

Promoting Access to Clean Cooking Fuels in Sub-Saharan Africa Through Entrepreneurial Initiatives: Challenges and Strategies

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Abstract

Energy has become one of the biggest brakes on the development of sub-Saharan African countries. Despite the vast potential of the region, which contains significant energy resources, most of its population still lack access to electricity and modern cooking fuels such as liquefied petroleum gas (LPG), ethanol or biogas and this slows down economic growth and social development. Although considerable progress is being made in improving electricity access, the development of the cooking-fuel sector is lagging behind. In fact, 86% of the region's population still use charcoal, firewood or kerosene, with the resulting negative impact on health, the environment and living conditions.

What are the consequences of this tragic reality? Why do the adoption of better cooking fuels and private investment in the sector remain so limited? Can this be an attractive market for entrepreneurs keen on making a significant social impact? Also, for those investing in the sector, what are the main barriers to overcome and how can these challenges be tackled? In this paper, all these questions are analyzed. Furthermore, there is a particular focus on understanding the common trends in the strategies adopted by four promising start-ups operating in the sector and how they are innovating to create solutions and business models that respond to the sector's biggest challenges.

Keywords: Cooking Fuels; Energy Access; Sub-Saharan-Africa; Energy Poverty; Strategy and Entrepreneurship in the Cooking Sector.



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1. Access to Cooking Fuel Is Lagging Behind

Energy has become one of the biggest brakes on the development of sub-Saharan African countries. Despite the vast potential of the region, which contains considerable reserves of crude oil and natural gas and untapped renewable resources—such as solar, biomass, geothermal and wind—and despite the progress made in recent years, most of its population still lack access to electricity and modern cooking fuels, which is slowing down economic growth and social development.

In the last decade, the electricity sector has attracted growing attention from private initiatives, financial institutions, development banks and governments. Thanks to the decreasing price of renewable and off-grid solutions, as well as further liberalization and reforms of the sector in several African countries and disruptive new business models such as pay-as-you-go¹ solar home solutions, more and more feasible projects are emerging, resulting in increasing rates of electricity access. Although much remains to be done, from 2015 to 2016 the population with access to electricity grew by 14.4%, which led to an average access rate of 42.8% in the region (World Bank. Access to Electricity. 2018). In Tanzania, for example, the population with electricity access rose from 15% in 2015 to 32% in 2016 (Ibid)

The cooking-fuel sector, on the contrary, has been struggling to catch up. According to the World Health Organization global household energy database, in 2016 only 14.3% of the region's population had access to modern and cleaner cooking fuels and technologies, such as liquefied petroleum gas (LPG), natural gas, ethanol or biogas, while the vast bulk of its population (85.7%) still used charcoal, firewood or kerosene, with the resulting negative impact on health, the environment and living conditions (World Bank. Access to Clean Fuels and Technologies for Cooking. 2018).

The energy landscapes vary immensely from one country to another in the region. Just 2.16% of the population used modern cooking fuels in Tanzania but the percentage in Ghana was 21.71% (2016 figures). However, in reality, the lack of cooking-fuel alternatives affects most of the population living in sub-Saharan Africa (World Bank. Access to Clean Fuels and Technologies for Cooking. 2018). Rural areas are especially affected and this exacerbates the economic and social development gap between rural and urban areas.

What are the consequences of this tragic reality? Why do the adoption of better cooking fuels and private investment in the sector remain so limited? Can this be an attractive market for entrepreneurs keen on making a significant social impact? Also, for those investing in the sector, what are the main barriers to overcome and how can these challenges be tackled? In the following sections, all these questions are analyzed. Furthermore, there is a particular focus on understanding the common trends in the strategies adopted by four promising start-ups operating in the sector and how they are innovating to create solutions and business models that respond to the sector's biggest challenges.

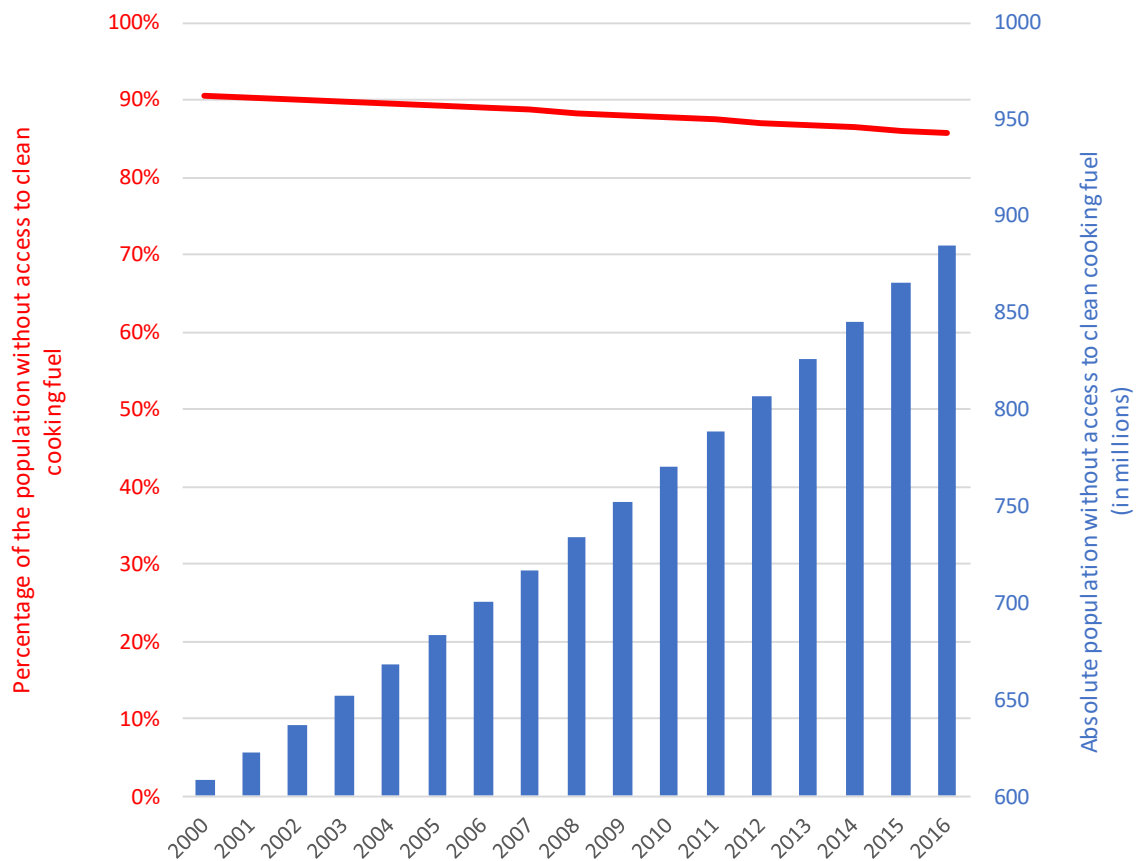
¹ The pay-as-you-go solar model was introduced by M-Kopa in Kenya and implemented for the most part by more than 100 companies across Africa. With this model, in exchange for a small up-front payment, the company installs a solar kit, which includes a small solar panel (generally with a capacity of 10 W to 20 W), a battery and basic appliances such as LED lights, a mobile charger, and a radio. To use the service, the customer then makes small payments in advance (credit), via mobile money. Once the payment has been received, the system is enabled. When the account runs out of credit, the company can disable the solar panel, which will not work again until the customer tops up the credit. After a period of one to two years (depending on the company), the company usually transfers ownership of the panel to the customer, who no longer needs to pay to use it.



2. A Growing Problem With Devastating Effects on Health, the Environment and Social Development

From 2015 to 2016, the region's population with access to clean cooking fuels increased by only 5.3% (World Bank. Access to Clean Fuels and Technologies for Cooking. 2018). Such modest progress is even more worrisome when the region's demographic growth is taken into account. The population grew by 2.74% per year on average, from 2000 to 2016. As a result, although the population with no access to clean cooking fuels has declined as a percentage, it has increased in absolute terms. As shown in **Figure 1**, every year there are around 20 million more people with no access to modern cooking fuels compared to the previous year.

Figure 1
Comparison of the Absolute Number and Percentage of People in Sub-Saharan Africa Without Clean Cooking Fuel, 2000–2016



Source: Prepared by the authors based on data from the World Bank 2018: Access to Clean Fuels and Technologies for Cooking and Population.

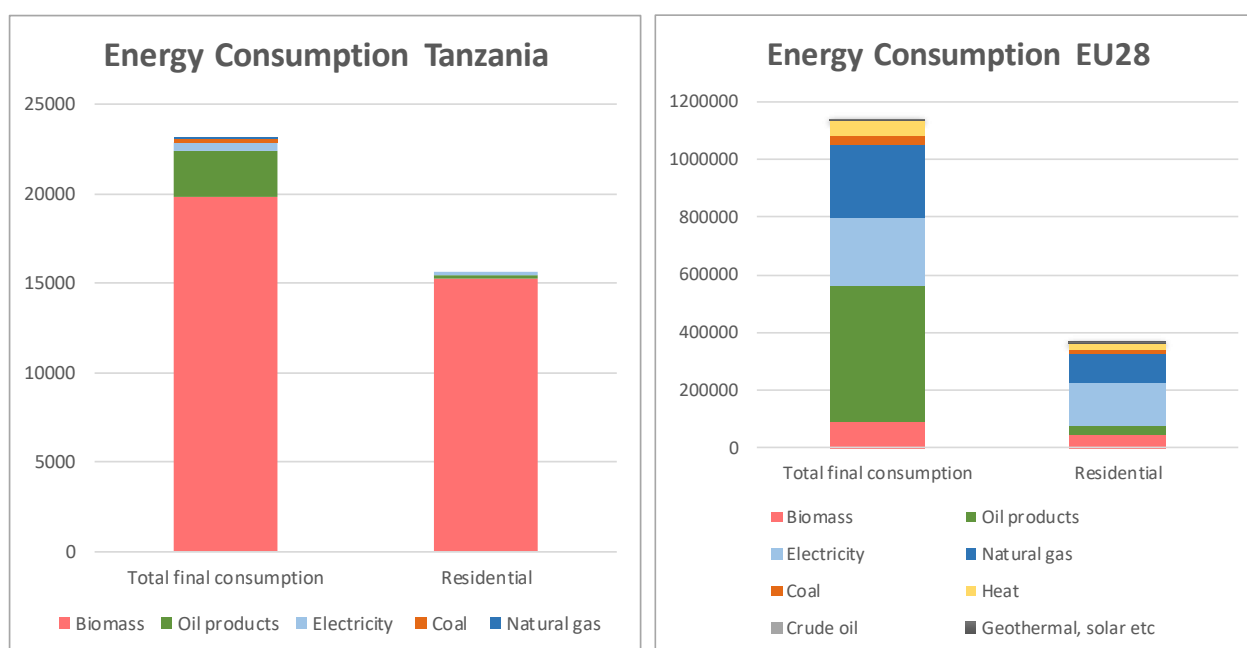
Using charcoal and firewood is highly energy inefficient compared to cooking with modern fuels as they have lower energy density than cleaner solutions such as LPG, ethanol or pellets. Moreover, in the traditional three-stone open fires, up to 80% of the heat energy is lost through dissipation, as the heat-transfer efficiency is low. And the rudimentary carbonization process to transform wood into charcoal using traditional kilns is very inefficient too, due to the high conversion losses.



All things considered, 10.8 kg of wood or 3.6 kg of charcoal (which in turn requires up to 30 kg of wood in the carbonization process) are needed to produce the same amount of useful energy found in 1 kg of LPG (Sepp 2014). The combination of this extremely inefficient energy chain and the fact that 86% of the sub-Saharan African population relies on it results in huge consumption of solid biomass from the forests.

For most economies in sub-Saharan Africa, the main energy sources are charcoal and wood. As shown in **Figure 2**, in Tanzania, solid biomass (in this case, charcoal and firewood) represented 85% of total consumption, driven by the residential usage of these inefficient cooking fuels, while electricity accounted for just 2%. The situation was entirely different in developed countries such as the EU-28, which relied on a mix of different energies (heavily based on oil and natural gas).

Figure 2
Comparison of Total Energy Consumption by Source, 2016



Source: Prepared by the authors based on data from the International Energy Agency (2018).

Although wood-based fuels can be a renewable source in theory, if produced and consumed sustainably, the reality is that wood collection and charcoal production are informal activities with little organization and often they are not subject to any specific regulations or restrictions. This contributes to deforestation, especially in the areas surrounding an urban nucleus and villages. Deforestation, in turn, compromises biodiversity and the quality of the soil, air and water. Even in countries that adopted measures against indiscriminate logging, enforcing such regulations has been extremely difficult.

Moreover, as forests are destroyed, the poorest people have to walk longer distances to collect free firewood at different spots. Added to the long hours dedicated to preparing and cooking food, this reduces the time that women and children—those usually in charge of cooking—can devote to other productive or leisure activities such as farming, studying or playing.



However, the worse impact is on the health of such women and children due to exposure to the highly polluting smoke produced by the wood or charcoal burned in traditional stoves. According to the Global Burden of Disease Study 2010, indoor pollution led to around 3.5 million annual deaths and was therefore even riskier than poor water and sanitation (Lavelle 2012). This number was more than the combined number of deaths related to malaria (1.2 million) and HIV/AIDS (1.5 million deaths) (Putti, et al. 2015) Furthermore, charcoal and firewood are often used with open fires or rudimentary stoves, which increase the likelihood of injuries while cooking (Putti et al. 2015).

3. The Root Causes: Barriers to the Adoption of Alternatives

The change to cleaner cooking fuels could reduce life-threatening respiratory illness, slow down the degradation of the environment and free up time that could be dedicated to education or farming, resulting in better economic and living conditions.

However, despite all the potential positive effects, the adoption of modern and cleaner alternatives remains very limited, as does private companies' interest in the sector. Why? The choice of household fuel is determined by three main aspects that represent barriers to switching to new fuels—and therefore barriers to companies investing in the sector:

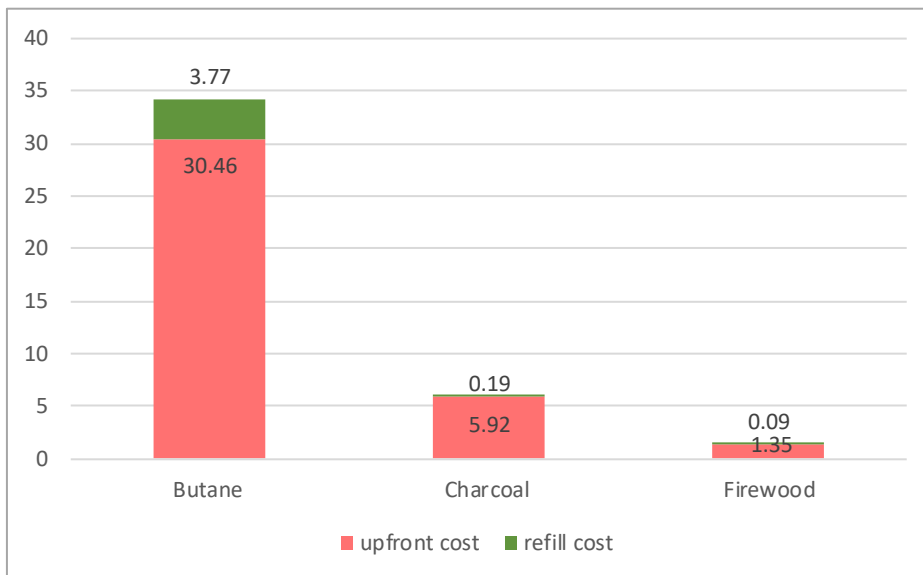
Availability (or accessibility): Cooking is an everyday task that requires easy and frequent access to fuels. Therefore, positioning the fuel's point of sale as close as possible to customers and guaranteeing enough stock are key. However, setting up a steady supply chain for a new—and highly inflammable—fuel is a puzzle that is difficult to solve in sub-Saharan Africa. Problems abound throughout the whole chain: most countries in the region lack the required production, storage and refilling capacity of controlled fuels such as LPG, importing can be complex, and the poor road infrastructure leads to significant losses and delays in transportation. Moreover, the demand for such products in rural areas is low and scattered, although half of the population lives there. Therefore, setting up efficient and cost-competitive sale channels to bring the product to rural populations has proven to be a challenge, especially in the last mile. This creates a vicious circle or a chicken-and-egg problem, where no clean fuel is available because there is not enough demand, and demand never grows as no products are available.

Affordability: The fuel price needs to fit the household's budget, which is a tricky challenge in a region with the world's lowest-income populations. As shown in **Figure 3**, the up-front costs of modern fuels are often higher than those of charcoal or wood, largely due to the high logistic costs. This makes it extremely difficult to offer competitive solutions for those at the base of the revenue pyramid, especially for the 41% living below the poverty line (World Bank 2018). For example, a 6 kg LPG stove with the appropriate subsidized butane cylinder costs around \$30 in Ivory Coast. Though this may seem to be a moderate up-front cost, it can be an insurmountable barrier for the 46.3% of the population living in poverty, on less than \$38.25 a month² (Tape et al. 2015). Even though it would be cheaper in the long run to switch to clean cooking fuels, many families cannot afford the initial payment.

² People were considered poor if their consumption expenditure was less than 269,075 CFA francs a year in 2015. At the exchange rate of July 1, 2015, this corresponded to expenditure of \$38.25 a month per person.



Figure 3
Comparison of Up-Front and Refill Costs for LPG, Charcoal, and Firewood in Ivory Coast³



Source: Prepared by the authors based on data in Giordano, Assogba, and Rahnema (2018), Table 11.

Acceptability (or convenience): The new method of cooking must be convenient for its users and their cooking habits, which means it should be easy to use and suitable for the kinds of meals prepared. The lack of convenience is often mentioned as the reason why solar cookstoves have not spread yet as apparently they take too long to heat up and work only when it is sunny, being unsuitable for preparing meals in the morning or evening.

It is in terms of acceptability that LPG, ethanol and pellets, when combined with advanced cookstoves, have their main advantage as they are much easier to deal with and cleaner and faster, and they give users greater control over the heating compared to wood and charcoal—although some traditional meals are said to taste better if prepared in the old style.

However, as cooking habits, staple foods and traditional recipes change from country to country—and even from community to community—a solution that is broadly accepted in one area may not work in another. Therefore, creating cheap locally adapted products is essential but this requires significant investment in research and development, which in turn is no guarantee of being able to scale up that solution as the local market is limited. Furthermore, it can be costly to implement a marketing strategy to introduce a new product—which may fit the needs of only a relatively small group—and prove its worth.

On the positive side, when households are finally convinced to test a new solution—one that is readily available and is within the family budget—they usually do not regret the change. For example, the authors' recent field survey in Ivory Coast indicated that 73% of the households

³ The components of the upfront cost of butane consist of a cylinder deposit (=23.69\$), a burner (=5.08\$) and a cooker (=1.69\$) whereas the upfront cost for charcoal and firewood solely consist of a cooker. The minimum refill cost for firewood vary between 0.07-0.1\$, in the graph is shown the average of roughly 0.09\$.

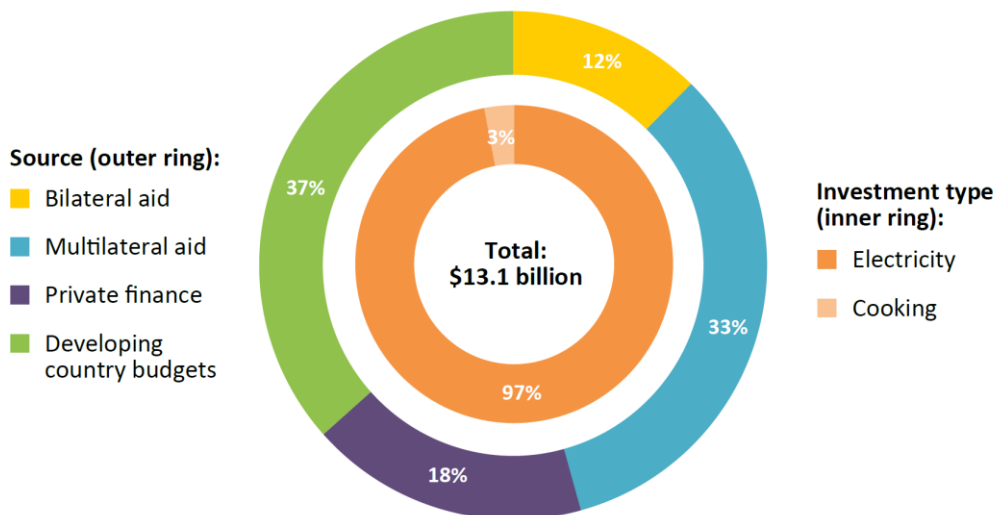


that had adopted LPG used it as their preferred and primary fuel, regardless of the fact that 76% of LPG users still used charcoal and wood as secondary fuels (Kouadio, et al. 2018).⁴

In addition to these challenges, which companies must overcome to be successful in their ventures, government intervention in some cooking-fuel markets can sometimes create distortions and cause uncertainty, jeopardizing private companies' interests. For example, the subsidies that are often applied to LPG can make ethanol and biogas less competitive. In Ivory Coast, LPG has a regulated and subsidized price but there are constant shortages in the supply (which is imported by a state-owned company), and some retailers end up applying higher margins. In Kenya, ethanol for cooking used to be overtaxed at the same level as alcohol for beverages, making it unaffordable, until companies willing to promote it as fuel for cooking convinced the government to differentiate taxes according to the final usage.

In summary, all these barriers—a low-income population, high up-front costs and no access to credit, free or cheap substitutes, difficulties in setting up an efficient and steady supply chain to reach the rural population, varied cooking habits, and unstable regulations or regulations regarded as hostile to private companies—explain why no global players or one-size-fits-all solution have emerged yet in the cooking sector. These barriers are also reflected in the low level of public and private investments. As shown in **Figure 4**, according to the International Energy Agency (IEA), only 3% of the energy-access investments went to the cooking sector, while 97% were directed to electricity projects.

Figure 4
World Energy-Access Investment by Type and Source, 2013



Source: International Energy Agency 2015.

⁴ “The practice of using more than one type of fuel in the same household is quite common to all developing countries, and it is aligned with the so-called stacking theory [...]. According to this theory, as their income increases, households move up the energy ladder and use cleaner, more efficient and more expensive fuels, switching gradually from traditional biomass to electricity [...]. Interestingly, however, households do not simply substitute one fuel for another but, instead, start to diversify, adding more types of fuels in the process of fuel stacking” (Giordano, Assogba, and Rahnama 2018).



At a global level, trackable investment in clean cooking initiatives across 20 high-impact countries⁵ averaged \$32 million in 2013–14, well below the estimated \$4.4 billion per year that was needed, according to the IEA, to achieve the Sustainable Energy for All (SEforALL) objectives by 2030. In comparison, finance commitments in electricity projects averaged \$19.4 billion in 2013–14, still below the \$45 billion needed to meet the 2030 objectives of universal electrification (Sustainable Energy for All (SE-forALL), Climate Policy Initiative and the World Bank 2017).

4. Opportunity

While most entrepreneurs and investors see a fragmented, complex and unattractive market, others see an opportunity the size of the continent and are motivated by the positive impact they can have on many lives. After all, it is a market of a billion customers.

Through our research, the authors had the opportunity to find out about five promising initiatives operating in the sector—four companies operating in Africa and one national program in Nepal—that were challenging the market barriers to prove that, with innovation, it was possible to create sustainable models and profitable businesses with a social impact:

KopaGas is an LPG distribution company operating in Tanzania through a pay-as-you-go model. KopaGas delivers customers a kit consisting of a full LPG cylinder attached to a smart meter, a burner, and a stove, for a total cost of about \$100, with an up-front payment of 10% (\$10). Customers ensure they have a supply of gas by paying installments from as little as 30 shillings (\$0.30) per day by mobile money account. Using a mobile phone, customers are also able to monitor their gas account and can decide when it is time to top it up for the amount they desire. The smart meter serves to switch off the butane flow if the client runs out of credit and also to monitor the level of gas in the customer's cylinder remotely, so the company knows when it is time to pick up the empty cylinder and deliver a full one.

KOKO Networks sells liquid ethanol in modern dispenser machines, called KOKOpoints, located inside neighborhood convenience shops in the Kenyan capital Nairobi. Customers can buy small quantities of the fuel in reusable bottles and pay using mobile money. The ATM-style ethanol dispensers have sensors and are digitally connected, sending real-time information about the fuel level to the company. Therefore, KOKO Networks can foresee demand better and optimize the routes of the fleet of “microtankers” used to refuel the KOKOpoints.

Inyenyeri is a Rwandan “social benefit company” that sells fuel pellets in membership packages of 30 kg, 45 kg or 60 kg per month in exchange for firewood. The idea is that rural customers collect only half as much firewood as they did previously but they bring this biomass to Inyenyeri. The company then uses this biomass as a feedstock to produce wood pellets, which are in return delivered gratis to the rural customers. The customers also receive efficient stoves for free. Using this method and taking advantage of the higher energy efficiency of the stoves, Inyenyeri has additional pellets left over to sell to urban customers.

Nepal's Biogas Support Program is a donor-supported national program that promotes the construction of household-scale biogas plants in rural Nepal as a mainstream source of renewable energy. The program has allowed more than 250,000 rural households to purchase

⁵ The SE4ALL Global Tracking Framework identified 20 countries whose efforts were critical to achieve the SEforALL objectives by 2030, based on the fact that approximately 85% of the 3.04 billion people without access to clean fuels and technologies for cooking lived in these 20 countries in 2014.



biogas plants from private suppliers through a combination of subsidies and loans. By using animal dung as a raw material, the families can produce biogas to meet their daily cooking needs for free. Subsidies are provided through the companies selling the biogas plants, while wholesale loans are provided to microfinance institutions (MFIs), which in turn lend to households. Disadvantaged groups can benefit from additional subsidies. The program applies a market-based approach by encouraging the private sector's participation as product suppliers, and these created more than 10,000 jobs.

(B)energy is a Germany-based social business that offers low-tech, low-cost medium-size biogas solutions via local franchisees to households in rural Africa. The plants use organic waste to produce enough biogas for several families. Therefore, those who decide to buy the company's biogas technology become not only biogas users but also biogas providers for their neighbors. By producing more biogas than their own families need for consumption, buyers can secure an income through the sale of biogas, pay for their biogas investment and make a profit. The biogas produced by the biogas digester is taken home by the end users in the innovative (B)pack, a plastic bag that can be carried as a backpack and hooked up to a biogas cooking stove at home. In addition, the residues of gas production serve as fertilizer.

5. “Winning” Strategies: Where Should the Effort Be Focused?

As the broad array of business models and technologies used by these companies shows, there is no one-size-fits-all strategy for offering alternative cooking solutions in Africa. The different companies' paths have been determined by several factors, many of them responding to local conditions that can be quite diverse from one country to another. Natural resources, geography, the profile of customers, government support, infrastructure, the stage of development of the local market, among other factors, all play a role when identifying the opportunity and deciding which way to go.

However, despite offering very diverse solutions, all of these initiatives have in common an awareness of the significant challenges the market imposes and they have clear strategies on how to overcome them. As a result, most of these initiatives have managed to raise funds that will allow them to move away from the pilot stage and scale up.

Moreover, all of these initiatives are combining proven fuel technologies—such as ethanol, biogas, pellets or LPG—with innovative operating and business models, to make their products more affordable and readily available by overcoming the last-mile distribution challenge. The following section identifies and sets out some common trends in the strategies these companies are adopting in the face of the challenges.

6. Strategies to Tackle “Affordability”

Even when the selling price of clean cooking fuels matches the cost of charcoal, the high up-front investment required—consisting of the stoves and the recharge cost—is still a major constraint for potential customers. Stoves that are compatible with clean fuels cost between \$20 and \$100 per unit, depending on the technology. A World Bank report of 2017 noted that stove prices had started to fall: “These prices are beginning to decline—for example, the CleanCook ethanol cookstove has decreased in price from \$250 a decade ago to \$50 a few years ago to \$25–35 today—but they are still cost prohibitive for most households” (Kappen, et al. 2017, 18).



To make the problem even bigger, most families have no access to any kind of credit. They are out of the reach of financial institutions and most of the time do not even have a bank account. Only those who have a formal job and a monthly salary have a bank account—and therefore a remote chance of getting a small loan. This is a significant limitation in countries where most of the population are self-employed, whether they work in agriculture or other sectors, and have irregular and daily incomes.

As up-front costs remain unaffordable to the poorest households, many companies fail to reach this segment, the base of the pyramid. To make their products affordable, the initiatives mentioned have deployed four key tactics: producing alternative fuels from local resources, accepting payments in kind instead of cash payments, resizing their product format, and improving access to credit.

6.1 Using a Local Source for Fuel

Perhaps the most natural way to decrease the cost of a new cooking solution is to lower the cost of the fuel feedstock by harnessing locally available resources. This approach is the cornerstone of many cooking solutions: biomass is transformed into briquettes or pellets; crops with a high sugar content are used to produce ethanol; agricultural, animal and human waste are used to produce biogas. Moreover, the prices of locally produced fuels are less susceptible to price volatility than imported fuels such as LPG or kerosene, which depend on the oil price on the international markets.

Inyenyeri, for example, manufactures pellets from locally available biomass. The firewood is sustainably harvested, ground and pressed into fuel pellets, and then used in highly efficient cookstoves. By using local biomass, Inyenyeri can provide a cooking fuel at a price as low as zero cash for rural customers who trade collected firewood for pellets and at price comparable to or below the cost of cooking with charcoal (about \$1 a day) for urban households.

Both the Biogas Support Program developed in Nepal and the biogas companies operating in sub-Saharan Africa, such as (B)energy, base their strategy on offsetting the high cost of purchasing a biogas plant by the savings generated by the use of a free-cost, locally available feedstock.

In particular, the biodigester strategy exploits the special conditions in which cattle are raised in Nepal. The conditions are ideal for providing animal dung, the feedstock necessary to fuel biogas home systems. Besides being a source of milk as well as a draught animal, the cow is a revered and sacred animal in Nepal and is therefore well cared for, reared close to the farmhouse and kept for a long period. Most small farmers have two cows or buffaloes, which is the minimum number required to feed the biogas systems with a 4 m³ capacity promoted by the program. These farmers therefore have a continuous source of feed for the biogas systems at basically no cost.

The production of fuel at the regional level also helps to create jobs and stimulate the local economy, translating into more benefits for the community. For example, the owners of (B)energy biogas plants are given incentives to purchase the raw material—animal dung, kitchen waste, and agricultural residues—from their neighbors, paying in cash or swapping the raw material for bags of biogas they have produced.



6.2 Payment-in-Kind Method

Another way chosen by the initiatives to lower the selling price of their solutions for the poorest households is allowing payments in kind.

For example, Inyenyeri provides its rural customers with the possibility of paying for pellets by trading the biomass they have collected. With this method, those in the poorest Rwandan households, who already gather firewood daily, can meet their cooking-fuel needs by spending half as much time collecting wood. As the pellets and the improved cookstoves offered by Inyenyeri are highly efficient, the firewood collected by one rural household provides pellets for four urban households. Revenues from the sale of fuel pellets to urban households help to sustain the model.

Nepal's Biogas Support Program provides specific subsidies and a loan and also ensures that households can pay in kind for 20% of the cost of the biogas plant, such as by contributing unskilled or construction labor or locally available building materials. The possibility of paying in kind, in addition to specific subsidies, helps to reduce the proportion of the cost financed with a credit loan, so cutting the monthly installment paid by households and improving the overall affordability of the biogas plant.

6.3 Resizing

As an alternative to reducing the price of the cooking solution, some companies pursue affordability by reducing the cost of a recharge, meaning the amount of fuel sold in a single purchase.

The KOKOpoints—the ATM-style ethanol dispensers designed by KOKO Networks—allow customers to top up their reusable fuel canister with as little as 30 shillings (\$0.30) worth of fuel at a time. This is enough for cooking a few times and so people do not need to buy a whole month's supply at once.

Similarly, (B)energy's solution to the affordability problem consists of repackaging the large quantities of biogas produced by the biogas plant, dividing them into quantities as small as a light backpack. The (B)pack enables the storage and transport of 1.2 m³ of biogas, equivalent to two to four hours of cooking. This strategy is based on the idea that, while many households—especially in rural areas—cannot afford a home biogas system, they can afford a backpack of biogas.

6.4 Improving Access to Credit

In other cases, the barrier of affordability has been tackled by increasing customers' access to credit, through microcredit loans or pay-as-you-go solutions.

In Nepal, the Biogas Support Program has been working with banks and other microfinance institutions (MFIs) to extend loans for the purchase of the biogas plants. The creation of the Alternative Energy Promotion Center, the government body in charge of operating the Biogas Credit Fund, has played a crucial role in this regard. The Biogas Credit Fund is a revolving fund of \$3.5 million used to provide wholesale loans to MFIs at a 4% annual interest rate. The MFIs then lend the money to farmers at a maximum interest rate of 14%. Through these loans, most farmers are able to purchase a biogas system for the equivalent cost of a liter of milk per day.



However, in situations where there is no national program and no donations to support the implementation of the solution, companies have to address the lack of access to credit in different ways. In this respect, the pay-as-you-go model is one of the most innovative solutions to this challenge. Instead of paying for the product all at once, customers pay as they use it, in small daily or weekly installments, usually through mobile money.

In Tanzania, for example, KopaGas understood that many families had informal jobs and irregular daily incomes, with no domestic saving capacity. Therefore, even if the cost of preparing a meal using LPG is similar to the cost of using charcoal, they cannot afford to buy a full LPG cylinder all at once so they prefer to buy small quantities of charcoal every day. The solution that KopaGas found consists of delivering the whole LPG kit (a full cylinder, stove, and accessories) for just 10% of its price. The customer repays the balance while using the gas, in installments of as little as 30 shillings (\$0.30) per day, using mobile money.

Similarly, in Rwanda, Inyeryeri offers fan-assisted gasifier stoves free of charge to customers who sign up for a monthly membership. Customers can choose between supplies of 30 kg, 45 kg or 60 kg of pellets per month, depending on the size of their family. The margins applied to the price of membership serves to recover the cost of the stove provided.

7. Strategies to Overcome the Last-Mile Distribution Challenge

Making the initial sale and delivering fuels regularly are among the most difficult challenges in countries where roads and other infrastructure are either absent or underdeveloped. Building a distribution and sales network to reach the last-mile customers can be very costly and operationally complex, particularly for fuels such as ethanol and LPG that require specialized transportation and storage infrastructure.

Sometimes the alternative has been to decentralize production. Another alternative has been to use franchise contracts and take advantage of wholesale and retail distribution networks that were already in place. The most disruptive distribution models have been those leveraging technology and particularly digitization.

7.1 Decentralization for Proximity Distribution

To reach remote and scattered populations and avoid investing capital in a distribution network, sometimes companies have chosen to decentralize production near the end users. This makes sense, especially when, because of the nature of the fuel itself, transportation and storage are particularly costly, as in the case of ethanol, or when the end customers can also be the providers of feedstock, as in the case of biogas or pellet solutions.

In the case of the Biogas Support Program in Nepal, decentralization has been taken to the highest level. Biogas is produced at the household level, through home-scale anaerobic digesters, thus eliminating the need for fuel distribution.

In sub-Saharan Africa, the high fixed cost of installing a biogas plant at the residential level—in the absence of a government program that would provide financing solutions—poses a big challenge. Moreover, not all households own enough cattle to provide the minimum amount of raw material necessary to feed a digester. Therefore, the (B)energy solution decentralizes production at a village or neighborhood level. An investor from the community buys and operates the biodigester, selling the biogas produced to the neighbors. The investors are usually



farmers or restaurant or hotel owners with access to large quantities of waste from the kitchen or toilets in the premises. The last mile of biogas distribution, from the biogas producer to the households, is covered using the (B)pack.

With respect to the Inyenyeri initiative, although the production of pellets takes place in one facility, which guarantees economies of scale, collection is decentralized through a network of rural hubs, where firewood is collected from rural customers and transformed into chips to reduce the volume to be transported to the factory. The chips are transformed into pellets, then redistributed to the rural hubs for sale (or trade for biomass) and to urban shops.

7.2 Using Existing Networks

Another tool to address the challenge of last-mile distribution consists of using existing wholesale and retail distribution networks, instead of an organization investing in the creation of its own channels.

For example, KOKO Networks partners with the major fossil-fuel companies, such as Vivo Energy, for the storage and transport of ethanol. After being purchased from local distilleries or on the international market, ethanol is stored in the partners' depots and tanks at the gas station and then delivered by KOKO's tankers to the various retail points. Similarly, for retail distribution, KOKO Networks uses the network already in place, with franchised vending machines located next to small urban retailers and high-traffic businesses such as convenience stores, supermarkets and hair salons. In this way, KOKO Networks still controls the distribution network by tracking fuel levels across the supply chain and organizing deliveries and payments—and therefore optimizing the planning and distribution functions—with minimum investment in distribution infrastructure. For their part, fuel companies and retail outlets have the opportunity to add a new line and differentiate their offer.

At Inyenyeri, although distribution currently takes place through a network of its own proprietary rural hubs, urban shops and bicycle riders, the company considers that, as the business grows, it could be convenient to diversify the retail network through partner vendors in the future.. Owning its own stores allowed Inyenyeri (1) to bring together the collection and distribution of pellet activities (and to give the poorest households the opportunity to buy pellets in exchange for biomass, instead of paying cash), (2) to focus on customer training and service and (3) to receive feedback from users and find out their preferences. These are all essential aspects in the early stages of implementing a new solution. However, as the business matures, diversifying the distribution network through partnerships with third-party retailers could help the company to cut the amount of investment needed and to scale up more quickly.

7.3 Digitization

One emerging trend in relation to the last-mile challenge is the harnessing of Internet of things (IoT) technologies that allow for remote coordination and real-time optimization of the distribution process.

KopaGas, for example, uses the smart meters attached to its LPG cylinders to remotely monitor the level of gas in customers' cylinders and more efficiently manage its deliveries, which are undertaken by its distribution fleet of 25 drivers. By tracking consumption patterns, KopaGas improves logistics and stock management. If, traditionally, four cylinders per customer were needed along the supply chain to ensure a continuous supply, through the smart-meter system the number of cylinders dropped to two, cutting storage costs.



Similarly, the depots and tankers of KOKO Network's partners and all the ATM-style ethanol dispensers across Nairobi are equipped with smart systems and sensors connected to cloud-based software, enabling the fuel distribution to be coordinated efficiently through the remote monitoring of ethanol levels across the whole supply chain.

Although the start-ups described are still in the early stages of development and scaling up their solutions is a challenge yet to be overcome, they offer valuable lessons about how to make modern and cleaner cooking fuels more affordable and readily accessible to low-income populations, in both urban and rural areas. By combining existing fuel technologies with groundbreaking operating and business models, they are proving that there is room for private investment in the fight against energy poverty in the cooking sector too.



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