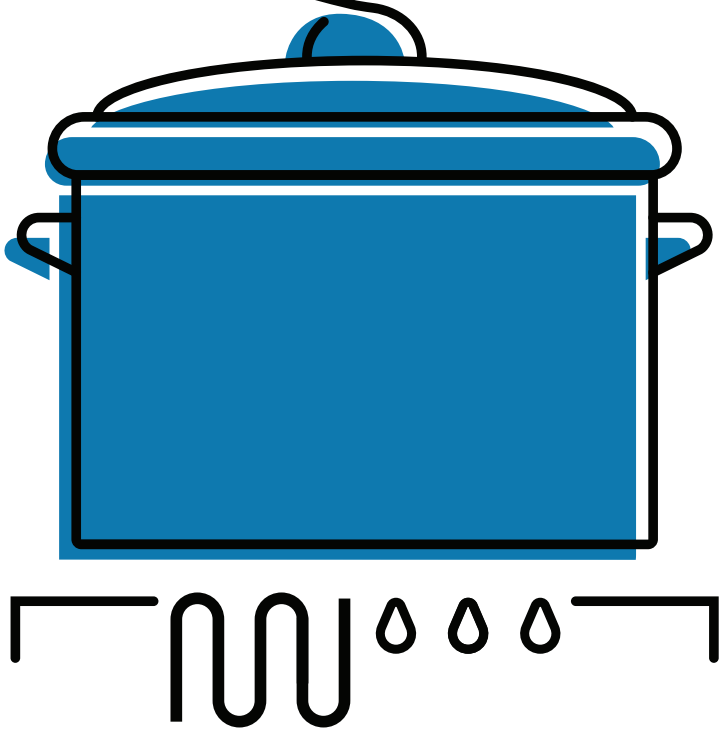
IRENA
International Renewable Energy Agency

ADVANCING RENEWABLES-BASED CLEAN COOKING SOLUTIONS

Key messages and outcomes



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About IRENA

The International Renewable Energy Agency (IRENA) serves as the principal platform for international co-operation, a centre of excellence, a repository of policy, technology, resource and financial knowledge, and a driver of action on the ground to advance the transformation of the global energy system. An intergovernmental organisation established in 2011, IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

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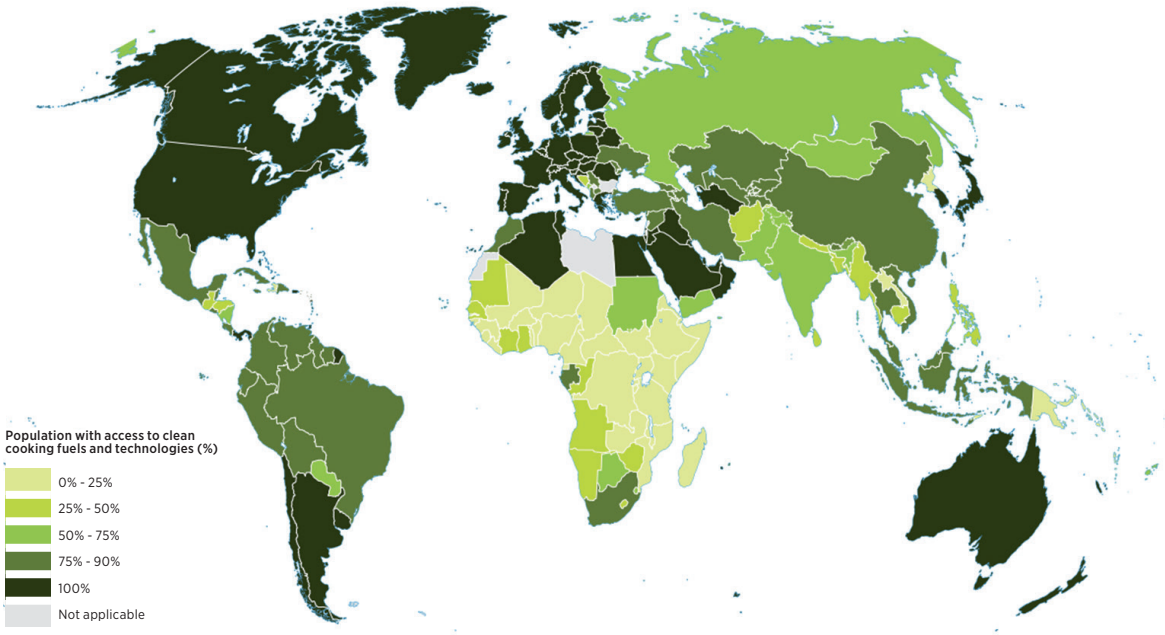
DISCLAIMER

INTRODUCTION

Using inefficient and traditional biomass for cooking, including charcoal, firewood and kerosene, poses a significant threat to human health, climate and the environment (WHO, 2023). Transitioning to clean cooking is crucial, as it directly impacts lives and livelihoods. A key pillar of a just and inclusive energy transition that leaves no one behind is the achievement of universal modern energy access – as outlined within Sustainable Development Goal (SDG) 7 (IRENA, 2023a). According to the Tracking SDG 7 report, the world is not on track to achieve universal access to clean cooking by 2030 (IEA *et al.*, 2023), and disparities in clean cooking access rates persist across different regions (Figure 1). In sub-Saharan Africa alone, the demand for access to clean cooking grows at the rate of about 20 million a year. Without a transformative shift in approaches to achieving clean cooking access, this growing demand, as well as the set targets for 2030, are unlikely to be met.

Figure 1 **Share of population with access to clean cooking fuels and technologies, 2021**



Source: (WHO 2023).

Disclaimer: This map is provided for illustration purposes only. Boundaries and names shown on this map do not imply any endorsement or acceptance by IRENA.

To achieve clean cooking access targets, countries have defined strategies encompassing a mix of renewable and non renewable solutions. The mix depends on local conditions including affordability, resource availability, consumer preferences and awareness, supply chains for fuels and products, and long-term operation and maintenance needs. The mix is expected to evolve with changes in the local conditions and the maturity of the market for new solutions. Targeted investments driven by well-defined policy frameworks play a crucial role in shaping the overall development of the market, by setting targets for what constitutes access, ensuring that no one is left behind, as well as aligning the fuel mix with broader development, environment and climate change goals.

Renewables-based clean cooking solutions,[1] including biogas, bioethanol, solid biomass and renewables-based electricity, are often given less attention in the policy and investment discourse when compared with other clean cooking options, despite the benefits they offer over their fossil fuel-based counterparts. For instance, over the last decade, more focus was given to liquefied petroleum gas (LPG)-based solutions, through the support of large governmental contributions and programmes. This resulted in over 70% of the progress made towards providing clean cooking access being mainly achieved through LPG (IEA, 2023).

Renewables-based clean cooking solutions offer climate change-related benefits, fuel saving opportunities and co-benefits arising from supply chains across other sectors such as agriculture (Mazorra *et al*., 2020). In recognition of the crucial role of renewables-based clean cooking solutions, greater efforts are needed to better understand the options, and unique challenges, and identify actions needed to scale up support for the sector. Against this backdrop, the International Renewable Energy Agency (IRENA) launched a virtual knowledge exchange series in 2023 to facilitate in-depth dialogue on each of the renewable clean cooking solutions and convene practitioners operating in sub-Saharan Africa and Asia, to shed light on the experiences and lessons learnt across regions (Box 1). This brief summarises the key findings and messages arising from the series. It is not meant to provide an exhaustive analysis of the renewables-based clean cooking landscape, but rather a summary of experiences, challenges and opportunities, along with the actions needed to scale up adoption drawing on the series.

Box 1 IRENA clean cooking knowledge and exchange

In April 2023, IRENA launched the virtual knowledge exchange series on renewables-based clean cooking to provide a platform to discuss the current status of solutions, challenges and opportunities. As part of the series, four deep-dive sessions were organised focusing on:

1. Bioethanol in partnership with the United Nations Industrial Development Organization (UNIDO)/Council on Ethanol Clean Cooking.
2. Biodigesters in partnership with SNV Netherlands Development Organisation (SNV).
3. Electric cooking in partnership with Modern Energy Cooking Services (MECS).
4. Solid biomass in partnership with Practical Action.

Over 370 experts participated in the discussions representing the private sector, financing institutions, development organisations and academia, among others. Recordings of the webinars are available online here: www.irena.org/Events/2023/Apr/Advancing-renewables-based-clean-cooking-solutions

[1] *The term "clean cooking" defines cooking solutions that achieve ISO Tier 4 and 5 of the multi tier frameworks for clean cooking or technologies that attain the fine particulate matter ($PM_{2.5}$) and carbon monoxide (CO) levels recommended in the World Health Organization's (WHO) global air quality guidelines (WHO, 2021). Clean cooking fuels and technologies include stoves powered by electricity, liquefied petroleum gas (LPG), natural gas, biogas, solar and alcohol. "Renewables-based clean cooking solution" narrows down the specificity of the clean cooking definition to encompass only technologies that utilise renewable fuel sources. These include biogas, bioethanol, solid biomass and renewables-based electricity.*

To co-ordinate these discussions, IRENA leveraged previous research and findings on these technologies, which can be found in the following reports:

- **Renewables-based electric cooking: Climate commitments and finance,** published in 2023.

  This report assesses countries' status on access to renewables-based electric cooking and climate commitments to understand the current situation and priorities on electric cooking. Because financing is one of the significant issues when translating electric cooking targets into action on the ground, the report looks into the financial landscape, challenges and supportive policies to address the challenges. The report provides action plans to scale up electric cooking solutions for different groups of countries.

- **Bioenergy for the energy transition: Ensuring sustainability and overcoming barriers**, published in 2022.

  This report highlights the need to achieve clean cooking with renewables-based solutions, including efficient cookstoves, modern forms of biomass, biogas and methane. It noted the existing gaps and clear gender inequities, along with the unaffordable cost of renewables-based solutions for many households as major barriers. With the guidance of dedicated clean cooking targets, public financing mechanisms such as results-based financing (RBF) schemes, and public awareness programmes, these barriers can be addressed.

- **Renewable energy policies in a time of transition: Heating and cooling**, published in 2020.

  The report notes the distinctions used when defining biomass and charcoal fuels for clean cooking. In principle, biomass and charcoal are renewable; however, when used inefficiently, they can lead to significant indoor and outdoor pollution and can also put pressure on local resources. In addition, opportunities to transition from fossil fuel-based LPG and kerosene to biogas, improved cookstoves, and ethanol fuel cookstoves are presented as solutions to support sustainable energy transitions and energy access.

The brief comprises five sections. The first explores shared experiences in adopting and scaling up clean cooking solutions across all technologies. Sections 2 through 5 provide detailed insights into solid biomass, bioethanol, biogas and electric cooking, respectively.

1. RENEWABLE CLEAN COOKING SOLUTIONS: CROSS-CUTTING CHALLENGES AND OPPORTUNITIES FOR SCALING UP

Notable progress has been made in sub-Saharan Africa and Asia by governments, the private sector and development practitioners in facilitating the adoption and scaling of clean cooking solutions; however, certain challenges remain. Across the four dedicated deep-dive sessions (on solid biomass, bioethanol, biogas and electric cooking), there was a common theme of challenges experienced by practitioners in the scaling up and adoption of clean cooking. These can broadly be clustered into policy and planning, finance and enterprise investment, end-user affordability, and awareness-raising challenges. This section highlights these challenges and for each of these, it offers recommended interventions and actions needed to address them.

POLICY AND PLANNING

The clean cooking sector in most countries, especially those in Africa, is still nascent and often overlooked. Renewables-based clean cooking operates in this landscape, where planning and prioritisation are limited. The scope of the clean cooking solutions also cuts across multiple sectors of the economy, which adds to the complexity of having to co-ordinate among different ministries for effective planning.

In most countries, there is no planning or established strategies for tackling the clean cooking challenge. Where such strategies exist, they do not always consider the range of solutions available along with clear targets with an allocated and stable budget outlay and implementation plan. In addition, renewable clean cooking often is not fully integrated within broader national energy strategies. This signals a huge gap in the policy prioritisation of renewables-based clean cooking by countries. The lack of planning is sometimes attributed to issues such as the lack of in-house technical capacity, skills and resources.

Recommended actions to overcome these challenges include setting benchmarks (*e.g.* whether to target transition, access or high-tier performance) and establishing a strategy that guides investment and action. It is important that governments develop clean cooking roadmaps and strategies (Box 2) that are well integrated within broader energy policies and plans and that consider a mix of solutions based on the local context, infrastructure, demand and resource availability (Box 3). Moreover, it is key to set clear clean cooking targets with an allocated budget for implementation. To build the needed capacity, governments can lean on the support from development partners and the hub of existing information (Box 4) and established best practices.

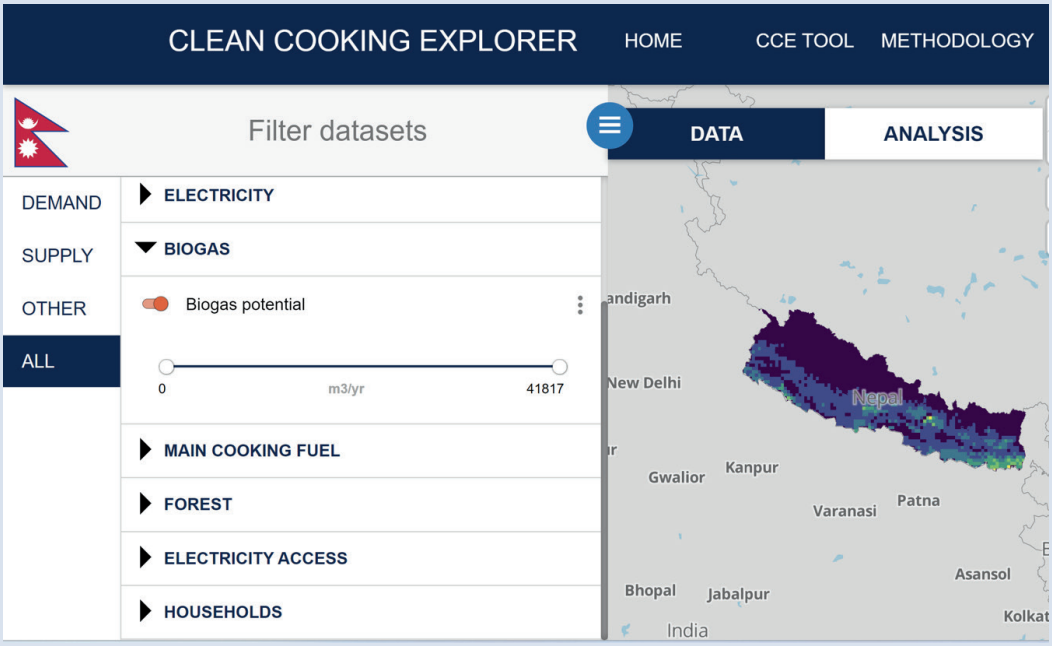
Box 2 Kenya's integrated energy plan for clean cooking access

In 2022, Kenya initiated the Kenya National Clean Cooking Strategy to implement its pledge to ensure universal access to clean cooking by 2028 and contribute to its Nationally Determined Contributions (NDC) target to abate the emission of 2.8 million tonnes of carbon dioxide equivalent in 2030. It is expected that the plan will help identify gaps and opportunities in Kenya's clean cooking sector to develop a roadmap for 2028 and determine the most adequate clean cooking mix to meet universal access (MECS, 2023).

Box 3 Geospatial tool to accelerate access to clean cooking in Nepal

In 2022, the Clean Cooking Alliance (CCA) in collaboration with the World Resources Institute (WRI) and other stakeholders launched the Clean Cooking Explorer (Figure 2) in Nepal, a geospatial planning tool designed to help governments achieve their clean cooking targets. The platform facilitates data-centric planning, co-ordination and decision making by incorporating and facilitating the analysis of geospatial datasets pertaining to both the anticipated demand and availability of clean cooking services. This is aimed at promoting the acceptance and integration of clean cooking practices within the country.

Figure 2 The Clean Cooking Explorer



Source: Clean Cooking Alliance, 2023.

Box 4 The Clean Households Energy Solutions Toolkit – An information repository by the World Health Organization

The Clean Household Energy Solutions Toolkit (CHEST) by WHO offers a set of resources that countries and programmes can utilise to create policy action plans for enhancing access to and utilisation of clean household energy (WHO, 2022). Developed with input from experts, CHEST is designed to assist professionals and policy makers in various sectors, enabling them to implement recommendations from the WHO Guidelines on Indoor Air Quality: Household Fuel Combustion. By furnishing tools for energy planning, CHEST empowers policy makers to devise programmes that promote access to clean and secure household energy, ensuring tangible and significant health benefits. CHEST aids in formulating policies that encourage the adoption of clean household energy at local, programmatic or national levels.

Comprising six modules, CHEST provides resources for tasks such as mapping key stakeholders, conducting situational assessments, identifying technological and policy interventions, establishing standards, carrying out monitoring and evaluation, engaging the health community, and enhancing communication and awareness.

The toolkit incorporates specific tools within these modules, including models for estimating emissions, health impacts and cost-effectiveness of household energy interventions. It also includes survey questions for tracking household energy use, databases containing information on fuels and technologies used in homes and their health impacts, training materials, and communication strategies.

FINANCE AND INVESTMENT FOR ENTERPRISE DEVELOPMENT

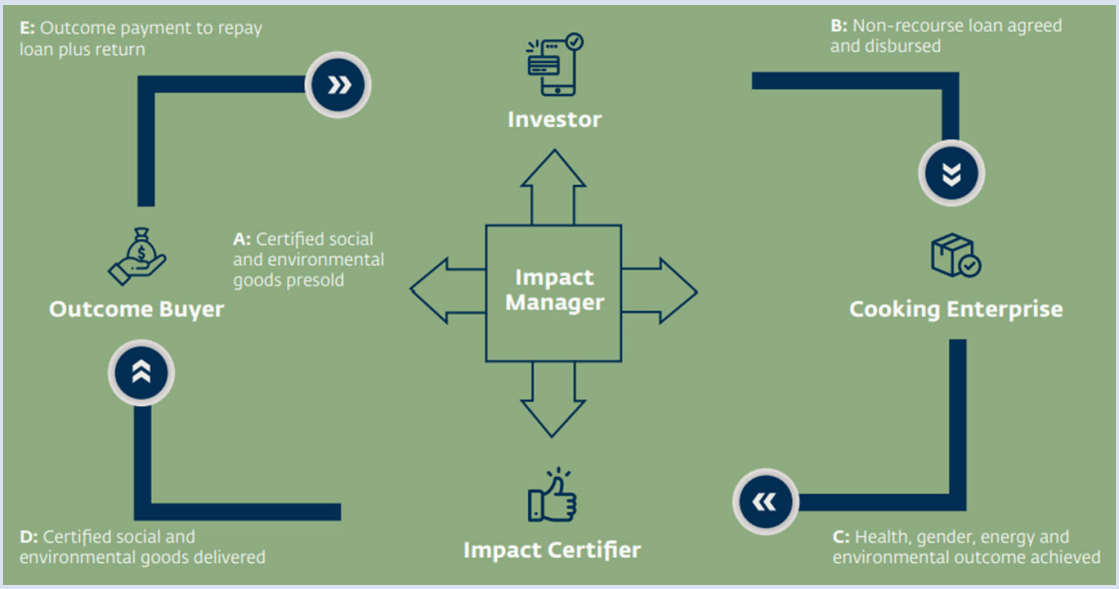
Access to finance is a huge obstacle for suppliers of clean cooking solutions (cookstoves and fuels). Financiers perceive the sector as too risky for investment, mainly because it is still relatively new, with very few business cases demonstrating investment returns. External volatility and rapid changes in the policy and regulatory framework (trade facilitation, tariff setting, tax exemptions, etc.) also adds to this perceived risk. As a result, enterprises secure financing at a high cost, and they pass on these expenses to end users, who may struggle to afford the products. Enterprise financing needs vary from context to context and depending on the stage of the enterprise, necessitating different finance instruments. The current landscape of enterprise financing in the clean cooking sector is dominated by debt from various sources including multilateral and development finance institutions and foundations. Carbon finance is also gaining traction as a source of revenue for enterprises.

To bridge enterprise-level investment gaps, a blend of private and concessional finance is required to provide affordable capital to clean cooking enterprises. Tailored financing is also needed along different stages of enterprise growth and development. A combination of grants, including results-based grants, concessional debt and patient equity is needed. Alongside these investments, public financing can be used as both a demand stimulant in the market, and a de risking tool for investors and enterprises. Over recent years, RBF (Box 5) and carbon financing (Box 6) have emerged as additional capital and revenue sources for enterprises.

Box 5 The Clean Impact Bond, an RBF loan to monetise gender and health benefits

The Clean Impact Bond (CIB) was officially launched in 2022. It is a partnership among Cardano Development, International Finance Corporation (IFC), BIX Capital, the Osprey Foundation and Sistema.bio. The bond aimed to improve the aversion of ill health and mortality, and an increase in women's quality time, using the biogas digesters provided by Sistema.bio to rural families across ten regions of Kenya. The structure of the bond involves five parties (Figure 3). Cardano Development, as the **impact manager**, initiates and manages transactions in the CIB. It sells "social and environmental impacts" for health and gender to an **outcome buyer**, to be delivered at a future date. BIX Capital, as the investor, provides upfront working capital financing in the form of a **non recourse loan** to the tune of USD 300 000 to Sistema.bio, the **cooking enterprise**, which uses the financing to scale up operations to reach low-income customers. The **impact certifier**, Gold Standard, independently verifies and certifies that health and gender outcomes have been achieved during Sistema.bio's operations, and Osprey Foundation, as the outcome buyer, makes the payment to the investor repaying the loan plus return. The Osprey Foundation committed up to USD 500 000 to pay for health and gender outcomes after they had been independently verified and certified to have been achieved. The outcome payments from the Osprey Foundation will cover delivery costs of the CIB, including measurement, reporting and verification, and the repayment of BIX Capital's investment (IFC, 2023).

Figure 3 Clean Impact Bond structure



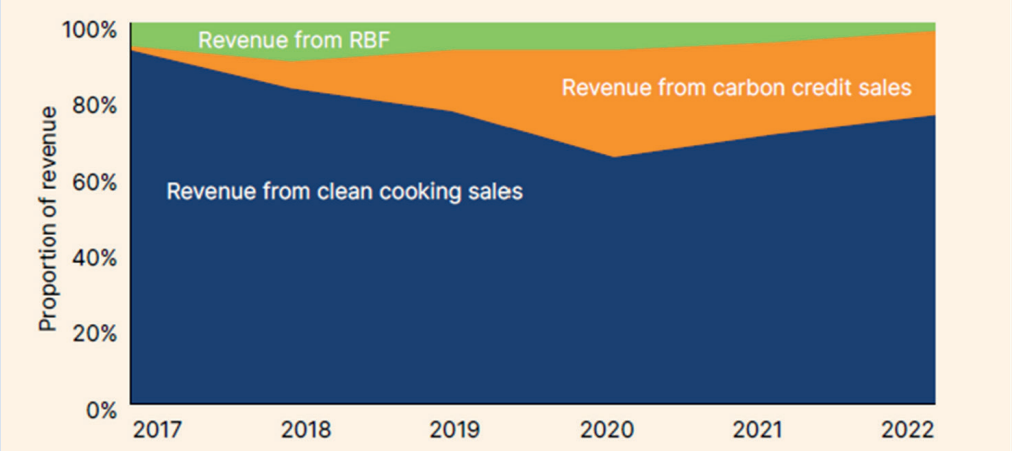
Source: (IFC, 2023).

Box 6 Carbon finance as a source of revenue for clean cooking

Carbon finance consists of generating funds by selling carbon credits or offsets that result from projects aiming at reducing greenhouse gas (GHG) emissions, such as clean cooking initiatives. At its core, it can be considered as a RBF mechanism because it links a financial payment to achieved emissions reductions (Mikolajczyk *et al.*, 2023). It has played a role in mobilising private sector engagement within the clean cooking space.*

According to a report by the CCA, the sale of carbon credits from clean cooking contributed 22% of the overall revenue for clean cooking enterprises in 2022 (Figure 4) (Clean Cooking Alliance, 2023).

Figure 4 The rise of carbon credit sales as a source of revenue for enterprises



Source: Clean Cooking Alliance, 2023.

* *While clean cooking carbon offset projects are useful in providing additional revenue for enterprises, their governance needs to be adequately tracked to avoid overestimation, as referenced here.*

END-USER AFFORDABILITY

From a demand-side perspective, a barrier to the adoption and sustained use of renewable clean cooking fuels and technologies is end-user affordability, especially among low-income households. Renewable clean cooking solutions can have high upfront costs due to the cost of the technology itself, import-related expenses, and logistical costs depending on location that are passed on to consumers. In addition, most sales related to clean cooking stoves and appliances are made through cash, and consumer financing is lacking.

Bridging the affordability gap often requires a combination of supply-side and demand-side measures to bring down the cost of fuels and technologies and enable access to financing products and incentives to facilitate adoption among the users. On the supply side, grants delivered as capital subsidies to enterprises can significantly lower the cost of the product for consumers. Innovative and inclusive consumer finance solutions such as pay-as-you-go (PAYGO), or in the context of clean cooking, pay-as-you-cook (PAYC) (Box 7), have also been developed to address this key obstacle in renewable clean cooking uptake.

Box 7 The emergence of PAYGO clean cooking business models

There has been an emergence of a number of PAYGO cooking providers into the market, inspired by the off-grid solar sector (Next Billion, 2023). These companies supply a range of clean fuels such as bioethanol, biomass pellets and electric cooking devices. Their business models rely on smart metering and IoT (Internet of things) innovations that allow digital monitoring of consumer consumption patterns, and processing of payments. To enhance convenience and affordability, the purchase costs for the stove can be made available through ongoing credit sales via mobile money. Additionally, running costs for the fuel can be paid using mobile money.

Companies that use the PAYGO model typically provide warranties to ensure the long-term functionality of their equipment. They also deliver fuel replenishments directly to households or create distribution points closer to the consumer.

The PAYGO model helps low-income households to transition to clean cooking by:

- Reducing the cost of purchasing fuel by bringing it closer to the end user.
- Bridging upfront affordability gaps for clean cooking.
- Solving availability issues by bringing the fuel closer to its consumers.

Targeted subsidies towards low-income households are also key in ensuring the transition to renewable clean cooking. Kenya and Uganda have implemented exemplary subsidy models, such as electric cooking subsidy tariffs (Box 12). This lifeline tariff model reduces affordability constraints for low-income consumers and promotes electric cooking.

AWARENESS AND ACCESS TO INFORMATION

The lack of awareness and access to information is a problem for end users. Prospective technology users may be unaware of the benefits and cost-saving opportunities provided by clean cooking solutions. For end users that have some awareness, cultural beliefs and traditional practices can hinder adoption, leading to continued use of polluting methods such as traditional biomass. For example, some cultures believe that food cooked with electricity will not taste as good as if cooked with firewood or charcoal.

To address this issue, training, maintenance support and after-sales services is needed for users to be encouraged to adopt cleaner solutions (Box 8).

Box 8 Pika na Power – Kenya Power's flagship electric cooking campaign

In 2023, Kenya Power, the utility operator in Kenya, made a commitment to raising awareness of electric cooking for increased uptake by its customers (Ochieng *et al.*, 2023). It launched the Pika na Power public awareness campaign, which is designed to show customers how quick, easy and affordable it is to cook with electricity. Through this campaign, demonstration centres have been set up in Nairobi, Kisumu, Nakuru and Mombasa to advance the electric cooking agenda nationally.

The campaign also uses online communication channels and news outlets to disseminate information. This initiative has gained a lot of traction on the ground and has received significant online engagement.

CROSS-CUTTING CHALLENGES – KEY MESSAGES

A summary of recommended cross-cutting actions to support clean cooking is listed below.

Develop an integrated national strategy for clean cooking assessing the role of all available solutions and the evolution of the mix to 2030/set universal access target year.

Formulate strategies and dedicated policies specific to renewables-based clean cooking solutions addressing adoption, consumer financing, awareness raising, quality and standards, and supply chain considerations.

Designate institutional responsibility for implementation and financing mobilisation for clean cooking strategy with adequate capacity and mandate to facilitate cross-sector collaboration (*e.g.* agriculture, job creation, climate)

Address significant data and information gaps in the sector impacting planning and decision making, as well as design of consumer-oriented interventions to facilitate adoption of clean cooking.

Place end user and inclusion at the centre of the clean cooking strategies integrating local dishes, cooking perspectives, gender roles and most marginalised communities, in addition to technologies and economics.

Catalyse financing at the scale necessary to bridge funding gaps across the clean cooking landscape, including enterprises, consumers and wider enabling environment comprising community groups, non governmental organisations, development agencies, technical institutes, etc.

2. SOLID BIOMASS DEEP DIVE

The session on solid biomass was co-organised with Practical Action.

BACKGROUND

In principle, biomass is renewable; however, its traditional use in cooking leads to significant indoor and outdoor air pollution which has severe consequences along with other environmental and socio-economic impacts (IRENA, IEA and REN21, 2020). In addition, the low efficiency of cookstoves means that fuel requirements are high and often exceed local sustainable supply, leading to pressure on local forestry resources and deforestation. The collection of biomass such as firewood for cooking is very time-consuming and takes time away from other income-generating activities and education.

Advanced and modern biomass cooking solutions offer characteristics such as high efficiency, low emissions and greater safety when compared with traditional fire stoves (Ahmad *et al.*, 2022). Solid biomass fuels can be derived from by-products of agricultural production and forest residues. The fuel has a role in expanding clean cooking access alongside the adoption of fuel-efficient cookstoves (or improved cookstoves) that can also reduce indoor air pollution. The cookstoves can burn a variety of solid biomass such as crop waste, dung, wood, charcoal, briquettes, pellets, coal and woodchips.

By definition, clean cooking fuel technologies are technologies that attain the fine particulate matter ($PM_{2.5}$) and CO levels recommended in the WHO global air quality guidelines (World Health Organization, 2021). Biomass clean cooking systems are considered clean and receive the highest tier (Tier 5), if they meet the emissions rate targets provided by the guideline. A confirmed laboratory testing following an international laboratory testing protocol with tests conducted by a third party is needed to get a ranking. As of January 2024,[2] WHO has designated only one biomass cookstove as being "clean" (Achieving Tier 5), and three as being "transitional" (Achieving Tier 4), due to their related emissions as tested.[3] Guided by this classification, the roadmap envisions a phased shift from transitional cooking solutions to achieving net-zero emission cooking by 2050.

Building markets for modern biomass cookstoves requires an understanding of the customer base, their socio economic status, cultural factors, and energy- and consumer-related behaviours. Biomass fuel continues to be a vital solution for low-income and rural households because of its ease of adoption. It requires minimal adjustments when switching to the technology, because it involves a change in only the cookstove and not the type of fuel.

DESIGNING UNIVERSAL CLEAN COOKING STRATEGIES: WHERE DOES SOLID BIOMASS FIT IN?

The traditional use of biomass for cooking is widespread in various contexts, with nearly 70% of the population in sub-Saharan African countries relying on it. There is a recognised need for a shift in perception and usage, moving from traditional to modern biomass.[4] However, enforcement remains a critical challenge. This lack of implementation hinders government measures aimed at reducing such practices. To facilitate

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[2] *The date on which the data were retrieved.*

[3] *WHO's definition of clean, transitional and polluting fuels and technologies used for cooking, heating and lighting as well as the associated tier levels are described here.*

[4] *See IRENA's definition of traditional and modern biomass here.*

the implementation, development organisations such as the United Nations Development Programme (UNDP) have initiated regional-level efforts such as those seen in West Africa to formulate country-level clean cooking action plans which highlight the role of modern biomass cooking in the energy mix. These initiatives aim to raise awareness on the distinctions between efficient and inefficient use of biomass, shedding light on the environmental impact of traditional biomass practices, especially on forestry. From a technological perspective, these efforts prioritise understanding end-user cooking needs. They encourage the adoption of technology that aligns with user requirements, emphasising a user-centric approach rather than expecting users to conform to existing technology.

BUILDING SUSTAINABLE AND INCLUSIVE MARKETS AND SUPPLY CHAINS: WHAT LESSONS ARE EMERGING?

The supply chain of solid biomass fuel is closely interconnected with forestry and agriculture. In Rwanda, pellet and briquette manufacturers utilise raw materials such as sugar cane waste and bagasse. The supply of these raw materials is affected by agricultural production, leading to fluctuations based on agricultural output. Manufacturers also face upfront challenges in setting up facilities for briquette production, as the process involves multiple steps such as drying, grinding, sieving, compacting and cooling. The machinery required for these processes can be expensive, adding to the overall costs for manufacturers.

Affordability concerns can also be noted from an end-user perspective. They arise from the initial costs of acquiring a cookstove and from a fuel perspective. Higher-tier cookstoves tend to be relatively more expensive than lower-tier cookstoves, and processed biomass in the form of briquettes and pellets is typically sold at a price, compared with the freely available firewood that consumers commonly use.

From an enterprise perspective, testing and complying with internationally approved standards for cookstoves can impose added production costs on suppliers. Testing is an important aspect for determining if a stove can be categorised as transitional or clean. It requires that for each biomass cookstove, a standard protocol is followed and that the results are standardised. Capacity, and laboratory resources needed for testing, reporting and publicising the results, are often limited. To overcome this, WHO has partnered with organisations such as the CCA to build that needed capacity for testing and developing standards, so that cookstoves that are introduced to the market are meeting at least the upper tiers of performance. To address the challenges related to additional resources needed for testing, development partners in Bangladesh have enlisted the assistance of technical institutes such as the Bangladesh University of Engineering and Technology to help enterprises with testing and laboratory facilities at subsidised rates.

The categorisation of biomass cooking technology as transitional also introduces uncertainties in future business models. Companies currently active in the market will eventually need to phase out the supply of lower-tier cooking stoves and shift towards providing higher-tier cooking stoves to align with development goals and qualify for financing and investment. Companies such as BURN Manufacturing in Kenya and Practical Action in Nepal are already undergoing this internal transition by incorporating electric cookstoves into their product offerings. It is anticipated that such transitions will involve additional expenses for the suppliers.

SESSION KEY MESSAGES

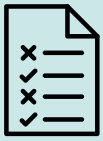
A summary of the recommended actions towards developing and scaling solid biomass solutions is listed below.

CLEAN COOKING STRATEGIES AND PLANS

Recommendations

- Recognise the role of solid biomass, in combination with improved stoves, as a clean or transitional solution in the path to achieve universal clean cooking access in national strategies and programmes. Challenge the perception that all biomass is unsustainable, noting that sustainable production and residue use can offer crucial clean or transitional alternatives.
- Assess co-benefits offered by more advanced technologies, including biomass gasifiers which produce biochar as a by-product that can be used to enhance soil fertility and fix the carbon in the soil.
- Approach the transition holistically, accounting for impacts on, for instance, artisanal stove and charcoal producers from the clean cooking transition. Furthermore, implications of policy and regulatory decisions, including setting technology and performance standards, should also be considered.
- Build institutional capacity and strengthen co-ordination among relevant ministries, including forestry, environment, energy and climate.

STANDARDS AND TESTING

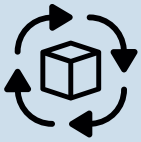


- Set enabling standards for clean cookstoves building on those developed by the ISO voluntary performance targets and the Energy Sector Management Assistance Program (ESMAP) Multi Tier Framework, adopted by WHO. However, these need to be context-specific and tailored to end-use preferences and needs rather than the other way around.
- Invest in accessible and affordable testing and third-party certification facilities for stove manufacturers to enhance market access for quality products and solutions. Partner with technical institutes to develop quality standards for biomass cookstoves adapted to local contexts.

FINANCING MECHANISM AND FISCAL AND FINANCIAL INCENTIVES

- Offer incentives and support for capacity development and training for local enterprises and manufacturers to build and test cookstoves that meet performance standards and criteria.
- Deploy public financing and donor support across the value chain to build capacity among local enterprises, financing institutions and communities to maintain systems and utilise cookstoves for traditional dishes.
- Combine supply-side and demand-side measures (*e.g.* upfront grants, RBF) to increase affordability of cookstoves and solutions for end users, particularly with high-tier stoves with greater capital costs. Targeting incentives at suppliers may support distribution and market creation.
- Strengthen enterprise financing particularly from local sources overcoming demands of securities and collaterals and make accessible for small suppliers. Capital is needed also in production stage for various equipment (*e.g.* dryer, kiln, presser).

SUPPLY CHAIN DEVELOPMENT



- Adopt an ecosystems approach focusing on end-to-end value chain development from suppliers to end users, looking at domestic markets but also potential for exports.
- Increase funding commitments for developing supply chains for modern biomass solutions and addressing the sustainability of existing value chains (*e.g.* charcoal).
- Ensure the raw material for fuel (*e.g.* pellet, briquette) should have a local recipe to it with visibility on long-term availability and local capacity for production.

ENABLE CARBON FINANCING AND TRADE

- Enhance access to carbon financing for enterprises and programmes, with proceeds going towards making products and solutions more affordable as well as to support the enabling environment for the transition.
- Develop policy and guidelines for carbon trade to build confidence of carbon project developers. Carbon financing requires a lot of monitoring and evaluation, with financial commitments. Could bring inequalities in the market. Those enterprises that cannot access face disadvantage in marketing their products. But has helped to increase more access and affordability.

AWARENESS RAISING

- Engage community groups in producing stoves, awareness raising and marketing with opportunities for generating alternative income sources.

INNOVATION AND RESEARCH AND DEVELOPMENT (R&D)

- Support technology innovation by targeting incentives at manufacturers to adapt to unique local conditions (*e.g.* flood tolerant, disaster setting).

3. BIOETHANOL DEEP-DIVE

The deep-dive session on bioethanol was co-organised with the Council on Ethanol for Clean Cooking and UNIDO.

BACKGROUND

Bioethanol value chains include fuel production, cookstove manufacturing, distribution (of the fuel and the cookstove), and end use. The production of bioethanol is directly linked with the agricultural sector as it is produced through the fermentation of first-generation food- and sugar-based feedstock such as corn, sugar cane, wheat and straw. In sub-Saharan Africa, the main source of feedstock is molasses, which is a by-product of sugar manufacturing (Ministry of Energy, Kenya, 2021). There is also a demand for cellulosic bioethanol, produced from non food residues such as sawdust and algae, to address concerns regarding the energy-food conflict. In West and Southern Africa, several private sector entities are working in partnership with farmers and developing fuel production chains to deliver bioethanol for cooking.

The bioethanol market in sub-Saharan Africa was initially limited to small-scale projects. However, in recent years, widespread adoption and commercialisation led to over a million bioethanol cookstoves distributed to households in Kenya alone (Osiolo *et al.*, 2023). Progress towards market development and the integration of bioethanol in the energy mix varies significantly among countries. The dedication session on bioethanol captured various country-level best practices for integrating the fuel into national clean cooking strategies and the experiences emerging from building sustainable supply chains and strengthening local enterprises.

LINKING BIOETHANOL WITH THE NATIONAL CLEAN COOKING STRATEGIES

Governments have started defining targets for achieving nationwide adoption of bioethanol. Kenya has set the precedence by developing an Ethanol for Cooking Masterplan[5] which sets the target to have 22% of the clean cooking energy mix comprise bioethanol fuel and technologies by 2028. The country has also embraced the entry of the private players into the market, with the likes of KOKO Networks setting up shop. Since its launch in 2019, KOKO has distributed over 800 000 bioethanol cookstoves to households (Box 9).

Box 9 The KOKO business model

KOKO Networks (KOKO) is a clean cooking technology company serving more than 550 000 urban households in Kenya (Clean Cooking Alliance, 2022). KOKO manufactures a two-burner KOKO cooker, which runs on KOKO fuel, a liquid bioethanol produced from the local and global sugar industry. Each KOKO cooker comes with a smart KOKO canister, unique to each customer, which holds and dispenses the fuel. Through their network of over 600 fuel distribution points, known as "KOKO points", which are installed inside local convenience shops, customers can buy clean bioethanol fuel in small quantities and closer to home. All of this is managed through KOKO's cloud software, which monitors the activity of the distribution points, enabling safe and low-cost last-mile fuel distribution to its consumers.

Through its tech-enabled model, KOKO distributes bioethanol at about KES 17 (Kenyan shillings) per litre at a price lower than kerosene, retailing at around KES 145 per litre, in Kenya.

[5] *LPG is envisaged to still contribute the largest portion of the mix at 44% because it is the most widely adopted fuel in the market. Improved cookstoves take up 36%, biogas 3%, and electricity 4% (Ministry of Energy, Kenya, 2021).*

Tanzania has benefited from its partnership with UNIDO, which led to the launch of the Promoting Ethanol as a Clean Alternative Fuel for Cooking project. The five-year project assumes a private sector-driven market model with a target of 500 000 households adopting bioethanol cookstoves by 2024 in Dar es Salaam (Box 10).

Box 10 Promotion of bioethanol as alternative clean fuel for cooking

The project seeks to promote the use of bioethanol as an alternative clean cooking fuel in Tanzania (UNIDO, 2018). This is done by enabling the production of bioethanol from molasses. Molasses is highly underutilised in Tanzania's sugar factories when it comes to its potential for energy production. The project takes advantage of this untapped potential and establishes local capacity to three key industries: stove suppliers and manufacturers, ethanol fuel producers and suppliers, and retail distributors responsible for the provision of both the cookstoves and the fuel.

The project improves the capacity for market development for production of the fuel, assists the government in developing a conducive policy and regulatory environment necessary for market establishment and growth, designs an enabling framework for switching 500 000 households from traditional polluting fuels to bioethanol for cooking, and creates a market for 90 million litres/year of ethanol fuel supply.

BUILDING SUSTAINABLE SUPPLY CHAINS AND STRENGTHENING LOCAL ENTERPRISES

Challenges to reaching the needed scale include factors such as an undeveloped local bioethanol supply chain. For instance, local bioethanol production in Kenya is estimated at 1.2 million litres, while the demand is estimated at 8 million litres. Some countries rely on imported bioethanol,[6] which poses risks of currency fluctuations that affect its cost and resale price. Mozambique, for example, which imports some of its bioethanol from South Africa, went through several economic recessions, which increased its currency's exchange rate to around MZN 63 (new Mozambican metical) to USD 1. The cost of bioethanol during this time increased drastically. Food versus fuel concerns have also been raised as most countries use food plants such as molasses, sugar cane, cassava and bamboo as feedstock.

To address these challenges, enterprises have resorted to engaging with farmer groups to create a value-added partnership to supply feedstock. Companies such as Giraffe Bioenergy in Kenya adopted a vertically integrated agricultural model. With this model, they plan to produce a large quantity of cassava and become the main off-taker to produce bioethanol. If produced at large scale and at globally competitive prices, it could also be directed towards distributors such as KOKO Networks. This model is intended to strengthen the availability of fuel and ensure stable prices while removing the burden of last-mile distribution from Giraffe Bioenergy. Moreover, it could contribute to improving suppliers' ability to attract large-scale capital funders through sustainable business models. The potential partnership between producers and distributors would strengthen the supply chain, making the development of the market a common objective for business prosperity. To address the challenge of competing with food sources, companies such as Green Energy Biofuels in Nigeria have opted to utilise second-generation feedstock, such as sawdust. Agricultural waste products are a common alternative. For example, Econexus Ventures Limited in Ghana uses pineapple crowns as feedstock.

[6] *Bioethanol sourced from imports has other applications outside of clean cooking.*

SESSION KEY MESSAGES

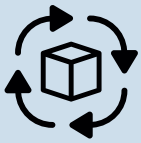
A summary of the recommended actions towards developing and scaling bioethanol solutions is listed below.

POLICY AND PLANNING

Recommendations

- Design a dedicated bioethanol policy with targets catering to diverse delivery models (*e.g.* vertically integrated, distributor and refiners with offtake agreements) and incentives for agriculture sector and residue access. Offer long-term and stable investment framework for private sector participation covering household consumers and institutions (*e.g.* schools).

SUPPLY CHAIN DEVELOPMENT



- Support local feedstock production to reduce long-term import dependence, mitigate foreign exchange variability risk, and maximise benefits for local enterprises and smallholder farmers. Strengthen partnerships with academia and R&D institutions.

FINANCING MECHANISM AND FISCAL AND FINANCIAL INCENTIVES

- Design a holistic fiscal regime to support bioethanol solutions covering fuels and stoves and ensure long-term stability and predictability.
- Enhance opportunities for accessing carbon financing through Article 6* and voluntary carbon markets with transparent accounting frameworks and equitable benefits sharing.
- Complement supply-side measures (*e.g.* fiscal incentives, concessionary capital) with demand-side incentives (*e.g.* grants, consumer financing) to bridge the affordability gap for many consumers.
- Recognise that funding is needed beyond products and equipment and for other aspects of bioethanol market development (*e.g.* marketing, R&D, logistics, transportation).
- Address subsidies on traditional fuels (*e.g.* kerosene) which distort markets for clean cooking fuels while maintaining energy security for consumers.

AWARENESS RAISING

- Invest in gender-sensitive awareness raising through multiple routes, including radio, television, demonstrations, and primary and secondary education curriculum.

QUALITY STANDARDS

- Strengthen standards, labelling and certification framework for stoves and improve access to testing labs through partnerships with local technical institutions.

* *Article 6 of the Paris Agreement allows countries to voluntarily co-operate with one another to achieve emissions reduction targets set out in their NDCs. Under Article 6, a country (or countries) will be able to transfer carbon credits earned from the reduction of GHG emissions to help one or more countries meet climate targets.*

4. BIOGAS DEEP-DIVE

The webinar session on biogas was co-organised with SNV.

BACKGROUND

The production of biogas involves the anaerobic breakdown of organic matter (animal, food, crop or municipal solid waste), typically in a biodigester (IRENA, 2017). Biogas-based solutions have co-benefits which include improved environmental outcomes through waste management, mitigated emissions and deforestation, and enhanced agriculture using bio slurry – a by-product of the production process, as fertiliser or compost.

IRENA estimates that there are about 122 million people using biogas for cooking in Africa and Asia, as of 2022 (IRENA, 2022). Almost 970 000 households in select Africa and Asia countries[7] had invested in a biodigester by 2021 (SNV, 2022). In Africa, the technical potential for household biodigesters was estimated to be 32.9 million as of 2019, based on the rise in the number of agricultural households, access to water, livestock ownership and the strong growth of the dairy sector in Africa (SNV, 2019).

To realise this potential, several countries have implemented market-oriented biodigester programmes and regional initiatives to build an enabling ecosystem for the scale-up of household and institutional biodigester solutions. This session highlighted the progress in the adoption of biodigester solutions and facilitated an in-depth dialogue on how such solutions can be scaled up, as part of a holistic strategy to accelerate clean cooking access and advance rural development.

REGIONAL AND NATIONAL PROGRAMMES: IS THE AMBITION SET RIGHT AND WHAT ARE WE LEARNING?

Progress towards mainstreaming biodigester technology is relatively more advanced in Asia and East Africa when compared with other regions of sub-Saharan Africa. Regional and national programmes have played an important role in the biodigester market in developing countries. For example, the Africa Biogas Partnership Programme, implemented in East Africa, is a public-private partnership focused on establishing commercially viable biodigester markets. It offers biodigester solutions, along with agricultural solutions in the form of bio slurry and compost. To date, more than 65 000 biodigesters have been installed through the programme, benefiting over 325 000 people.

In Asia, countries such as India have made notable policy intervention strides that include the establishment of codes and standards on biogas plant construction, as well as larger national biogas and waste-to-energy programmes with more streamlined online application processes for enterprises.

Given the interrelation between biogas production and the agricultural sector, there is a growing inclination to introduce policy measures that encourage co-operation between agriculture and energy. One way to doing this could be mandating livestock farmers to include biodigesters as part of their waste management procedures, coupled with offering provisional incentives to encourage their adoption.

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[7] ***Africa:*** *Benin, Burkina Faso, Ethiopia, Kenya, Rwanda, Uganda and Zambia.* ***Asia:*** *Bangladesh, Bhutan, Cambodia, Indonesia, Nepal, Pakistan and Viet Nam.*

BIODIGESTER MARKET DEVELOPMENT: WHAT IS MISSING?

Translating the theoretical potential of biogas into a practical pipeline of projects on the ground comes with several challenges. From an entrepreneurial perspective, reaching the necessary scale needed to make a business case can sometimes be difficult. The challenges related to scale stem from seasonal variations in feedstock availability, resulting in insufficient raw materials to meet the required biogas production levels. In Indonesia, for instance, the outbreak of foot-and-mouth disease in cattle resulted in a decrease in overall feedstock availability. Technology costs can also pose a challenge. The installation cost of a biodigester can vary significantly based on factors such as the type of biodigester, manufacturing materials, labour and logistical considerations. Higher-end costs associated with logistics, for example, often place a heavier burden on rural and isolated areas compared with urban areas.

Projects seeking funding to alleviate some of their financial challenges must meet the criterion of being deemed as bankable. Project bankability, in the experience of market supporters such as African Biodigester Component (ABC) Programme, depends on the choice of technology available on the market (brick-constructed biodigester domes or prefabricated biodigester tanks), as well as the optimal use of bio slurry by-product as an additional income-generating stream for the biodigester business model (Box 11). Early-stage market development of biodigester technology across different countries such as India started with the brick-constructed domes. Brick domes have some challenges related to delivering consistent biogas quality and necessary after-sales services. The introduction of prefabricated domes drastically changed market dynamics. The advantage that they have over brick domes is that their biogas quality is constant, and they have better after-sales services. This makes them preferred by investors.

Box 11 Brown gold: The potential of bio slurry as fertiliser

The feedstock of a biodigester can come from crop residues and animal and human waste. During the process of digestion, 25-30% of the total dry matter from the feedstock is converted into combustible gas and a residue of 70-75% of the total solids content of the fresh dung comes out as sludge, which is known as bio slurry (Warnars and Oppenoorth, 2014).

Bio slurry can be used in liquid, compost and dry form to build healthy, fertile soil for crop production. Bio slurry contains more readily available plant nutrients and higher amounts of overall nutrients and micronutrients when compared with farmyard and composted manure (Malav *et al.*, 2015).

Projects that install a biodigester stand to benefit from both biogas for cooking, and a readily available supply of high-quality manure for crops. This by-product can be packaged and sold to farmers as an enriching and organic fertiliser.

SESSION KEY MESSAGES

A summary of the recommended actions towards developing and scaling biogas solutions is listed below.

POLICY AND PLANNING

Recommendations

- Strengthen institutional co-ordination among relevant ministries of energy, agriculture, livestock and climate, preferably with biogas programmes positioned under an overarching institution.
- Create forward-market linkages for bio slurry needs, especially in the context of increasing cost of chemical fertilisers and emphasising regenerative and organic farming. This involves investing in complementary infrastructure to process, store and transport bio slurry, as well as recognise it under policy as organic manure to support its offtake, including by institutional players.
- Tap into the significant potential for medium- to large-size biodigesters for businesses and public entities (*e.g.* schools) (50 cubic metres (m^3) to +2 000 m^3 of biogas per day capacity) with dedicated policy and regulatory guidelines.
- Complement fiscal incentives with policy and regulatory measures, including mandates for investments in biodigesters for livestock projects in certain areas and inclusion in priority sector lending for local financing institutions.

FINANCING MECHANISM AND FISCAL AND FINANCIAL INCENTIVES

- Design a mix of public financing interventions needed to support biodigester adoption, beginning with grant requirements for early-stage project development; consumer financing at local level through dedicated funding lines and de-risking facilities leveraging local capital; and revolving funds for enterprises, capitalised through grants to support projects looking for viability funds.
- Level the playing field for local small and medium-sized enterprises through access to financing, incubation support, incentives and facilitation to access carbon markets potentially with aggregation models.
- Leverage impact bonds to monetise verified co-benefits across multiple SDGs, including SDG 3 and SDG 5 (*e.g.* Gold Standard). Build the evidence base on co-benefits and quantify them, including for black carbon, health and gender, and identify potential impact buyers to complement traditional debt and equity structures, and carbon financing, to reduce costs for consumers and to improve market attractiveness for the private sector.

AWARENESS RAISING AND DATA COLLECTION AND SHARING

- Invest in awareness raising and building the social, economic, environmental and commercial case for biodigester solutions tailored to local contexts and embedded in national priorities, such as food security, agriculture development and reduction of chemical fertiliser imports. Community engagement to address the nexus between cultural preferences and solutions should be public finance-led to support market development.
- Address data and information gaps on local markets, demand characteristics, and quantification of long-term direct and indirect benefits, including with success stories and end-user business cases.

INNOVATION AND RESEARCH AND DEVELOPMENT (R&D)

- Leverage digital innovation for remote monitoring, including for operational diagnosis and carbon monitoring to reduce costs and unlock carbon financing and other forms of impact financing.
- Support applied R&D and standards development to improve products and adapt to local conditions, given changing livestock-keeping habits and end-user needs.

SUPPLY CHAIN AND SKILLS DEVELOPMENT

- Strengthen the training framework for biodigester plant users, installers and inspectors, with academia/training curriculum to integrate different facets of biodigester market development.
- Deepen supply chains to bring solutions to doorsteps and accessible in remote, rural areas. Digital and online platforms can enable better linking of farmers with implementing agencies/solutions providers/financing solutions.
- Address data and information gaps on local markets, demand characteristics, and quantification of long-term direct and indirect benefits, including with success stories and end-user business cases.

5. ELECTRIC COOKING DEEP-DIVE

The deep-dive session on electric cooking was organised in collaboration with MECS Programme, which is led by Loughborough University in partnership with ESMAP and funding from UKAID (Foreign, Commonwealth and Development Office).

BACKGROUND

The adoption of electric cooking is correlated with electricity. But electric cooking consistently lags behind electrification efforts in almost every country, primarily because policies promoting access to electricity are more robust and better funded (IEA, IRENA, UNSD, World Bank and WHO, 2021). Additionally, the planning of electric cooking is underdeveloped. A study by IRENA found that out of 185 countries globally, only 22 have included electric cooking targets in their NDCs or Long-Term Low Emissions Development Strategies (IRENA, 2023b). There is a need for intentional, detailed planning and target setting as prerequisites for widespread adoption.

To better understand the total addressable market for electric cooking in areas that lack access to clean cooking, MECS conducted a global market assessment (GMA) which provides a country-level view of the market potential for electric cooking for 130 countries around the world (Coley *et al.*, 2021). The GMA provides indicators across economic, physical, human and infrastructure categories to derive a score representing countries' market potential for electric cooking. These indicators are weighted, and countries are scored on three viable electrification options (national grid, mini-grid and stand-alone),[8] and receive an overall score.

The GMA found that electric cooking is viable for countries[9] where households already pay for polluting fuels (such as kerosene and charcoal), and for countries[10] whose people may face affordability hurdles with polluting fuels. It also highlights the importance of electricity infrastructure in transitioning to electric cooking. For the viable electrification options, a strong regulatory environment was found to be an enabler, while for the mini-grid and off-grid options, the market size and strength of the technologies were observed as additional enablers, coupled with financial flows into the sector for all three electrification options.

The session with MECS took stock of the progress in the adoption of electric cooking solutions and facilitated in-depth dialogue on how to accelerate deployment as part of a holistic strategy to accelerate clean cooking access. It showcased lessons from developing countries and various initiatives.

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[8] *In the report, "mini-grid" and "off-grid (standalone)" refer to renewables-powered systems (e.g. hydro mini-grids, solar home systems) only; non renewable sources (e.g. diesel generators) are excluded from these terms.*

[9] *The People's Republic of China, Kenya, Laos, Malaysia, Myanmar, Nigeria, the Philippines, Rwanda, Tanzania, Thailand and Uganda.*

[10] *Bangladesh, Rwanda and Sri Lanka*

DESIGNING HOLISTIC ENERGY ACCESS PLANS: WHERE DOES ELECTRIC COOKING[11] FIT IN?

Countries with relatively higher electricity access rates and low clean cooking access rates are not making sufficient use of electricity for cooking purposes. For instance, Kenya has a long-standing history of maintaining a relatively high electrification rate[12] but continues to have lower usage of that electricity for cooking purposes. Kenya has made strides in setting electric cooking targets as part of its clean cooking energy mix for 2028. Its strategy, however, assumes a conservative approach to projecting the share of electric cooking (4%) in the energy mix.[13] It anticipates that low-income households will have difficulties in affording electricity for cooking. The roadmap gives top priority to bioethanol and LPG, assigning them the largest share in the clean cooking mix.

The government of Uganda has embraced electric cooking as being an integral part of its national electrification strategy, aiming to achieve a 50% adoption rate for electric cooking by 2030. Uganda has spent the last 30 years investing in electricity as a key priority of the national budget, which has resulted in an apparent surplus in supply. Consequently, the government is strategising on ways to increase the demand for this surplus, and electric cooking provides a very good opportunity for that. Towards this, Uganda's utility company, Umeme Limited, has introduced a pilot electric cooking tariff strategy (Box 12) to stimulate the uptake of electric cooking, and to bridge affordability barriers for low-income households.

Box 12 Uganda's electric cooking tariff

In 2021, Uganda's Minister of Energy and Mineral Development launched an amended electricity tariff structure that includes the introduction of the cooking tariff, applicable to customers served by the utility, Umeme Ltd (Manyire, 2021).

The tariff is a deliberate strategy by the government to displace charcoal and other biomass sources for cooking fuel, by making the cost of electric cooking lower. The tariff was introduced under a declining block tariff structure, which allows for differentiated tariff levels based on the amount of energy consumed, whereby the units of electricity consumed by a domestic customer beyond a set monthly threshold, announced by the authority, are charged at a lower tariff. With the cooking tariff, consumers pay UGX 412 (Ugandan shillings) for each unit of electricity in the threshold approved by the Electricity Regulatory Authority (from 81 kilowatt-hours [kWh] to 150 kWh).

For rural and isolated communities in Uganda, micro- and mini-grids are promoted as part of the national electrification strategy. The government has observed practical cases where electric cooking has become a productive use case of energy when coupled with a mini-grid.

Studies from MECS have also indicated positive outcomes that arise from this kind of pairing for productive use of energy (Box 13).

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[11] *Electric cooking is renewable only when powered by a sustainable and renewable energy source.*

[12] *Access to electricity as a percentage of the population in Kenya was 76.5% in 2021, compared with the 50.6% estimated in sub -Saharan Africa in the same year (World Bank, n.d.)*

[13] *Kenya envisages that by 2028, the energy mix will comprise 4% electric cooking, 3% biomass, 36% improved cookstoves, 22% bioethanol and 44% LPG.*

Box 13 Electric pressure cooking: Accelerating microgrid e-cooking through business and delivery model innovations

To better understand the potential impact of electric pressure cooker (EPC) use on microgrid electricity, PowerGen Renewable Energy, with support from MECS, conducted a small-scale pilot study in Tanzania (Schreiber *et al.*, 2020). EPCs were selected as the technology of choice due to their high cooking efficiency and relatively shorter cooking times when compared with both conventional electric cooking technologies and traditional biomass cooking. Data collected through smart meters show that EPC customers' electricity consumption increased by almost 20% after purchasing the product. This data demonstrated that the introduction of EPC technology into households leads to more usage of electricity and creates a demand for microgrid electricity consumption.

In the rural parts of India, the penetration of electric cooking is less than 3%, as governments have prioritised LPG for cooking over electric cooking over the years. To incorporate electric cooking as part of its future energy mix, the government of India is developing a national cooking strategy and a separate electric cooking strategy that links electricity policy priorities with electric cooking.

The government of Nepal has set the ambition to ensure that 25% of households nationwide adopt electric cooking by 2030. It has committed to providing reliable and affordable electricity access to meet this goal. As a result, there have been a lot of investments in electricity infrastructure, such as increasing capacity in hydropower. The government has also outlined electric cooking as one of the key consumption areas for increasing domestic consumption as part of its strategic and evidence-based roadmap outlined in its Country Action Plan of 2021. The idea behind these investments is to gradually replace imported LPG in the longer run, to reduce current trade deficits it has from fossil fuels.

The adoption of electric cooking as a cost-effective solution for clean cooking can be achieved by integrated planning alongside the planning of electrification and related investments. This co-ordinated planning approach not only facilitates the adoption of clean cooking but also introduces an additional revenue stream for the electricity system, which makes for better use of the infrastructure assets. Early signs of the success of this kind of integrated planning model are seen for mini-grids and off-grid infrastructure where electric cooking is coupled as a productive use technology.

ENHANCING ENTERPRISE AND END-USER DEVELOPMENT: WHAT HAS WORKED AND WHAT GAPS REMAIN?

From a national perspective, some countries, especially those in emerging markets, experience an unstable power grid, leading to frequent power outages. This poses a significant challenge for the electric cooking appliance model that relies on a reliable grid. For example, Bangladesh, despite having an almost 100% electrification rate, has consistently experienced power cuts over recent years. To tackle the grid supply challenges experienced by countries such as Bangladesh, distributed photovoltaic and other embedded generation technologies are touted as an alternative power supply for activities such as cooking, either as stand-alone systems or integrated with the existing grid.

Box 14 PAYGO Electromagnetic induction stoves in Bangladesh

Clean cooking social enterprise ATEC addresses the challenge of affordability by using PAYGO financing through its patented eCook stoves, which combine all the benefits of electromagnetic induction cooking with the flexibility of upfront purchasing options (ATEC, 2022). ATEC chose to produce electromagnetic induction cookstoves due to their high efficiency of about 90%. The higher the efficiency, the less energy that is wasted, thus resulting in lower running energy costs than those associated with LPG. The stoves are sold using a PAYGO model that allows ATEC and its distribution partners to sell the cookstoves on monthly instalment plans which cost USD 5/month. Lower running costs, coupled with affordable monthly purchase costs, make this model the most affordable solution.

ATEC projects an increase in demand for electromagnetic induction stoves, which will also drive down their cost. Based on other industry examples, it expects to see the unit cost of these stoves go down by approximately 10-15% every time production doubles. Through its modelling, it forecasts that unit costs of PAYGO electromagnetic induction stoves will reduce by more than half by 2030, with pricing targets in the lower range for base-of-pyramid households.

The affordability of electric cooking appliances poses a significant challenge, particularly for low-income households. In countries such as Kenya and Bangladesh, suppliers of these appliances also face import-related expenses when acquiring the necessary technology or components. These additional costs contribute to the overall price of the product, placing a burden on end users. To address the affordability challenge, enterprises such as ATEC have adopted PAYGO solutions within their business models (Box 14).

Consumer perception can also pose a challenge when it comes to adopting electric cooking. End users often perceive electric cooking appliances as being high consumers of electricity, leading to concerns about high electric bills if they purchase them. In Nepal, for example, some enterprises observed consistent dips in consumption during the middle of the month, coinciding with the periodic meter readings by electricity providers. This decline is attributed to users fearing the prospect of incurring elevated bills due to the use of electric cooking appliances. To tackle this issue, enterprises and the government can undertake awareness-raising campaigns to reduce the misconceptions about using electricity (Box 8).

SESSION KEY MESSAGES

A summary of the recommended actions towards developing and scaling electric cooking solutions is listed below.

CLEAN COOKING STRATEGIES AND PLANS

Recommendations

- Recognise explicitly electric cooking as a mitigation technology solution under Article 6.4* to mobilise carbon financing.

POLICY AND BUSINESS MODELS

- In contexts with surplus generation capacity, consider the introduction of electric cooking tariffs to facilitate the adoption of electric cooking with a specific focus on expanding lifeline tariffs. Strong co-ordination needed among government, utilities/private mini-grid operators, and regulators.
- Support delivery model innovation, including in displacement settings, to strengthen consumer access to electric cooking appliances, including through upfront cost financing schemes. Explore partnerships with on- and off-grid utilities to deploy on-bill appliance financing alongside other instruments (*e.g.* tax incentives).

SUPPLY CHAIN DEVELOPMENT

- Strengthen the supply chains for appliances to improve accessibility through firm-level development and incentives for local R&D. Incentives, such as well-designed RBFs, can support the development of distribution networks (*e.g.* sales agents, demonstration centres).
- Support local assembly and manufacturing of equipment over time to reduce import dependency.

FINANCING MECHANISM AND FISCAL AND FINANCIAL INCENTIVES

- Introduce an enabling fiscal regime covering technologies and appliances (*e.g.* taxes on EPCs), which is key for manufacturers and suppliers to reduce costs for consumers and enhance affordability.
- Increase public financing outlay for local-level market activation campaigns focused on awareness raising on potential efficiency gains and perception issues (*e.g.* rising electricity bills) and knowledge creation (*e.g.* cookbooks) to stimulate consumer demand in partnership with city councils and community-oriented bodies.
- Improve enterprise financing access, particularly equity capital. More concessional financing is needed, including first-loss capital to unlock more lending for the sector.

INNOVATION AND RESEARCH AND DEVELOPMENT (R&D)

- Support technology innovation and address quality challenges through tailored standards and testing infrastructure, alongside labelling products.

AWARENESS RAISING AND DATA COLLECTION AND SHARING

- Improve methodologies and tools to ensure transparency, accountability and equitable benefits sharing in voluntary carbon markets. Leverage digital monitoring and verification systems to track utilisation and consumer patterns, as well as unlock carbon revenue with improved transparency and accuracy.
- Improve data and information base to inform decision making to link clean cooking policies with electrification and power sector planning. Pilot projects are necessary to map adoption trends, economics, impact of incentives and demand uptake in different contexts, as well as offer visibility on generation- and distribution-side investments needed to ensure quality and sufficiency of supply.

** Article 6 of the Paris Agreement sets out how countries can pursue voluntary co-operation to reach their climate targets. There are three tools under which countries can draw upon under Article 6. One of them is the Article 6.4 mechanism, which is the integrity carbon crediting mechanism. It allows countries to raise climate ambitions and implement national action plans more affordably. Further elaboration of the mechanism can be found here.*

6. CONCLUSIONS DRAWN FROM THE SERIES OF WEBINARS

POLICY AND REGULATION THAT PLACES LIVES AND LIVELIHOODS AT THE CENTRE ARE NEEDED TO DRIVE RENEWABLES-BASED CLEAN COOKING

The development of a renewables-based clean cooking market depends on supply, demand and an enabling ecosystem. In the early stages, market development relies on proactive interventions, often facilitated by government support programmes. The interventions aim to introduce the technology, build capacity and ease affordability hurdles. As the market matures, technology adoption is driven by market dynamics, necessitating streamlined policy and regulation. Policy and regulation formulation needs to place lives and livelihoods at the centre (enterprises and end users), enable the injection of crucial finance and investment into the market, and encourage continuous innovation through R&D.

TARGET SETTING INCLUDING POLICY PLANNING WITHIN THE SECTOR IS NEEDED

Addressing the gap in renewables-based clean cooking requires strong political will, coupled with the creation of an enabling environment through policy and regulation. This includes setting well-defined targets for clean cooking, the integration of clean cooking within broader national energy policies and strategies, co-ordination with other sectors (*e.g.* agriculture, health and the environment) and among clean cooking solutions and pathways, based on context-specific resources, cultural habits, and electrification rate. This concerted effort would enable the development of a comprehensive and inclusive renewable clean cooking market that addresses affordability and availability constraints.

PUBLIC INVESTMENT AND FINANCE ARE CRUCIAL

Through public finance, governments can de risk investment flow to private actors for sustainable long-term business models. It can also support end users' affordability challenges, along with awareness-raising initiatives, training, and research and technology innovation. Donors and development partners play an important role in providing concessional and blended financing, provided that the sector has challenges in attracting private investments.

THERE IS A WIDER ROLE FOR DONORS AND DEVELOPMENT PARTNERS

Partnerships to increase knowledge based (through data, resources analysis and tools) on the renewable clean cooking sector to drive innovation, knowledge sharing and investment is important. Donors and development partners can significantly contribute to improving capacity within governments for the elaboration of clean cooking roadmaps and by extending business development support to suppliers.

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