

Off-Grid Equipment for Productive Use

Using advanced energy solutions for productive and business use in areas with limited access to the energy pyramid

HIGHLIGHTS

- Renewable energy solutions, such as solar pumps, are cheaper in the long-run than traditional equipment powered by diesel.
- Companies reduce upfront costs by allowing small holders or micro-entrepreneurs to only buy the service per use and not the equipment.
- Having continuous access to irrigation improves farm productivity and allows farmers to grow cash crops with higher water requirements and higher value.



Summary

Productive businesses need reliable energy solutions to run machinery or communication devices, dairy farmers need cold storage to avoid spoilage, and farmers need irrigation for high yields. These are major challenges in areas without access to the electricity grid and for entrepreneurs and farmers with little income. Innovative, stand-alone, renewable energy solutions that are customized for the Base of the Pyramid (BoP) market can create access to electricity and thus multiply productivity and profits for micro-, small- and medium-sized enterprises.

Development Challenge

In 2013, some 1.2 billion people lacked access to electricity (IEA n.d.). Most of them lived in rural areas in Sub-Saharan Africa and South Asia. Power supply is critical to economic and human development, but utilities in many low- and middle-income countries either lack the financial capacity to expand their grids to isolated rural areas or choose not to do so because of the low return on investment. Rural consumers must therefore rely on traditional biomass, kerosene, and batteries, which are expensive and pose environmental, safety, and health risks. Moreover, these energy sources are insufficient to power machinery needed to improve agricultural productivity and value added, trapping farmers in a cycle of low agricultural productivity and income.

Business Model

Components of the Model

Companies that provide off-grid equipment for productive use deliver advanced energy solutions for agriculture, manufacturing industries, and the service sector in areas with limited access to electricity. Productive use is defined as a direct input to the production of goods or provision of services.

The target groups are (micro) entrepreneurs or farmers with some existing capital, or some income or collateral. Under the right circumstances, productive use of electricity can result in increased productivity, higher economic growth, and a rise in employment (Cabral, 2005).¹

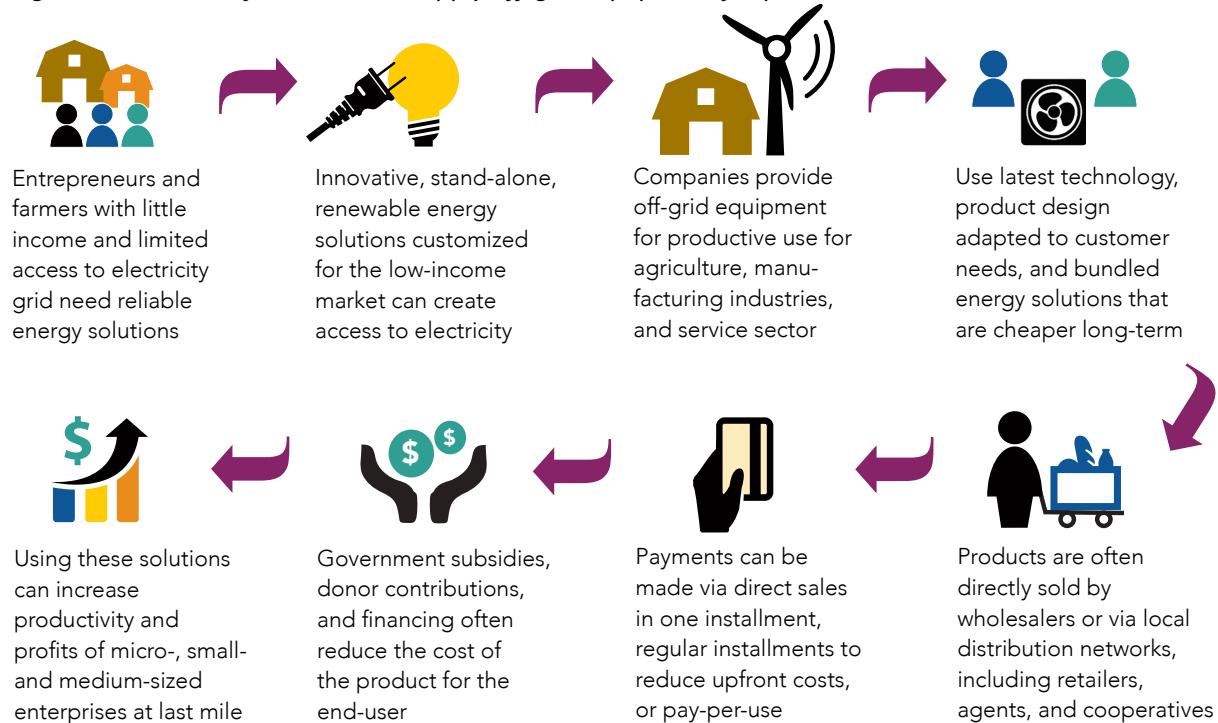
Typical applications of energy for productive use at the BoP include:

- Heating and cooling (e.g., air conditioning, ice making, milk cooling)
- (Agro-)processing (e.g., meat and fish drying, flower, rubber and spice drying, milling)
- Water-related equipment (e.g., pumping for irrigation, pumping for drinking water)
- Communication (including Internet, telephone, video projection)
- Energy production and conversion (e.g., battery charging, phone charging)
- Manufacturing equipment (e.g., tailoring, handicraft production)

This report focuses on companies that offer bundled solutions, which include the generation of electricity and the equipment involved (Figure 1). Energy is typically generated via solar panels, but also by hydro or wind power. Equipment such as pumps, cold storage, or drying systems are specially designed to work in an energy-efficient way and on low currents.

The companies offering off-grid equipment for productive use are predominantly for-profit or hybrid models that receive financial support from international donors or local governments. Most players have entered the market during the last ten years and are still in a pilot or roll-out stage.

Figure 1. Features of models that supply off-grid equipment for productive use



Cost Factors

Key cost factors are the upfront research and development costs for development of off-grid solutions, market outreach, upfront financing, and setting up distribution. Many enterprises design and manufacture their own equipment. Costs incurred on research and development, product design, and testing constitute a significant share of the overall costs for enterprises providing off-grid productivity solutions. The team interacts with rural stakeholders to understand the nature of the activities and intended benefits of mechanizing an activity. Enterprises also require significant working capital, since most products are paid over time rather than at point of delivery. Since enterprises need to educate rural consumers about the benefits of productive equipment before they acquire them as customers, they also incur costs toward hiring field agent experts, training, and maintenance coverage. Distribution costs also comprise a significant share of costs; enterprises either directly undertake last-

mile delivery to farms or partner with farmer groups, farmer co-operatives, and local village stores for distribution in remote areas.

Revenue Streams

Key revenues streams are the sale and use of the off-grid equipment.

Financial Viability

Many of the businesses active in the field of off-grid equipment for productive use have only entered the market recently and have not reached financial viability yet. In their current stage of Research & Development (R&D) and project pilots, most of the businesses analyzed either depend on public grants or government subsidies, with 30–90 percent of the product costs subsidized. Proximity Designs generates about one-third of their income through sales, with the rest coming from donor grants and other donations. SunDanzer, which is still in a nascent stage and operates at a relatively small scale, is currently 100 percent dependent on grant money for product development and proof of concept.

In the medium-term, for the rollout and scale-up phase, several of the businesses analyzed aim to become profitable through their sales. Nevertheless, they need concessional, blended, and innovative financing to ensure enough working capital for expansion. Some of the businesses take a non-profit approach and often remain dependent of grants and donations.

Table 1. Comparison of payback time across different productive off-grid equipment

Example	End-user costs
Solar pumps	The price of a solar pumping system varies according to its power but it is a lot more expensive than a diesel pump. In case of Claro, a 2-horse power (HP) solar pump costs around USD 4,266 while a 2 HP diesel pumps costs around USD 683. However, the two differ significantly in terms of their running cost. The high cost of diesel translates into an additional USD 1,706 of annual running cost while solar pumps have no operating costs. With cost savings on diesel and improved farm productivity due to continuous supply of power, customers are able to achieve break even after two years.
Solar cooling	The price of solar refrigeration systems varies according to its size and cooling capacity. In the case of SunDanzer, a 24-liter refrigerator costs around USD 2,000 in Kenya. If the refrigerator is used for milk chilling of evening milk that otherwise would not be sold to the market, the pay-back period is 225 days. ²
Solar dryer	Dehydration, or drying, is a simple, low-cost way to preserve food. Surplus grain, vegetables, and fruit preserved by drying can be stored for future use. Electric dryers tend be the quickest but incur high running cost, while air drying is the cheapest with almost no running cost but high risk of spoilage. The solar dryers fall in between these two categories. ³ The price of solar dryers, depending on the construction, size and technique starts from USD 15 for a simple coconut tent dryer with 7m ² of drying area to USD 5,500 for a much more sophisticated solar tunnel dryer with 20m ² of drying area. ⁴ Running costs are generally very low. Commercial electric dryers start at USD 200 for a 10-tray commercial grade configuration, but have high running cost.

Source: Schnitzer and others 2014.

Partnerships

NGOs and local distributors: Companies often rely on local partners such as NGOs for product acceptance and awareness and on local distribution networks for market penetration and outreach. In the case of Ecozen, NGOs and cooperatives create a link between the company and its target market

to understand the customers' irrigation and cold storage needs. SunDanzer's main partner for milk chilling in Kenya is Winrock International, a non-profit organization with more than 25 years of experience of renewable energy based rural electrification. The NGO knows the market and has established contacts with dairy farmers and cooperatives. Promethean Power Systems partners with a large Indian private dairy company and a large Indian solar installer to promote its solar-powered milk chilling systems.

Funders and financing institutions: Development organizations such as UNIDO and international donors such as the World Bank, USAID, and GIZ, with their "Powering Agriculture" program, play an active role by providing financial assistance and creating a conducive ecosystem through advocacy and pushing for policy changes. Some businesses also receive early stage funding by private and socially motivated investors. Governments reduce end-user costs for BoP customers by subsidizing production costs or incentivizing the use of low-cost technology. Because most businesses lack access to working capital they form alliances with credit institutions, commercial banks, micro-finance institutions (MFIs), and Saving and Credit Cooperatives (SACCOs) to provide credit to end-users. Businesses sometimes provide in-house financing solutions to retain the profit margins that external lending institutions would earn.

Implementation: Delivering Value to the Poor

Awareness

To create demand for their products, businesses, or their partner NGOs, do demonstrations that show the economic benefits and use of the technology. This is especially important for products that the target group is not familiar with, such as solar dryers when farmers have traditionally used air drying techniques. Word-of-mouth is critical for promotion. Less frequently, local sales agents play a role in creating product awareness. Companies also speak to ecosystem stakeholders such as governments, MFIs, and commercial banks, who need to be aware of the technology and create suitable financing arrangements.

Acceptance

Off-grid equipment for productive use provide a cleaner and cheaper alternative to machinery powered by fossil fuels in the long run due to low operating costs. In addition, users do not have to rely on an unstable fuel supply. To create tailor-made applications that meet the needs of their users, companies conduct market studies, cooperate with local universities, and monitor the usage of their products.⁵ To support after-sales services, some companies, such as the pump producer Claro Energy, have started using remote monitoring tools, while other companies, such as Nishant Bioenergy, have developed a network of local partners who ensure maintenance at short notice.

Availability

Products are often directly sold by wholesalers or via local distribution networks, including retailers, agents, and cooperatives. For example, Proximity Designs in Myanmar sells its pumps via 800 village agents that work on a commission basis and generate more than 50 percent of the total transactions.⁶ SunDanzer distributes its fridges via dairy farmer cooperatives.⁷

Affordability

Government subsidies and/or donor contributions often reduce the cost of the product for the end-user. To make the products affordable, companies also partner with MFIs or commercial banks to provide financing for their customers.

Generally, three different sales models are used depending upon the local environment and customers' buying power. While the capital goods-oriented direct sales model requires high upfront

capital outlays, payment by instalment and pay-per-use models are models especially developed for the BoP market to overcome the barrier of high upfront costs.

- **Direct sales:** The entire amount of the purchase is paid in one instalment. Customers either pay the full amount from their savings or arrange for a financing source on their own. For more expensive equipment, this requires substantial cash savings or collateral from the customers.
- **Instalment payments:** Companies provide credit to reduce upfront payments from the customers or accept payment in instalments for a predefined period of time after which the ownership is transferred to the customer. Claro Energy uses this model for selling its solar pumps to the BoP segment in India and Nishant Bioenergy for selling commercial cooking stoves to schools. Proximity Designs sells their pumps by providing low-interest loans with only a 10 percent interest rate to customers. Full repayment of the loan is due by the second harvest after it is taken out.⁸
- **Pay-per-use:** This strategy allows the customer to pay for the use of the asset without bearing the full capital cost of owning it. This model is especially suitable for areas like agriculture, where high-cost machinery only needs to be used sporadically. Claro Energy, for example, sells its pumps to franchisee farmers who then rent it out to other farmers.

Results and Cost-Effectiveness

Scale and Reach

In recent years, many new companies have entered the market providing energy solutions for productive use, and existing companies have recently enlarged their traditional portfolios to address the BoP target groups. Of the businesses analyzed, many are still in pilot or initial rollout stage with a limited number of households reached. The Indian solar water pump producer Claro, for example, reaches 17,000 people with 1,200 pumps across 12 Indian states. Only some NGOs, which also have a market-based approach, have reached large numbers of customers. Proximity Designs has sold 90,000 pumps reaching 450,000 people while the Centre for Rural Technology has set up improved water mills in Nepal reaching 330,000 people.

Replication of business models has not happened yet. This is also why most models are still quite localized, targeting one specific region. However, development challenges such as cold storage or irrigation needs are widespread in developing and emerging countries, and the products therefore are conducive for replication if financial viability can be achieved.

Improving Outcomes

Evidence indicates that electrification can lead to the creation of new companies, which generate additional income and employment and ultimately enhance local demand.⁹ Besides, access to reliable modern energy sources increases productivity, lowers energy and production costs, and improves access to information.¹⁰ Continuous access to irrigation through solar water pumps, for example, not only improves farm productivity but also allows farmers to grow cash crops with higher water requirements and higher value.¹¹ And small-scale solar cooling systems like the ones from SunDanzer allow dairy farmers to sell more and better-quality milk for better prices to processors.¹²

Regarding environmental impact, clean energy solutions contribute to the mitigation of greenhouse emissions by using renewable energy instead of diesel generators. They reduce carbon dioxide emissions and save fossil fuels. The 1,200 solar pumps installed by Claro in India, for example, reduce more than 500 tons of carbon dioxide every year.¹³

Scaling Up

Challenges

The availability of consumer finance is a key challenge because the products have high upfront costs. Capital outlays are mostly too high for MFIs, and commercial banks rarely offer adequate financial arrangements. Businesses often do not have enough working capital to provide financing solutions themselves. The targeted customers need access to credit, access to markets, and the knowledge, skills, and technical and financial management capacity to make use of the product.¹⁴ If these preconditions are met, the business models for off-grid equipment for productive use would have great potential for growth because of the large size of the potential market.

After-sales services like maintenance are often very weak in remote rural areas, discouraging farmers from buying costly and technologically complex products.¹⁵ A common barrier described by businesses is the lack of skilled labor able to provide installation and maintenance services, as well as run commercial operations. Long travel distances also make prompt service delivery difficult. To avoid challenges of after-sales service provision in remote areas, products should be manufactured with the aim to require as little maintenance as possible. Remote monitoring tools can help to detect damage or dysfunctions of products and provide maintenance services more efficiently.

Information gaps also pose a key challenge. The lack of knowledge about the technology and its potential, particularly in the agricultural sector, has been one of the key reasons for limited demand for productive energy products.¹⁶ Likewise, new market entrants often lack access to reliable information on their target group. Businesses have to conduct their own market research, increasing time and budget necessary for R&D.

Improving the market ecosystem requires coordinated support from financial institutions and the government. Development organizations can influence governments and shape policies while NGOs, cooperatives and local retailers are often involved in distribution, awareness raising and after-sales services. In government alone, different departments are often exploring the options of utilizing specific energy applications, but often in an uncoordinated manner. All these actors need to work together effectively to create a conducive ecosystem.

Role of Government and Public Policy

Governments and international agencies provide grants for product development to companies providing energy solutions for productive use. Governments reduce end-user costs by subsidizing production costs or incentivizing the use of low-cost technology. Companies criticize this practice as these subsidies distort the market and reduce the customers' willingness to pay once the subsidies end.

Strong market environments arise from supportive renewable energy policies.¹⁷ The government also regulates the market by setting quality standards and defining eligibility criteria for subsidies. Governments can also develop and adopt new policies to encourage the private sector and public-private partnerships; they can provide product subsidies.¹⁸ Governments may also act as a product promoter by buying innovative green applications for their own facilities like water pumping stations.

Table 2. Enterprises providing off-grid equipment

Company	Country	Solution description
Claro Energy Private Limited	India	Claro offers solar powered water pumping solutions to power-deficit regions in India. The company offers solar powered water pumping solutions to meet irrigation water needs of remote and rural parts;

		solar water pumping solutions for drinking water to households, government departments, and commercial entities; and portable and stationary solar powered water purification systems.
<u>Ecozen Solutions Private Limited</u>	India	Ecozen designed a pioneering and innovative micro cold storage—a solar-powered cold storage system. The company also designs and installs independent solar water-pumping systems for water requirement up to 60 thousand liters/day, community water pumping station for the village to cater a capacity up to 500,000 Liters/day and portable 1HP solar surface pumping systems for increasing water flow rate. Small farmers who cannot afford independent system will buy water from the community station.
<u>Nishant Bioenergy</u>	India	Nishant Bioenergy developed the Earth Stoves that run on biomass pellets and are clean and smoke free. The stoves are used in schools or for commercial purposes. The stove can be used for cooking/heating/water heating (with minor modifications). It has a blower (12V DC) for providing air for improved combustion.
<u>Promethean Power Systems</u>	India	Promethean's refrigeration solution uses a thermal energy battery pack that charges on solar power and/or a few hours of grid electricity. This provides cold storage around the clock despite inconsistent access to electricity. Dairy processors can collect raw milk from remote dairy farmers and keep it cold in a rapid milk cooler, reducing the time that milk is not chilled by 75 percent. Promethean will design and deploy the refrigeration systems in collaboration with India's largest private dairy and one of India's largest solar installers.
<u>Proximity Designs</u>	Myanmar	Proximity Designs distributes treadle pumps and other sustainable agriculture technologies (solar pumps, drip irrigation kits, etc.) to BoP customers in Myanmar. Combined with water-saving drip irrigation technology, pumps that draw up water from wells can dramatically increase yields and incomes.
<u>SunDanzer Refrigeration</u>	Kenya	SunDanzer is developing a small-scale cooling system tailored for use in the Kenyan dairy market. The system comprises a photovoltaic refrigerator that uses solar energy to cool a chest refrigerator.
<u>Centre for Rural Technology</u>	Nepal	The Centre for Rural Technology is replacing the wooden shaft turbine of traditional water mills with an improved metallic one increases the efficiency, load factor and output of the mill.

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Endnotes

¹ Cabraal, R. et al. 2005. *Productive Use of Energy for Rural Development*.

² One liter of milk in Kenya sells for about US\$ 0.37. Assumed that the full capacity of the refrigerator of 24 liters per day is exploit, it takes 225 days (US\$ 2,000 / (US\$ 0.37 * 24 liters)). The numbers used for the calculation have been provided by SunDanzer.

³ GTZ. 2001. *Solar Drying Equipment: Notes on Three Driers* http://www.gate-international.org/documents/techbriefs/webdocs/pdfs/e015e_2002.pdf - accessed April 2015.

⁴ GTZ. 2001. *Solar Drying Equipment: Notes on Three Driers* http://www.gate-international.org/documents/techbriefs/webdocs/pdfs/e015e_2002.pdf - accessed April 2015.

⁵ Brian Jensen, Manager of Commercial Products at SunDanzer, Phone interview with author, April 2015

⁶ Ashden Awards. 2014. *Case study summary – Proximity Designs, Myanmar*

http://www.ashden.org/files/case_studies/PROXIMITY%20DESIGNS%20case%20study.pdf

⁷ Brian Jensen, Manager of Commercial Products at SunDanzer, Phone interview with author, April 2015

⁸ Ashden Awards. 2014. *Case study summary – Proximity Designs, Myanmar*

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¹¹ Kartik Wahi, Founder of Claro Energy, Phone interview with author, April 2015.

¹² Powering Agriculture, “2013 Winners Profile: SunDanzer,” Powering Agriculture

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¹³ India in Business, “India at a Glance,” India in Business

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¹⁴ Fishbein, R.E. 2003. *Survey of Productive Uses of Electricity in Rural Areas*. Washington, D.C.

¹⁵ GIZ. 2012. *Improving the Market Ecosystems for Solar Irrigation Pumps* http://www.igen-re.in/files/flyer_-solar_water_pumping.pdf

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¹⁷ G8 Renewable Energy Task Force. 2001. cited in Etcheverry, J. 2003. *Renewable Energy for Productive Uses: Strategies to Enhance Environmental Protection and the Quality of Rural Life*. Toronto.

¹⁸ Etcheverry, J. 2003. *Renewable Energy for Productive Uses: Strategies to Enhance Environmental Protection and the Quality of Rural Life*. Toronto.

Profile: Claro Energy

Increasing agricultural productivity in India with solar-powered mobile water pumps

Challenge

India's rural population highly depends on agriculture, which, given the erratic nature of the monsoon, depends largely on groundwater irrigation. Lacking access to grid power, many farmers in remote areas rely on diesel pumps. A less expensive form of power for irrigation would allow them to keep more of their earnings, with less damage to the environment.



Innovation

Claro Energy (www.claroenergy.in/) offers solar-powered water pumping solutions to meet irrigation and drinking water needs in off-grid rural areas. The 0.5–10 horsepower systems are suitable for all irrigation needs, including flood, sprinkler, and drip irrigation, as well as for lifting water from canals. The pumps can also be used to charge cellphones.

Although the initial outlay is high, solar pumps are much more economical than diesel pumps over the long term. They provide clean and continuous power and entail almost no operating cost. Subsidies from the central government and state governments cover 30–90 percent of the cost of the pumps. To cover the rest, Claro Energy offers several innovative payment models. Under the service model, a franchisee farmer owns a movable solar-powered pump and rents it to neighboring farmers. Under the rental-purchase model, farmers own the pumps after the completion of a lease period, typically 12 months.

Impact

Claro Energy has installed more than 1,200 pumps since 2012, reaching more than 17,000 people in 12 states in India. It has brought more than 3,160 acres of land under irrigation and reduced almost 511 tons of carbon dioxide a year, according to the company. Having continuous access to irrigation improves farm productivity. It also allows farmers to grow cash crops with higher water requirements and higher value, such as sugar cane.

Scaling Up

The main driver for the business are subsidies provided by the government. By adding innovative features to its product line to meet specific rural requirements and consumer preferences, Claro Energy has capitalized on these subsidies, experiencing rapid growth since its inception. In the near future, it plans to expand its operations to Bangladesh, Nepal, and some African countries.

A key bottleneck is financing. A solar pump costs more than microfinance institutions generally finance, and commercial banks and other lending institutions are often unwilling to lend because the solar pumps are not perceived as sufficient collateral. To address the problem, Claro Energy has been raising the awareness of the benefits of solar pumps among the banking community, through workshops and seminars, to increase the credit availability.

Claro Energy faces high working capital requirements, as most payments are not received upfront. Attracting investment from private equity investors and venture capitalists is also difficult, because of the lack of track record of transactions in the off-grid energy industry. Banking and other lending institutions will have an important role to play in sustaining growth, particularly as subsidies may be phased out in India.

Profile: SunDanzer

Solar-powered refrigerators allow off-grid farmers to sell more milk



Challenge

Limited electrification in rural areas means that about 85 percent of Kenya's more than 800,000 dairy farms lack access to refrigerated storage. As a result, less than half the milk produced reaches dairy processors, with only milk obtained in the morning sold to processors. Evening milk is used by families or sold to neighbors (at a lower price) or to hawkers who resell it to local markets. Of the milk that does reach processors, up to 30 percent is of low quality because of the lack of cooling systems.



This farmer uses energy from photovoltaic modules to power his new refrigerator.

Innovation

With a USD 1 million grant from the multi-donor Powering Agriculture Initiative, SunDanzer (www.sundanzer.com) developed a small-scale cooling system tailored for medium-size dairy farmers and dairy cooperatives in Kenya. The photovoltaic refrigerator uses solar energy to cool up to 24 liters of evening milk, which can be sold to dairy processors with the fresh morning milk. Instead of using maintenance-intense batteries, SunDanzer's refrigerator freezes saltwater as thermal storage during the day. Its design is adapted to fit the aluminum milk containers Kenyan dairy farmers use. The refrigerator can also be used to store food and charge mobile phones.

SunDanzer itself is not involved in financing. Its partner cooperatives work with saving and credit cooperatives (SACCOs) to provide financing arrangements for the large capital outlay of USD 2,000 per unit. A liter of milk in Kenya sells for about USD 0.37. Assuming that a farmer can sell his evening milk, the payback period for one solar-powered refrigerator is about 225 days, according to the company.

Impact

SunDanzer's clean energy solution increases dairy farm productivity and income by allowing farmers to sell more and better-quality milk to processors. It reduces bacteria counts and improves the quality of the milk. By being able to refrigerate, dairy farmers are also less vulnerable to delays in milk collection, which otherwise would have caused the milk to spoil. The change in productivity is quite significant, with reports of 20 percent increase in farmer's milk production.

Scaling Up

Dairy collection cooperatives and dairy processors have a strong interest in providing dairy farmers with SunDanzer's chilling technology, in order to increase their milk supply and production capacity. Other important enablers for growth are SunDanzer's experienced local partners, which are involved in product design, distribution, and financing. SunDanzer's main partner in Kenya is Winrock International, a nonprofit organization with more than 25 years of experience in renewable energy-based rural electrification. Winrock knows the market and has contacts with dairy farmers and cooperatives. It has established contacts with local dairy cooperatives for product distribution and with SACCOs for financing.