

THE BOTTOM LINE

Since its inception in 2003, Bangladesh's solar home system program has installed about three million electrification systems in rural households, two-thirds of them in the last three years. The program is the most dynamic off-grid electrification program in the world, benefitting more than 15 million people and contributing about 130 MW in renewable energy generation capacity.

Scaling Up Access to Electricity: The Case of Bangladesh

Why is this case interesting?

Off-grid electrification is crucial to reaching universal access

Worldwide, 1.2 billion people lack access to electricity. Many live far from the existing electrical grid. To ensure them access to electricity by 2030, off-grid electricity solutions will need to be scaled up. The International Energy Agency has estimated that to achieve universal access to electricity as much as two thirds of future energy investments will need to go to mini-grids and stand-alone systems (IEA 2013).

Achieving universal access to modern energy services is one of the three complementary objectives of the Sustainable Energy for All (SE4ALL) initiative. Formally launched in the UN General Assembly in September 2012 and co-chaired by the president of the World Bank Group and the UN Secretary-General, SE4ALL calls on governments, businesses, and civil society to address urgent energy challenges, including universal access, by 2030 (SE4ALL 2012).

Despite significant challenges in its power sector (box 1), Bangladesh has succeeded in developing the largest and most dynamic national off-grid electrification program in the world, yielding lessons that may be applicable to other countries considering off-grid solutions to improve access to electricity.

Since its inception in 2003, Bangladesh's solar home system (SHS) program has installed household electrification systems in three million rural households, two-thirds of them in the last three years. In the same time period, the country's rural electricity cooperatives have extended access to the national electrical grid to

about 1.3 million households. Currently, the SHS program is providing electricity to about 50,000 new households each month, making it the most dynamic off-grid electrification program in the world. Solar home systems are small, household-level electrical systems powered by solar energy. They consist basically of a solar panel, inverter, and battery. Depending on their size, they can power various domestic appliances, including lights, radios, TVs, fans, and refrigerators.

This success evolved from a small pilot introduced in 2002 by the World Bank's Rural Electrification and Renewable Energy Development (RERED) project. RERED initially relied on subsidies, but these have been phased out over time as system prices declined thanks to economies of scale and technological advances. Today, the solar home systems are provided practically on commercial terms.

Box 1. Key facts

- Population: 161 million
- Population density: 1,238 persons per km²
- GDP per capita: US\$ 752
- Electrification rate: 55 percent

Bangladesh's electrification rate is 90 percent in urban areas, but just 43 percent in rural areas (2011), where four in five Bangladeshis live. The country's power sector faces numerous challenges, including inadequate generation capacity, dependence on high-cost emergency power, weak financial conditions and governance structure of power sector entities, and limited technical capacity.

The installed generation capacity is about 6,500 MW against a peak demand of 8,000 MW, resulting in widespread power outages.



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“By 2002, it had become apparent that an off-grid approach was needed to complement efforts to extend the grid. A pilot was introduced to test whether solar home systems could help reach more remote rural households.”

A modest subsidy is available only for small systems designed for the poorest households.

Some aspects of the Bangladeshi SHS program may be unique to Bangladesh and difficult to replicate in other countries. For example, the program has benefitted from a strong pre-existing network of competitive microfinance institutions (MFIs) with deep reach in rural areas, including the world-known Grameen Shakti MFI. Other factors contributing to the program’s success were (i) the high density of Bangladesh’s rural population, which fostered competition and economies of scale; (ii) rising rural incomes and remittances from abroad, which stimulated demand for the off-grid solar systems; and (iii) the existence of entities interested in doing business with rural customers and the country’s entrepreneurial culture.

But Bangladesh’s experience also conveys many lessons that are applicable to any off-grid electrification initiative. Among those lessons:

- The presence of a competent and passionate local champion with a strong capacity to promote and manage an off-grid electrification program
- Technical and financing solutions that match the target population’s ability to pay
- The quality of the solar home system and consumers’ awareness of its availability
- The patience to allow the program to evolve over time to reflect new technologies and market trends.

What challenges were faced?

Extension of the national grid to rural areas was slow and costly

Bangladesh’s rural electrification program was initiated in 1977 with the creation of the Rural Electrification Board (REB). The program was modeled after the rural cooperatives system of the United States. The REB oversees rural electric cooperatives (*palli bidyut samity*), which are autonomous organizations that own and operate rural distribution systems in specific areas. The REB arranges financing to build the distribution lines and hands over the finished infrastructure to the cooperatives for commercial operations (billing, collection, and regular maintenance). The performance of the cooperatives is

monitored by the REB under agreements that specify performance targets. Although rural cooperatives extended power to many rural households, by the early 2000s concerns about the pace and costs of rural grid electrification had arisen.

It was estimated that at the prevailing pace of grid electrification, Bangladesh would take 50 years to reach universal access. The REB was connecting four to five hundred thousand consumers annually to the grid—far fewer than required to reach universal access—and connection costs were rising. Given that rural households tended to use electricity primarily for lighting, the government was interested in exploring more cost-effective solutions for remote households. The reliability of grid power had also been a concern, with grid-connected households facing frequent power outages because of insufficient generation.

By 2002, it had become apparent that an off-grid approach was needed to complement efforts to extend the grid. A pilot was introduced to test whether solar home systems could help reach more remote rural households.

When the World Bank’s first RERED project was being designed in 2002, a two-pronged approach was adopted to promote the use of solar home systems in rural areas, thereby leveraging the country’s renewable energy potential, while continuing to help the REB and rural cooperatives improve their operational and financial performance.

What approach was taken?

An ownership model based on microfinance proved most successful

The first approach tested by the RERED project was the “ownership” approach that had previously been successful in Sri Lanka (Govindarajalu, Elahi, and Nagendra 2008). In that model, private dealers in solar home systems would make agreements with MFIs to extend financing to eligible customers.

This model was considered in Bangladesh, but there were concerns about the ability of private dealers to gain household trust. Instead, the SHS program opted for a modified approach that leveraged the strong presence of Bangladesh’s MFIs in rural areas. These MFIs (most of which are nongovernmental organizations, NGOs) became dealers, responsible for all aspects of the solar home

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system business (technical, commercial and financial). The advantage of this approach was that these MFIs already had established relationships with their clients to whom they could offer yet another service. For this approach to work, however, it was necessary to ensure that the MFIs gained proficiency in the new market. This was addressed by substantial training in technology, supplier-selection, and after-sales services.

This unique feature of Bangladesh’s approach has proven difficult to replicate in other countries, where MFIs in general have been reluctant to venture outside of their core role of financiers.

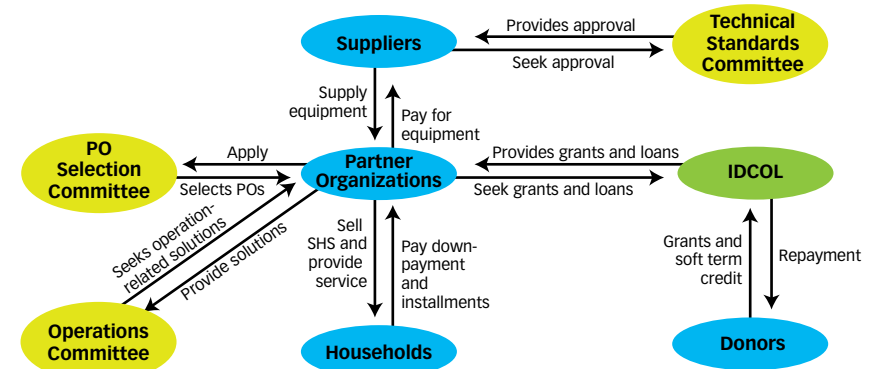
The second approach was a “fee-for-service” approach to be implemented by REB and the cooperatives. This model built on the cooperatives’ strong presence in rural areas. Instead of extending the grid, the cooperatives would provide solar home systems to more remote households and charge a monthly fee for the use of the systems.

Because each approach had merits, the RERED project piloted them both. The microfinance model proved more dynamic, primarily because of the greater commitment and interest of the implementing agency (Infrastructure Development Company Limited, IDCOL) and MFIs to promote solar home systems as a core business line, whereas for REB and the cooperatives solar home systems remained peripheral to extension of the grid. By 2009, MFIs had installed 320,000 systems, compared to just 14,000 systems installed by the cooperatives. The fee-for-service approach was then discontinued, and the focus shifted to fine-tuning and scaling up the ownership model.

IDCOL is a government-owned financial intermediary with the mandate to provide long-term financing for private infrastructure projects. Although owned by the Ministry of Finance, IDCOL is governed by an independent board of directors drawn from government and the private sector.

IDCOL works with development partners, suppliers of solar home systems, and participating MFIs, which are considered partner organizations. IDCOL sets technical specifications, certifies products and components, and selects partner organizations based on clear eligibility criteria.

Figure 1. The microfinance ownership model for solar home systems



Source: Presentation by IDCOL at Energy Week, 2013.

SHS = solar home system(s)

All partner organizations are private (mostly NGOs with a strong base in microfinance), ranging from large, well-known organizations such as Grameen Shakti to very small entities operating in specific areas. They procure solar home systems from various suppliers and sell them to households and small businesses on microcredit terms spelled out in purchase contracts. They are expected to prefinance the systems, for which they can often obtain supplier credit. They also install the systems using their own technicians.

Once the systems are installed, IDCOL verifies the installations and refinances a portion of the partner organizations’ credit to the households. It may also release a subsidy to the partner organization. The refinancing and subsidies that IDCOL provides are drawn from its financiers—originally the World Bank but now other development partners as well.

Partner organizations remain in contact with customers during the loan repayment period (typically 2–3 years), collecting payments, providing maintenance, and training customers in both operation and maintenance. Once the loan is repaid, the partner organizations offer service contracts for an annual fee. They also extend a buy-back guarantee that gives customers an option to sell their system back to IDCOL at a depreciated price if the household obtains a grid connection within a year of purchase. Most customers have preferred to keep their solar system, because grid electricity remains unreliable.

“From the start, the SHS program emphasized quality assurance in order to build consumer confidence in solar home systems, which were not yet widespread in rural areas.”

The SHS ownership program has been successful primarily because it has provided technical and financing solutions to users that matched their needs.

Financing. The program has made systems affordable through a combination of consumer credit and (declining) subsidies. The idea was to bring monthly expenditures as close as possible to existing household spending on kerosene and dry cells. Subsidies were initially required to bring the overall costs of the systems down, but they have been gradually phased out.

Partner organizations provide microfinance loans to households. Households are required to make a downpayment equivalent to 10–15 percent of the cost of the system. The remainder is repaid in 2–3 years at prevailing market interest rates (typically 12–15 percent).

Sixty to eighty percent of the credit that the partner organization extends to the household is eligible for refinancing from IDCOL at the prevailing market interest rate of 6–9 percent, with a 5–7 year repayment period and a 1–1.5-year grace period. After technical and other verifications, IDCOL releases the credit to the partner organization, along with any applicable subsidy, within 21 days of the claim.

Partner organizations also often receive supplier credit of up to three months as a sort of bridge loan while awaiting refinancing by IDCOL.

Subsidies have evolved over time with regard to both purpose and amount. Originally conceived as market-development tools, subsidies were designed to help partner organizations market the systems by making them more affordable, while also covering the costs that new partner organizations incurred in setting up a new business line in solar home systems.

The market-development approach worked in Bangladesh, as economies of scale brought unit costs down. At the same time, the global costs of solar home systems fell, reflecting lower prices for photovoltaic panels and other components, efficiency improvements, and the emergence of more efficient appliances, including LED lights.

When the SHS program started, the average subsidy was \$90 per system. By 2006 it had been halved and by 2013 eliminated except for the smallest systems (table 1). The remaining \$20 subsidy for systems of 30 Wp and below is to enable poorer households to participate in the program.

The program has also provided indirect subsidies in the form of cofinancing for consumer training and awareness building. These activities were developed on a cost-sharing basis, with the partner organizations bearing 20 percent of the cost. The partner organizations are now responsible for most consumer training and awareness building.

In addition, the RERED project financed training for partner organizations and a comprehensive media campaign to promote the use of solar home systems throughout the country. These activities helped build consumer confidence in solar home systems in a way that partner organizations could never have done on their own. IDCOL continues to train partner organizations on topics such as cash flow management, business planning, and technical features.

Technical features. From the start, the SHS program emphasized quality assurance in order to build consumer confidence in solar home systems, which were not yet widespread in rural areas.

IDCOL’s technical standards committee prepares specifications and certifies products. Specifications are periodically updated to

Table 1. The gradual reduction of subsidies for the installation of solar home systems, 2003–14 (in US dollars)

Year	2003	2004/05	2006/07	2008/09	2010/11	2012	2013/14
Capital buy-down grant	70	55	40	40	25	25	20*
Institutional development grant	20	15	10	5	3	—	—

Source: Authors.

* Applies only to solar home systems below 30 Wp. An institutional development grant of \$3 per system applies to new and smaller partner organizations only.

“When the program started, batteries were the only component produced in Bangladesh. Today, all components (including solar panels on a limited scale) are produced locally.”

reflect new technical advances. Product warranties are required for all key components (panels, batteries and charge controllers).

In the program’s early stage, every installation was verified by IDCOL. Since the program reached the 50,000 target in 2005, installations have been verified on a sample basis. IDCOL verifies that the installations are in eligible areas, that the partner organizations have used certified products, and that the installations are consistent with technical requirements and are fully operational. Only then are

Box 2. World Bank support for the Rural Electrification and Renewable Energy Development (RERED) program

Preparation of the Bank’s first RERED project was supported through various grants, including a grant of \$340,000 from the Global Environment Facility to IDCOL to test the proposed microfinance approach. IDCOL bought 250 solar home systems and provided 50 systems each to 5 selected partner organizations. The performance of these partner organizations in installation, loan collection, and other challenges was tracked to hone the project design and selection criteria for partner organizations.

RERED 2002. About \$16 million from a larger credit from the International Development Association was allocated for the solar home system program, complemented by an \$8.2 million grant from GEF. The original credit supported 650,000 grid connections and 236,000 solar home systems.

RERED 2009. Additional financing of \$130 million supported sale of another 300,000 solar home systems, in addition to other support for lighting and generation of electricity (including from renewable sources).

RERED 2011. Additional financing of \$172 million supported installation of about 630,000 solar home systems.

RERED II (2012). Beyond supporting additional 550,000 solar home systems, the project (valued at \$155 million) is also extending the solar home system model to additional areas, including (i) solar irrigation pumps, (ii) renewable mini-and micro-grids, and (iii) cleaner cookstoves, including biogas digesters for cooking.

RERED II (2014). Additional financing of \$78.4 million is supporting sale and installation of another 480,000 solar home systems.

The program has also received funding from GPOBA, a World Bank-administered trust fund, for output-based subsidies (\$7.2 in original funding in 2010 and \$6.75 in additional funding in 2011).

the subsidy and refinancing released. IDCOL has 21 days from the date of a partner organization’s claim to carry out the verifications. It employs more than 100 technical inspectors to carry out the verifications and maintains a call center to handle customer complaints.

Partner organizations are responsible for providing maintenance and customer training during the loan-repayment period. They also offer after-sale service contracts to households that have repaid their loans.

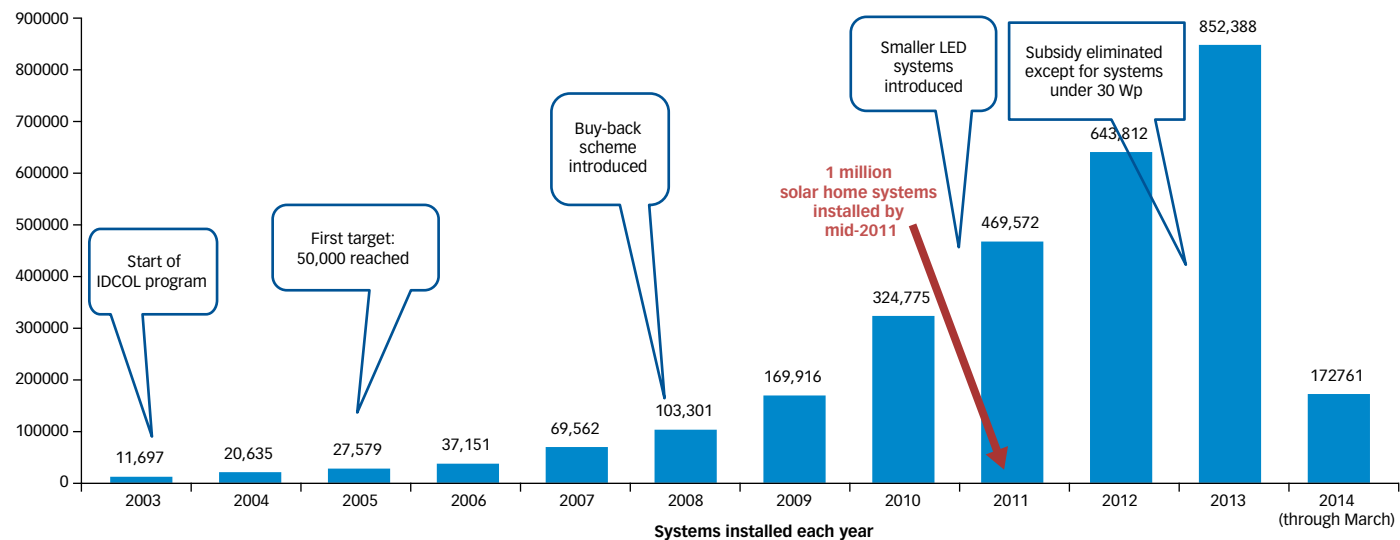
The SHS program has offered different system sizes to match customers’ willingness to pay. In the early years, the smallest eligible system was 40Wp, as smaller systems were considered unreliable. The best-selling system was 50Wp. Over time, technical improvements have driven system sizes down. Today, the program offers systems as small as 10Wp. The best-selling system is 30Wp, reflecting the fact that a 30Wp system today can offer more end uses (including powering a color TV) than a 50Wp system could in 2003.

Since the first RERED project was approved in 2002, the World Bank has provided continuous support (box 2). Funding has been used to provide (i) a credit line to IDCOL to refinance microfinance loans made by partner organizations; (ii) an output-based subsidy, and (iii) technical assistance, including for training and implementation of a consumer-awareness campaign.

In addition to providing financing, the Bank has offered critical advisory services and helped the government to obtain funding from other development partners. The SHS program is now also supported by the Global Partnership for Output-Based Aid, the Asian Development Bank, the Islamic Development Bank, the Japan International Cooperation Agency, KfW, GIZ (German Federal Development Corporation), and the U.S. Agency for International Development.

IFC is also contributing to the development of the off-grid electrification market in Bangladesh. Grameen Shakti was first exposed to solar home systems in 1998 through an IFC-financed program for small and medium-sized enterprises. Today, IFC’s Lighting Asia program is testing an introduction of solar lanterns (smaller than 10Wp) to further enhance the affordability of good-quality lighting for the poorest of the poor, and to develop micro-grids for more concentrated populations.

Figure 2. Solar home systems installed each year, 2003–14



Source: IDCOL.

“Overcoming the affordability barrier for Bangladeshi households through a combination of consumer credit, subsidies, and product choice opened the way to widespread adoption of solar home systems. Rural households will pay for a solar home system if monthly payments are commensurate with their current expenditures for alternative energy sources.”

What was the outcome?

Installations of solar home systems have mushroomed

Household access. In 2003, when the SHS program started, no more than 12,000 solar home systems had been installed throughout Bangladesh. The original target of the program was to install 50,000 systems by 2008. That target was achieved three years earlier than anticipated at a cost that was \$2 million less than anticipated. By mid-2011, the program had installed a million systems, and as of March 2014, that figure had risen to 2.9 million, benefitting more than 15 million people and contributing about 130 MW in renewable energy generation capacity. The program is currently installing more than 50,000 systems per month. IDCOL’s target is to reach a total of 6 million solar home systems by 2016.

Off-grid electrification programs typically have an “S” shape (figure 2). In the initial phases, the pace of connections tends to be slow, as the program concentrates on building enabling conditions

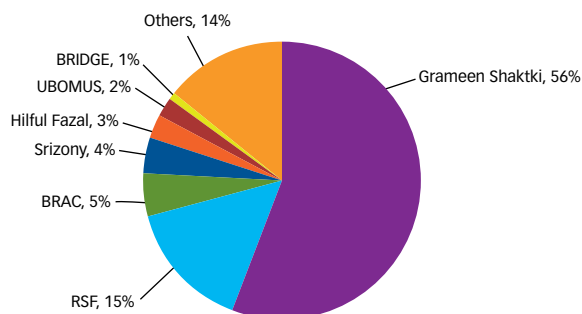
and fine-tuning approaches. That focus pays off in later stages, as evidenced by the exponential market growth in Bangladesh from 2006 onward.

When the SHS program started, it had five partner organizations, with Grameen Shakti holding a dominant market share. At present, the program works with 49 organizations, contributing to the creation of a vibrant renewable energy sector, although Grameen Shakti still accounts for the majority of sales (figure 3).

Initially, batteries were the only component produced in Bangladesh. Today, all components (including solar panels on a limited scale) are produced locally. In 2013, the International Renewable Energy Agency (IRENA) ranked Bangladesh as having the sixth-largest renewable energy–related workforce in the world—with 114,000 jobs.

An impact evaluation study (Samad and others 2013) confirmed a variety of benefits from solar home systems. It estimated that household access to the systems increases per capita food expenditure by 9.3 percent, per capita nonfood expenditure by 4.7

Figure 3. Market share of partner organizations, 2013



Source: Samad and others 2013.

“The program’s final design is a good example of how international experience and local know-how can come together to yield an innovative design that suits the country’s circumstances.”

percent, and total per capita expenditure by 5.1 percent, because of savings derived from the solar home system or time freed up for productive activity. The study also found that evening study hours for both boys and girls have increased thanks to the installation of solar home systems. Solar power was also found to have a positive health impact, especially for women, partly owing to avoidance of kerosene fumes. Adopting a solar home system reduced respiratory disease in women by aged 16 and above by 1.2 percent. Separately, a gender-responsive social assessment of RERED carried out in 2012 found that owning a solar home system increased mobility and entrepreneurial ambitions among women.

In many places around the world, the sustainability of the ownership approach has been questioned due to the difficulties to ensure after sales services. This has not been the case in Bangladesh. Optional after-sale services are provided by partner organizations that have a strong local presence and are both willing and able to provide such services to their customers.

Financial sustainability has also been strengthened through the presence of MFIs with strong financial track records. Partner organizations have an average loan-collection efficiency of more than 90 percent while servicing their debts to IDCOL on time. Meanwhile, dependence on subsidies has been significantly reduced.

What have we learned?

Some conditions are unique to Bangladesh but many key lessons are transferable

Some program features may be unique to Bangladesh.

Strong microfinance support from established grassroots MFIs/NGOs helped penetrate rural markets. The SHS program leveraged an extensive MFI network that has historically provided microfinance for income-generating activities in rural areas. Early on, the program benefitted from the extended network and reputation of Grameen Shakti, but as it evolved, additional MFIs have become solar home system dealers, deepening penetration in rural areas.

Rising rural incomes helped reduce the need for subsidies. Improved agricultural productivity and the huge influx of remittances from Bangladeshi workers abroad have made solar home systems more affordable than they were a few years ago, a factor that has made it possible to reduce subsidies almost to the vanishing point. The feasibility of phasing out subsidies, of course, depends on what is happening with household income levels.

High population density has enabled economies of scale, contributing to the price reductions. As one of the most densely populated countries in the world, Bangladesh was able to leverage economies of scale. The average cost of a 40 Wp solar home system, which is enough to run a few lights, a mobile phone charger, and a TV, is about \$300. This is less than half the cost of a similar system in Uganda, for example. High population density also promotes competition in the market, as dealers compete vigorously to provide attractive credit packages to consumers. While economies of scale can be achieved in less densely populated countries, the approach to achieving the scale may need to be different (competition for customers is likely to be more limited).

Many of the program’s lessons may be applicable in other countries. Finding a competent and passionate local champion is important. One of the early challenges that the program encountered in Bangladesh was that the traditional financiers of the partner organizations were unwilling to finance “nonproductive loans” such as those for solar home systems. An alternative source of funding was found in IDCOL, which at the time was facing a

“Scalability is more important than scale. In other words, it is less important to aim at developing a “a large-scale program” than to focus on developing scalable solutions.”

slowdown in its core financing activities and was looking for a new area in which to expand. IDCOL has turned out to be both an enthusiastic promoter of off-grid solutions and an extremely effective implementer. Its professional management is overseen by a qualified board.

The program must take into account the target population’s ability and willingness to pay. Overcoming the affordability barrier for Bangladeshi households through a combination of consumer credit, subsidies, and product choice (different system sizes to match varying consumer needs) opened the way to widespread adoption of solar home systems. Rural households will pay for a solar home system if monthly payments are commensurate with their current expenditures for alternative energy sources. Although microfinancing hinges on having institutions willing to lend for solar home systems (which is not the case in all countries), alternative payment methods are possible, such as pay-as-you-go schemes.

Even with affordable financing, actions to foster consumer trust in the new technology are needed. If consumers are expected to invest a significant share of their income in a solar home system, they have to know that the system will work. That confidence has been built in Bangladesh through a combination of several parallel efforts:

- Ensuring technical quality. The need to set standards and provide quality assurance for solar home systems was recognized early. Stringent quality standards were set, including a 20-year warranty for the solar panel and a 5-year warranty for batteries, and the standards were strongly enforced. Optional after-sale services have helped keep customers satisfied with the systems.
- Consumer awareness and training. Consumer awareness and training in the use of new solar home systems promote sustainability. Fostering a sense of ownership helps ensure proper maintenance and upkeep. Consumer awareness has included a broad set of activities from face-to-face interactions to media campaigns, particularly in the early stages of the program.
- Risk perception. Initially, the partner organizations followed the REB’s electrification plans to avoid areas that were scheduled to be electrified, but they soon found that they were missing customers that they could have served. Conversely, many

households hesitated to buy a solar home system if they believed that they would soon be connected to the grid. To deal with this twin challenge, dealers introduced a guarantee to repurchase the solar home system within a year if the household obtained a grid connection. The buy-back scheme has proved very persuasive. In reality, the guarantee has rarely been called upon, as grid electrification has been slow and even most electrified households elect to keep their solar systems due to the unreliability of the grid.

Successful programs must evolve over time to reflect new technologies and market trends. The Bangladeshi SHS program adapted its technical specifications over time to take advantage of new technology developments. The program often faced trade-offs between the desire to bring new technologies to customers quickly and the need to maintain the reputation for reliability of solar home systems—it has typically chosen the cautious approach. For example, the program initially offered only systems of 40Wp and larger, owing to the reliability problems of the smaller systems then available. Over time, however, the program introduced smaller systems that increased affordability, while updating technical specifications to allow new components, such as LED lighting.

Operational lessons from the World Bank’s RERED I and II projects. RERED took about two years to prepare. Time was needed to adapt the model the Bank had used in other countries, to find implementing agencies and develop institutional arrangements in a country in which solar home systems were not widespread, and to test the new approaches. Ultimately, the time spent in project preparation hastened implementation. The SHS program reached its initial target three years ahead of schedule.

The program’s final design is a good example of how international experience and local know-how can come together to yield an innovative design that suits the country’s circumstances. The Bank’s initial design ideas were similar to the approach applied in the earlier Sri Lanka project, but insights from IDCOL and partner organizations produced the microfinance ownership approach, which leveraged the country’s unique strengths.

The project’s design was flexible (with a range of subsidies and system sizes, for example), allowing for quick adaptation to evolving technology and market conditions—and to consumer feedback.

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Details of the pilot implementation were left flexible, which made it possible to adapt quickly to experience without resorting to restructuring or other lengthy administrative processes.

Scalability is more important than scale. The Bangladesh SHS program, the largest off-grid electrification program ever supported by the World Bank, began as a modest pilot aimed at reaching 50,000 connections over a five-year period. This experience shows that it is less important to aim at developing a "a large-scale program" than to focus on developing scalable solutions. The approach was developed in several phases, as detailed in box 2. The SHS program was scalable because its design leveraged Bangladesh's strengths while effectively addressing the identified barriers and allowing for careful and timely adjustments to insights gained during implementation.

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Live Wire aims to raise the profile of operational staff wherever they are based; those with hands-on knowledge to share. That's your payoff! It's a chance to model good "knowledge citizenship" and participate in the ongoing change process at the Bank, where knowledge management is becoming everybody's business.



If you can't spare the time to contribute to *Live Wire*, but have an idea for a topic, or case we should cover, let us know!

We welcome your ideas through any of the following channels:

Via the Communities of Practice in which you are active

By participating in the Energy and Extractives Global Practice's annual *Live Wire* series review meeting

By communicating directly with the team (contact Morgan Bazilian, mbazilian@worldbank.org)



