

## INCLUSIVE INNOVATIONS

# Bringing Solar Home Systems to Off-Grid Communities

*Affordable products and innovative financing are improving people's lives and powering small businesses*

### HIGHLIGHTS

- Innovative financing options—including pay-as-you-go and rent-to-own models—increase affordability.
- The wide range of products and prices increase take-up.
- Use of solar home systems increases evening study hours, reduces fuel collection time, improves health, increases security, gives people more time for socializing, and increases savings.
- The systems create jobs for, and increases the incomes of, the people who sell, install, and service them.



### Summary

Millions of people in rural and remote areas of low-income countries are not connected to the electric grid. They use kerosene, biomass, and other sources of fuel that are expensive, unhealthy, and unsafe. Solar home systems (SHSs) are an affordable and environmentally friendly solution for providing off-grid populations with electricity. Innovative payment models increase the affordability of the systems by people with low incomes.

### Development Challenge

Some 1.3 billion people live without access to electricity, and another 1 billion have extremely unreliable access. Lack of ready access forces them to use kerosene lanterns and battery-powered flashlights for light, as well as charcoal, firewood, and candles. These alternatives are not only inefficient, hazardous and expensive, they also generate pollution and cause serious health and environmental problems. In India 75 million rural households are not connected to the electrical power grid and another 80 million are underserved by electrical utilities. In Africa some 630 million people and more than 10 million small businesses are not connected to the grid (IFC 2014). Effective clean-energy solutions exist, but they require significant upfront costs that often make them unaffordable. Clean but affordable energy is needed to bring power to low-income customers using a decentralized and flexible payment system.

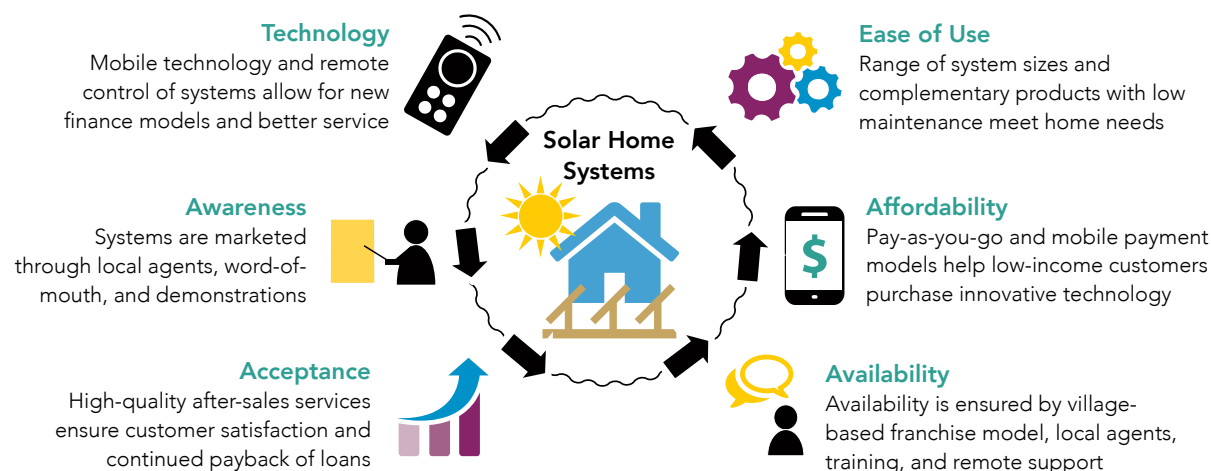
### Business Model

#### Components of the Model

A solar home system (SHS) is a small-scale, autonomous source of electricity for households, offices, or businesses that are off-grid or have unreliable access to energy. It typically consists of a solar panel; a battery set, which stores the electricity; and a charge controller, which protects the battery from overcharging. The battery is charged during day hours, and energy is stored to power appliances during the night. System sizes range from 20W to more than 300W. SHSs generate direct current (DC) that can be used to power a range of electrical appliances, including lights, mobile phones, USB

chargers, small televisions, radios, fans, and refrigerators. Some companies, such as BGET in Thailand and Kingo Energy in Guatemala, are also developing alternating current (AC) systems, which allow people to plug in their appliances. The target consumer group for these systems is households with some capital and income who can afford to pay USD 5–50 a month. Properly designed and installed systems operate without supervision and require only minor routine maintenance by end-users.

*Figure 1. Model of affordable solar home systems*



### Cost Factors

A good-quality SHS sells for USD 200–400. It typically includes a solar panel, battery, charge controller, three or four lighting points, a mobile phone charging port, and power for charging or powering small DC devices. An SHS is an expensive purchase, but companies offer payment options that create regular revenue streams.

### Revenue Streams

Customers can pay for the SHS itself in installments, or they can buy only the power generated or used, through a fee-for-service or pay-as-you-go model. Use of mobile payments greatly facilitates the adoption of SHS, by making payments easier for the user and lowering the costs of collection.

### Financial Viability

Most companies are either for-profit businesses or use a hybrid business model in which more expensive products cross-subsidize products for low-income customers. Some for-profit business models are financially viable (Sunlabob) or in the process of becoming so (Mobisol, Oenergy).

One of the markets that has seen better penetration of SHS is Bangladesh, where in some villages almost 30 percent of the population owns an SHS. However, this also poses a challenge for SHS providers since a growing number of players are competing in a comparatively saturated market.

Low payback have led to SHS providers struggling financially in the country. In this scenario, pay-as-you-go models that tie repayment to usage can help assure customer payback.

### Partnerships

To reach scale, companies need substantial working capital, particularly if they produce the systems themselves and provide in-house financing. For this reason, businesses need support from international donors or development agencies or investment from impact investors. The following actors offer support:

- *Development agencies and foundations:* Grants or soft loans from donors support M-Kopa, Mobisol, Off-Grid Electrics, and ONergy. This support is usually used to finance the initial installations; customer fees cover long-term service delivery.
- *Development banks and challenge funds:* Grants and loans from the World Bank support Grameen Shakti, Kamworks, Off-grid Electric, and Sunlabob. Mobisol received preferential loans from German Development Cooperation (GIZ) and the Africa Enterprise Challenge Fund.
- *Governments:* Governments play an important role in financing and raising awareness. The Infrastructure Development Company Limited, a government-owned nonbanking financial institution, provides financing for the Bangladeshi Solar Home System Programme, which installed more than 3 million SHSs in rural Bangladesh. In Tanzania the government established the One Million Solar Homes Initiative and commissioned Off-Grid Electric for the roll-out.
- *Private investors:* Commercial or impact investors can support businesses through equity and debt financing. Two impact investors—ARTHA and Halloran Philanthropies—funded ONergy in India.

Local NGOs increase outreach to communities and raise awareness. Sales agents and microentrepreneurs distribute products and provide after-sales services.

## Implementation: Delivering Value to the Poor

### Awareness

Businesses use a range of strategies to create awareness about solar electricity:

- *Local agents:* Grameen Shakti, ONergy, and Sunlabob create awareness of their products through local sales agents. Grameen Shakti trained more than 1,200 agents to go door to door to demonstrate the effectiveness of SHSs. It also uses community members, such as teachers, to market products.
- *Word of mouth:* In Uganda word of mouth is the most important sales driver for SolarNow.
- *Demonstration plants:* Placing demonstration SHSs in highly visible places, such as schools or community centers, helps spread the word. ONergy in India established Renewable Energy Centers, where people are trained to become microentrepreneurs and mentors to other SHS users. These centers are also sales points and locations for public demonstrations of SHS products.

### Acceptance

Most businesses offer a large product range. Grameen Shakti offers 14 SHS products, ranging in price from USD 100 (for a 10W system) to USD 580 (for a 135W system). Kamworks incorporates suggestions from its customers in designing its products. Many businesses also offer ancillary and complementary goods. Fosera and Mobisol offer energy-efficient domestic appliances that run on direct current.

Reliable service is important for gaining customer trust. Companies such as SELCO guarantee service provision at the customer's doorstep within 24 hours and offer consumer-friendly practices such as buy-back systems and removal of dead batteries. Most businesses offer product warranties for up to three years on the SHS and two years on batteries.

A vast rural distribution network of sales agents and a community-based franchisee model helps establish trust. It develops because potential customers associate the brand with someone from their community. Having a local person responsible for maintaining the systems over time also increases acceptance.

## Accessibility

Businesses in areas with high population density make their products available through local agents. Businesses in areas with lower population density must develop additional mechanisms. Many companies work through networks of rural distribution agents who maintain existing systems and sell new products. M-KOPA, for example, has built a network of about 1,000 direct sales managers across East Africa.

Training by local technical or government institutions enables low-skilled people to install SHSs. In 2014 Mobisol established the Mobisol Academy to train local entrepreneurs as technicians and sales agents. Barefoot Power and Onergy train local people in India to become entrepreneurs and build their own businesses or become micro-franchisees and distribute and install SHSs.

When customers cannot be reached within a short time or have a problem, support from a distance is a feasible alternative. M-KOPA installed a free service hotline that users can call seven days a week.

## Affordability

A variety of payment models increase the affordability of an SHS (table 1). Under the pay-as-you-go model, customers make micro payments over a period of time at the end of which they own the solar home system. Under the rent-to-own model, a share of every watt purchased goes into the customer's account, allowing customers to acquire the system over time. The fee-for-service model offers electricity at a lower price without the option of ownership. On a pay-per-use plan, customers acquire solar systems for a deposit and then purchase daily usage "credits" for less than the price of traditional kerosene lighting. After one year of payments, customers own their solar systems and can upgrade to more power.

*Table 1. Prices and financing of solar home systems by selected companies*

Company/country	Price of solar home system	Financing model
BGET (Thailand)	<ul style="list-style-type: none"><li>20W = USD 260</li></ul>	In-house. Customers sign two-year contract, paying about USD 130 a year. Payment is generally made once or twice a year, often after harvest time.
Grameen Shakti (Bangladesh)	<ul style="list-style-type: none"><li>20W = USD 135</li><li>40W = USD 213</li><li>80W = USD 351</li><li>135W = USD 489</li></ul>	In-house. Installment plan allows customers to make a 10–25 percent down payment and pay the balance over one to three years at a 5–8 percent annual interest rate. Customers who pay cash receive a four percent discount.
Mobisol (Tanzania, Rwanda)	<ul style="list-style-type: none"><li>30W = USD 351</li><li>80W = USD 801</li><li>120W = USD 1,245</li><li>200W = USD 1,742</li></ul>	Rent-to-own. Payments on company's 36-month pay-as-you-go installment plan are made using mobile banking services.
Off-Grid Electric (Tanzania)	n.a.	Fee-for-service. For a USD 6–USD 10 installation fee, company provides customers with panels, lithium batteries, lights, and a meter. Monthly payments start at USD 0.20 a day for a 20W SHS.
SELCO (India)	50W = USD 250	External. Customers typically put 10–25 percent down, paying the balance over three to five years, at interest rates of 5–14 percent annually with participating banks.

Rather than provide financing themselves, other companies work closely with banks, NGOs, and microfinance institutions to facilitate financing. Interest rates tend to be high. SELCO has forged relationships with 19 banks to create a separate line of credit for financing solar equipment.

Many companies accept payments by mobile phone, allowing customers without bank accounts to purchase a system and relatives from other locations to help finance it. Other companies sell vouchers for different quantities of electricity at shops in rural areas.

The breakeven point for SHS users depends on kerosene and candle prices, which vary across countries. Household electricity expenses range from about USD 4–USD 6 a month in India to about USD 9–USD 10 a month in Kenya and Thailand. In Bangladesh a kerosene lamp producing 37 lumens of electricity four hours a day consumes about three liters of kerosene a month. A 30W SHS that substitutes for the use of three kerosene lamps has the potential to save nine liters of kerosene a month, a savings of about USD 8. If the SHS costs USD 250, the purchaser would break even after about 32 months (European Microfinance Platform 2014).

## Results and Cost-Effectiveness

### Scale and Reach

The biggest player in the market, Grameen Shakti, has reached about 8 million people in Bangladesh, installing more than 1.5 million SHSs. Most other businesses have reached 100,000–1 million people and are in the process of scaling up, including by expanding to other countries and continents. Sunlabob, for example, started operations in 2001 in the Lao People's Democratic Republic. Since then it has become a global player, operating in Afghanistan, Cambodia, Tanzania, and Uganda.

Several new businesses, including Fosera, M-Kopa, Mobisol, and Off-Grid Electric, have entered the African market in recent year. They offer smart financing models (some of them using mobile technology) and use their distribution channels to sell complementary goods, such as DC televisions, fans, and refrigerators.

### Improving Outcomes

Adoption of SHSs improves many outcomes. It increase evening study hours, which can improve educational outcomes and long-term income-earning potential (Khandker, Barnes, and Samad 2012). It reduces fuel collection time for women; increases the use of televisions, which, by providing information, empowers people; improves health, by limiting the spread of respiratory diseases from kerosene consumption (Samad and others 2013); increases security; gives people more time in the evenings for socializing and entertainment (Banerjee and others 2014); and increases savings.

SHSs can also have a major impact on the incomes of people who sell, install, and service the systems. One-third of Mobisol customers have become at least part-time entrepreneurs. Mobisol estimates that they collectively earn more than USD 8 million a year (interview with Klara Lindner, Service Design Lead, Mobisol, May 21, 2015). In Bangladesh most local entrepreneurs and managers selling SHSs are women (interview with Sebastian Groh, CEO, SOLshare, May 18, 2015).

SHSs reduce greenhouse gas emissions and pressure on natural resources used to produce electricity. They cut waste from dry batteries and leaks from kerosene or diesel. The potential negative effects of lead used for the batteries of SHSs on the soil and the rest of the environment have not yet been sufficiently analyzed.

## Scaling Up

### Challenges

Large investments are needed to reach scale. SHSs require multiple components in separate packages and tools for installation. Batteries are heavy, and cushioned packaging must be used to prevent damage to solar cells in transit (Samad and others 2013). SHSs require a strong after-sales service

network, which is challenging to create in rural areas with low population density. (For this reason, many businesses have not yet entered the most remote areas, according to Sebastian Groh, CEO, SOLshare, interviewed May 18, 2015). The other concern is that in the longer term, once people start expanding business activities and needing more electricity, SHS cannot generate enough power.

In some cases, negative incentives can distort the market. Highly subsidized electrical tariffs in on-grid areas in Lao PDR, for example, distort the market and make off-grid customers less willing to pay sustainable rates for power. Off-grid solutions are frequently politicized and considered inferior to on-grid solutions (interview with Albert Kwaw Eliason, Country Officer, Lighting Africa, April 25, 2012).

Because SHSs can provide only a certain amount of DC electricity, domestic appliances must be energy efficient and adapted to DC. This demand has created opportunities for businesses to offer complementary goods as a package solution to SHS users, with potential to boost business viability. However, for many countries, these appliances and the SHS will need to be imported, requiring access to large amount of foreign currency and making the market vulnerable to foreign exchange fluctuations.

Bangladesh, which pioneered SHSs, shows that governments can support the creation of local supply chains. Grameen Shakti based its expansion strategy on existing SHS infrastructure (local manufacturers and technology) and local human capacity for maintenance services (interview with Sebastian Groh, CEO, SOLshare, May 18, 2015).

### Role of Government and Public Policy

Governments can foster the development of SHSs in several ways. They can create a conducive ecosystem for social enterprises to reach scale, as the government did in Bangladesh through the state-owned Infrastructure Development Company Limited (IDCOL). IDCOL works with over 50 participating nongovernment organizations, known as partner organizations, that sell, install, and maintain the SHSs. IDCOL provides direct subsidies that encourage reductions in SHS prices to customers, as well as support for microcredit financing, which makes the price of SHSs affordable (ADB 2015). In terms of tax incentives, Bangladesh, India, Kenya, and Tanzania impose no duties on imported SHSs and exempt renewable energy from value added tax. Tanzania subsidizes the purchase of solar photovoltaic. Other countries have used targeted credit lines for solar power, or established funds directed to offsetting the high upfront capital costs for wide scale deployment of SHS.

In 2015, the Tanzanian national government announced its One Million Solar Homes initiative, aimed at providing 1 million homes with access to reliable solar electricity by the end of 2017. Off-grid Electric Ltd. will be implementing this initiative, which will help the company reach scale. The International Finance Corporation's Lighting Asia and Lighting Africa initiatives, which multiple governments support, are likely to support the scaling up of SHS businesses in Asia and Africa.

Governments can also support businesses by providing market contacts and information on their own electrification plans. The government of Rwanda, for example, shared its grid extension strategy with Mobisol to guarantee the most effective electrification coverage. It shared grid maps with the company and facilitated entry by providing contacts at the village level (interview with Klara Lindner, Service Design Lead, Mobisol, May 21, 2015).

*Table 2. Selected companies selling solar homes systems in low-income areas*

Company	Countries	Description
<a href="#">Barefoot Power Limited</a>	Kenya, Rwanda, Uganda	Develops and sells affordable high-quality 1.5W–30W solar products to off-grid households around the world.



<a href="#">Border Green Energy Team (BGET)</a>	Thailand	Rents equipment customers need to use company's installed solar panels. Offers other solutions commensurate with villagers' financial means, ranging from personal-use lanterns and mobile chargers to state-of-the-art home systems.
<a href="#">Fosera</a>	Ethiopia, India, Kenya, Mozambique, Portugal, Thailand	Sells high-quality systems for light generation, phone charging, and powering of radios and televisions. Special features are Li-Battery technology, ultra-efficient LEDs, and modular system design, which allows systems to grow with demand by user.
<a href="#">Grameen Shakti</a>	Bangladesh	Offers market-based program with social objective; includes other renewable energy technologies for millions of rural villagers. Their work not only focuses on the technical and capacity-building sides of renewable energy promotion. They have also adopted the Grameen Bank's experience in micro financing to make renewable energy applications affordable for poor rural people.
<a href="#">Kamworks</a>	Cambodia	Designs and manufactures products such as a plug-and-play SHSs and the award-winning MoonLight Solar Lantern.
<a href="#">Kingo Energy</a>	Cambodia, Guatemala	Sells prepaid electricity, allowing customers to consume energy on a pay-per-use basis. Customers do not pay for installation or maintenance.
<a href="#">M-KOPA</a>	Tanzania, Uganda	Makes solar products affordable to low-income households on a pay-per-use plan. Customers acquire solar systems for a deposit and then purchase daily usage "credits" for less than the price of traditional kerosene lighting. After one year of payments, customers own their solar systems and can upgrade to more power.
<a href="#">Mobisol</a>	Rwanda, Tanzania	Combines solar energy with microfinancing to reduce barriers rural poor face to adopting renewable energy technologies.
<a href="#">Off-Grid Electric</a>	Tanzania	Sells prepaid electricity, which customers buy weekly via mobile money.
<a href="#">Onergy</a>	India	Provides lighting, cooking, and electrification solutions in rural areas.
<a href="#">SELCO India</a>	India	Provides customized solar home lighting systems, partnering with banks to provide financing.
<a href="#">SIMPA</a>	India	Sells prepaid power based on usage, with part of each payment going toward the purchase price of the SHS.
<a href="#">SolarNow</a>	Uganda	Sells SHS at affordable financing terms.
<a href="#">Soluz Honduras</a>	Honduras	Provides, distributes, and finances solar energy products in areas with no access to electricity grid.
<a href="#">Sunlabob Renewable Energies Ltd.</a>	Afghanistan, Cambodia, Lao PDR, Tanzania, Uganda	Offers range of energy products and services; pioneered franchised approach to rural electrification.
<a href="#">Zara Solar</a>	Tanzania	Sells and installs SHSs in rural households and institutions. Imports products from reliable suppliers from all over the world.

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# Profile: Mobisol

*Bringing Solar Power to Off-Grid Homes in East Africa*



## Challenge

Just 9 percent of the rural population of Sub-Saharan Africa has access to electricity (Public Private Partnership in Infrastructure Resource Center n.d). The rest use kerosene lamps and other fossil fuel sources, which are inefficient, unhealthy, harmful to the environment, and very costly.

## Innovation

Mobisol ([www.plugintheworld.com/mobisol/](http://www.plugintheworld.com/mobisol/)) offers high-quality solar home systems (SHS) and direct current (DC) appliances to rural customers in Rwanda and Tanzania, financed through an innovative payment scheme. The pay-as-you-go installment method circumvents initial investment hurdles for customers who could previously not afford a high-quality SHS.



Mobisol systems are available in four sizes: 30, 80, 120 and 200 watts. The smallest version can light two rooms and charge four mobile phones a day. The largest version powers multiple lights as well as consumer appliances, such as laptops, TVs, and refrigerators; it can also charge up to 10 mobile phones simultaneously. Mobisol also designs business kits for entrepreneurs. Such systems can power multiple phone chargers or a barber's hair clipper.

The company offers a 20-year warranty on the solar panel and a 3-year warranty on the battery and lighting equipment. While the product is under warranty, the company provides free maintenance and repair. Using a global system for mobile communications modem allows the company to both address maintenance problems swiftly and lock the system if payments are not made.

To buy the smallest system, customers make a USD 27 down payment and agree to pay USD 9 a month for 36 months. They then transport the SHS to their homes themselves; a Mobisol technician comes to the customer's home the next day to install the system. Payments are made via mobile phones. After customers complete the 36-month installment plan, Mobisol electronically unlocks the SHS, which can then be used free of charge.

In 2014 the company established the Mobisol Academy to train local entrepreneurs to service customers and represent Mobisol as a leader in the sustainable energy industry in East Africa. After three weeks of theoretical and practical training, the entrepreneurs start providing customer services.

## Impact

Since its establishment, in 2010, Mobisol has installed over 70,000 SHSs reaching more than 300,000 people in Rwanda and Tanzania and reducing CO<sub>2</sub> emissions by approximately 30,000 tons a year. The systems have increased the number of hours of light in the evenings, allowing children to study and families to spend more time together. One-third of Mobisol customers become at least part-time entrepreneurs, using the additional electricity they generate to offer services to their communities.

## Scaling Up

Connecting the rural areas in which Mobisol operates to the grid is not financially viable; even government electrification strategies have started looking at decentralized energy solutions like SHS.

There is thus high demand for off-grid electricity supply and Mobisol has been experiencing triple digit growth to respond to the demand. The company operates in Rwanda, Tanzania and more recently Kenya, with plans to go into Ethiopia and other countries. In Rwanda the company is coordinating its expansion strategy closely with the government, which invited Mobisol to complement its national electrification strategy and provides Mobisol with contacts at the village level.

Scaling up the program depends critically on the presence of mobile networks and mobile money services. Both are already widespread in East Africa, and penetration is increasing.

Two main factors constrain expansion. The first is finance, as systems are paid for overtime rather than upfront and this requires financing. The second is the lack of DC appliances. Mobisol's systems work only with DC appliances, which are more energy efficient and require less maintenance than alternating current (AC) appliances. In the countries where Mobisol is operating, no sales infrastructure for DC appliances exists; Mobisol therefore has to supply users with these products, which often need to be imported and can face foreign exchange restrictions.

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## Profile: ONergy India

*Bringing solar power to rural India*



### Challenge

One out of four people in India lacks access to electricity, according to the World Bank's Sustainable Energy for All database. Most of them live in rural areas that are too remote to have a grid connection.

Low-income households without access to electricity rely on wood or other biomass for cooking and heating—sources of fuel that are expensive and create both indoor and outdoor air pollution. Adopting clean energy solutions is often difficult, however, because remote areas often lack the after-sales services and infrastructure that make such solutions feasible.



### Innovation

ONergy ([www.onergy.in](http://www.onergy.in)) offers solar products to rural people in India. Its best-selling products are solar home systems (SHS) of 20–75 watts, which sell for USD 130–300. Customers pay 20–30 percent of the price as the down payment, financing the remainder with a five-year loan.

In 2014, ONergy introduced several new products, including a 10-watt plug-and-play solar home lighting system (USD 50–90), solar irrigation pumps (USD 2,000–10,000) and solar micro-grids (USD 1,000–50,000). Other innovative products include solar energy-powered TVs, computers, micro-grids, and irrigation systems that are not offered by any competitor in the states in which the company operates. The company has also developed a specific charge controller, which includes a mobile phone charger and shows the level of battery charge remaining.

ONergy develops high-quality products, supports them with a strong after-sales service network, facilitates consumer financing, and develops an ecosystem for sustainable development and rural empowerment. It has created a full-service infrastructure by establishing distribution centers (known as “renewable energy centers”) operated by a network of trained rural entrepreneurs and leveraging existing networks of local NGOs, self-help groups, and microfinance institutions to market its products, raise awareness, and provide financing.

### Impact

Since its foundation, in 2009, ONergy has established 18 renewable energy centers, reaching over 2,000 villages. It has set up more than 150 micro-grid systems and installed 40 solar-driven irrigation pumps. Its solar solutions are estimated to have improved the lives of over a quarter million people.

### Scaling Up

ONergy is operating in some of the poorest states in India, where energy infrastructure and electricity supply are lacking. Few other energy companies are active in these regions, resulting in massive market potential for ONergy. The poor state of infrastructure in these states is also a challenge, however. Many people in rural India either do not know about solar solutions (and thus need to be convinced of the added value) or have had a bad experience with solar products and are not interested in trying solar energy again. ONergy works to overcome these barriers by educating consumers about the value of its products.