.

The analysis revealed that while initial costs for adopting clean cooking technologies are significant, the long-term benefits, including health, time, and environmental advantages, justify the investment. However, for LPG and Ethanol stoves, policy interventions like subsidies are necessary to offset their high operational costs. The scenario development focused on promoting technologies like Advanced Biomass, Electric, Biogas, and Solar cooking systems, emphasizing technological improvements, resource availability, and sustainability to foster the adoption of clean cooking solutions aligned with economic and environmental goals.

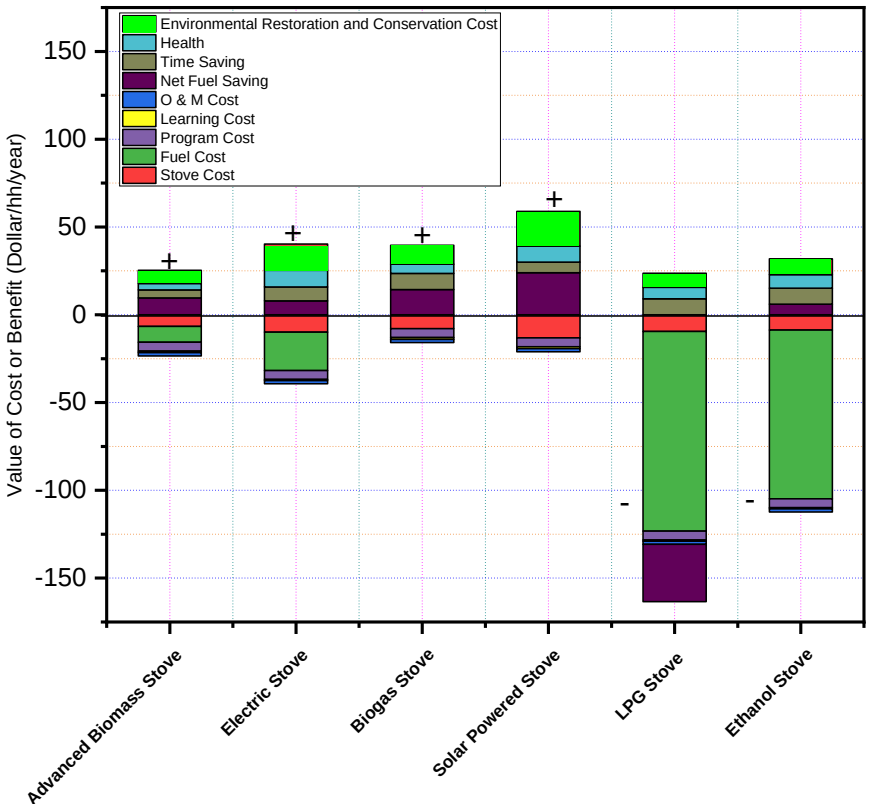



*Figure 5 : Cost-Benefit Analysis of Different Types of Clean Cookstoves*

## 5.6. Social Benefits : Wood Saving and Job Creation Opportunities for the Moderate Intervention Scenario

The transition from traditional three-stone stoves to advanced cooking technologies brings immense social benefits, particularly in wood saving and job creation. Traditional three-stone stoves consume an average of 4 tons of wood per household annually[20]

**Wood Savings:** Advanced biomass stoves, which offer 50% savings compared to traditional stoves, save approximately 2 tons of wood per stove annually, while electric stoves completely eliminate wood usage, saving 4 tons per stove annually[21]. Biogas stoves save an average of 3 tons per year, and solar-powered stoves contribute partial savings of 1.5 tons per year[22]. Based on the adoption of 18,557,143 advanced biomass stoves, 16,167,857 electric stoves, 852,273 biogas stoves, and 669,643 solar-powered stoves, the total wood saved annually amounts to 37.1 million tons for advanced biomass stoves, 64.7 million tons for electric stoves, 2.6 million tons for biogas stoves, and 1 million tons for solar-powered stoves. Together, these technologies save approximately 105.3 million tons of wood annually, significantly alleviating pressure on forest resources and mitigating deforestation.

**Job Creation:** In addition to environmental benefits, the adoption of these clean cooking technologies creates substantial employment opportunities across manufacturing, distribution, installation, and maintenance. For every 1,000 stoves, advanced biomass stoves create 10 jobs, electric stoves create 8 jobs, biogas stoves create 15 jobs, and solar-powered stoves

[20] Global Alliance for Clean Cookstoves (2015). *Clean Cooking Catalog: Fuel Consumption Data*
[21] World Bank (2020). *The State of Access to Modern Energy Cooking Services*.
[22] United Nations Environment Programme (2021). *Benefits of Clean Energy Technologies in Reducing Deforestation*.

create 12 jobs[23]. This translates to the creation of over 185,571 jobs for advanced biomass stoves, 129,343 jobs for electric stoves, 12,784 jobs for biogas stoves, and 8,036 jobs for solar-powered stoves, totaling more than 335,700 jobs. These economic opportunities contribute significantly to local livelihoods, enhancing income generation and community development.

The combined benefits of wood savings and job creation highlight the transformative impact of clean cooking technologies. By reducing wood consumption by over 105 million tons annually and generating hundreds of thousands of jobs, clean cooking technologies not only support environmental conservation but also drive socioeconomic growth, making them vital for sustainable development.

**Gender Impact: Time Savings and Economic Value:** In Ethiopia, women and girls typically spend around **2 hours per day** collecting firewood for cooking[24]. Clean cooking technologies, such as solar, biogas, and electric stoves, can significantly reduce the time spent on this task. On average, these technologies save up to **50%** of the time spent collecting firewood, amounting to **1 hour per day** per stove. The total time saved annually by the adoption of these clean cooking solutions is substantial.

For advanced biomass stoves, the total time saved is **6.77 billion hours per year** (18,557,143 stoves × 365 days), benefiting approximately **1.85 million women**. Electric stoves save **5.90 billion hours per year** (16,167,857 stoves × 365 days), benefiting **1.61 million women**. Biogas stoves save **0.31 billion hours per year** (852,273 stoves × 365 days), benefiting around **85,000 women**, while solar-powered stoves save **0.24 billion hours per year** (669,643 stoves × 365 days), benefiting approximately **66,000 women**. In total, these clean cooking solutions save around **13.22 billion hours annually** for Ethiopian women and girls, providing them with more time for education, income-generating activities, or self-care, ultimately improving their well-being and expanding opportunities.

The economic value of this time saved can be estimated by assuming a modest hourly wage of **$0.50**, which is typical for many rural areas in Ethiopia. Based on this estimate, the time saved by the deployment of clean cooking solutions translates to an economic value of approximately: **$6.77 billion** for advanced biomass stoves ; **$5.90 billion** for electric stoves ; **$0.31 billion** for biogas stoves and **$0.24 billion** for solar-powered stoves. Thus, the total **economic value** of the time saved by these clean cooking technologies is approximately **$13.22 billion annually**, representing a significant contribution to the economic empowerment of women and the broader economy of Ethiopia.

## 5.7. Phases, Strategies and Interventions Recommended to Achieve Access Targets Projected (2025-2035)

Based on the provided Clean Cooking roadmap, the suggested strategies, technologies, and activities for the ten-year period (2025 - 2035) the following technologies, targets, interventions are suggested for three phases of implementation for the optimal and selected Scenario of Moderate Intervention ( NDC Aligned):

### Phase 1 (2025 - 2027): Foundations and Early Scaling

#### A. Technologies to Promote

- Advanced biomass stoves and electric cooking technologies (where grid access is available).

[23] Clean Cooking Alliance (2019). *The Role of Clean Cooking in Job Creation*.
[24] World Bank (2020). *The State of Access to Modern Energy Cooking Services in Ethiopia*.

- Pilot programs for biogas systems in livestock-rich rural areas.
- Promote solar cooking technologies in off-grid regions.

## B. Clean Cooking Access Targets : 18 %

- **Tier 3**: Contributes **55.05%** towards achieving an **overall clean cooking access rate of 18%** by utilizing a cumulative **2,050,000 advanced biomass stove units (2025-2027)** for urban and rural households.
- **Tier 4**: Contributes **4.09%** by introducing **152,192 units of biogas and solar-powered stoves (2025 - 2027)** for urban and peri-urban households.
- **Tier 5**: Contributes **40.86%** by introducing **1,519,643 electric stove units (2025 - 2027)** for urban and rural households to transition to electric and hybrid stoves.

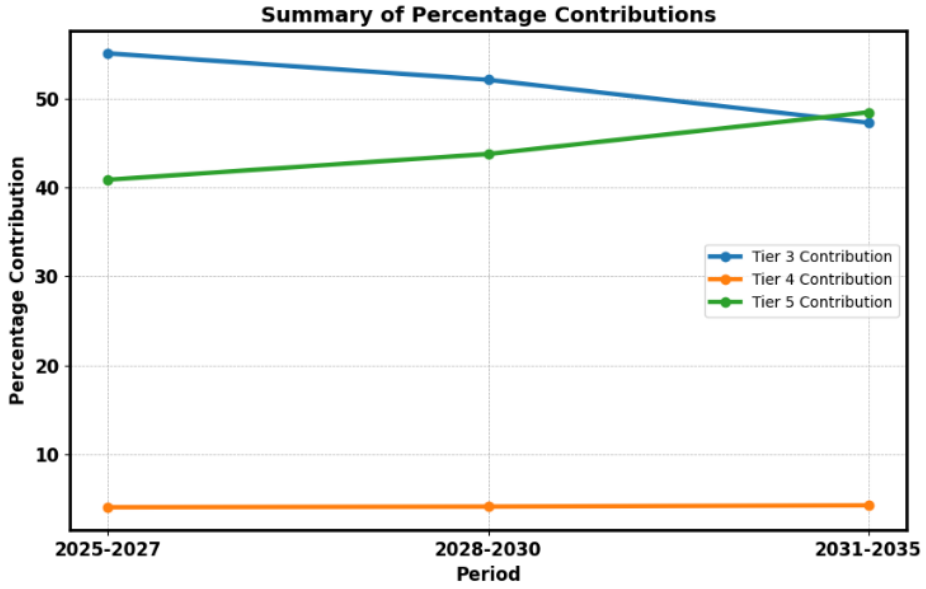



*Figure 6: Perctage contribution of Tier 3, 4 and 5 for Phase I (2025-2027), II (2028-2030) and III (2031 - 2035)*

## C. Key Interventions

### I. Strategies/Approaches

- Focus on awareness campaigns targeting rural and urban populations to emphasize the health, environmental, and economic benefits of clean cooking.
- Develop foundational infrastructure for supply chains to ensure the availability of cooking technologies and fuels in rural and underserved areas.
- Leverage subsidies and microfinancing to improve affordability for low-income households.

### II. Enhanced Carbon Market Access

- Integrate clean cooking projects into Ethiopia's Third Nationally Determined Contributions (NDCs).
- Develop Clean Cooking MRV procedures and structures and link into National Integrated MRV/M&E system currently under development
- Build capacity for project design and reporting under international carbon market frameworks (e.g., Gold Standard, Clean Development Mechanism).

- Establish partnerships with carbon buyers and funds to subsidize clean cooking solutions for households.
- Channel carbon revenues into value chain development for biomass and LPG stoves.

#### III. Legal and Regulatory Requirements

- Establish a dedicated regulatory body under MoWE to oversee the clean cooking sector.
- Develop national standards for clean cooking appliances, aligned with global best practices (e.g., WHO and ISO standards).
- Create incentives like tax exemptions for manufacturers and importers of clean cooking technologies.
- Strengthen enforcement mechanisms for existing policies to ensure compliance by private actors.

#### IV. Research and Development

- Launch widespread community engagement and education campaigns on clean cooking benefits.
- Launch studies on locally appropriate cooking technologies that align with cultural practices.
- Focus R&D efforts on improving fuel efficiency, durability, and affordability of Tier 3 stoves.

#### V. Support for Private Sector Actors

- Provide grants and loans to small and medium-sized enterprises (SMEs) involved in manufacturing and distributing recommended stoves.
- Provide technical training for local technicians to ensure maintenance and repair capabilities.
- Encourage public-private partnerships (PPPs) to improve logistics and supply chains.
- Develop partnerships with private and public sectors to improve LPG and ethanol fuel supply chains.

### Phase 2 (2028–2030): Expansion and Consolidation

### A. Technologies to Promote

- Scale biogas and ethanol stoves with expanded production facilities.
- Roll out smart cookstoves with real-time feedback and IoT-enabled features in urban areas.
- Broaden access to LPG for semi-urban and rural areas with developed distribution infrastructure.

### B. Clean Cooking Access Targets: 57.74%

- **Tier 3**: Contributes **52.08%** towards achieving an **overall clean cooking access rate of 57.74%** by utilizing a cumulative 8,107,143 advanced biomass stove units (2028-2030) for urban and rural households.
- **Tier 4**: Contributes **4.17%** by introducing **649,350 units of biogas and solar-powered stoves (2028 - 2030)** for urban and peri-urban households.
- **Tier 5**: Contributes **43.75%** by introducing **6,803,571 electric stove units (2028 - 2030)** for urban and rural households to transition to electric and hybrid stoves

### C. Key Interventions

#### I. Enhanced Carbon Market Access

- Scale up verified carbon projects based on lessons from Phase 1.

- Use carbon financing to subsidize advanced Tier 3, 4 and 5 stoves for low-income households.
- Strengthen monitoring, reporting, and verification (MRV) systems to ensure transparency and accountability.

**II. Legal and Regulatory Requirements**

- Strengthen regulatory frameworks and enforce standards for clean cooking technologies.
- Introduce mandatory energy efficiency and safety labels for all stove technologies sold in Ethiopia.
- Establish penalties for non-compliance with clean cooking standards.
- Develop regional regulatory frameworks to standardize adoption across Ethiopia's diverse administrative regions.

**III. Research and Development**

- Review progresses over the two phases and update plan and Scale up successful pilot projects and integrate lessons learned from Phase 1.
- Focus R&D on optimizing Tier 4 and 5 technologies for Ethiopian cooking habits.
- Explore cost-reduction strategies in the production of electric and biogas stoves.
- Promote innovation in fuel production, such as ethanol from agricultural residues.

**IV. Support for Private Sector Actors**

- Intensify behavioral change campaigns to address cultural resistance and improve technology adoption.
- Implement advanced market-based models for clean cooking fuel distribution.
- Expand financing mechanisms like pay-as-you-go (PAYG) models to promote affordability.
- Facilitate access to low-interest loans for manufacturers of Tier 4 and 5 stoves.
- Develop business incubation hubs to support local entrepreneurs in clean cooking value chains.
- Conduct targeted capacity-building programs for local manufacturers and distributors.
- Enhance regional collaborations for funding and innovation/Foster partnerships between local and international firms for technology transfer.

### Phase 3 (2031-2035): Universal Access and Sustainability

**A. Technologies to Promote**

- High-efficiency Tier 5 electric and biogas stoves tailored to urban and rural needs. Focus on achieving universal clean cooking access through final scaling efforts.
- Integrate solar-biogas hybrid solutions for off-grid and semi-urban areas.
- Promote scalable modular cooking technologies for diverse household sizes.

**B. Clean Cooking Access Targets: 75.87%**

- **Tier 3**: Contributes **47.26%** towards achieving an overall clean cooking access rate of 75.87% by utilizing a cumulative **5,007,143 advanced biomass stove units (2031-2035)** for urban and rural households.
- **Tier 4**: Contributes **4.31%** by introducing **456,575 units** of biogas and solar-powered stoves **(2031 - 2035)** for urban and peri-urban households.
- **Tier 5**: Contributes **48.43%** by introducing **5,130,357 electric stove units (2031 - 2035)** for urban and rural households to transition to electric and hybrid stoves

**C. Key Interventions**

- Focus on achieving universal clean cooking access through final scaling efforts.

**I. Enhanced Carbon Market Access**

- Use carbon credits to fund maintenance and distribution systems for clean stoves.
- Develop Ethiopia-specific methodologies for carbon offset projects to maximize financial returns.

**II. Legal and Regulatory Requirements**

- Ensure universal compliance with quality standards and emission reduction targets (Implement a national clean cooking policy mandating universal access).
- Update/Institutional structure and mandate of the regulatory body established to oversee the clean cooking sector.
- Introduce performance-based subsidies to reward stakeholders meeting access targets.

**III. Research and Development**

- Focus on next-generation technologies that combine high efficiency with low cost.
- Develop hybrid systems (e.g., solar-biogas setups) for underserved areas.
- Invest in local universities and research centers to create innovative cooking solutions.

**IV. Support for Private Sector Actors**

- Develop long-term public-private partnerships for sustainable clean cooking solutions.
- Offer fiscal incentives for long-term investments in clean cooking technologies.
- Encourage value chain integration to reduce costs and increase efficiency.
- Host national and regional forums to share progress, innovations, and best practices.

# 6. Policy and Investment Analysis

## 6.1. Assessment of Policy Options and Interventions

Effective policy and investment frameworks are essential to accelerate the adoption of clean cooking technologies. This section outlines critical interventions - subsidies, awareness campaigns, infrastructure development, and capacity-building initiatives - aimed at addressing financial, social, logistical, and technical barriers to achieving universal access to clean cooking solutions and summarized in table 11.

*Table 5 : Assessment of Policy Options and Interventions*

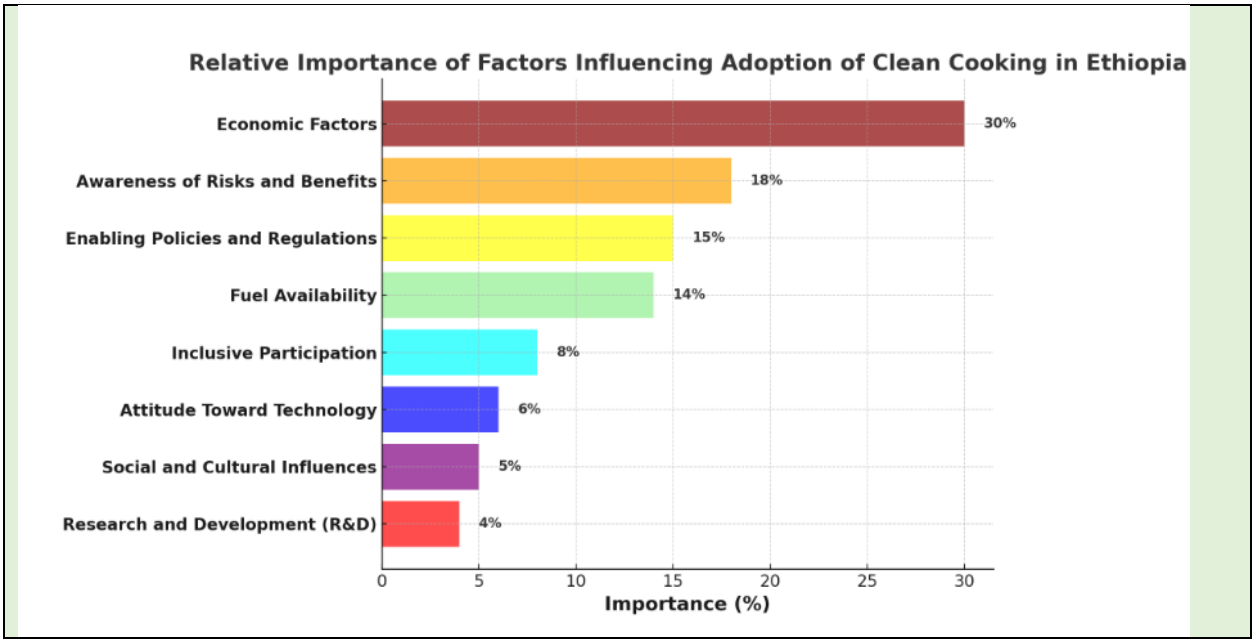
| Aspect | Actions to Promote Access | Specific Recommendations | Lead Implementer | Timeframe |
|---|---|---|---|---|
| **Subsidies and Incentives** | – Implement direct subsidies for rural households to reduce upfront costs.<br>– Offer tax incentives for manufacturers and suppliers.<br>– Develop results-based financing mechanisms to reward private sector adoption milestones. | – Establish a clean cooking fund to support subsidies.<br>- Integrate subsidy schemes with social safety nets.<br>– Provide urban subsidies for e-cooking technologies. | MIF, MoWE | Short-term |
| **Awareness Campaigns** | – Launch nationwide campaigns on health, economic, & environmental benefits.<br>– Use radio, social media | – Develop urban campaigns on cost-saving benefits of Clean Cooking.<br>– Conduct rural | Ministry of Communication, NGOs, Regional Energy Office, CSOs, Minster of | Medium-term |

| | | | | |
|---|---|---|---|---|
| | & community meetings for outreach.<br>– Partner with community leaders and NGOs for message dissemination. | awareness sessions on biomass stoves and biogas systems.<br>– Train women as advocates for clean cooking. | Women and Social Affairs, Community Leaders | |
| **Infrastructure and Supply Chain Development** | – Expand distribution networks for clean fuels and devices in rural areas.<br>– Develop nation-wide Biogas plant<br>– Improve rural road networks for enhanced access. | – Establish public-private partnerships for infrastructure investments.<br>– Create local manufacturing hubs<br>– Ensure grid stability to promote electric stove adoption. | MoWE, Ministry of Transport, Private Sector | Medium- to long-term |
| **Capacity-Building Initiatives** | – Conduct technical training for manufacturers, suppliers, and entrepreneurs.<br>– Build government capacity for monitoring and evaluation.<br>– Promote research collaborations | – Develop rural training for women entrepreneurs in distribution and retail.<br>– Strengthen certification frameworks for quality assurance.<br>- Establish centers of excellence for clean cooking innovation. | MoWE, Universities, TVETs, NGOs, CSOs, Ministry of Labor and Skills | Medium- to long-term |

### Relative Importance of Factors Influencing Adoption of Clean Cooking in Ethiopia[25,26]

Based on international best practices, local experience, and literature on clean cooking, the key factors influencing adoption in Ethiopia are **Economic Factors** (30%, with a range of 25-35%), **awareness** of risks and benefits (18%, with a range of 15-21%), **enabling policies and regulations** (15%, with a range of 12-18%), and fuel availability (14%, with a range of 12-16%). Other important factors include **inclusive participation** (8%, with a range of 5-9%), **attitude toward technology** (6%, with a range of 4-8%), **social and cultural influences** (5%, with a range of 3-7%), and **research and development** (4%, with a range of 2-6%). These complementary factors play a supportive role in fostering adoption efforts. By addressing these factors with tailored solutions and creating an enabling environment, Ethiopia can ensure long-lasting impacts and broader adoption of clean cooking. Prioritizing both the critical and complementary factors is essential for achieving sustainable and inclusive progress.

[25] Household Cooking Fuel Choice and Adoption of Improved Cookstoves in Developing Countries | Clean Cooking Alliance
[26] Smith, A.B., & Jones, C.D. (2023). Factors influencing the adoption of clean cooking technologies in rural Ethiopia. *Energy Policy*, 172, 113-125.




## 6.2. Impact Analysis of Policies on Adoption Rates and Scenarios

Policies promoting clean cooking technologies in Ethiopia have demonstrated varied impacts on adoption rates across urban and rural settings. Subsidies and incentives have significantly improved affordability for urban households, enabling more families to transition to cleaner cooking solutions. However, rural populations continue to face economic and logistical barriers, which hinder widespread adoption. Awareness campaigns have contributed to improved public understanding of the benefits of clean cooking, particularly in regions where localized behavior change programs were implemented. Meanwhile, infrastructure development has played a critical role in reducing logistical barriers, ensuring better access to clean fuels, and increasing adoption rates in remote areas. To enhance the effectiveness of these policies, regular monitoring and analysis of adoption trends should be conducted. Regional pilot programs can provide valuable insights into policy effectiveness before scaling up interventions nationwide. Additionally, leveraging data analytics can help identify underserved areas and optimize resource allocation. Tailored subsidy policies that focus on low-income households and remote regions, coupled with partnerships with research institutions for evidence-based interventions, are recommended to address existing gaps. The Ministry of Water and Energy (MoWE) should lead these efforts, with regular assessments conducted every six months.

## 6.3. Evaluation of Interventions Such As Subsidies, Awareness Campaigns, and Infrastructure Development

The evaluation of key interventions - such as subsidies, awareness campaigns, and infrastructure development - highlights their crucial role in promoting clean cooking solutions. Subsidies have effectively reduced financial barriers; however, their impact can be improved by implementing better targeting mechanisms to reach the most vulnerable populations, particularly in rural areas. Awareness campaigns have successfully increased understanding and acceptance of clean cooking technologies, but they need to be further tailored to meet the socio-cultural needs of rural communities. While infrastructure development has enhanced

supply chain reliability in urban areas, rural regions continue to face significant challenges due to inadequate transportation networks and logistical constraints. Strengthening monitoring and evaluation systems is vital for tracking the effectiveness of these interventions and ensuring accountability. To enhance outcomes, it is recommended to develop rural-focused messaging for awareness campaigns, involve community leaders, and expand public-private partnerships to address infrastructure gaps. Additionally, revising subsidy frameworks to prioritize low-income and rural households, and investing in targeted infrastructure projects - such as improving road networks and establishing local fuel production facilities are essential steps. The Ministry of Water and Energy (MoWE), the Ministry of Finance, and local NGOs should lead these efforts, with implementation aimed for the medium term, while engaging the private sector.

## 6.4. Recommendations for Resource Allocation under Different Scenarios

To enhance Ethiopia's clean cooking program, sustainable resource allocation must integrate innovative and diverse financing mechanisms. The proposed approach emphasizes leveraging international grants, carbon finance, community mobilization funds, crowdfunding, microfinance, public-private partnerships (PPPs), and revolving funds to ensure financial stability and scalability. A dedicated Clean Cooking Fund managed by the Ministry of Water and Energy (MoWE) should consolidate these resources, ensuring transparent and efficient allocation to high-impact initiatives.

### Diverse Financial Strategies

To advance Ethiopia's clean cooking initiatives, a multi-faceted approach to financing is crucial. Firstly, **international grants and donor contributions** can be leveraged by engaging with global climate funds like the Green Climate Fund (GCF) and the Global Environment Facility (GEF) to secure substantial funding for research, development, and capacity building. Partnerships with international development entities such as GIZ, SNV, and the World Bank can further support these efforts, ensuring that clean cooking technologies align with the Sustainable Development Goals (SDGs).

In terms of **carbon and climate finance**, utilizing carbon credit mechanisms can help subsidize the costs of advanced clean cooking technologies. A dedicated steering committee should be established to manage these projects, ensuring they align with global climate goals while also generating revenue for reinvestment into the program.

**Public-Private Partnerships (PPPs)** offer another avenue for funding, where the government can encourage private sector involvement through tax incentives, import duty exemptions, and supportive policies that promote local manufacturing. These partnerships could also extend to improving supply chains, maintenance services, and marketing strategies for clean cooking solutions.

**At the community level**, mechanisms like rotating savings and credit associations (ROSCAs) and grassroots crowdfunding can mobilize local resources, fostering ownership and participation. Rural savings and credit cooperatives (RUSACCOs) can provide microloans on favorable terms to enhance the adoption of clean cookstoves.

**Innovative financing** models like Pay-As-You-Go (PAYG) systems can make these technologies more accessible to low-income households, while Results-Based Financing (RBF)

can incentivize private sector involvement based on tangible outcomes such as reduced emissions and increased adoption rates.

To ensure financial sustainability, **revolving funds** could be created where repaid loans are recycled into new projects, supporting the long-term viability of clean cooking programs.

For collaborative implementation, an integrated coordination platform, led by the Ministry of Water and Energy (MoWE), should be established to streamline efforts among stakeholders. This includes setting up national and regional steering committees with representatives from various sectors like MoWE, Ministry of Health (MoH), Environmental Protection Authority (EPA), NGOs, Development Partners and private sector entities to manage resource allocation. Strengthening partnerships with international agencies will align Ethiopia's clean cooking initiatives with broader environmental and health objectives globally.

## 6.5. PESTEL Analysis

For the selected and optimal scenario, a PESTEL analysis has been performed to assess the multifaceted factors influencing the adoption of clean cooking technologies in Ethiopia. **Politically**, government support through policies and subsidies is crucial for successful implementation. **Economically**, affordability and financing options are vital, especially for low-income households. Social acceptance, influenced by cultural factors, plays a pivotal role in user willingness to transition from traditional methods. **Technologically**, Technological innovation and infrastructure availability are essential for the sustainability of clean cooking solutions. **Legally**, establishing clear frameworks and regulations ensures quality control and consumer protection. **Environmentally**, adopting clean cooking technologies can significantly reduce deforestation and greenhouse gas emissions. Addressing these factors through targeted actions and recommendations is essential to achieve Ethiopia's clean cooking access goals by 2035 as shown in Table 12.

*Table 6 : PESTEL Analysis*

| P | E | S | T | L | E |
|---|---|---|---|---|---|
| **Political** | **Economic** | **Social** | **Technological** | **Legal** | **Environmental** |
| • Political support is crucial for the promotion and wider adoption of clean cooking technologies, as government policies and subsidies can significantly influence implementation success.<br>**Actions**<br>• Advocate for government support in clean cooking policies and subsidies.<br>• Establish public-private | • Economic factors, including affordability and financing options, play a significant role in the adoption of clean cooking solutions, especially in low-income households.<br>**Actions**<br>• Design affordable financing schemes for households (microcredit, pay-as-you-go models). | • Social acceptance and cultural factors are pivotal in the adoption of clean cooking technologies, as they influence user behavior and willingness to transition from traditional methods.<br>**Actions**<br>• Conduct awareness campaigns highlighting health benefits of clean cooking.<br>• Engage | • Technological innovation and the availability of appropriate infrastructure are essential for the successful implementation and sustainability of clean cooking solutions.<br>**Actions**<br>• Promote research and development (R&D) in locally adaptable clean cooking technologies.<br>• Establish technology incubation hubs to | • Legal frameworks and regulations are vital in standardizing clean cooking technologies, ensuring quality control, and protecting consumers.<br>**Actions**<br>• Develop clear regulatory frameworks for clean cooking technology standards.<br>• Strengthen enforcement against non | • Environmental considerations are critical, as the adoption of clean cooking technologies can significantly reduce deforestation and greenhouse gas emissions.<br>Actions:<br>• Develop community-led reforestation programs linked to clean cooking initiatives, incentivizing households adopting clean |

| | | | | | |
|---|---|---|---|---|---|
| partnerships (PPPs) for infrastructure development.<br>• Develop and enforce regulations to phase out traditional biomass stoves and promote higher tier clean cooking<br>**Recommendations**<br>• Align clean cooking initiatives with Ethiopia's development and climate goals.<br>• Promote inter-ministerial collaboration between the Ministry of Environment, Energy, and Health to streamline efforts.<br>• Leverage Ethiopia's commitment to SDG7 | • Develop subsidies or tax incentives for clean cooking solutions (e.g., biogas, ethanol ,LPG stoves).<br>• Enhance local manufacturing capabilities to reduce costs.<br>**Recommendations**<br>• Collaborate with financial institutions to provide low-interest loans for stove purchases.<br>• Engage with donors like the World Bank and MasterCard Foundation for investment.<br>• Promote income-generating activities linked to clean cooking, such as briquette production. | community leaders to advocate for clean cooking adoption.<br>• Provide training programs for households on the use and maintenance of new technologies.<br>**Recommendations**<br>• Address cultural preferences by developing stoves that accommodate traditional cooking methods.<br>• Implement pilot programs in communities to demonstrate benefits and gather feedback.<br>• Collaborate with Develoment partenrs, NGOs , CSOs, to reach marginalized and rural populations. | foster innovation.<br>• Ensure robust after-sales service networks for stove maintenance and repairs.<br>**Recommendations**<br>• Partner with universities and technical institutions for capacity-building in stove design.<br>• Introduce IoT-enabled solutions for monitoring and reporting stove usage.<br>• Develop standards for efficiency and safety in clean cooking devices. | efficient cookstove distributions<br>• Ensure consumer protection through warranties and product quality assurance.<br>Recommendations:<br>• Collaborate with NGOs and industry groups to draft policies supporting clean cooking.<br>• Incorporate clean cooking mandates into urban planning and development policies.<br>• Advocate for tariff reductions on imported clean cooking equipment. | cooking technologies.<br>• Promote stoves that utilize renewable fuels to reduce deforestation.<br>• Conduct environmental impact assessments for large-scale adoption plans.<br>• Implement monitoring systems to track environmental benefits of clean cooking adoption.<br>Recommendations:<br>• Link clean cooking initiatives with reforestation programs.<br>• Monitor and report emissions reductions to attract carbon financing. |

# 7. Technology Development and Innovation Recommendations

## 7.1. Suggestions for Technological Advancements to Accelerate Adoption

In Ethiopia, the push towards clean cooking involves deploying a range of improved cookstoves (ICS) designed for baking and cooking with various biomass fuels. These stoves aim to decrease fuel usage, lower emissions, and enhance cooking efficiency. To ensure these technologies are both economically viable and widely adopted, they must align with the cultural and cooking preferences of local communities. The concept of advanced biomass and charcoal stoves should be introduced, focusing on models like fan-assisted gasifier stoves, forced-draft stoves, rocket stoves, insulated charcoal stoves, pellet micro-gasification stoves, and thermoelectric generator stoves. These designs can significantly improve energy efficiency, reduce fuel consumption and emissions, enhance safety, and are culturally appropriate. By adapting these technologies to traditional cooking methods and training locals to make and maintain these stoves using local materials, the adoption of cleaner cooking solutions can be accelerated.

## 7.2. Recommendations for Cost Reduction and Performance Improvement

To make clean cooking technologies more accessible, it's vital to focus on cost reduction and performance enhancement. This can be achieved by supporting local manufacturing and using local materials, which reduces both production and transportation costs. Continuous research and development can optimize stove designs for better efficiency, reduced emissions, and increased durability. Financial strategies like subsidies, pay-as-you-go, or lease-to-own models can lower the initial investment for households. Encouraging the use of alternative fuels like biomass briquettes and pellets can also decrease fuel expenses while improving stove

performance. Training local technicians in maintenance ensures the longevity of the stoves, while technological tools like mobile apps or IoT can help monitor performance, providing users with feedback to optimize their cooking practices. Standardizing stove designs and certifications can aid in achieving economies of scale and quality control. Governmental support through policies and incentives can further reduce costs and improve access, with private sector involvement fostering innovation and competition.

### 7.3. Priority Areas for Future Innovation, Research, and Development

Future technological innovations should prioritize solutions that are tailored to Ethiopia's diverse regional conditions and fuel availability. This includes developing advanced biomass stoves for biomass-rich areas, promoting biogas systems where there's ample livestock, and exploring solar cooking where solar energy is abundant. Addressing logistical challenges with ethanol and promoting LPG in urban areas are also key. These innovations must consider local fuel options, affordability, convenience, and environmental impact to ensure they are widely adopted, improving millions of lives through cleaner cooking practices.

### 7.4. Alignment with User Needs and Preferences (By Socio-Cultural Characteristics and Rural/Urban Settings)

Understanding the socio-cultural context and the differences between rural and urban settings is crucial for the successful adoption of clean cooking technologies. In rural areas, where biomass is predominant, the focus should be on efficient biomass stoves and biogas systems, tackling fuel access and storage issues. Urban settings, with better access to electricity and gas, benefit from promoting electric and LPG stoves, addressing affordability and user-friendliness. Engaging communities in the design process ensures that technologies meet specific cultural and practical needs. Education on the advantages of clean cooking, alongside dispelling myths and overcoming resistance to change, is essential for broad acceptance and long-term sustainability of these technologies in Ethiopia.

## 8. The Path to Clean Cooking for Ethiopia (2025 - 2035)

Ethiopia’s roadmap to achieving universal access to clean cooking by 2035 is structured around three phases: Short-Term (2025–2027), Medium-Term (2028–2030), and Long-Term (2031–2035). Each phase outlines specific goals and actions to transition households to higher-tier clean cooking solutions, ensuring sustainability and inclusivity.

**In the Short-Term (2025 - 2027)**, the focus is on laying a strong foundation for scaling up clean cooking initiatives. A Clean Cooking Coordination Unit will be established within the Ministry of Water and Energy to centralize efforts, streamline resources, and implement monitoring and evaluation systems. Clean cooking will be elevated to a national priority by integrating it into broader energy, health, and environmental policies and appointing champions to drive institutionalization and resource mobilization. Awareness and advocacy will be enhanced through nationwide campaigns highlighting the health, economic, and environmental benefits of clean cooking, training local technicians and entrepreneurs, and empowering women and marginalized groups to participate in decision-making. Financial support will be provided on both the demand and supply sides, with subsidies and flexible financing mechanisms for households and tax incentives, grants, and low-interest loans for manufacturers and entrepreneurs. Infrastructure development will focus on expanding distribution networks, improving rural access to clean cooking technologies, and establishing local manufacturing hubs. Pilot projects in

selected regions will demonstrate the effectiveness of clean cooking technologies, with lessons learned used to refine and scale successful models.

**The Medium-Term (2028 - 2030)** phase emphasizes expanding access and enhancing adoption. Policy and regulatory frameworks will be strengthened to integrate clean cooking into energy, health, and environmental objectives while fostering public-private partnerships for infrastructure investments and innovation. Technological advancements will be promoted by supporting advanced biomass stoves, biogas systems, and solar cookers, along with research and development to improve efficiency, reduce emissions, and lower costs. Capacity building efforts will train manufacturers, suppliers, and government personnel, while market development will encourage private sector engagement and sustainable solutions. Clean cooking initiatives will be aligned with broader development programs in health, education, and gender equality, leveraging synergies to maximize impact. Additional financing will be mobilized through mechanisms such as results-based funding, carbon credits, and climate funds, ensuring efficient resource allocation.

**The Long-Term (2031 - 2035)** phase focuses on achieving universal access and ensuring sustainability. Efforts will prioritize transitioning households to higher-tier solutions, such as Tier 3 and above, to improve efficiency and reduce emissions. A sustainable market for clean cooking will be built through enhanced local production, supply chains, and private sector innovation. It will reduce greenhouse gases, deforestation, and indoor pollution, improving health. Progress will be monitored to refine strategies, with Ethiopia leading globally through international collaboration and best practice sharing. Knowledge gaps will be addressed by improving data use, modeling, and inclusivity, especially for women and vulnerable groups.


***Figure 7 : Road to Access to Clean Cooking in Ethiopia (2025 - 2035)***

*Table 7 : The Path to Clean Cooking for Ethiopia (2025 – 2035) (Timeframe,Goals, Key Actions and Responsbilbe Unit*

| Timeframe | Goals | Key Actions/Activities | Responsible Units |
|---|---|---|---|
| **Short-Term (2025-2027): Laying the Foundation and Scaling Initiatives** | Establish a Dedicated Clean Cooking Coordination Unit at MoWE | • Establish a centralized unit in Ethiopia to coordinate all clean cooking initiatives, streamline resources, ensure coherent strategies across all levels, and implement monitoring and evaluation systems to track progress and impact. | MoWE, Ethiopian Electric Power, Ethiopian Electric Utility, Regional Energy Bureaus |
| | Elevate Clean Cooking to a National Priority | • Develop a comprehensive national strategy for clean cooking that integrates with energy, health, and environmental policies, and appoint a dedicated champion to promote institutionalization and mobilize resources. | Ministry of Water and Energy (MoWE), Ministry of Planning, Ministry of Health, Ministry of Women and Social Affairs |
| | Increase Awareness, Education, & Advocacy through Community Engagement | • Launch nationwide awareness campaigns on the benefits of clean cooking, partnering with community leaders and local influencers | Ministry of Water and Energy (MoWE), NGOs, Community Leaders, Local Influencers |
| | Subsidies and Financial Support for Demand and Supply Side | | |
| | Demand Side: | • Implement direct subsidies for low-income households<br>• Develop flexible financing mechanisms & Offer microfinance options to make clean cooking tech more accessible. | Ministry of Water and Energy (MoWE), Microfinance Institutions, Private Financial Institutions |
| | Supply Side: | • Offer tax incentives for manufacturers and suppliers<br>• Provide grants and low-interest loans to local manufacturers<br>• Support local entrepreneurs & business in clean cooking sector | Ministry of Water and Energy (MoWE), Microfinance Institutions, Private Financial Institutions |
| | Infrastructure Development | • Expand distribution networks<br>• Improve rural road networks<br>• Establish local manufacturing hubs for cookstoves. | Ministry of Water and Energy (MoWE), Private Sector, NGOs |
| | Pilot Projects and Demonstrations | • Implement pilot projects in selected regions to demonstrate the effectiveness of clean cooking solution and Collect data and feedback to refine and scale up successful models. | Ministry of Water and Energy (MoWE), Academic and Research Institutions, Development Partners |
| **Medium-Term (2028-2030): Expanding Access and Enhancing Adoption** | Policy and Regulatory Frameworks | • Develop and implement a unified national strategy for clean cooking<br>• Strengthen monitoring and evaluation systems<br>• Foster public-private partnerships | MoWE, National Clean Cooking Coordination Unit, NGOs, CSOs |
| | Technological Advancements | • Advance clean cooking through better stoves, biogas, solar, and alternative fuels research. | MoWE, Private Sector, Academic & Research Inst. |

| | | | |
|---|---|---|---|
| | Capacity Building | • Enhance clean cooking by training manufacturers, strengthening government policy capabilities, and fostering research collaborations | MoWE, Universities, TVETs, NGOs |
| | Market Development and Private Sector Engagement | • Encourage private sector investment, develop market-based solutions, and support local clean cooking entrepreneurs. | Ministry of Water and Energy (MoWE), Private Sector, NGOs |
| | Integration with Other Development Programs | • Align clean cooking initiatives with broader development programs, such as health, education, and gender equality.<br>• Leverage synergies with other sectors to maximize impact and resource efficiency. | Ministry of Water and Energy (MoWE), Ministry of Health, Ministry of Education, Ministry of Women and Social Affairs |
| | Increase Funding and Finance for Clean Cooking | • Mobilize finance from development and climate funds, using results-based financing and carbon credits for efficient resource allocation in clean cooking initiatives. | MoWE, Development Partners, Private Financial Institutions |
| **Long-Term (2031-2035): Achieving Full Access and Sustainability** | Focus on transitioning households to higher-tier clean cooking solutions | • Focus on transitioning households to higher-tier clean cooking solutions (Tier 3 and above). | MoWE, National Clean Cooking Coordination Unit, NGOs, CSOs |
| | Sustainable Market Development | • Establish a sustainable market for clean cooking technologies, supported by local production and supply chains.<br>• Encourage private sector investment and innovation in clean cooking solutions. | Ministry of Water and Energy (MoWE), Private Sector, NGOs |
| | Environmental and Health Impact | • Significantly reduce greenhouse gas emissions and deforestation associated with traditional cooking methods<br>• Improve public health outcomes by reducing indoor air pollution and associated respiratory diseases. | Ministry of Water and Energy (MoWE), Ministry of Health, Environmental Protection Authority |
| | Long-Term Monitoring and Evaluation | • Implement robust monitoring and evaluation frameworks to track progress and impact over time.<br>• Use data and feedback to continuously improve clean cooking programs and policies. | Ministry of Water and Energy (MoWE), Academic and Research Institutions, Development Partners |
| | Global Leadership and Collaboration | • Foster international collaborations and share best practices with other countries. | MoWE, International Development Partners |
| | Bridging the Knowledge Gap | • Improve data tools for decision-making, promote knowledge sharing and capacity building across levels, and include women and vulnerable groups | Ministry of Water and Energy (MoWE), Academic and Research Institutions, NGOs |

## 8.1. Theory of Change

The **Theory of Change** is depicted in Figure 15. The expected **outcomes** include significant health improvements, environmental preservation, economic growth, energy security, social welfare, sustainable development, job creation, and women's empowerment. To achieve these goals, the initiative targets several **outputs**, such as increasing access to clean cooking technologies, enhancing local manufacturing capacity, expanding financial inclusion, raising public awareness, establishing enabling policies and regulatory frameworks, and advancing research and development in clean cooking solutions.

To deliver these outputs, various **actions** are planned, including strengthening the supply and demand for clean cooking technologies, building local production and value chains, fostering a supportive policy environment, and empowering women and youth through tailored programs. Other actions include establishing a robust coordination unit within the Ministry of Water and Energy (MoWE), running awareness campaigns, and monitoring progress through impact tracking and measurement systems. These efforts rely on critical **inputs**, such as financial and human resources, enabling policy and regulatory support, infrastructure development, stakeholder engagement, capacity building, and technology transfer and innovation.

The initiative also addresses **root causes** of limited access to clean cooking, such as traditional cooking practices, high production costs, infrastructure gaps, limited awareness, weak coordination, fragile supply chains, and inadequate research and development. Furthermore, it tackles **key challenges** like high initial costs, cultural preferences, policy and regulatory barriers, infrastructure limitations, and supply chain inefficiencies.

The success of this initiative depends on several assumptions, including strong government commitment, adequate funding from donors and public-private partnerships, the development and maintenance of supporting infrastructure, public willingness to adopt clean cooking technologies, and the availability of a reliable market to meet demand. By addressing these factors through a comprehensive and multi-stakeholder approach, Ethiopia aims to establish a sustainable, inclusive, and resilient clean cooking sector by 2035.


*Figure 8 : Theory of Change*

## 8.2. Action plan (2025 - 2035)

The proposed action plan for the widespread adoption of clean cooking technologies is crucial for implementing the suggested scenarios. The plan focuses on strengthening supply, enhancing demand, fostering an enabling environment, empowering women and youth, and integrating clean cooking into broader development and climate goals. These pillars aim to create a sustainable and inclusive clean cooking ecosystem by addressing both immediate and long-term needs.

1. **Strengthening Supply of Clean Cooking Technologies:** Key interventions include developing a national network of suppliers to enhance production, distribution, and knowledge sharing of clean cooking technologies. Immediate actions involve convening supplier meetings, establishing regional clusters, and integrating clean cooking technologies into existing distribution networks. Ongoing efforts focus on advocating for tax exemptions, supporting women-led networks for distribution, and strengthening after-sales services through warranty programs and quality assurance mechanisms. Research and development (R&D) will drive innovation, with partnerships supporting prototype development and dissemination of findings.
2. **Enhancing Demand for Clean Cooking Technologies:** Consumer-focused interventions aim to understand and address barriers to adoption. Immediate actions include conducting preference studies, launching awareness campaigns tailored to local contexts, and equipping small and medium enterprises (SMEs) with marketing tools. Long-term strategies involve offering microcredit and innovative financing mechanisms to improve affordability. Campaign effectiveness will be tracked, and marketing materials updated to reflect evolving consumer needs.
3. **Fostering an Enabling Environment:** This pillar emphasizes creating a supportive policy and infrastructure framework. Actions include developing and enforcing national cookstove standards, building monitoring and evaluation (M&E) frameworks, and advocating for integrated policies across energy, health, and environmental sectors. Expanding fuel infrastructure, particularly for ethanol, LPG, and biogas, is critical. Carbon finance opportunities will be leveraged to subsidize costs, with capacity building to support stakeholder participation and reinvestment in clean cooking initiatives.
4. **Empowering Women and Youth:** The initiative seeks to involve marginalized groups through gender-sensitive training and support for women-led cooperatives. Women entrepreneurs, technicians, and distributors will receive capacity-building support, while youth innovation hubs will foster creativity and provide mentorship. Financial and leadership opportunities for women and youth will ensure equitable participation in the clean cooking sector.
5. **Strengthening Local Production and Value Chains:** Domestic production of clean cooking technologies and components will be encouraged to reduce import dependency, create jobs, and stimulate economic growth. Immediate actions include identifying local manufacturing opportunities, supporting technology transfer, and promoting sustainable raw materials. Skills development for local artisans and technicians will ensure high-quality production while fostering environmental sustainability.
6. **Integrating Clean Cooking into Development and Climate Goals:** The initiative aligns with Ethiopia's Sustainable Development Goals (SDGs), focusing on poverty reduction, gender equality, improved health, and environmental sustainability. Clean cooking interventions will also contribute to national climate commitments under the Nationally Determined Contributions (NDCs) and the Long-Term Low Emission Development Strategy (LT-LEDS). Efforts include monitoring contributions to SDG targets, conducting climate assessments, and advocating for international climate finance.

*Table 8 : Action plan*

| Pillar | Intervention | Rationale | Immediate Actions | Ongoing and Future Actions |
|---|---|---|---|---|
| **Strengthen Supply of Clean Cooking Technologies** | Develop a national network of suppliers | Enhance production, distribution, and knowledge sharing among suppliers. | - Establish regional supplier clusters. | - Advocate for tax exemptions and financial incentives. - Organize national workshops and training programs. |
| | Add clean cooking technologies to distribution networks | Leverage existing product distribution channels | - Map non-cooking product distribution chains for integration. | - Partner with women-led networks for distribution. - Support SMEs in last-mile delivery. |
| | Strengthen after-sales services | Ensure consumer satisfaction through warranty programs and quality assurance mechanisms. | - Collect best practices in after-sales services. - Develop standardized service guidelines. | - Establish warranty programs. - Monitor compliance and ensure customer feedback mechanisms. |
| | Promote R&D for new technologies | Foster innovation in clean cooking solutions tailored to socio-cultural contexts. | - Identify funding sources for R&D through partnerships. | - Support prototype development and field-testing & disseminate research finding |
| **Enhance Demand for Clean Cooking Technologies** | Conduct consumer preference studies | Understand consumer needs and barriers to adoption. | - Initiate comprehensive market research on preferences and affordability. | -- Tailor technology features based on findings. - Update studies to track evolving consumer needs. |
| | Launch national awareness campaigns | Increase awareness of health, economic, and environmental benefits of clean cooking solutions. | - Develop culturally tailored campaign strategies. - Partner with local leaders and influencers. | - Utilize multi-platform media (radio, TV, social media). - Monitor campaign effectiveness and refine messaging. |
| | Develop marketing materials | Equip SMEs with professional promotional tools to reach target consumers effectively. | - Design behavior change communication (BCC) tools, brochures, and commercials. | - Train SMEs in marketing techniques. - Periodically update materials to reflect feedback and new trends. |
| | Increase affordability through consumer finance | Enable wider adoption by offering microcredit and innovative financing mechanisms. | - Assess existing financing options and explore gender-inclusive programs. | - Pilot tailored microfinance programs. - Monitor repayment rates and adjust mechanisms. |
| **Foster an Enabling** | Develop and Enforce national cookstove | Ensure product quality, performance, and | - Establish a technical committee to draft | - Align standards with international benchmarks (ISO). - |

| | | | | |
|---|---|---|---|---|
| **Environment** | standards | safety through enforceable standards. | and validate standards. | Develop testing and certification centers. |
| | Build monitoring and evaluation (M&E) frameworks | Track program progress, assess impact, and ensure accountability. | - Draft M&E guidelines defining metrics for health, environmental, and economic outcomes. | - Train stakeholders in M&E best practices. - Establish a centralized database for reporting and analysis. |
| | Advocate for supportive policies | Create a favorable policy environment through integrated strategies | - Integrate clean cooking into energy, health, and environmental policies. | - Strengthen international collaborations. - Develop tax incentives for manufacturers and consumers. |
| | Expand fuel infrastructure | Address gaps in ethanol, LPG, and biogas distribution networks | - Identify underserved regions for infrastructure investment. - | - Scale up clean fuel distribution network |
| | Leverage Carbon Finance | Utilize carbon credits to subsidize cookstove costs and promote adoption. | - Capacity building for stakeholders on carbon finance; support registration of carbon finance | - Monitor carbon revenue streams to reinvest in clean cooking initiatives. - |
| **Empowering Women and Youth** | Provide Gender-Sensitive Training and Capacity Building | Focus on women entrepreneurs, technicians, and distributors. | - Conduct gender assessments in the clean cooking sector; partner with women's organizations to design trainings | - Monitor the impact of gender-specific interventions; advocate for policies supporting women's participation in the clean cooking sector. - |
| | Support Women-Led Cooperatives and Microfinance | Encourage women-owned businesses in the clean cooking sector | - Provide access to finance for women-led enterprises | - Promote leadership opportunities for women in clean cooking initiatives. |
| | Establish Youth Innovation Hubs | Create platforms for young people to develop & test innovative clean cooking solutions | - Initiate innovation challenges for youth entrepreneurs. | - Provide mentorship and seed funding for promising projects. |
| **Strengthening Local Production and Value** | Supporting local manufacturing: Encourage domestic production of clean cooking technologies & components. | Local production can create jobs, reduce reliance on imports, and stimulate economic growth. | - Identify potential for local manufacturing of key components. | - Facilitate technology transfer and knowledge sharing with local manufacturers. |
| | Developing local raw | Utilizing local resources can | - Support the development of | - Monitor the environmental and |

| | | | | |
|---|---|---|---|---|
| **Chains** | material supply chains & Building local expertise. | improve environmental sustainability & reduce transportation costs. | local standards for raw materials. | social impacts of local production. |
| **Integrating Clean Cooking into Sustainable Development Goals (SDGs)** | Align clean cooking programs with Ethiopia's SDG commitments to ensure inclusive and sustainable benefits | Clean cooking contributes directly to poverty reduction, gender equality, improved health, & environmental sustainability | - Collaborate with SDG-focused task forces to align goals; initiate baseline data collection for SDG-related indicators. | - Monitor and report progress on clean cooking technology contributions to SDGs; strengthen multi-sectoral collaborations to ensure sustained impacts. |
| **Integrating Clean Cooking into Climate Goals (NDC, LT LEDS)** | Align clean cooking programs with national climate commitments (NDCs and LT LEDS) | Enhance climate change mitigation & adaptation through the widespread adoption of clean cooking solutions. | - Conduct a comprehensive assessment of the current contribution of clean cooking to climate goals. | - Monitor & evaluate the effectiveness of clean cooking interventions in achieving climate objectives. |

## 8.3. Cost of inaction

The cost of inaction in Ethiopia due to reliance on traditional cookstoves is staggering, with profound implications across health, environment, economy, and social well-being. On the health front, approximately 63,000 premature deaths annually are attributed to household air pollution (HAP), primarily affecting women and children. When considering the value of statistical life (VSL) at $500,000 per individual, the economic loss from these deaths alone amounts to $31.5 billion. Additionally, healthcare costs for treating HAP-related illnesses, such as respiratory and cardiovascular diseases, affecting roughly 20% of the 100 million biomass stove users, are estimated at $12 billion annually.

Environmental impacts further compound the problem. Unsustainable wood harvesting, estimated at 0.4 million tons annually, results in ecosystem service losses valued at $20 million. Traditional biomass burning releases 2.2 million tons of $CO_2$ equivalent each year, which, at a social cost of carbon (SCC) of $50 per ton, translates to an additional $110 million in environmental damage.

Economic losses are immense. Women and children spend an average of 800 hours per household annually collecting fuel, representing a time cost of $10 billion, based on a national wage rate of $0.5 per hour. Households also face direct financial burdens, with an average annual expenditure of $120 on biomass fuels, summing to $2.5 billion nationwide.

Socially, the reliance on traditional cookstoves exacerbates gender inequities and hinders development. Missed opportunities for education and employment due to time spent on fuel collection are estimated to cost $4 billion annually. These combined factors bring the total cost of inaction to approximately $65 billion per year, highlighting the urgent need for Ethiopia to transition to clean cooking technologies to address these multifaceted challenges.

# 9. Conclusion

## 9.1. Summary of Findings, Scenarios, and Recommendations

Ethiopia faces critical and persistent challenges in ensuring access to clean cooking technologies for its population. Over 100 million Ethiopians rely on traditional biomass fuels such as wood, dung, and crop residues, which result in severe health hazards, environmental degradation, and economic inefficiencies. Despite national efforts, progress remains slow, with only **8.8%** of the population having access to clean cooking technologies as of 2022. This limited access is compounded by stark disparities between urban and rural areas, with urban access at **28.6%** and rural access at a mere **0.6%**. The rising costs of traditional fuels have exacerbated energy insecurity, prompting many households to engage in fuel stacking combining multiple cooking methods to manage costs. In urban areas, eCooking has shown promise as a cleaner alternative, with **4.1%** of households adopting electric stoves due to relatively better electricity access. However, infrastructure limitations, financial barriers, and low consumer awareness hinder broader adoption across the country.

Key factors influencing clean cooking technology adoption in Ethiopia include **economic factor**, which accounts for approximately **30% of the barriers**; **awareness of the health, environmental, and economic benefits (18%)**; **enabling policies and regulations (15%)**; and consistent **fuel availability (14%)**. Complementary factors, such as **cultural influences, inclusive participation, social attitudes toward technology, and innovation in research and development**, further shape adoption rates. Without addressing these critical factors, clean cooking adoption will remain limited, perpetuating health and environmental challenges and hindering progress toward Ethiopia's development and climate goals.

To explore potential pathways for scaling up clean cooking adoption, three scenarios were modeled: **Conservative Growth, Moderate Intervention, and Aggressive Transformation**. The Conservative Growth scenario aligns with the National Sustainable Energy Development Strategy (N-SEDS) and aims to achieve **49.86% clean cooking access by 2035**. This approach focuses on improved biomass stoves, electric cooking, and minimal adoption of biogas, resulting in projected **emissions reductions of 48.75 $MtCO_{2eq}$ at a cumulative cost of $1.60 billion (2025 - 2035)**. The Moderate Intervention scenario, which aligns with Ethiopia's Nationally Determined Contributions (NDC), proposes a more ambitious target of **75.87% clean cooking access by 2035**. **This scenario emphasizes a balanced mix of technologies, including advanced biomass stoves (45%), electric stoves (50%), and biogas or solar cooking (2.5%), achieving 75 $MtCO_{2eq}$ reductions at an estimated cost of $2.60 billion**. The **Aggressive Transformation scenario**, aligned with the **Long-Term Low Emission Development Strategy (LT-LEDS)**, targets **91.88% clean cooking access by 2035**, relying heavily on electric cooking (70%) and high-tier solutions like biogas and solar hybrid systems. This scenario may achieve substantial emissions reductions of **100 $MtCO_2$-eq** but at a significantly **higher cumulative cost of $3.14 billion (2025 – 2035).**

**Given Ethiopia's resource constraints and the need for impactful yet practical interventions, the Moderate Intervention scenario emerges as the optimal pathway.** It balances feasibility with ambition and aligns with Ethiopia's development and climate objectives. This scenario also ensures urban-rural equity, benefiting **90.6 million people** and addressing key barriers such as affordability, infrastructure limitations, and consumer awareness. A phased implementation strategy spanning **2025 - 2035** has been outlined to facilitate this transition. It has to be noted that **30%** of the cumulative total cost of cookstoves (**$2,601,393.26)**, amounting

to **$ 780,417,978**, were also considered additionally to run program, advocacy, awareness creation, management, and incentives. These funds cover a range of activities essential for program success, including distribution logistics, installer training, quality control, after-sales service, public awareness campaigns, community outreach, collaboration with local leaders, program management, monitoring and evaluation, reporting, and the provision of financial and non-financial incentives to consumers. This allocation, when added to the overall cookstoves cost of **$2,601,393.26**, results in a total expenditure of **$ 3,381,811,240**

**Phase 1 (2025 – 2027**) : The first phase, from **2025 to 2027**, focuses on foundational efforts to promote advanced biomass and electric cooking technologies in areas with grid access. It also recommends piloting biogas systems in livestock-rich rural areas and introducing solar cooking technologies in off-grid regions. **By 2027**, the goal is to reach **18% clean cooking access**.

**Phase 2 (2028 – 2030)** : emphasizes expanding the production and distribution of advanced cookstoves, developing ethanol and LPG infrastructure, and rolling out smart cookstoves with IoT-enabled features in urban areas. The target for this phase is **57.74% access**.

**Phase 3 (2031 – 2035)** : aims to achieve universal access by promoting high-efficiency Tier 5 electric stoves, integrating solar-biogas hybrid solutions, and introducing modular cooking technologies for diverse household sizes, with a target of **75.87% clean cooking access**.

## Specific action and recommendations

- Promote the adoption of advanced biomass stoves (Tier 3 and above), electric stoves, biogas systems, solar cookers, LPG, and ethanol stoves, **tailored to meet regional needs**, while exploring hybrid systems where traditional fuels can be used more efficiently, like biomass with gasification technology for cleaner combustion.
- Make clean cooking a **national priority and agenda** by further **integrating it into policies, strategies, and frameworks, engaging leaders to be part of the initiatives, ensuring continuous media coverage,** appointing a **dedicated champion, mobilizing funds and innovative financing**, and incorporating clean cooking into **national education curricula** to raise awareness from a young age about the benefits and methods of clean cooking.
- Establish a **dedicated National Clean Cooking Coordination Unit** at the Ministry of Water and Energy, and **inter-ministerial task force** to streamline policy development, resource allocation, and monitoring & evaluation related to clean cooking initiatives.
- Develop robust infrastructure for distribution and maintenance, especially in rural areas, using mobile service units for stove maintenance and repair in remote areas.
- Support **local private sector production and entrepreneurship capacity** for clean cooking by facilitating public-private linkage, training and knowledge transfer, and creating incubators or acceleration programs specifically for clean cooking technology startups.
- **Promote research and innovation** to improve stove efficiency and affordability by establishing partnerships with international universities and research institutions for technology transfer and local adaptation.
- Implement **results-based financing** schemes to incentivize clean cooking technology adoption while ensuring affordability for end-users, utilizing carbon finance by linking stove distribution programs with carbon credit markets.

- Introduce subsidies, flexible payment options, and public-private partnerships to improve affordability and access, looking into **community-based microfinance models** where groups can collectively purchase stoves and share the benefits.
- Develop **regional hubs and demonstration centres** for clean cooking technologies, aligned with **cultural preferences**, using these hubs for demonstration, cultural adaptation of cooking practices, hosting cooking competitions, and culinary training using clean technologies.
- **Foster public-private partnerships (PPPs) and industry associations** to incentivize private sector investment in large-scale manufacturing, technology development, and infrastructure expansion for advanced biomass, electric cooking, biogas, LPG, and ethanol solutions, involving local NGOs with grassroots reach to bridge the gap between technology providers and end-users.
- **Integrate specific clean cooking goals into broader climate and development strategies**, including N-SEDS, NDCs and LT-LEDS, ensuring that clean cooking metrics are part of national progress reports to international bodies like the UNFCCC.
- Prioritize the **inclusion of women in the development, distribution, and adoption of clean cooking technologies**, including **targeted financing options, training programs, and promoting women-led enterprises** within the clean cooking sector, establishing networks or cooperatives for women in clean cooking to share experiences, technologies, and business strategies.
- Develop incentives and support mechanisms for local and large scale production of clean cooking stoves and fuels, focusing on creating jobs and reducing reliance on imports, this includes fostering partnerships with SMEs and integrating clean cooking goals into industrial development policies, providing **tax incentives** or **import duty waivers for raw materials used in stove manufacturing**.
- Introduce the concept of higher-tier cookstoves and fuels in the **context of locally produced improved stoves by aligning with cultural preferences and focusing on efficiency improvements** adapted to modify existing cooking and baking systems, thereby drastically reducing costs, while **conducting cooking habit culture studies to understand deeply how cooking practices can be modernized while respecting traditional methods**.
- Develop and **enforce national standards for clean cooking technologies**, ensuring quality and safety compliance while encouraging innovation, engaging in regional harmonization of standards even with neighboring countries to facilitate technology transfer and market access.
- **Develop and operationalize a national carbon market framework** linked to clean cooking projects by leveraging Ethiopia's potential to **generate high-quality carbon credits**, streamlining certification processes, building capacity for local stakeholders, and reinvesting carbon revenues into scaling higher-tier clean cookstoves, training local communities on carbon credit mechanisms.
- **Create a centralized database to track clean cookstove distribution**, the number of households served and cookstoves distributed, time saved, emissions reductions, carbon credits, job creation, and forest savings, integrating community-level data with national monitoring to improve transparency and decision-making, using **blockchain technology** (a decentralized, unchangeable record system for secure, transparent tracking) for transparent and tamper-proof tracking of stove distribution and impact metrics.

- **Develop a comprehensive stakeholder engagement plan** that includes regular consultations, knowledge-sharing workshops, and a joint work plan to ensure coordinated action and resource mobilization across sectors, establishing a national clean cooking day or week to foster public engagement and awareness.