

INCLUSIVE INNOVATIONS

Business Models for Converting Waste to Energy

Innovation solutions are generating energy from landfill-bound waste, providing environmental benefits

HIGHLIGHTS

- Waste-to-energy enterprises reduce CO₂ emissions, save trees, save time spent on collecting firewood, provide smoke-free energy, and deliver cash savings from replacement of expensive fuel.
- On-site waste-to-energy enterprises empower households to recycle the waste they generate into energy (mainly biogas) for their own consumption or sale to their community.
- Off-site waste-to-energy enterprises are highly scalable and provide products (briquettes, liquid fuel) that are more cost-effective than traditional energy products (wood charcoal, diesel).



Summary

Inefficient disposal of waste in large quantities chokes landfills and water bodies, ultimately resulting in health and environmental issues. Low and middle income countries lack adequate infrastructure and technology required for efficient solid waste treatment. Mixed waste is particularly difficult to treat due to heterogeneity and lack of suitable technology. All waste, therefore, ends up, in landfills and open dumps, and poses risks of garbage fire and choking water channels. Alternatively, it is incinerated, which often causes air pollution and deteriorates the environment. Untreated waste causes huge environmental impact on wildlife, ecosystems and to human health.

Much of this waste, however, retains value, and can be recycled and reused. Significant amount of waste can produce energy that replaces expensive fuels. In recent years, research and development efforts have resulted in many waste treatment solutions that generate energy from landfill-bound waste. Waste-to-Energy enterprises bring innovative technologies aimed at addressing waste while ensuring better sustenance of the environment and minimum damage to the ecosystems. The two major types of waste-to-energy technologies are on-site (decentralized energy generation near the source of waste) and off-site (centralized waste generation away from the source of waste). These technologies produce energy products such as briquette and biogas for heating and cooking purposes and electricity generation. A few enterprises have also invented technology to convert plastic waste into petroleum-based fuel.

Development Challenge

Globally, millions of tons of waste is generated, of which 60 percent¹ is organic and can be reprocessed. Low-income communities are often unable to afford structured waste management processes to dispose their trash. Most of the waste ends up in open dumpsites near residential areas, causing diseases, polluting the environment and occupying extensive space. While recycling and reusing are disposal options, they are not always feasible for all types of waste. Recyclable waste can also become so contaminated that they cannot be economically or

¹ Clean India Ventures Ltd.

practically recovered. Moreover, since waste is not segregated at source, it is difficult and unviable to recycle mixed waste. Hence, the waste is typically dumped into landfills without being treated, posing higher risks of environmental damage.

Incineration is another commonly employed means of managing waste. Estimates of global black carbon emissions suggest that 40 percent comes from open burning of biomass, including forest and grassland fires and open burning of both urban and agricultural waste, while 60 percent comes from energy sources, including power plants, industry, transport and residential fuel use². Lack of effective methods in disposal of non-biodegradable plastics leads to soil degradation and impacts groundwater tables. Since plastics are manufactured from crude oil derivatives, dumping used plastic in landfills represents a huge waste of energy that, if recovered, could diminish the pace at which fossil fuels are being depleted globally.

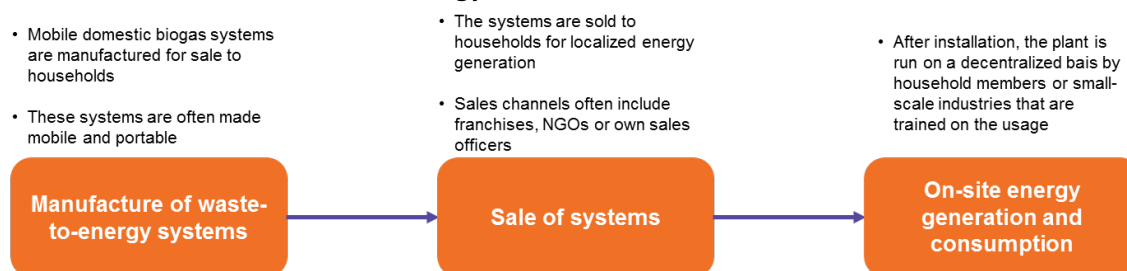
With growing populations, there is increasing pressure on the Earth's resources for energy. Waste-to-energy solutions to convert different types of organic waste into clean-burning fuel helps save forests and cuts greenhouse gas emissions by replacing wood, charcoal and fossil fuels for cooking and industrial processes. Besides being cleaner and easier to manage, biomass briquettes are also less polluting and have a higher calorific value than the traditionally used wood and charcoal. Wet organic matter like animal dung, kitchen leftovers and human waste can be used to produce biogas, a mixture of methane and carbon dioxide, as well as a semi-solid residue for compost. For families in the developing world, using biogas can replace the less efficient wood that emits health-damaging smoke. Biogas and briquette usage also reduces deforestation and greenhouse gas emissions, thus helping in climate change efforts.

Business Model

In recent years, social enterprises have commercialized waste-to-energy technologies to convert the unrecyclable waste to affordable fuel products, either at the source of waste generation (on-site) or at a centralized facility (off-site).

Components of the Model

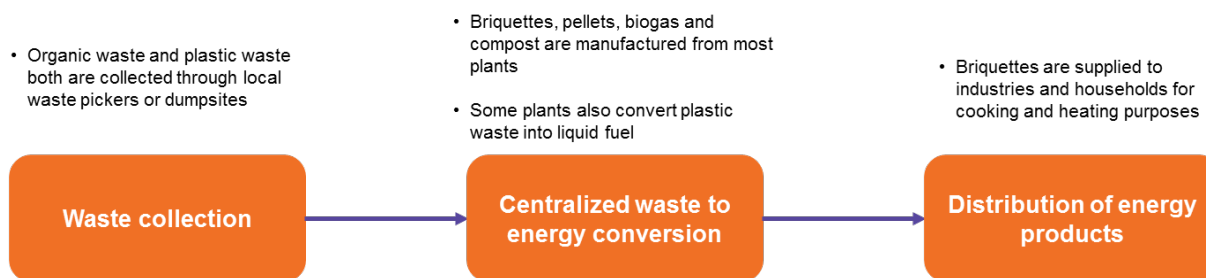
Figure 1. On-site conversion of waste to energy



Many social enterprises provide innovative solutions that enable households or businesses to convert the waste they generate into useful energy. These enterprises treat waste at source to bring down transportation inefficiencies and consume low-cost energy for domestic/industrial purposes. For example, The Waste Transformer, an enterprise that operates in Sub-Saharan Africa, offers gasifier waste-to-electricity installations that can handle a wide variety of waste streams as its input, including wood, food, plastics and agricultural waste. These wastes are then turned into heat and gas. The resultant gas can then be used to generate electricity.

Figure 2. Off-site conversion of waste to energy

² Global Waste Management Outlook, UNEP



Some enterprises deploy large scale solutions where waste is procured, transported to processing facilities and centrally processed into liquid fuel or briquettes. These enterprises employ waste collectors to aggregate waste and transport it to their plants thereby providing livelihood opportunities to local people and reducing the flow of waste to landfill dumps. For example, India-based Rural Renewable Urja Solutions makes biomass briquettes using forest residues or agro-waste which include dry leaves, grass, weeds, forest residue, cow dung, sawdust from local sawmills, and highly inflammable pine needles. These briquettes are then supplied to brick kilns, manufacturers, boiler operators for steam generation, and food processing industries that use coal for heating purposes. Similarly, SGFE (Sustainable Green Fuel Enterprise), an enterprise in Cambodia, manufactures charcoal briquettes using coconut waste and wood char waste.

Figure 3. Description of on-site and off-site conversion of waste to energy



Cost Factors

On-site waste-to-energy enterprises incur high costs on developing and manufacturing the waste treatment systems while off-site waste-to-energy enterprises incur high costs for setting up the waste treatment plants³. Off-site enterprises incur higher capital expenditure overall.

Table 1. Cost components for enterprises

³ Information gathered through primary interviews with SimGas, Clean India Ventures, SGFE and Biotech India

Type	Examples of enterprises	Main cost components
On-site waste-to-energy enterprises	Habona, SimGas, Clean India Ventures, (B)energy, Biotech India, Samuchit EnviroTech	<ul style="list-style-type: none"> Waste-to-energy technology/product: 40 percent - 60 percent Sales and marketing costs: 10-15 percent Installation and transportation costs: 10-20 percent Staff costs: 20-25 percent Miscellaneous costs: 10 percent-20 percent
Off-site waste-to-energy enterprises	Ankur Scientific Energy Technologies, SGFE, Bright Energy Africa, Sistema Biobolsa, Urja Solutions	<ul style="list-style-type: none"> Initial outlay (capital expenditure): 60-70 percent Electricity and running costs: 10-15 percent Waste collection and other raw material costs: 10-15 percent HR and other organizational costs: 10-20 percent

On-site waste-to-energy systems treat waste locally, and hence, do not incur costs associated with waste collection. For example, consumers of SimGas and (B)energy collect their own organic waste (e.g. animal dung, kitchen waste, human faeces, and agricultural residues) and feed them into the mobile biogas systems provided by the enterprises. Some enterprises provide community level solutions, which treat waste and generate biogas for a few households. The capital cost of setting up a community biomass gasification plant is USD 1,500 per kW for plants up to 1000 kW, and USD 1,200 per kW for plants of 100-1000 kW. Running costs are estimated at about USD 0.05 per kWh.

Off-site waste-to-energy enterprises, on the other hand, have to collect waste for conversion into fuel products such as briquettes and biogas. They also incur significant capital expenditure in setting up the centralized facility to convert waste into fuel. A typical off-site biogas plant costs around USD 50,000. However, with growing commercial interest in biomass gasification, these costs are declining with a reduction in input costs. High-pressure briquetting plants are expensive because the equipment needs to withstand the pressure involved in the conversion process. For example, a typical piston press from India with a 65 kW motor costs about USD 17,000, and the whole plant (including driers, grinders and handling equipment as well as the press) costs about USD 50,000⁴. Such a plant produces about 700 kg/hour of briquettes, or about 1,500 tons per year. In India, production costs are about USD 60 per ton, although this varies depending on the cost of the agricultural residues⁵.

Around USD 2,200 (RWF 1.7 million) is spent by Habona Biogas on monthly remuneration of its employees

Revenue Streams

The major revenue streams for waste-to-energy enterprises include sale of waste treatment systems and energy products such as biogas and briquette.

Briquettes are sold by off-site waste-to-energy enterprises at prices that are generally comparable to wood charcoal of the same calorific value. Typically, briquettes and pellets are retailed at USD 80 and USD 300 per ton, respectively⁶. The prices of these household plants vary from country to country, but they are typically priced around USD 500⁷. Samuchit Enviro Tech in India retails a 0.3 m³ digester for USD 320 and a 1 m³ digester for around USD 400.

Domestic biogas plants cost around USD 550 and institutional biogas plants cost around USD 50,000

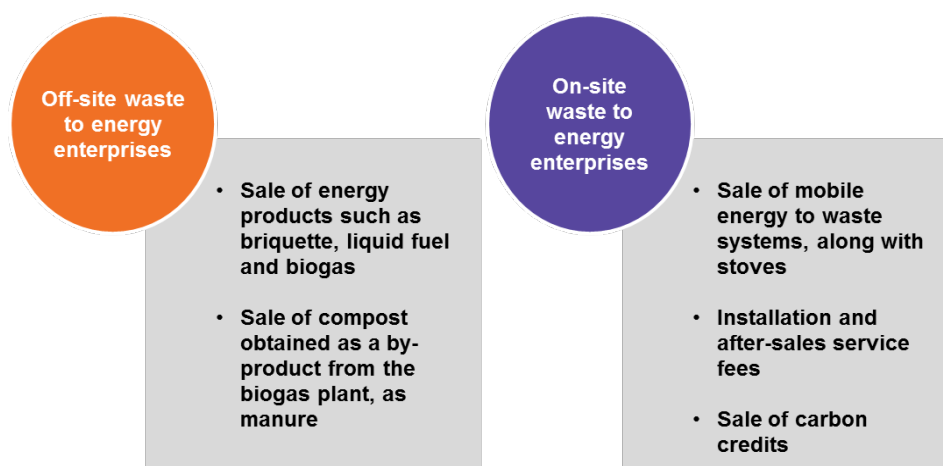
Figure 4. Sales for waste-to-energy enterprises

⁴ <https://www.ashden.org/briquettes>

⁵ Ibid

⁶ <https://www.ashden.org/briquettes>

⁷ <https://www.ashden.org/biogas>



Some enterprises such as Ventana CleanTech have a hybrid model wherein it has both on-site and off-site systems. Ventana CleanTech earns revenues by designing, manufacturing, and selling waste-to-energy systems to industrial waste-plastic recyclers and other waste management companies that aggregate waste plastics from municipal, industrial and commercial sources. It also plans to sell high-grade fuel from its self-owned plants to industries that consume petrol or diesel for its operations.

A few enterprises have adopted an asset-light franchise model wherein they outsource both, manufacturing and sales of the systems, and earn a commission for training, marketing and consultancy. For example, (B)energy obtains the biogas systems from a manufacturer and has appointed rural entrepreneurs as franchises to market and sell the systems. It takes a small commission of around 10 percent on each system⁸.

Financial Viability

On-site biogas enterprises such as SimGas earn revenues from sale of the biogas system (includes cook-stoves and other components). SimGas sells the entire kit for an average price of USD 750. It has also tied up with the World Bank's carbon credit program, where it is paid fees based on the carbon credits earned by its customers. SimGas uses these funds to cross-subsidize product prices for its customers.

Generally, USD 1-2 is paid per carbon credit and one household reduces emission by around 8 carbon credits

Profitability in briquettes depends upon the cost and availability of raw materials and the market price (often based on prices of competing fuels). This makes the viability of briquetting as a business very site specific⁹. Per ton, charcoal is more expensive than wood because of its higher energy content and the same applies to char-briquettes. SFGE's cheapest char-briquettes retail for about the same price as wood-charcoal in Cambodia, about USD 0.35 per kg (USD 350 per ton). However, many restaurants are prepared to pay twice as much for their highest-quality briquettes, because these burn more slowly and evenly.

Partnerships

Many off-site waste-to-energy enterprises piggyback on government waste management programs to install centralized small-scale waste-to-energy systems. For example, Clean India Ventures (CIVL), an enterprise in India that manufactures waste re-processors, has joined the Swachh Bharat Mission (Clean India Mission) to install community-based waste re-processor machines. Each waste re-processor upcycles 0.5–3 tons of organic waste like garden waste, temple waste, kitchen waste and vegetable waste into high-quality organic compost to be used as fertilizer or biofuel for cooking. CIVL has also partnered with New Delhi Municipal Council, a local Government body in India, to install plants in localities, parks and gardens. Each of the plants costs USD 0.2

⁸ Primary interview

⁹ Ibid

million¹⁰. Waste (of which 90 percent is organic waste and 10 percent is non-biodegradable plastic waste) is collected from neighboring households. This is expected to divert at least 60 percent of the 4000 tons of waste generated in Delhi per day from landfills. CIVL also employs young rag-pickers from nearby areas for garbage collection and running of the plants.

Waste-to-energy enterprises also partner with local manufacturers, R&D experts and NGOs throughout the development and implementation of their products. For example, digesters are developed and designed by SimGas BV in the Netherlands in close collaboration with Silafrica and other local partners. SimGas has also entered into strategic partnerships with multilaterals such as Hivos, Global Alliance for Clean Cookstoves, Africa Biogas Partnership Program, SNV and others. Husk Power Systems, an enterprise based in India, has established strategic partnership with Shell Foundation and IFC for capacity building, establishing health and safety procedures and training infrastructure.

Implementation: Delivering Value to the Poor

Awareness

Most waste-to-energy enterprises use non-traditional marketing channels to create awareness about their products and services. For example, SimGas promotes its products through local churches and NGOs that are well connected with the local community. Habona promotes its product through social media (Facebook), while Biotech organizes roadshows around southern India, demonstrating the benefits of biogas plants to a wide audience. The enterprises share that they are able to convince many people to install biogas plants as a result of the publicity, as well as because of the rising cost of alternative fuel such as Liquefied Petroleum Gas (LPG). Clean India Ventures advertises its products through outdoor exhibitions and through the championship of Government officials. SGFE advertises its product on tuks-tuks (three-wheeler public transport) to target low-income consumers.

Biotech India has organized 26 Energy Clubs in rural and urban areas with the association of local NGOs for the effective implementation of non-conventional energy schemes, waste management and energy conservation programs.

Some enterprises also provide awareness and capacity building services to customers who purchase their solutions. For example, Sistema Biobolsa (Biobolsa) is a social enterprise that produces bio-digesters for smallholder farmers in Mexico and Latin America. It not only offers to build and install the machinery required to carry out waste conversion but also helps and teaches farmers about the system. Biotech India has a well-equipped training center to provide training to 75 -100 people at a time. Similarly, Sky Link, a social enterprise that builds and installs biogas plants in Kenya, trains local technicians so that they have the skills to build biogas plants.

Acceptance

Waste-to-energy enterprises create win-win situations for their customers (access to clean energy) and entrepreneurs/franchise partners (additional source of income). (B)energy, a waste management enterprise based in Ethiopia, provides households in rural Africa, Asia, and Latin America with access to cooking biogas by converting organic solid and liquid waste to biogas and fertilizer. It supplies a semi-mobile biogas production unit that is quick and easy to install in homes and is affordable. (B)energy customers (entrepreneurs and franchises) can produce up to 1.5 m³ of biogas from 20 kg cow dung daily, and further sell the biogas to consumers (neighbors and community members) in a 'biogas backpack' at the rate of USD 4 for 100 liters¹¹. The mobile backpack makes it easy and affordable to transport the gas, which can be used as clean cooking fuel.

¹⁰ <http://www.cleanindiatech.com/wp-content/uploads/2014/07/news-3.jpg>

¹¹ <http://www.be-nrg.com/b-products/>; 43.50 Euros for 1.2m³ is equivalent to USD 4 for 100 litres

Some enterprises use local champions as employees to drive acceptance of their waste-to-energy solutions within the community. Bright Energy Africa employs farmers to run briquette fabricators in central locations. It leases kilns to local farmers to make biomass char and buys that char back at a higher rate than the kiln lease. BEA also employs unemployed women and youth as commission-based sales agents, who advise families in their network to replace traditional wood charcoal with smokeless briquette for cooking. This community-led model drives acceptance and trust through word-of-mouth within the community network.

Off-site waste-to-energy enterprises have innovative models to incentivize waste collection for energy conversion. CaribShare, a Caribbean off-site waste-to-energy social enterprise (NGO), collects organic food waste from hotels and livestock farms, and converts it into biogas and then into affordable, reliable electricity to serve the needs of communities in rural Jamaica. Participating hotels reduce their waste disposal cost by more than 50 percent as CaribShare picks up their organic waste free of charge and enhances its green/CSR branding. Participating farms receive a cash reward and high-quality fertilizer in return for the cow or pig manure they supply. These novel techniques encourage the hotels and farmers to participate in the waste-to-energy programs.

SGFE's provides free trial samples to restaurants and distributors. This is very effective to generate interest and ensure future sales

Accessibility

Waste-to-Energy enterprises tap into the existing rural network to ensure last-mile delivery of their systems. For example, (B)energy has a decentralized hub-and-spoke distribution model wherein it appoints 'social franchisees' at a local level and imparts training to them for filling in the biogas in the backpacks. (B)energy also involves local NGOs and convinces them to manage the transportation of biogas systems and thus offset carbon footprints. End users are able to consume or sell the biogas they produce using the (B)energy backpacks (1 backpack can produce 3-4 hours of biogas). This innovation has made biogas portable and empowers households to generate, consume and sell biogas, thus increasing accessibility.

Often households are reluctant to invest in a biogas plant because they consider the running and maintenance of the plant highly technical. Some of the standard products may also have parts that are not readily available locally or may not be suitable for installation at their homes. To address this issue, some enterprises provide modular or customizable solutions. For example, India-based Samuchit Enviro Tech provides a do-it-yourself kit consisting of all critical components (biogas stove, feedstock inlet assembly, overflow outlet assembly, drain valve assembly, biogas outlet assembly) along with an instructional video. Tanks and pipes can be purchased locally, and the plant can be installed with the help of any local plumber, thus making the operations easier for the consumer. Similarly, Sistema Biobolsa ensures that it customizes its product to suit each farmer's requirements and provides suitable training pertaining to its use and implementation. The distribution of these machines is done through micro-entrepreneurs who use micro-finance channels to make distribution easy, convenient and accessible.

Affordability

Some enterprises make their on-site plants affordable by partnering with local governments that offer subsidies to consumers for the use of the systems. For example, the Ministry of Nonconventional Energy Sources (MNES) in India offers a subsidy of USD 60 for each Biotech India domestic plant up to 10 m³ capacity, and the local and district panchayats provide further subsidies - typically USD 60 in urban areas and USD 80 in rural areas¹². Consumers pay the remaining amount directly to Biotech India. A typical family normally uses about 168 kg of LPG a year. Biogas replaces about 50 percent of this use, or about 84 kg per year, saving the family about USD 53 per year¹³. This means that the payback period for the cost of the plant is about three years, which can be shortened if they collect extra food waste from shops to increase their biogas production.

¹² https://www.ashden.org/files/biotech_percent20full_0.pdf

¹³ Ibid

The cost of implementation of biogas technology is significantly lower than for other renewable energy technologies (wind, solar, and hydro)¹⁴, thus making it a cost-effective source of energy for domestic consumption. Many biomass gasifiers produce biogas that can lower the price of energy for small-scale industries that are located in off-grid areas and rely on diesel as a source of energy. For example, Ankur Scientific Energy Technologies in India manufactures biomass gasifier systems that convert biomass such as rice husk, wood and sawdust into a combustible gas mixture (known as producer gas). This gas can replace fossil fuels (coal, natural gas, light diesel oil) in any application (furnaces, oil heaters and boilers). If connected with modified diesel engine-generator set, the producer gas can lower the cost of electricity produced by only diesel, by replacing 70 percent of the diesel.

Biotech plants directly avoid the emission of about 3,700 tonnes/year of CO₂, with further savings from the reduction in methane production from the uncontrolled decomposition of

Some enterprises also provide consumer finance to ensure that customers find their products affordable. For example, Takamoto Biogas (Schutter Energy) provides pay-as-you-go biogas systems in Kenya where their customers (mainly smallholder farmers) pay a small fee to install the biogas system and make mobile payments for the biogas they use. Takamoto monitors the biogas system through a GSM connected smart meter that sends information on unit maintenance and enables the PAYG function according to the customers' credit. Since 2012, it has partnered with Kiva to provide 0 percent interest financing for its clients who cannot afford to pay the full price of a bio-digester upfront¹⁵. Biobolsa has developed a series of questions about number of animals, types of crops, annual payment cycles, size of family, food costs, and education costs to assess the debt servicing capacity of farmers. It has also implemented a Salesforce and Taroworks solution that enables field technicians and sales representatives to enter information on their smart phones in the field and later upload to Biobolsa's Salesforce database once they have an internet connection. The enterprise can thus capture essential information about each customer in remote rural regions and help the credit committee make an informed loan decision¹⁶.

Results and Cost-Effectiveness

Scale and Reach

Off-site enterprises offer a more scalable and cost-effective solution for waste to energy conversion due to economies of scale. However, they are limited by the high capital investment required to start the business. The most commonly seen offsite waste-to-energy enterprises are briquette manufacturers. On-site enterprises are more effective in waste management as they divert waste from landfills. However, many households hesitate to install the plant in their homes due to the stench and space constraints. The most commonly seen onsite waste-to-energy enterprises are biogas plants. In general, the waste-to-energy business model is highly scalable and has the potential to reach thousands of households within a few years of operations. The scale of off-site enterprises can be measured by various metrics such as tonnage of output (e.g. number of briquettes sold per month), number of customers served (households, industries), number of countries reached etc. The scale of on-site enterprises can be measured by metrics such as number of biogas units deployed, geographies reached, tonnage of waste diverted from landfills etc.

Off-site biogas models achieve better scale and reach in terms of volume to people served. Domestic on-site biogas plants have a volume of 1-12 m³ and serve 5-10 people. Institutional biogas plants (for schools and communities) range in capacity from about 10 m³ to 25 m³ and each serve an average of 250 - 500 people. Off-site waste-to-energy plants, generally developed in association with a municipal body is around 50 m³ and serves around 2000–25,000 people¹⁷. The manufacture, installation and maintenance of the biogas plants is estimated at 13 days for each on-site domestic plant, 55 days for each off-site institutional plant and 80 days for a municipal off-site waste-to-energy plant. Sistema Biobolsa has installed more than 2,200 Bio-digesters in Mexico and Latin

¹⁴ <http://www.caribsharebiogas.com/projects>

¹⁵ <http://fellowsblog.kiva.org/fellowsblog/2016/08/09/by-the-numbers-sistema-biobolsa-is-ahead-of-the-curve-on-what-matters-most>

¹⁶ <https://fellowsblog.kiva.org/fellowsblog/2016/07/04/rural-microloans-20-a-mexican-social-enterprise-revamps-its-credit-program>

¹⁷ https://www.ashden.org/files/Biotech_percent20full_0.pdf; <http://www.newtimes.co.rw/section/article/2015-10-27/193856/>

America and treated 150,000+ tons of waste to produce 4500+ tons of biogas¹⁸. Biotech India has completed more than 22,000 household projects, 300 institutional projects, and around 60 electricity projects. The electricity generated is 40kW per year¹⁹. The total rate of biogas production from all installed plants in 2007 was estimated to be about 16,000 m³ /day, which replaces the equivalent of about 1,400 tons/year of LPG and diesel.

Briquette manufacturers generally produce around 100–200 tons of briquettes every month²⁰. Kampala Jellitone Suppliers (KJS) is Uganda's first producer of briquettes made from agricultural waste that includes sawdust, peanut husks and coffee waste. It has the capacity to produce about 2,000 tons / year of briquettes and sells about 130 tons of briquettes every month to 31 schools, universities and hospitals for cooking and to 5 factories for producing heat. Habona operates at a capacity of 100+ tons of briquettes per month and has the potential to increase it to 300 tons per month²¹.

Table 2. Scale and reach of select waste-to-energy enterprises²²

Enterprise	Country	Type	Scale and Reach
(B)energy	Ethiopia, Sudan	On-site	• 30 biogas backpacks (GesiShamba) sold through franchises, benefitting 250 people
SimGas	Tanzania, Kenya		• 800 customers served
Husk Power Systems	India	Off-site	• 15,000 households in 400 villages in rural India
Renewable Urja	India		• Capacity of 15,000 tons of briquettes per year, serving around 0.1 million rural households • Employment of 400 people, mostly women
SGFE	Cambodia		• 1,000 rural customers and 1,000 urban customers served
Clean India Ventures	India	Hybrid	• 25 machines installed, serving around 8,000 people
Skylink Innovators	Kenya		• Sold up to 200 domestic biogas plants and 6 large-scale ones, benefitting 5,200+ people

Improving Outcomes

Waste-to-energy enterprises create significant impact across many parameters such as carbon dioxide emission reduction, trees saved, time saved from not collecting firewood, health benefits of smokeless energy, and money saved by replacing expensive fuel with lower priced or more efficient fuel. Enterprises providing biogas solutions shared outcome data that highlights the multi-level impacts of this model, in addition to savings or additional income to farmer households.

Table 3. Impact of select waste-to-energy enterprises

Enterprise	Impact created
Takamoto Biogas	<ul style="list-style-type: none"> • Helps save around 3000 trees from getting cut each year • Avoids 1 MT CO₂ equivalent emissions • Saves a total of 331 man-hours spent in collecting firewood per day
SimGas	<ul style="list-style-type: none"> • Saves on average USD 250 per household per year on energy expenditure²³ • Each woman saves 2-4 hours a day by not collecting firewood
Sistema Biobolsa	<ul style="list-style-type: none"> • Treated 2.4 million tons of animal waste to produce 4,500+ tons of biogas and mitigate 17,000+ tons of CO₂

¹⁸ <http://sistemabiobolsa.com/?lang=en>

¹⁹ Primary interview with Biotech India, https://www.ashden.org/files/Biotech_percent20full_0.pdf

²⁰ Primary interview with SimGas

²¹ www.habona.rw

²² Primary interviews with the enterprises

²³ Primary interview with SimGas

	<ul style="list-style-type: none"> • With a bio-digester, farmers can replace costly chemical fertilizers with bio-fertilizer, saving USD 260 per year for a farmer with 3 hectares of land • Farmers can reduce or eliminate the amount of LPG they have to buy to power their homes and farms, resulting in savings of USD 28-40 per month
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Use of briquettes reduces the pressure on wood resources, and thus reduces deforestation. In addition, the agricultural residues used to make briquettes were previously burned as they were regarded as waste that posed a fire hazard. Less smoke is produced using briquettes than using wood, and it is removed by the stove chimney. Briquettes need very little space for storage, although it is essential to keep them dry. The Kampala Jellitone Suppliers (KJS) briquette stoves replace firewood or charcoal. One ton of briquette, used in an efficient KJS stove, replaces on average 1.2 tons of firewood and 0.3 tons of charcoal²⁴. The 1,530 tons of briquettes that the enterprise produces and sells, therefore, saves about 9,300 tons/year of CO₂. Low-income residue producers such as agricultural processors are paid USD 3-14 per ton of residue, giving them an additional source of income. Habona in Rwanda produces briquette that has a calorific value of 12-15 kilo Joules, whereas the calorific value of wood/charcoal is 3-6 kilo Joules.

An average of 6.1 tons of CO₂ is saved per ton of Kampala Jellitone Stove briquette used

Some enterprises create large-scale impact by implementing mini-grids in rural areas that complement the national power grid. While these are more mature and larger enterprises, they highlight the potential of how waste-to-energy models can achieve impacts beyond only managing waste. For example, Husk Power Systems, an off-site waste-to energy enterprise in India, generates electricity using a biomass gasifier that creates fuel from rice husk. Each plant generates 32 kW of electricity from 50 kg (110 lb) of husks per hour, enough to meet the basic energy needs of about 500 households, although there are several systems with higher generating capacity²⁵. Each plant saves approximately 42,000 liters of kerosene and 18,000 liters of diesel per year, significantly reducing indoor air pollution and improving health conditions in rural areas. It currently has 100+ operational plants in rural India, serving more than 200,000 people across 350+ villages. Husk Power extends villagers' activities beyond daylight hours, reduces indoor air pollution, increases the time children can study, reduces the amount of time women spend collecting firewood, and reduces emissions.

Power generation of 1000 MW from bioenergy in India requires an investment of USD 825 million. This has the potential to generate employment for 4 million people and reduce 5.6 million of CO₂ per year

For most domestic users, the main benefit of an on-site biogas plant is the easy, hygienic disposal of food waste and the savings made in LPG use. Operators of institutional plants are pleased with the absence of odor in the neighborhood. For the markets and councils, the removal of food waste and the associated public health risks is a great advantage. The effluent or residue in the biogas plant makes good fertilizer which results in higher farm yield.

Cost-Effectiveness

Waste-to-energy enterprises step in when local governments and the public sector are unable to effectively manage waste. Since waste-to-energy enterprises achieve impact across different parameters, particularly those such as health of vulnerable populations, women and children, their cost effectiveness is difficult to ascertain. However, enterprises that produce biogas or briquettes are ensured of a market for their energy products, and can ensure impact at a relatively reasonable cost, mostly similar to the charcoal wood costs. As

Briquettes cost about USD 16/tonne. Cost of cooking is similar to using firewood at USD 14/tonne because briquette stoves are more efficient. It is also considerably cheaper than using charcoal at USD 29/tonne

²⁴ https://www.ashden.org/files/KJS_percent20full.pdf

²⁵ https://en.wikipedia.org/wiki/Husk_Power_Systems

technology for efficient processing of waste into energy develops, the costs are likely to be lower than other traditional fuel.

Most waste-to-energy plants that manufacture briquette also produce organic compost that can be used as fertilizer. Several enterprises shared their cost and price of briquette and compost, indicating that they are able to earn reasonably while ensuring efficiency gains and cost savings for their customers. Habona, a waste-to-energy enterprise in Rwanda, collects waste from waste management plants using equipment that separates wet and dry waste to be used for making briquettes, biogas and compost. Each kg of briquette is sold to domestic clients for USD 0.25 (RWF 200) and lasts 3 times longer than charcoal of the same price. The price of briquette per kg for institutional clients is USD 0.05²⁶. The price of the compost is USD 40 per lorry i.e. USD 13.5 per ton²⁷. Bright Energy Africa (BEA), a Tanzania based enterprise, makes briquettes that are over 40 percent cheaper and last 35 percent longer than normal charcoal. Cooking using briquettes costs about the same as using firewood—the higher cost per ton of briquettes is balanced by the higher energy density and stove efficiency. Customers also find it easier to transport and store BEA briquettes, since they need a smaller volume per week. Similarly the briquette produced by Habona is around 40 percent cheaper than other substitutes such as wood and charcoal.

Some enterprises have adopted unique energy provision models that make the solution cost-effective for consumers. The cost-effectiveness is however, a function of local availability and price of raw material. In the case of Husk Power Systems, the rice husks used to fuel the process are purchased from local rice mills for less than USD 20 per ton. The cost of installation of a single biogas system is as low as USD 100 per kW. It further reduces costs by running insulated wires along bamboo poles directly to households, businesses and farms. For 7 hours of electricity, the enterprise charges USD 2-2.5 per household per month, on an average. The enterprise has also installed a remote plant monitoring system to monitor plant performance via internet. It also has a pay-as-you-go system with pre-paid meters available at USD 12-15 that allows customers to pay on a monthly basis²⁸.

Although very nascent, a few breakthrough technologies are being commercialized to convert waste into low-cost petroleum fuel. While their cost effectiveness is still being proven, these technologies have the potential to be disruptive. For example, Ventana, a waste-to-energy enterprise based in California with R&D in India, deploys a patent-pending, continuous de-polymerization process to convert waste plastics to petroleum fuels similar to diesel and gasoline. Most competing variants deploy capital-intensive systems to convert waste plastics to a mix of synthetic crude oil, waxes and slurries which have limited offtake and low economic value. Ventana has disruptively down-shifted the capital cost of plant and machinery from USD 10-20 million for a 20 tpd (tons per day) plant^{29,30}. The technology helps waste management companies save on disposal costs (USD 40-100+/ton) while additionally netting them cash flows of USD 200-250+ per ton of waste plastics³¹. Similarly, Sustainable Technologies & Environmental Projects (STEPS) in India, has developed two innovative technologies to produce liquid fuel. The algae-to-diesel technology converts algae found in water bodies into hydrocarbon diesel (1 ton of algae yields 500 litres of fuel) and bio-char, which has a high commercial value for use as cooking fuel³². STEPS' Polycrack technology converts waste plastic into petroleum fuels. This fuel can be further converted into various fractions like petrol and diesel. (1000 tons of waste can produce 120 tons of oil)³³.

²⁶ Primary interview with Habona Biogas

²⁷ Each lorry carries around 3 tons of compost

²⁸ [http://www.cseindia.org/userfiles/Gaurav percent20Kumar_Design percent20to percent20Scale.pdf](http://www.cseindia.org/userfiles/Gaurav%20Kumar_Design%20to%20Scale.pdf)

²⁹ <http://www.firstpost.com/business/startups-business/fuel-from-trash-how-plastic-waste-can-power-your-car-in-the-future-1956467.html>

³⁰ The enterprise prefers to keep the price of its solution confidential, and has not shared it with the research team.

³¹ https://zerista.s3.amazonaws.com/item_files/f50f/attachments/9569/original/ventana_cleantech.pdf

³² http://stepsenergy.net/web_documents/process_brief_algae.pdf

³³ http://stepsenergy.net/web_documents/divya_bhasker_translation_from_gujarat.pdf

Scaling Up

Challenges

Waste-to-energy enterprises face a number of challenges related to operations, funding, distribution and customer outreach. Capital to establish the plant and fuel operations seem to be the leading challenge. Habona lacked funds to ensure an adequate number of vehicles to transport waste to the treatment plant. It also faced some difficulty in mobilizing funds from investors and convincing them of the benefit of its technology. Its project to generate power from gas so as to complement the national power grid required an initial investment of around USD 50,000. Eventually, it received award money from the 2014 Young Innovator Award in Rwanda, African Innovation Prize and 2015 Mandela Washington Fellowship in USA, which it used to implement the plant.

Through the Polycrack technology, STEPS can produce 1 liter of petrol for just 20 cents

Waste-to-energy plants need maintenance support, and often face technical problems that need a dedicated technical staff. Enterprises find it difficult to hire and retain such staff close at hand in all their locations. For example, Biotech India occasionally faced minor problems with blocked gas pipes (or pipes chewed through by rats), water condensing in pipes, and broken tap fittings, which were quickly fixed by its engineers. Biogas cook-stoves also have a life of 2-3 years on an average and have to be replaced at a cost of USD 50³⁴. Briquette manufacturing also causes considerable wear in the machines due to the high pressure, and the pistons and dies have to be changed regularly.

In many cases, enterprises have to work hard to overcome people's expectations that waste-to-energy solutions have to be necessarily subsidized by Government programs. A huge amount of donor funding often distorts the market for private sector players and competing with highly subsidized LPG (a substitute for biogas) is difficult³⁵. Clean India Ventures faced a challenge with the mindset of the people who assume that waste management is the Government's job, and so, despite having small-scale plants in nearby localities, would not dispose waste at the plants.

Role of Government and Policy

Governments in developing countries are keen to support the waste-to-energy business model because it addresses two of their most pressing problems—that of energy access and dependence on fossil fuels, and waste management. In India, the Ministry of Nonconventional Energy Sources (MNES) offers a subsidy of USD 50 (INR 3,000) for each domestic plant up to 10 m³ capacity, and the local and district panchayats provide further subsidies - typically USD 50 (INR 3,000) in urban areas and USD 70 (INR 4,500) in rural areas³⁶. The Government of India has set itself a target to generate 700 MW energy from waste by 2019³⁷. For this, it has instructed the distribution companies to purchase power from any city generating energy from waste. The Government of India is also working towards reducing interest rates on loans for waste-to-energy projects. In Thailand, the Energy Regulatory Commission is planning to add up to 50 MW of waste-to-energy power capacity to cut down the country's reliance on natural gas and is partnering with private companies to build, operate and transfer the plants³⁸. In Ethiopia, the UK-based Cambridge Industries and China National Electric Engineering Corporation are undertaking a USD 95 million project to generate 50MW of electrical energy in collaboration with the Addis Ababa city administration.

However, clarity on policy governing privately-owned waste-to-energy mini-grids is important. Enterprises often invest considerably in a new market, only to find that the national grid is moving into the same market. Availability of low-cost grid electricity impacts the financial viability of waste-to-energy enterprises. Lack of regulatory clarity has adversely affected Husk Power System that had to shut 3 plants after consumers moved

³⁴ Primary interview with SimGas

³⁵ Primary interview with B-energy

³⁶ https://www.ashden.org/files/BIOTECH_percent20full_0.pdf

³⁷ <https://waste-management-world.com/a/indian-waste-to-energy-conference-potential-for-6-gw-capacity>

³⁸ <http://jakartaglobe.beritasatu.com/international/thailand-gets-strong-interest-waste-energy-power-plan/>

to the centralized grid in their area of operations. Centralized grids may jeopardize the viability of mini-grids as consumers prefer power from the government. In such cases, mini-grids should be allowed to feed in power into a central grid at a fair tariff³⁹.

Conclusion

The severe lack of existing municipal infrastructure and capacity to support efficient solid waste treatment in most developing countries indicates the potential opportunity for waste-to-energy enterprises. The dual impact of the waste-to-energy model in mitigating climate change and in serving as an energy resource makes a strong case for increased investment into this model.

On-site waste-to-energy enterprises are highly scalable and replicable given that these systems are easily portable and can be used to treat a wide range of organic waste including agricultural and domestic kitchen waste. Financial viability of such enterprises hinges on consumer awareness and uptake; the number of customers reached determines the extent to which system manufacturing costs are covered. The viability of off-site enterprises relies largely on the support of governments to cover capital costs incurred in setting up processing plants. Most off-site enterprises increase their scale of operations by leveraging partnerships with governments under their waste management programs. However, the scalability of the model is threatened by alternative renewable energy sources such as solar power and wind power that currently garner more attention than biogas or biomass energy sources.

Table 4. Social enterprises in waste-to-energy

Company	Country	Solution description
Abellon Clean Energy	India, Canada, Ghana, Italy	Abellon Clean Energy is involved in collection of municipal, industrial, agricultural and forest waste and converting them into different forms of energy (solid fuel, liquid fuel, gaseous fuel).
Agro Biogenics	India	Agro Biogenics recycles food materials such as processed foods and fodder and non-food resources such as engineered composites and products to bio-energy, bio-petrochemicals, bio-fertilizers and bio-water.
Ankur Scientific Energy Technologies	India	Ankur Scientific Energy Technologies converts agri residues (e.g. corn cobs, jute sticks, coconut husk, rice husk, coffee husk, groundnut shells) into energy through biomass gasification.
(B)energy	Germany, Ethiopia, Sudan	(B)energy converts organic waste (animal dung, kitchen waste, human faeces, agricultural residues) and liquid waste (water, waste water, urine) to biogas and fertilizer. It supplies biogas production unit, which is semi-mobile, quick to install and affordable.
Biotech India	India	Biotech is engaged in the implementation, promotion, popularization and research in bio-waste management, non-conventional energy and energy conservation programs.
Bright Energy Africa	Tanzania	Bright Energy Africa produces and distributes biomass briquettes from agricultural waste and uses youth and women as briquette sales agents in their communities. The company offers training, kiln leasing and briquetting technology for farmers as well as marketing support for retailers.
CaribShare Biogas	Jamaica	CaribShare is a social enterprise that converts organic waste from hotels and farms into biogas to produce clean energy and to help serve the development needs of the Caribbean.
Clean India Ventures	India	Clean India Ventures manufactures re-processors to produce valuable products from waste. The waste re-processors upcycle most of the organic waste like garden waste, temple waste, kitchen waste and vegetable waste into organic compost and liquid fuel.

³⁹ <http://www.financialexpress.com/economy/policy-gap-stops-investors-from-expanding-power-grids-in-rural-india/183909/>

Habona	Rwanda	Habona collects waste and converts it to Biogas and Biomass Briquettes and sells them to lower income populations at affordable price.
Husk Power Systems	India	HPS takes agricultural waste, rice husks otherwise left to rot, and converts it into gas that powers an off-the-shelf turbine to generate electricity.
Kampala Jellitone Suppliers	Uganda	Kampala Jellitone Suppliers (KJS) is Uganda's first producer of briquettes made from agricultural wastes that includes sawdust, peanut husks and coffee waste.
Rural Renewable Urja Solutions Pvt. Ltd.	India	Rural Renewable Urja Solutions makes biomass briquettes using forest residues. (These briquettes are then supplied to brick kilns manufacturers, boiler operators for steam generation, and food processing industries that use coal for heating purposes.
Samuchit Enviro Tech Pvt. Ltd.	India	Samuchit Enviro Tech offers customised biogas plants for kitchens, for converting kitchen/food waste into cooking energy.
Schutter Energy Ltd (Takamoto)	Kenya	Schutter Energy is a social enterprise that designs and manufactures biogas systems, which also generate quality biofertilizer. It sells biogas system under the brand name of Takamoto.
Sustainable Green Fuel Enterprise (SGFE)	Cambodia	SGFE (Sustainable Green Fuel Enterprise) works to reduce deforestation and improve waste management in urban areas, by developing a local economic activity: manufacturing charcoal using organic waste.
SimGas	Netherlands, Kenya, Tanzania, Rwanda	SimGas offers a range of biogas digesters and appliances suitable for different situations and requirements, from households to small enterprises and institutions. Its farm waste systems (GesiShamba) are designed for livestock farmers such as cattle holders
Sistema Biobolsa	Mexico	Sistema Biobolsa is a system that converts manure into biogas and natural fertilizers.
SkyLink Innovations	Kenya	Offers biogas digesters for households, schools and prisons to convert latrine waste into cooking gas, thereby almost halving the amount of firewood typically used.
Sustainable Technologies & Environmental Projects Pvt. Ltd (STEPS)	India	STEPS provides management and disposal of unsegregated waste at source through the Polycrack technology. The Polycrack reactor treats unsegregated garbage and converts it into gas, oil and carbon.

Further Reading

Global Waste Management Outlook, UNEP <http://www.unep.org/ietc/Portals/136/Publications/Waste percent20Management/GWMO percent20report/GWMO percent20full percent20report.pdf>

ISWA Guidelines: Waste to Energy in Low and Middle Income Countries

<http://www.waste.ccacoalition.org/document/iswa-guidelines-waste-energy-low-and-middle-income-countries>

Biomass briquettes and pellets <https://www.ashden.org/briquettes>

Biogas <https://www.ashden.org/biogas>

Biomass Gasification <https://www.ashden.org/biomass-gasification>

Biomass Briquettes: Turning Waste Into Energy <http://biomassmagazine.com/articles/5148/biomass-briquettes-turning-waste-into-energy>

Waste-to-Energy Facilities Provide Significant Economic Benefits (Whitepaper)

https://swana.org/portals/Press_Releases/Economic_Benefits_WTE_WP.pdf

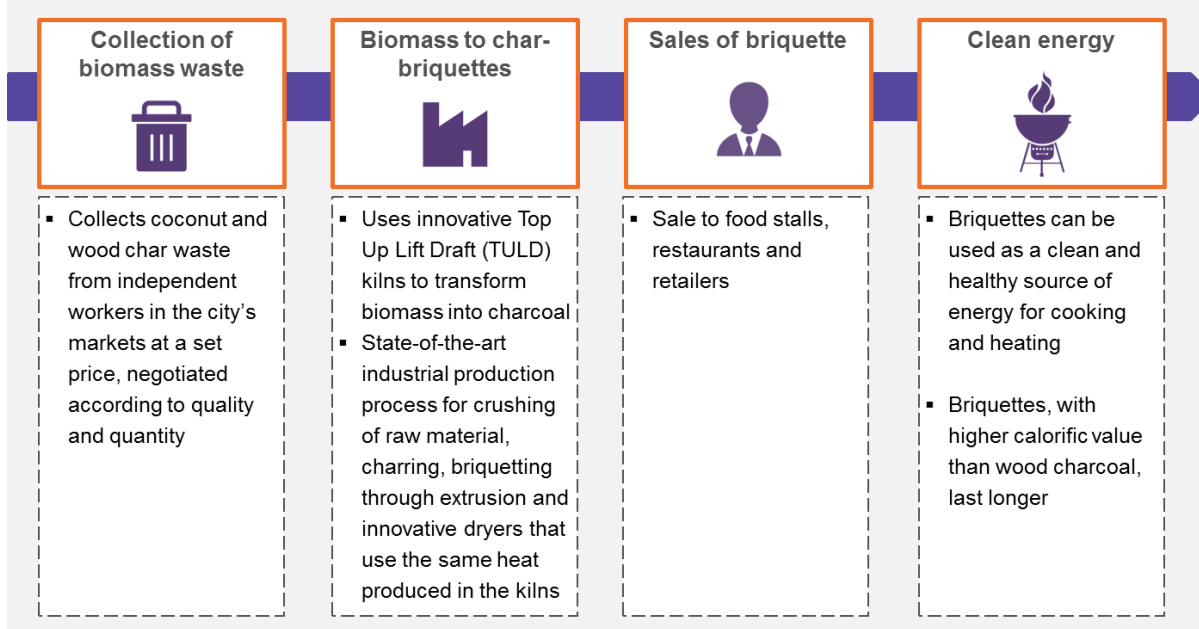
CASE STUDY: SGFE



Founding year: 2008
HQ: Phnom Penh
Countries of operation:
 Cambodia
Orientation: For-profit
Employees: 30
Turnover: USD 250,000

Sustainable Green Fuel Enterprise (SGFE) aims to provide an alternative sustainable cooking fuel (renewable and clean energy) to the Cambodian population, to replace the traditional charcoal. SGFE has set up a factory producing char-briquettes from biomass waste and hires workers from the poorest segments of the population, mostly waste-pickers in the informal sector, and provides them with social working conditions (salaries, health care, safety, etc.).

By selling its char-briquettes, SGFE contributes directly to the prevention of the deforestation caused by traditional charcoal production. Since SGFE's raw materials derive from recycled biomass waste, each ton of SGFE's char-briquettes leads to a reduction of 16.45 tons of CO₂ emissions. In 2014, SGFE achieved a CO₂ emission reduction of about 9,300 tons (sales of 570 tons of char-briquettes).



Operating Model

Cambodia has one of the worst rates of deforestation in the world. It lost 2.9 million hectares of forest (14 percent of its land area) from 1990 to 2010⁴⁰. Much of the Cambodian economy depends on wood, for timber, heat and power generation, and about 80 percent of households use wood or charcoal for cooking. Moreover, Cambodia is faced with an acute shortage of electricity (60 percent imported in 2012) and regular power cuts. As a result, the Government of Cambodia licenses and encourages private generators, including those using wood gasifiers. The char from the gasifiers is currently considered as waste. Sustainable Green Fuel Enterprise (SGFE) is trying to solve both the problems—lack of clean cooking energy and improper disposal of wood-char from gasifiers.



This series on Inclusive Innovations explores business models that improve the lives of those living in extreme poverty. Editors are Elaine Tinsley and Natalia Agapitova. Researched and developed by Intelicap.

⁴⁰ https://www.ashden.org/files/case_studies/SGFE_percent20case_percent20study_0.pdf

Over 80 percent of the population in Cambodia still uses biomass (wood or charcoal) for their daily cooking purposes. Charcoal is used primarily in urban areas (by 32 percent of the population), where the poor families use charcoal because alternative cooking fuels as LPG are very expensive (USD

SGFE is a social enterprise that started in 2008 as a result of a joint project of two NGOs—Group for Environment, Renewable Energy and Solidarity (GERES), which was the technical partner, and Pour un Sourire d’Enfant (PSE) which was the social partner. It became an independent private company in 2012. Since then, SGFE has gradually achieved financial sustainability, breaking even in 2013 and making a profit in 2014. SGFE produces high-quality char-briquettes from waste, replacing the need for wood charcoal, and thus reducing deforestation. It purchases biomass materials, which would otherwise go to waste landfills, and converts them into high-quality char-briquettes that are sold as a direct replacement to conventional charcoal, for cooking in homes and restaurants.

SGFE’s current production is equivalent to the total cooking needs of about 2,500 households or about 12,000 people

The enterprise currently uses char waste from wood-fired electricity generation, which SGFE buys from businesses that run the generators, and coconut shells, which SGFE buys from traders and converts into char in its own clean-burning kilns. Because coconut char makes higher quality briquettes, SGFE has also started selling coconut shells to some electricity generators, with a buy back arrangement for their waste coconut char.⁴¹

SGFE delivers about 30 percent of its production to retailers and 40 percent to restaurants and food stalls. The remaining 30 percent is bought directly from the factory by charcoal distributors for re-sale. Around 100 shops, many of which used to sell charcoal, now sell SGFE briquettes. Around 150 restaurants and food stalls use the briquette. SGFE leverages tuks-tuks⁴² to distribute and advertise its products. SGFE’s most effective marketing strategy is providing free trial samples to restaurants and distributors. It creates awareness among families through focus group discussions⁴³.

The sale per month presently is around 90 tons of briquettes

Financial Sustainability

In 2014, about 53 percent revenues were from sales of products and services, 28 percent from grants and 19 percent from sales of carbon credits⁴⁴. However, SGFE has progressed on the path of financial sustainability from core operations to achieve 98 percent revenues from sales and only 2 percent from the sale of carbon credits in 2016. It has not applied for or received any grants this year. The major cost components for SGFE include raw material and human resources.

SGFE produces its top brand ‘Diamond’ briquettes only from coconut char, and ‘Premium’ brand from 5 percent coconut char and 95 percent char residues. Both have higher carbon content than traditional wood charcoal, and produce more heat per kg. In addition, both contain less volatile material and less ash content, and therefore, produce less air pollution. Although the prices of SGFE produced briquettes are slightly higher than those of the traditionally used charcoal, the briquettes burn for a longer time due to their higher calorific value. This reduces the average cost for the consumer vis-à-vis traditional charcoal (see table below)

Type	Price per ton	Combustion time	Average cost per day ⁴⁵
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⁴¹ Waste biomass like coconut husks and shells are burned for two hours in refractory brick kilns until the material is carbonized. The production process has been modified to be as energy efficient as possible; the kilns used to carbonize the coconut and biomass ensure efficient combustion, reducing the emission of harmful gases and air pollution. The energy generated by the carbonization process is recovered and used to increase efficiency.

⁴² Three-wheeler public transport

⁴³ Primary interview with SGFE

⁴⁴ https://www.ashden.org/files/case_studies/SGFE_percent20case_percent20study_0.pdf

⁴⁵ Assuming 1.5 kg and 2 hours use per day on an average, as per the information obtained through primary research

Premium briquette	USD 300 - 350	2 hours	USD 0.45–USD 0.6
Diamond briquette	USD 750	5 hours	USD 0.5–USD 0.6
Traditional charcoal	USD 250–300	1 hour	USD 0.75–0.9

SGFE has received USD 0.3 million grant from the Spark Fund of the Global Alliance for Clean Cookstoves. It is also in the process of raising equity investment to scale up production capacity and expand to overseas markets. As the effective price of SGFE's briquette fuel is same or below the price of wood charcoal, it is highly competitive resulting in a low substitution cost for the consumer. SGFE's profits are reinvested into the company's assets and fairly distributed among the employees to maximize social impact.

Impact

SGFE char-briquettes are 100 percent recycled biomass, have a longer burning time (higher fixed carbon content), they make no sparks (which can cause domestic fires), make no smoke (which cause respiratory diseases in indoor cooking) and come already in a small cut, easy-to-use size and shape. The briquettes are less fragile, so they are easier and cleaner for both users and traders to handle and store. At the end of the day, any remaining fuel can be extinguished in an air-tight container and used again the next day.

Each ton of char-briquettes replaces the use of about 10 mature trees (7 tons of dry wood). With its monthly sales exceeding 100 tons, SGFE saves over 700 tons of wood per month, which is not cut from Cambodia's forests and reduces CO₂ emissions for almost 20,000 tons per year⁴⁶. Users of SGFE briquettes save around USD 60 per year, because the briquettes produce more heat and less waste than wood charcoal⁴⁷. Greenhouse gas emissions are cut by replacing non-sustainable wood with biomass from waste. They are reduced further by the use of top-lid-updraft gasifier (TLUD) kilns, which cut the emission of non-CO₂ greenhouse gases.

1kg of SGFE char briquettes has the same energy content as 1.1kg of traditional wood charcoal. 6kg of wood are needed to produce 1kg of charcoal. Therefore, using 1kg of SGFE char briquettes instead of traditional wood charcoal results in saving up to 6.6kg of wood from Cambodia's natural forests

SGFE also generates sustainable livelihoods by employing factory workers from the informal sector. The workers are from families that sort waste on rubbish dumps and do not have formal employment. These workers are selected through a children's charity called Pour un Sourire d'Enfant (PSE), which ensures that the children of these workers are enrolled in PSE-supported schools. SGFE pays a salary of USD 150-200 per month, and an additional USD 25-30 on health insurance and bonuses. SGFE and PSE work together to provide job and life skills training to the employees. In addition, SGFE often hosts factory visits for Cambodian and international school and university students, with the aim of increasing awareness about clean energy, environmental protection and social inclusion⁴⁸.

SGFE has onboarded 24 people, who used to work as waste pickers on the municipal landfill sites with improper working conditions, as employees

Challenges and Lessons

SGFE started its operations in January 2010, and by the end of 2011, SGFE was already facing the risk of closure, since the founding NGOs, who were subsidizing SGFE's finances, had terminated the budget dedicated to the project. The current owner (Mr. Carlo Figà Talamanca) took SGFE over in January 2012 to try to save it from closure. Through production management, renewed marketing strategies and development of its supply chain and distribution system, SGFE succeeded in breaking even within 2 years, increasing production and sales by 10-

⁴⁶ https://www.ashden.org/files/case_studies/SGFE_percent20case_percent20study_0.pdf

⁴⁷ Primary research

⁴⁸ <http://www.wame2015.org/case-study/1109/>

fold, from 5 to 50 tons/month by 2014. In the following 2 years, SGFE was able to grow by 100 percent again, reaching production and sales of 100 tons/month in 2016⁴⁹.

Road Ahead

SGFE has been able to increase the production capacity up to 135 tons per month in its current location. The projected sales of briquette for 2016 is 850 tons, which will reduce carbon emission of around 14,000 tons⁵⁰. SGFE is looking to expand its production capacity by building a bigger production plant through capital infusion by an impact investor. SGFE also plans to expand geographically to Africa by exploring a franchise model based on equity, in which it will provide initial capital outlay and technical assistance to waste-to-energy firms in return for equity.

⁴⁹ Primary interview with SGFE

⁵⁰ Primary interview with SGFE

CASE STUDY: SIMGAS



Founding year: 2009

HQ: Netherlands

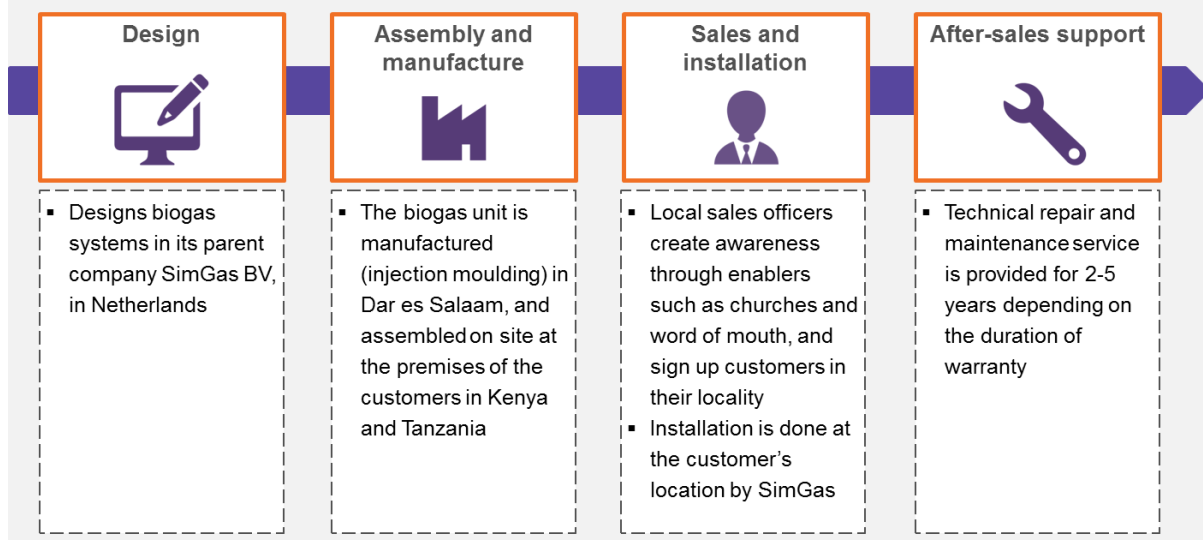
Countries of operation :
Tanzania, Kenya

Orientation: For-profit

Employees: 70

Turnover: USD 1 – 2 million

SimGas is an innovative design and production company focused on delivering affordable small-scale biogas systems to customers in (sub)tropical regions. These systems are fed with manure, kitchen waste and agricultural waste. SimGas offers a range of biogas digesters and appliances suitable for different situations and requirements, to households, small enterprises and institutions like schools. These systems are pre-manufactured, modular, expandable and easy to install. By providing clean and affordable energy, SimGas offers households tools to improve their lives and income positions. The users save time and reduce a large share of their energy expenses. Biogas is a clean and sustainable source of energy and contributes to a healthier indoor climate, reduced reforestation and reduced carbon emissions.



Operating Model

Worldwide, 3 billion people get exposed to toxic fumes, fuels and dangerous open fires while cooking their meals⁵¹. The direct consequences of inhaling toxic fumes cause 4 million people to die each year of lung cancer. In East Africa, cooking on charcoal and wood is the number-one cause of death, even before HIV / AIDS and malaria. Mostly women and children are victims of toxic gasses inhaled when burning fires indoors. Also, deforestation, driven by a high demand for wood, depletes Africa's forest cover by 1 percent - 2 percent per year. CO₂ emission, caused by traditional cooking methods, aggravates the greenhouse effect felt around the world. Biogas is a clean cooking fuel and can address these problems. However, conventional biogas systems in East Africa are large, expensive and cumbersome to build. SimGas, a waste-to-energy enterprise, has introduced a small-scale and mass-producible biogas system that is pre-manufactured and adapted for households.

SimGas biogas systems are fully integrated farm solutions, targeted at smallholder farmers. The system uses anaerobic digestion, where bacteria work symbiotically to convert organic waste into biogas. Slurry that has been fully digested exits the biogas system in the form of organic fertilizer. The biogas that is produced is a clean fuel that can replace wood fuel, charcoal and kerosene for cooking and other energy needs. The installation of the pre-fabricated kit takes one day compared to six man-weeks for a conventional system.

⁵¹ Africa Carbon Forum

SimGas products are made from recycled HDPE plastic and modular. They can be scaled from 2m³ to 25m³ (in 1m³ increments) for farmers with 1 to 30 cows. SimGas distributes the systems through retailers, and partners with local institutions and events like churches to create awareness about the products. At the time of sale, SimGas advises farmers on the size of biogas system they should go for based on the specific situation, like the number of farm animals.

SimGas has a network of customer service centers, in addition to 8 offices in Kenya and 4 offices in Tanzania. There are local sales officers who sell within 20 km radius and also support in the after-sales service. SimGas has 11 employees in the Netherlands and around 60 employees in Kenya and Tanzania.

The digesters are developed and designed by SimGas BV in the Netherlands and local partners and experts. SimGas is also supported by a number of major businesses and farmer support organizations, including CRDB, NMB, HEIFER and Tanga Fresh Ltd. It also partnered with Kenya Bureau of Standards to co-develop the standards on energy. In addition, SimGas has joined the Africa Biogas Partnership Program (ABPP), a PPP led by Hivos and SNV in supporting national programs on domestic biogas. The national biogas programs provide training to technicians on installation of brick and cement systems. SimGas leverages these skilled workers for installation of SimGas systems. SimGas is paid on the basis of the results, wherein the outcome is a target of installing a certain number of biogas systems in a stipulated period. SimGas has also entered into a similar strategic partnership with Tanzania Domestic Biogas Program to install the biogas digester systems in households.

SimGas has sold 1000 biogas digesters to rural farmers and 1000 systems to urban customers

Financial Sustainability

SimGas incurred an initial fixed investment (capital expenditure) of about USD 1.3 million on setting up its factory. Manufacturing the systems constitutes around 50 percent of the costs while the remaining 50 percent were incurred on transport, staff, installation and other miscellaneous costs. It earns revenues from selling the biogas system that comprises of cookstoves and other components. SimGas biogas systems (including biogas stove of around 5 cubic metres, installation materials, user training, delivery & installation, after sales service, and a 2-year warranty) are priced at USD 500–1000, varying with different countries (due to transport costs) and the size of the systems. Price of SimGas biogas systems are lower than that of competitors. However, the selling price of SimGas systems is slightly higher than the prices of Government-promoted biogas systems because the Government does not charge installation costs. However, the material costs of SimGas systems is lower than those of the Government-promoted systems.

SimGas has sold 1000 biogas digesters to rural farmers and 1000 systems to urban customers without

SimGas has signed an Emissions Reduction Purchase Agreement (ERPA) with World Bank's Carbon Initiative for Development (Ci-Dev) on the purchase of 500,000 Certified Emission Reductions (CERs)—commonly known as carbon credits—generated by SimGas' biogas systems in Kenya. The emission reduction is calculated based on the emission of the replaced energy sources like charcoal and woodfuel. Thus, this additional revenue stream serves as a subsidy (an average of 8 carbon credits are sold per system), lowering the retail price of biogas systems for households and thereby increasing the affordability of these systems to these families. SimGas is also able to extend the warranty on biogas systems from 2-3 years to 5 years, thereby increasing customer confidence in SimGas' systems. It expects the digesters to be bought by around 80,000 households initially in Kenya, which would otherwise use 3-7 tons a year of firewood to cook, much of it from unsustainable sources.

The sale of greenhouse gas reduction credits by Ci-Dev at a price that is higher than the market price of USD 1-2 enables SimGas to discount the prices of its biogas systems

SimGas has received equity and debt capital from impact investors, and has also won awards such as the Open IDEO and Empowering People Award from the Siemens Foundation. The external funding and the carbon credits program help SimGas to remain sustainable, though profitability is limited because it is a triple-bottomline company and maintaining affordability for farmers is important.

Impact

Biogas not only takes away the health hazards of indoor air pollution, but also saves time (about 2-4 hours a day). Using biogas lowers household energy expenditure and makes households independent of unreliable or non-existent power grids disbursement. Globally, an estimated 18 million acres of forest are lost each year for fuel wood. Replacing woodfuel by biogas reduces deforestation and helps to lessen global greenhouse gas emissions. SimGas can measure impact by remotely monitoring system performance and carbon emission reduction. Cooking on biogas reduces carbon emission with 5-10 ton CO₂ equivalent per household per year. This is about as much CO₂ as an average passenger car emits in two years and translates into energy savings of around USD 80-300 per hh/year, depending on previous fuel use.

Production of organic fertilizer from the biogas slurry also increases average yield of farms by 15 percent - 25 percent

Challenges and Lessons

Operational expenses in hiring staff and installation technicians are hurdles for the expansion of SimGas. It has faced some technical challenges in availability of electricity for production and materials. Consumer financing has also been a challenge; SimGas initially worked with MFIs, but the arrangement did not last due to high interest rates and complexity of the products.

Road Ahead

SimGas plans to expand to East Africa in countries such as Uganda, Zambia, Ethiopia, and also to South Asia in countries such as India and Bangladesh, where people require clean energy solutions. SimGas also plans to introduce a pay-as-you-go / lease-to-own model for its products by setting up a revolving fund.

SimGas also plans to introduce two other products. It is developing a biogas-based milk chilling machine for farmers that will provide off-grid biogas-powered milk cooling on-farm, allowing smallholder dairy farmers without access to electricity to store, deliver and sell the highest possible quality of raw milk, and increase their income. SimGas is also developing a safe bio-sanitation system to convert human faeces to energy and improve health and hygiene for schools and institutions.