Bringing clean, safe, affordable cooking energy to Kenyan households: an agenda for action

Key findings

- In Kenya, 76% of the population relies on traditional biomass for cooking, with serious implications for public health (including an estimated 15,000 deaths linked to indoor air pollution), as well as the environment, women's well-being and economic opportunities, and economic development.
- Kenya is already a leader within sub-Saharan Africa in developing and distributing clean cookstoves, but in order to achieve large-scale market transformation, it needs to play a larger role in supporting private-sector actors to reach scale, by removing market barriers to commercial cookstove initiatives, tapping local innovation, and facilitating access to end-user finance.
- There is an urgent need for the Kenyan government to recognize the value of biomass energy to the larger economy, especially in rural areas, and design/reframe energy and economic development policies accordingly. In particular, charcoal, which remains unregulated, requires targeted policy measures and policy coherence between ministries to ensure more sustainable production and slow demand growth amid rapid urbanization.
- There is no "one size fits all" approach to successful cookstove initiatives, but several key success factors are known. They include stove quality and features (efficiency, reduced emissions, design that meets the diverse needs of users, accessibility, ease of use); finance for both end-users and stove enterprises; an enabling policy and regulatory environment; and a commercial approach.

More than 700 million people in sub-Saharan Africa rely on traditional biomass cooking fuels – wood, charcoal, dung and agricultural residues. With population growth, that number is expected to rise to 880 million by 2020. Dependence on traditional biomass has many adverse impacts on people's health and on the environment, and it also holds back development, as the stoves used tend to be very inefficient, so the effort and costs involved are quite disproportionate to the resulting energy services.

In Kenya, 76% of the population – 35 million people – relies on traditional biomass for cooking. Yet cleaner, safer alternatives are available, and momentum is growing to scale up their use. Cookstove technologies have advanced considerably, and innovations in end-user finance are making stoves more affordable. Kenya is at the forefront of clean cookstove development, marketing and distribution, with more than 30 years of activity in the sector. Many improved-cookstove businesses are already operating across the country, and their numbers are growing as entrepreneurs recognize a significant economic opportunity.

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A micro-entrepreneur sells EcoZoom stoves (and nuts) on the side of the road outside Nairobi.

Yet as in most of sub-Saharan Africa, there are also large challenges. Cookstove initiatives and enterprises have to generate demand for stoves and fuels that may be expensive for low-income households. They have to develop functioning supply chains to reach dispersed populations, and overcome social and cultural barriers. And they need to ensure they have the financial and human resources to sustain operations in the long term. National policies and programmes may support them, but they may also pose obstacles.

This policy brief, which is based on a background paper for the 2015 Africa Progress Report, *Power, People, Planet: Seizing Africa's Energy and Climate Opportunities*, synthesizes the latest evidence on the impacts of relying on traditional biomass for cooking and discusses options for addressing these challenges, with recommendations for policy-makers in Kenya and across sub-Saharan Africa.

A major public health issue

The World Health Organization (WHO) has found substantial evidence that household air pollution from burning solid fuels increases the risk of acute lower respiratory infections in children under 5. In sub-Saharan Africa, exposure to smoke from traditional biomass stoves is estimated to have caused almost 600,000 deaths in 2012, almost half in children under 5. If no action is taken, by 2030, an estimated 870,000 people will die each year from acute lower respiratory infections and chronic obstructive pulmonary disease linked to solid fuel cooking.

Among adults, household air pollution increases the risk of chronic obstructive pulmonary disease (COPD), lung cancer and cataracts. A number of other conditions including cardiovascular diseases, acute lower respiratory infections and tuberculosis, are linked with exposure to household air pollution from cookstoves, though the evidence base is weaker. It also increases the risk of a number of adverse pregnancy outcomes, and may impair cognitive development.

In Kenya, female cooks and children are particularly exposed to indoor air pollution, which is linked to more than 15,000 premature deaths each year.[1] Roughly 8% of children under 5 show symptoms of acute lower respiratory infections at any given time, yet only 46% of children with such symptoms are taken to a health centre. Acute lower respiratory infections are second-largest cause of death overall, linked to 26% of all deaths reported in hospitals.[2]

A costly source of energy

The economic impacts of relying on traditional biomass for cooking, both at the household and national level, are staggering. Total annual spending on biomass cooking fuels (wood and charcoal) in sub-Saharan Africa was estimated to be US$12 billion in 2010 (or 0.9% of the region's GDP that year); this figure is set to increase to US$29 billion by 2020, assuming that current fuel price and consumption patterns continue (Rysankova et al. 2014).

Using cost-benefit analysis methods developed by the WHO, the World Bank recently estimated the annual economic losses and opportunity costs of solid-fuel dependence in terms of health, environment and economic cost to households (Rysankova et al. 2014). The opportunities and costs are considered in relation to a best-case scenario of full adoption of higher-performing biomass stoves by African households (Low), intermediate Tier 2–3 rocket stoves at the bottom of the range (High) and Tier 3–4 gasifier biomass stoves at the top of the range (Mid).

As shown in Table 1, in the worst case scenario, where biomass reliance is highest, the combined health, economic and environmental impacts are close to US$60 billion per year. It is also clear that the economic costs are substantial, US$36.9 billion or 2.8% of GDP, including US$29.6 billion in time wastage alone. This suggests significant opportunities for cost-saving from a shift to modern cooking, even after accounting for potential costs associated with the new stoves and fuels.

In most sub-Saharan African countries, the task of gathering fuelwood falls primarily on women and girls. In Kenya, women spend an average of one hour per day on this task, and they can suffer serious long-term physical damage from the strenuous work. They are also exposed to falls, bites or assault, particularly if they have to walk far from home. Cooking with traditional biomass can also take several hours. Reducing this drudgery would free up time for women and girls to pursue an education, engage in income-generating opportunities, or just rest.

For households that buy their fuels, biomass is also a major expense: total annual spending on fuelwood and charcoal in sub-Saharan Africa was an estimated US$12 billion in 2010, or 0.9% of the region's GDP that year; this figure is set to increase to US$29 billion by 2020, assuming that current fuel price and consumption patterns continue.

1 Institute for Health Metrics and Evaluation (2014). Total DALYs Linked to Household Air Pollution for Selected African Countries. University of Washington, Seattle, WA.

2 GVEP International (2012). Accelerating Access to Energy: Global Alliance for Clean Cookstoves, Kenya Market Assessment, Sector Mapping. http://cleancookstoves.org/resources_files/kenya-market-assessment-mapping.pdf.

Given all these factors, the economic impact of dependence on traditional biomass for cooking is staggering, both at the household level and nationally. Using cost-benefit analysis methods developed by the WHO, the World Bank recently estimated the annual losses and opportunity costs of solid-fuel dependence in terms of health, environment and economic cost to households (see Table 1).

Table 1: Annual economic losses and opportunity costs associated with solid-fuel dependence in sub-Saharan Africa, 2010 (in billion USD)

	Low	Mid	High
Mortality from household air pollution	$0.3	$3.5	$6.8
Morbidity from household air pollution	$0.2	$0.7	$1.1
Other health conditions (burns, eye problems)	$0.1	$0.8	$1.5
Total health	$0.6*	$5.0	$9.4
Spending on solid fuels	$0.4	$3.8	$7.3
Time wastage (fuel collection)	$0.6	$6.5	$12.4
Time wastage (cooking)	$3.3	$10.2	$17.2
Total economic	$4.2	$20.6	$36.9
GHG emissions (fuel consumption)	$0.2	$2.1	$3.9
GHG emissions (charcoal production)	$0.2	$0.7	$1.2
Deforestation	$0.2	$3.5	$6.7
Total environment	$0.6	$6.3	$11.9
Total all categories	$5.4	$31.8	$58.2

Source: Rysankova et al. (2014). Sums may not match due to rounding.

Compared with a best-case scenario of full adoption of rocket stoves by African households, the combined health, economic and environmental impacts are close to US$60 billion per year. It is also clear that the economic costs are substantial, US$36.9 billion or 2.8% of GDP, including US$29.6 billion in time wastage alone. This suggests significant opportunities for cost-saving from a shift to modern cooking, even after accounting for potential costs associated with the new stoves and fuels.

Unsustainable biomass use and the need to target charcoal

There have long been concerns that fuelwood use in certain parts of sub-Saharan Africa is unsustainable – that is, that the rate of depletion of renewable biomass outstrips the rate of regrowth – and recent data confirm this. Kenya is part of a "hotspot" of unsustainable biomass use across East Africa that also includes Eritrea, western Ethiopia, Uganda, Rwanda and Burundi. Growing charcoal demand, which is associated with urbanization, is a particular concern.

More than 80% of urban households in sub-Saharan Africa use charcoal as their main source of cooking energy, and the demand is likely to increase for several decades. The increasing demand for wood energy, especially by urban consumers, places heavy pressures on forest resources.

Most charcoal producers in sub-Saharan Africa use traditional earth kilns, with wood-to-charcoal conversion efficiencies of 8–20%, so large quantities of wood are used per unit of charcoal produced. Given the rapid urbanization taking place in Kenya – already 25.6% of the population lives in urban areas, and by 2045, it is expected to be 41%[3] – demand for charcoal is likely to keep rising. Charcoal production and trade also provide important seasonal and supplementary income to rural and peri-urban farming households. In Kenya, an estimated 700,000 people work in the charcoal sector, which is estimated to be worth 135 billion KSH (about US$1.3 billion).[4]

Yet policy-makers across sub-Saharan Africa often dismiss charcoal as a "dirty" and undesirable fuel, and either do not regulate charcoal production, or ban it, driving it underground. In both situations, this means governments forgo the opportunity to steer producers towards more sustainable practices, or collect revenues from licensing fees for charcoal production and trade. It also keeps the market price of charcoal kept artificially low, which is closely linked with wasteful and inefficient production and consumption practices, and creates a formidable disincentive for forest management and tree cultivation.

A more effective approach is to regulate charcoal production and sale, with strong enforcement. Incentives are needed to ensure the collection of revenue from license fees and fines on illegal production and trade. One option is to allow local authorities to retain what they collect, and use it to cover the costs of managing the charcoal sector. Further important steps include shifting from open-access forests to secure tenure and sustainable forest management, and the introduction and promotion of efficient charcoal kilns.

Weighing up technical options for addressing the problem

A large-scale shift from traditional biomass to clean fuels[5] or to electricity brings about the largest reductions in household air pollution, and consequently, the most significant improvements in health. However, the reality is that in many poor rural communities, clean fuels may not be reliably available or affordable, and access to grid electricity may be many years off. Thus, interim solutions are urgently needed to improve the situation for Kenyan households.

There are many different types of cookstove technologies in use across Africa, ranging from stoves that are just slightly more efficient than a three-stone fire, to efficient biomass cookstoves (ranging from rocket stoves to pellet gasifier stoves) and clean fuel options using liquid petroleum gas (LPG) and ethanol. Different technology choices imply different efficiencies, costs, distribution models, and challenges in terms of meeting end-user needs.

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A woman cooks with an improved stove.

For energy planners and policy-makers, it is important to consider the implications of each cookstove technology/fuel option for the cost of the programme, the health benefits that can be expected, and the potential for climate change mitigation (through avoided emissions and deforestation). Not all cookstove interventions targeting household health have climate co-benefits; for example, improved cookstoves with chimneys can be an effective means of removing smoke from the home, but the ambient air pollution remains unchanged. Table 2 compares the options.

Under laboratory conditions, "intermediate" improved cookstoves for solid fuels, when used properly, have been found to significantly improve energy efficiency and reduce household air pollution. As a result, they have been widely disseminated to promote cleaner cooking. In 2009, US$70 million in capital investments were made to provide 7 million people with advanced biomass cookstoves. However, achieving high efficiency "on paper", in the laboratory, is only one part of the puzzle; ensuring that cookstoves are used correctly and consistently by households is crucial for potential health and climate benefits to be realized. There is often a large discrepancy between how well improved cookstoves perform under laboratory conditions and their performance in the field. Recent evidence from two randomized control trials found no statistically significant improvement of health outcomes where these stoves have been introduced.

Another challenge is ensuring that households actually use improved cookstoves. Several studies have found that following the introduction of a new cookstove, many (if not most) households continue to use the existing traditional device or fuel in parallel, and they may revert to it entirely. This may be due to practical reasons, such as the stove uses a commercial fuel that is not affordable or is not always available, or cultural reasons, such as a preference for grilled breads or meats. Thus, the World Bank estimates that fewer than 5% of African households use LPG exclusively for cooking.

The transition to exclusive use of very-low-emission devices and fuels is thus likely to take time, with a progressive shift

3 UN (2014). *World Urbanization Prospects: The 2014 Revision*. United Nations Department of Economic and Social Affairs, Population Division, New York. http://esa.un.org/unpd/wup/.

4 Iiyama, M., Chenevoy, A., Otieno, E., Kinyanjui, T., Ndegwa, G. and Johnson, O. (2014). *Achieving Sustainable Charcoal in Kenya: Harnessing the Opportunities for Cross-Sectoral Integration*. ICRAF and SEI policy brief. World Agroforestry Centre and Stockholm Environment Institute, Nairobi. http://www.sei-international.org/publications?pid=2542.

5 Clean fuels can be defined as fuels that do not cause indoor air pollution in homes, and include biogas, ethanol and LPG. Processed biomass (e.g. wood pellets) can also be a clean fuel when burned in a highly efficient stove. A related, but much broader term is "modern energy" for cooking, which the International Energy Agency defines as facilities that are considered safer, more efficient and more environmentally sustainable than the traditional facilities using solid biomass that are commonly used across sub-Saharan Africa.

Table 2: Comparison of improved cooking stoves and clean fuel options in terms of health impact, climate impact, and cost

Technology evaluated	Health impact	Climate impact	Renewable potential	Unit cost of technology (USD)	Comments
Advanced biomass stoves using forced ventilation	High	High	High	30–100	Fuel processing is required (e.g. pellets or small cuttings), which may increase fuel cost.
Intermediate stove technologies using improved combustion chambers	Moderate	Moderate	High	10–40	Performance varies widely between models, and on how used/maintained
Simple improved stoves with some improvement to combustion	Low	Low	High	5–15	Performance varies greatly depending on design and condition.
Liquefied petroleum gas (LPG)	High	High	None	45–60	Convenient, clean and relatively safe, but relatively expensive
Kerosene	Moderate	Moderate (high with efficient pressurized combustion)	None	15–25	Emerging evidence has linked kerosene use with a number of respiratory diseases, including tuberculosis.
Biogas	High	High	High	100–1,000	Digesters require a water supply and a waste supply from at least two livestock. Initial cost of digester is high.

Source: WHO (2014).

towards a higher proportion of energy usage provided by the newer, cleaner options. There is no "one size fits all" when it comes to designing an approach – some policy-makers may find it useful to promote advanced cookstove technologies in parallel with lower-cost intermediate "transitional technologies"; others, may want to wait to introduce advanced cookstoves, to allow the market to mature and build the wider innovation system needed to support the technology. Table 2 provides an overview of technologies reviewed in our study.

As part of our project, we also conducted four case studies across Africa, including one of EcoZoom in Kenya that is summarized in the box below. Table 3 summarizes the costs and benefits of the stoves identified in those case studies. All appeared to be having a positive impact on household health. For three of the five stoves, lab tests suggested a reduction in $PM_{2.5}$ concentrations (fine particulate matter) of between 56% and 80%. For two of the three charcoal stoves, significant reductions in carbon monoxide (CO) were reported, 56–57%.

Elements of successful cookstove initiatives

Despite more than three decades of efforts by governments and development agencies, progress on scaling access to cookstoves has been slow, for several reasons. Many past stove programmes – and even some current ones – were based on cookstoves designed in laboratories and built by local artisans. These stoves often performed well in the laboratory or when first installed, but over time, their efficiency and ability to remove smoke from the household deteriorated.

Many programmes also gave stoves to households for free or at highly subsidized prices, which helps overcome cost barriers at the outset, but can reduce the perceived value of the stoves and is also unsustainable in the long run. It has become clear that in order to make a substantial and long-term impact, cookstove initiatives need to produce a transformation of local stove markets which is self-sustaining and demand-driven. Studies of past projects have identified several elements needed to achieve such a transformation:

Table 3: Costs and benefits of improved cookstove interventions in case studies

Cookstove technology	Cost to household (USD)	Reported health benefits	Savings annually (USD)	Payback period	CO_2e savings annually per cookstove
TEL improved Charcoal	8	Less coughing, less irritated eyes (Self reported)	27	3-4 months	1.03 tonnes
SEWA improved charcoal	5.33	None reported (lab tests suggest 56% reduction in CO)	25	2.6 months	2.2 tonnes
EcoZoom improved charcoal	7	Lab results show 57% reduction in CO (compared with traditional charcoal stove)	168	3.3 months	1–3 tonnes
EcoZoom improved wood	39	Less coughing, wheezing and eye irritation. Lab results show 73% reduction in CO and 57% reduction in $PM_{2.5}$ (compared with open fire)	60	8.3 months	1–3 tonnes
Gaia Association (ethanol fuelled "CleanCook" stove)	40	Less coughing, wheezing, less irritated eyes; field tests show reduction in $PM_{2.5}$ and CO to below WHO recommendation)	15-20	2 years	3 tonnes

- **Stove quality and features:** improved efficiency and reduced emissions; design that meets the diverse needs of users, and is seen as a real improvement over traditional stoves; durability; affordability; availability of stoves and fuels in local markets; ease of installation and use in the home;

- **Finance:** access to start-up finance for the business/enterprise; access to finance for the household/use;

The EcoZoom experience

EcoZoom is a social enterprise with the mission of transforming lives by supplying healthy, efficient charcoal- and wood-burning cookstoves and solar lights and offering the services needed to support the long-term uptake of these products. Operations in EcoZoom Kenya began in October of 2013; since then, the company has sold more than 17,000 stoves.

The charcoal stove costs US$47 and saves households on average US$14 per month, with a payback time of 3.3 months. Ecozoom estimates that its charcoal stove will save the average household US$845 during its lifetime. The wood-burning stove costs US$39 and will save the average household US$5 per month, amounting to an average payback period of 8.3 months. The wood stove will save the average household US$283 during its lifetime. EcoZoom stoves also have climate benefits, avoiding about 1–3 tonnes CO2e per stove per year.

EcoZoom does not provide end-user subsidies. Instead, it works to make products affordable to all customers by providing credit terms to distributors who then pass them on to end-users; by working with microfinance institutions to provide loans for product purchases; and by partnering with corporations that use "check-off" programmes with their staff.1 The company is also piloting a direct financial inclusion programme where loans are provided to end-users and are repaid over a three- or six-month period via mobile money.

Ecozoom largely attributes its success in tapping the Kenyan cookstove market to its "human-centred" design process, where products are carefully developed to meet the specific needs and preferences of users. The company has also prioritized high-quality customer service after purchase, including training on stove use and maintenance, monitoring and follow-up to troubleshoot, repair stoves as needed, and honour warranties.

Although the company is growing, some key barriers remain, mostly related to difficulties importing the cookstoves. The Kenyan government levies a 25% import duty on cookstoves. This, combined with the VAT and railroad tax, adds about 47% to the cost of a stove, making it difficult to maintain healthy margins throughout the value chain while keeping stove prices affordable to end-users. As local manufacturers cannot produce enough improved cookstoves to meet the demand, this policy is keeping some Kenyans from gaining access to clean stoves. EcoZoom also says that the import duties levied on raw materials and have prevented it from setting up a factory in Kenya.

1 A check-off programme is a system where the employers pays the whole cost of the product to EcoZoom upfront and deducts the cost of the product from staff wages over a three- to six-month period.

- **Enabling policy and regulatory environment:** this includes an established system of standards/regulations for cookstoves;

- **Commercial approach:** a fully commercial approach, as opposed to simply distributing clean stoves through development programmes, has been found to be the most important factor in achieving long-term sustainability in cookstove initiatives.

Conclusion and recommendations

Despite the many challenges, it is clear that improved cookstove interventions yield health, development and environmental benefits, creating a clear imperative to act. Based on our research and on consultations with experts and stakeholders in sub-Saharan Africa, we developed the following recommendations:

- Biomass energy is of significant economic value to African economies, and is the single most important energy source for a majority of households. Governments in the region should **recognize the value of biomass energy** to the larger economy, especially in rural areas, and design/reframe energy and economic development policies accordingly.

- **The charcoal sector is in urgent need of regulatory reform**: Policy coherence is crucial for the emergence of a vibrant sustainable biomass energy sector, and regulatory reform is needed on both the supply and demand sides. Governments should consider removing fuelwood under-pricing policies to truly reflect the cost of sustainable charcoal production and incentivize the uptake of efficient charcoal cookstoves and charcoal production practices. Cross-subsidization could then be used to target subsidies for charcoal to the lowest-income market segments.

- Governments in sub-Saharan Africa could encourage the uptake of clean cooking stoves and their components by **removing taxes and duties to exempt technologies that are imported** and by reducing the number of licenses required by cookstove manufacturers and distributors. A specialized agency should be established to plan and promote clean stoves, coordinate technology standards and testing and manage national and sub-national data on biomass energy supply and demand.

- Targeted funding should be provided, both through donor commitments and public finance, to build the **capacity of regional cookstove testing centres**. Governments could play an important role raising awareness about the benefits of clean and safe cookstoves and fuels by communicating information on cookstove standards to the public, for example, through product labelling.

- There is a need to **tap local innovation**: Research and development in the local cookstoves sector should be promoted to match the support (finance and policy access) that larger, international cookstove partners can access. Research and development (R&D) institutions should be strengthened – governments should invest in special innovation funds.

- To support market transformation of the cookstove sector**, subsidies** (whether carbon finance, donor or government) within cookstove businesses should generally be **targeted**

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A woman sells charcoal near the Kibera slum in Nairobi.

upstream in the value chain (R&D, manufacture, distribution) rather than downstream to the end-user. Targeted end-user subsidies could be used to support very low-income households to gain access to clean cookstoves.

- Clean cookstove businesses can **access end-user finance for their products through range of proven innovative approaches,** including microfinance loan schemes, payment in instalments, community savings clubs, etc. National, regional and local authorities can encourage such schemes by providing information, soft loans and loan guarantees to smaller actors seeking to set up business. Banks, microfinance institutions and other lenders should provide interest-free or very-low-interest loans for stove purchasers. A specific governmental agency should be established to support and coordinate these activities, with a dedicated fund to finance the agency. This fund could be replenished using a combination of revenues from a reformed charcoal sector, donor funds, and ministerial budgets (e.g. energy, health and environment).

- **Carbon finance can be a catalytic finance mechanism** for cookstove projects, particularly those that do not rely exclusively on carbon revenues to maintain and scale implementation. Carbon revenues can bring about a range of ancillary benefits for the project developer and end-user, including quality assurance, monitoring and reporting of progress over an extended time period.

- **End-user behaviour and preferences should inform every clean/improved cookstove intervention.** All implementers of clean cookstove interventions, including businesses, NGOs, and governments, should take the **cookstove users' needs and behaviour as their starting point**. There will be no panacea for addressing the household cooking challenge in sub-Saharan Africa; instead, a differentiated approach based on specific socio-cultural contexts is recommended. Better and more disaggregated data on cookstove users' preferences, willingness and capacity to pay for a clean cookstove at the sub-national level will be invaluable for directing investment and innovation in the clean cookstoves sector.

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