# DECENTRALIZED OFF-GRID ENERGY SOLUTIONS

## in the South Asian region

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South Asia, comprising of eight countries and one-fifth of the world's population in just 4% of the world's land mass, is the most densely populated geographical region in the world. In this region, a large section of the population lives in rural areas. However, electricity is available in only 50% of the rural areas, thus leaving one out of every two people in these areas—about 614 million people—without access to electricity.

While the figure serves as a common denominator to the problem, there exists wide disparity in rural electrification in South Asia. Sri Lanka has a rural electrification rate higher than the global average, while only 12% of the rural population in Afghanistan is connected to the grid. India, Pakistan, and Bangladesh alone constitute more than 90% of the populace that lack access to electricity in the region while the remaining 10% is in the other smaller countries. While the South Asian countries historically had similar developmental challenges, as most of these countries were either part of the Indian subcontinent or maintained very close cultural and economic linkages, this similarity also offers potential for greater South-South co-operation for addressing many of the challenges, especially for an enhanced electricity access learning from each others' experiences.

This article shares the experiences of off-grid electrification in the South Asian region with special emphasis on

four countries—India, Nepal, Sri Lanka, and Bangladesh. These are the countries that have taken the lead in using off-grid technologies in creating access to electrification in the rural areas through various schemes and models.

## Current trends

Out of the 614 million rural people without electricity in the region, many reside in isolated communities, far from the national electricity network. These so-called 'off-grid' communities are generally small and dispersed, consisting of low-income households with characteristics that are economically unattractive to potential private-sector energy providers or even government electrification programmes that usually prioritize the allocation of the scarce resources. Unserved consumers are also found in rural and peri-urban communities close to the grid where more than the accessibility issue, it is the poor financial condition and low electricity supply that stops people from accessing electricity.

In these areas, the progress made in implementing off-grid solutions for rural electricity has shown mixed trends. The most common technologies that have been used for off-grid electrification are solar photovoltaic (PV) and mini/micro hydro systems. While mini/micro hydro systems have been used to create mini-grids to supply electricity locally, solar PV technology applications cover both solar home systems as well as solar PV mini-grids. In addition, biomass gasifiers have also been used in India for off-grid electrification. In terms of country coverage, Sri Lanka and Nepal have extensively used micro hydro power based mini-grids to provide electricity services. Bangladesh, on the other hand, relied more on solar home systems to cover households, which had no access to grid electricity. India has tested almost all off-grid electrification technologies, but solar PV and biomass gasifiers have received more attention than the other technologies. Countries such as Afghanistan, Bhutan, and Pakistan show relatively lesser penetration of off-grid systems.

While off-grid projects or programmes have and continue to be set up mostly with the help of grants and donors driven in most countries like Nepal, Pakistan, and India, free markets have started to develop in Bangladesh, Sri Lanka, and even India. Free markets are showcasing innovations in system design and financial and institutional mechanisms, especially for the solar home systems market. Case studies of different countries revealed that community-based models were mostly adopted for off-grid electrification in the South Asian region, albeit with different names like village energy committees (VECs), village development committees (VDCs), fee for service models, rural energy service companies, and rural electricity cooperatives.

## Emerging trends

With distributed generation systems holding great relevance for off-grid rural electrification on account of the key challenges of ensuring energy security to all communities, as well as global challenges to meet the Millennium Development Goals (MDGs) including education, health, environment protection, and livelihood generation, effective service delivery and innovative financial models could be instrumental in providing the required thrust to the sector. The following are the new paradigms within which distributed generation systems seem to be finding newer markets apart from off-grid electrification.

- Improving household electrification level in electrified villages where households are scattered and grid extension is not economically feasible;
- Augmenting the electricity supply in electrified villages for achieving better healthcare, education, and community services;
- Providing dedicated power to livelihood activities, such as food processing, rice hulling, computer kiosks, small shops, and skill-development centres, to boost the local economy;
- Managing areas of low demand such as street lights and compound lighting in the night in institutions/campuses where large diesel gensets run for daytime peak loads;
- Pre-electrifying villages that are likely to be electrified in the near future for intruding basic electricity services initially, and subsequently facilitating load growth for making grid extension viable in future; and
- Meeting universal service obligations by improving the household electrification level in electrified villages and providing electricity in de-electrified villages.

## Specific trends: India

In India, grid connections have been the most favoured approach for the majority of rural households. In addition, renewable energy based off-grid technologies, such as solar PV and biomass gasifiers, have also been disseminated in areas, which are either inaccessible to grid connectivity or areas, as per the national census records, not recognized as villages. Also, privately-owned diesel generators supply electricity to both un-electrified and electrified villages (that do not receive electricity in the evening hours due to a deficit supply situation, usually referred to as *chotti bijli* in local parlance), especially in the rural markets places and to economically better off households on a light point basis.

The off-grid technologies have been used either through the creation of local mini-grids or disseminating household level technologies such as solar PV for lighting and other low consumption activities. Data from the Ministry of New and Renewable Energy (MNRE) indicate that about 583 429 solar home systems and 792 285 of solar lanterns had been deployed by March 2010. The off-grid power plants based on renewable energy are typically in the range of 1–500 kWp, and within dependent distribution network, that is, mini-grids. The MNRE statistics indicate that about 404.56 MWp of cumulative off grid/ distributed renewable power including captive plants combines heat and power (CHP) exists in the country.

Most of India's off-grid systems have been promoted under government schemes like Remote Village Electrification (RVE) Programme, Village Energy Security Programme, and the Technology Demonstration Programme. In addition, NGOs have also been in the forefront of creating access to electricity through off-grid options in rural areas with the help of financial support from various bilateral and multilateral agencies. The RVE programme was initiated in 2001 for covering un-electrified census villages and hamlets that are not likely to receive grid connectivity. By focusing on remote villages and hamlets of electrified census villages, the RVE has been aiming at bringing the benefits of electricity to people living in the most backward and deprived regions of the country. Under the RVE programme, solar home systems, solar PV power plants, small hydropower plants, biomass gasification systems in conjunction with 100% producer gas engines or with dual-fuel engines using non-edible vegetable oils, non-edible vegetable oil-based engines, and biogas engines will be promoted. However, almost 95% of the remote census villages taken up for electrification under RVE are provided with solar home systems or solar power plants. As on March 2010, the number of villages and hamlets electrified under the RVE was 5348 and 1408, respectively.

Though the Jawaharlal Nehru National Solar Mission (JNNSM), launched recently, as part of the 2008 Indian National Action Plan on Climate Change (NAPCC) has not been established to foster rural electrification per se, it does mention the use of solar energy as a means for rural electrification. It is envisaged that by the end of the Thirteenth Five-year Plan, in 2022, the JNNSM should have led to the deployment of 20 million solar lighting systems in rural areas.

## Nepal

In 2008, the national electrification rate in Nepal was 64.5% with very uneven urban-rural distribution. In urban areas, where less than 20% of the population lives, the household electrification rate is 93.1%, while the rural electrification rate is only 52.5%— being highest in the accessible lowland regions (the Terai) and lowest in the mountain regions. The per capita electricity consumption is only 81 kWh, one of the lowest in the world. Though the electrification rate is still relatively low, since the beginning of this decade the country has made significant progress in extending electrification to the rural areas. Interestingly, in Nepal, almost 30% of electricity supplied in the rural areas has been through the off-grid route. The use of alternative energy sources for rural electrification took place because of the early realization by the Government of Nepal that the central electricity grid may not reach most rural populations. Thus, various renewable energy programmes were set up with the common objectives of strengthening the rural economic system, improving the quality of rural life by supplying energy, increasing the opportunity of employment, and contributing to environmental sustainability.

The Energy Sector Assistance programme (ESAP) has also been instrumental in supporting the Alternate Energy Promotion Centre (AEPC) to promote micro-hydro schemes of up to 100 kW. Besides loan financing available through commercial banks, there was also the provision of financial subsidy for these projects. Also, a total of 69 411 solar home systems were installed in the country, bettering the programme target of 40 000 systems under ESAP Phase 1. The programme was also successful in

establishing guidelines for administering solar energy subsidies and putting in place quality assurance and monitoring systems for the solar energy projects. Currently, it is reported that 26 pre-qualified solar PV dealers operate in the country who sell their systems through retailers trained in the basics of system maintenance and after sales services. Almost 83% of the installed solar home systems (SHS) are smaller than 40Wp capacity indicating that these are mainly used for lighting.

The current phase of ESAP, extending from 2007 to 2012, aim to provide energy solutions to more than 1 million households in Nepal through its various programme components—biomass energy support programme, solar energy support programme, and mini-grid support programme. The programme is supporting the creation of mini-grids to be fed by hydro power with capacity of 5 kW to 1 MW, as pre-grid electrification options. If and when the national grid is extended to these areas, the mini-grids could be directly connected to the national grid. ESAP Phase 2 plans to generate 20 MW of electricity to benefit 150 000 rural households served through mini-grids across the country. Furthermore, solar home systems are also being promoted to power lights and operate small appliances under ESAP 2. In addition, the programme is also supporting new solutions such as small solar powered lamps (solar tuki) and is aiming to cover 150 000 households with solar home systems and about 250 000 households by solar tuki systems.

## Sri Lanka

Sri Lanka stands out among the South Asian countries for its high rate of household electrification. During the period 1986–2005, the national electrification rate improved significantly from 10.9%–76.7%. Almost 75% of the rural households in Sri Lanka are connected to the electricity grid, while another 2% of the households are provided with basic electricity connection through the off-grid option. In the off-grid sector, small hydro power has been the preferred option with the first off-grid village hydro scheme commissioned in 1992. Since then, the village hydro schemes have become very popular, especially in the Southern and Sabaragamuwa provinces, to provide power to rural households that are far from grid electricity. In these villages, hydro schemes were built, owned, and operated by rural communities through electric co-operative societies that are set up for this purpose. Apart from the micro hydro, solar PV home systems have also been used to a large extend to provide access to electricity.

The country has one of the most successful solar PV home system programme, promoted through innovative financing schemes such as Energy Services Delivery (ESD) and Renewable Energy for Rural Economic Development (RERED) project, with private sector involvement. The ESD project provided the basis for a market-based approach for introducing renewable energy development in the country. The ESD credit programme resulted in a dramatic increase in the development of grid-connected and off-grid renewable energy projects, prepared and implemented by the private sector and village communities. The project catalysed the solar market by installing 20 953 solar home systems, with a total capacity of 985 kW, against a target of 15 000 systems; 31 MW of mini-hydro capacity installed through 15 projects against a target of 21 MW; and 350 kW of capacity through 35 village hydro schemes serving 1732 beneficiary households against a target of 250 kW through 20 schemes.

After the successful implementation of the ESD project, the government, with the help of the World Bank and the Global Environment Facility (GEF), established the renewable Energy Rural Economic Development (RERED) Project, which electrified more than 130 000 rural households through solar home systems and independent mini-grids and provided 1000 off-grid electricity connections to small and medium enterprises and public institutions. This helped thousands of rural households to switch from poor-quality kerosene lamps to more efficient electric lighting.

Studies have concluded that the large-scale penetration of SHS in Sri Lanka have helped the rural communities to improve socio-economic conditions and reduce adverse environmental impacts.

The success of the off-grid projects in Sri Lanka can be attributed to flexible project design responsive to the needs

of implementing organizations, suppliers, and beneficiaries. The work has been further aided by improved access to capital, innovative easy payment schemes introduced by micro-financing institutions, and output focused approach adopted by the private companies and non-governmental organizations. The projects had effective, after-sales maintenance networks in place, particularly for systems financed by the micro-finance institutions, which were trained in basic technical-repair skills. Furthermore, strong outreach networks enabled the micro-finance institutions to reach the rural customers with the help of effective service delivery channels.

### GRAMEEN SHAKTI MODEL

Incorporated in 1996 as a not-for-profit company, Grameen Shakti (GS) has developed one of the most successful market-based programme with a social objective of popularizing solar home systems including other renewable energy technologies to millions of rural villagers in Bangladesh. GS used its Grameen Bank concept of micro-credit to evolve a financial package suitable for the rural people, especially to bring down the costs. The customized pricing system based on installments helped GS to reach economy of scale with the increase in sales. Their business is centred on customer service excellence and GS engineers pay monthly visits to households during instalment payment and offer their services for a small fee, upon the signing of an annual maintenance agreement by clients. GS also undertakes several other activities (such as educational loans, gift schemes, and so on) that go well beyond the energy service alone and help develop trust between GS and the local communities. By the end of December 2009, the total number of installations reached to 113 736 SHS. And GS plans to meet a target of 220 000 SHS by the end of 2010.

## Bangladesh

According to the International Energy Agency (IEA), the overall electrification rate in Bangladesh was 41% in 2008, with 76% of the urban population and only 28% of the rural population having access to electricity. Though the rural household electrification rate is poor, Bangladesh has recorded an impressive rural electrification performance with the help of solar PV technology especially solar home systems. The solar PV programme was developed by Infrastructure Development Company Limited, Bangladesh (IDCOL, Bangladesh) with the help of the World Bank. The project is now implemented by IDCOL, Bangladesh, through its 23 partner organizations (POs), including leading names such as Grameen Shakti and Bangladesh Rehabilitation Assistance Committee (BRAC). IDCOL provides grants and refinances the systems, sets the technical specifications for the solar equipment, develops publicity materials, provides training for the PO capacity building, and monitors PO performance. The role of PO is to select the project areas and potential customers, offer micro-financing to the customers, install the systems, provide maintenance support, ensure that spare parts are available, consult with the users before installation, disseminate knowledge for productive use of the system, and provide training to the users and local technicians in order to create local expertise and ownership on the system. IDCOL offers refinancing through soft loans to the POs and channels grants to reduce the SHS costs as well as support the institutional development of the POs. In addition, the IDCOL also provides technical, logistic, promotional, and training assistance to the POs. The POs provide credit to the customers. A customer has to pay 10% of the total cost of the system as down payment, and the outstanding amount is to be paid in the form of monthly installments with a 12% service charge, which covers the maintenance cost of the system.

IDCOL started the programme in January 2003 and its initial target was to finance 50 000 SHS by the end of June 2008. The target was achieved in September 2005, three years ahead of schedule. IDCOL then revised its target

### CONSUMER CREDIT THROUGH THE MICROFINANCE INSTITUTIONS

The most popular SHS financing model under Sri Lanka's Renewable Energy for Rural Economic Development Project (RERED) is consumer credit through the microfinance institutions that work closely with the solar companies. The project's centerpiece has been the market-based credit programme available to the participating credit institutions (PCI)—commercial banks, microfinance institutions, and leasing companies that meet the eligibility criteria. The solar companies, via their dealer networks, sell SHS and offer operation and maintenance services. The business model is structured through a memorandum of understanding between the microfinance institution and the solar company. The PCIs can refinance up to 80% of their loan amount and offer households, community-based organizations, and private developers sub-loans, to finance SHS, village hydropower systems, and mini-hydropower projects, respectively.

and decided to finance 200 000 SHS. This was also achieved in May 2009, seven months ahead of the schedule. IDCOL now targets to finance 1 million SHS by the end of year 2012, out of which a total of 438 000 SHS have already been installed as on December 2009.

### LIGHTING A BILLION LIVES CAMPAIGN

TERI has evolved an innovative renting model for providing access to clean lighting through solar lantern under its Lighting a Billion Lives (LaBL) campaign initiative. Launched in 2008, the campaign aims to bring light into the lives of one billion rural people by displacing kerosene and paraffin lanterns with solar lighting devices, thereby facilitating education of children; providing better illumination and kerosene and smoke free indoor environment for women involved in household chores; and providing opportunities for livelihoods both at the individual and village level. LaBL operates on the basis of the fee-for-service or the rental model, whereby centralized solar charging stations (SCS) are set-up in villages for charging the lanterns and providing the lanterns daily on rent to households and enterprises. A typical solar lantern charging station consists of 50 solar lanterns with five numbers of solar panels and junction boxes. The charging stations are operated and managed by entrepreneurs (Self Help Groups/individual youths) who qualify the selection criteria, which is set as part of the LaBL campaign. These entrepreneurs are selected and provided the handholding support by local LaBL implementation partners called LaBL associates. The rent is collected by the entrepreneur, a part of which is used for operation and maintenance of the charging station and for replacement of batteries as may be required after 18–24 months of operation. TERI has successfully extended the campaign in 566 villages spread across 15 states in India impacting more than 150 000 lives.

## Conclusion

The success stories in the dissemination of solar technologies in Bangladesh, Sri Lanka, Nepal, and India demonstrate the possibility of implementing off-grid programmes in association with the private sector and microfinance institutions that operate in the rural areas. The projects could be suitably scaled up with improved access to capital, development of effective and reliable after-sales service, customer-centric market development, and regular stakeholder involvement. While these experiences may be true in the case of delivery of solar systems, the design principles key to their success can also be extended to cover other off-grid technologies. This is to provide access to electricity to people in the remote areas for the overall socio economic development and inclusive growth of the South Asian region in general and its constituent countries in particular.

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