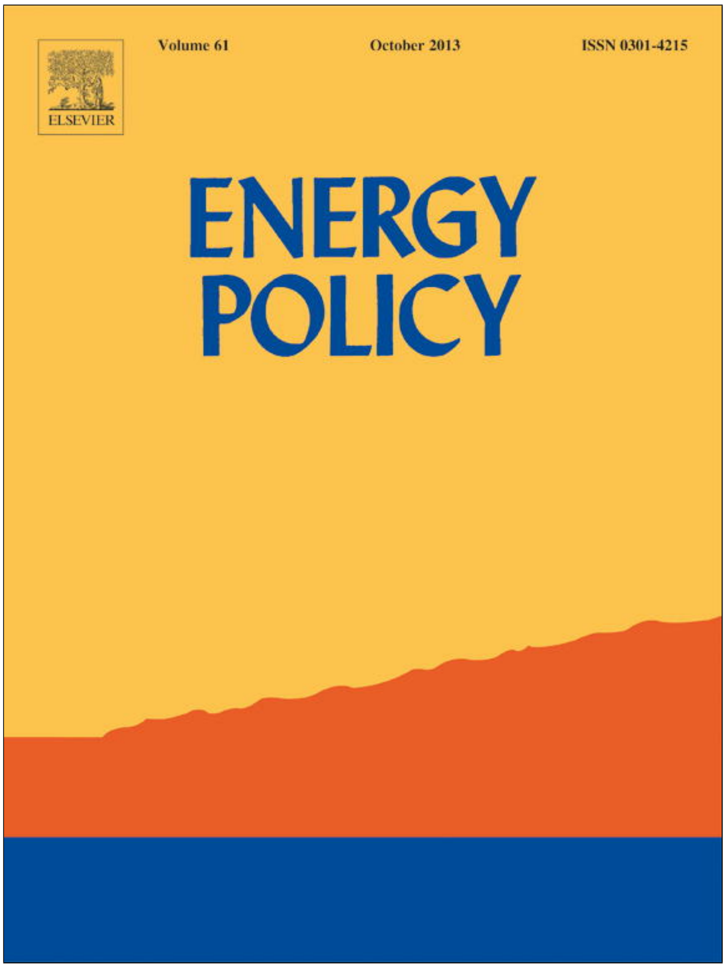
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Driving and hindering factors for rural electrification in developing countries: Lessons from Bangladesh

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HIGHLIGHTS

- Rural electrification is essential for bringing about socio-economic developments.
- The pace of rural electrification in the developing countries has been very slow.
- A multitude of issues plays behind in making the task a success or a failure.
- Lack of policy reforms, unrealistic tariffs are the main hinderers.
- Rural electrification cannot be successful by sticking to a rigid model.

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ABSTRACT

Rural electrification is essential for bringing about social and economic developments, but the progress is distressingly slow in most developing countries. The Bangladesh Rural Electrification Program (BREP) has been highlighted as a positive case among developing countries, but from 2006 onwards there have been doubts about the program's chances of success. In this paper, we examine the rural electrification practices in Bangladesh and evaluate the claim that, whereas they were successful up to 2005, they then began to decline in terms of their performance. This study determines the factors behind the initial success of the program as well as those that account for the recent downturn in BREP. We found that the BREP was a clear success in terms of its growth and progress; however, its performance has been declining since 2006. The key driving factors for the success of this program had to do with prioritizing system investment, community involvement, anti-corruption features, standardized practices and performance-based incentives while excluding political parties. The major issues accounting for the decline were the lack of organizational autonomy, a shortage of funding, unrealistic tariffs, and power supply shortages. Renewable-based, off-grid technologies have been successfully supplementing the on-grid program in remote areas.

1. Introduction

Rural electrification is an essential element in bringing about the social and economic development of the underprivileged rural populations (Barnes, 2007; Barnes et al., 2011; ESMAP, 2007; Palit and Chaurey, 2011; World Bank, 2010a). Still, 1.3 billion people around the world do not have access to electricity, 85% of whom live in rural areas (IEA, 2010). When considering the great importance of electricity, the international community has long emphasized the need to expand modern energy services (including electricity) to the populations of developing countries to alleviate poverty and address other economic, social and environmental issues (IEA, 2010). Governments of all countries have given a high priority to providing access to electricity for their citizens (World Bank, 2008a). Despite the continuous efforts of the

Abbreviations and acronyms: BDT, Bangladesh Taka (1US$=70 BDT, 2010); BPDB, Bangladesh Power Development Board; BREP, Bangladesh Rural Electrification Program; IDA, International Development Association; IDCOL, Infrastructure Development Company Limited; IEA, International Energy Agency; NRECA, National Rural Electric Cooperative Association; PBS, Palli Bidyut Samity (Rural Electric Cooperative, REC); PO, Partner Organization; PTA, Performance Target Agreement; REB, Rural Electrification Board; REP, Rural Electrification Program; RET, Renewable Energy Technology.

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international community and governments throughout the world, the pace of rural electrification in many developing countries is still very slow (Paul, 2011).

Rural electrification typically poses more challenges than urban electrification in terms of policy, finance, and institutional setup because of its distinct features. Some of the common features that make rural electrification more difficult than urban electrification are the lower number of connections per kilometer of line, the low level of consumption, the lack of industrial load, the heterogeneous landscape, and the lack of motivation for private investors. Despite these challenges, some developing countries have been more successful in providing electricity to their rural populations (Barnes, 2007; Mohan, 1988).

Bangladesh Rural Electrification Program (BREP) was initially applauded for being one of the most successful programs of its kind in a developing country. The country started its rural electrification program in 1980, when barely 2% of rural people had electricity (10% overall coverage). From the beginning, the performance of this program was treated as an exemplary model for other low income countries to emulate (Taniguchi and Kaneko, 2009). Despite the fact that rural electricity coverage in Bangladesh was not very high (35%) compared to other major rural electrification cases, such as Vietnam (33%), Sri Lanka (79%), India (53%), and the Philippines (33%), Bangladesh's REP possessed many unique characteristics that helped label it a successful and made it an exemplary model for other struggling countries. The program received a very distinctive status in South Asian countries with respect to its well-functioning administrative and financial operations and steady progress. The program also pioneered a model for how to tackle adverse economic conditions, a poor infrastructure, and inefficient government services. In light of this distinctiveness, many countries, such as India, Nepal, Senegal and Rwanda, sought to learn from Bangladesh's rural electrification experience. But since 2006, the program has been facing many issues that are raising doubts about its success (Taniguchi and Kaneko, 2009).

International organizations and research institutions have conducted numerous research and case studies to determine the issues influencing the REP's performance (Barnes and Foley, 2004; Fulkerson et al., 2005; Palit and Chaurey, 2011; Peters et al., 2009). Barnes (2007), for instance, summarize the crucial factors determining the success of rural electrification programs in developing countries. These studies allow for the fact that the performances of the different programs vary due to a number of different factors. Although the rural electrification program in Bangladesh has been an applauded case, no study has been performed to figure out the real causes behind its performance. In this paper, we comprehensively examine the Bangladesh's REP with the aim of evaluating the extent to which the program is successful and later cast doubt on the reasons for its success. We also determine the driving and hindering features influencing the performance of the program. This study can provide valuable insights for other developing countries facing electricity access problems.

This paper is organized in the following manner. Section 1 introduces the background to the problems and the research objectives of this paper. Section 2 discusses the methodological approach adopted in this paper. Section 3 describes the status of rural electrification in Bangladesh and its position in major developing countries. Section 4 presents the challenging features of rural electrification in a generic form for developing countries, but emphasizes that they are equally applicable in Bangladesh's case. Section 5 provides a rural electrification overview for Bangladesh, while Sections 5.1–5.3 deal with technology, institutional, and financing policy issues. Section 6 describes the performance of rural electrification in Bangladesh and examines the extent of the program's successes as well as its setbacks. Section 7 highlights the driving factors behind the success of the on-grid and off-grid rural electrification program in Bangladesh. Section 8 presents the factors hampering the success of the program. Section 9 presents the corrective measures needed to tackle the issues hindering the program, and finally, Section 10 offers some conclusions.

2. Methodological approach

This paper examines the Bangladesh Rural Electrification Program (BREP) with the aim of evaluating the performance and determining the driving and hindering factors influencing the performance of the program. The rural electrification program involved multiple aspects such a technology, institutional and financing policy issues, and there appear no clear methodological framework to deal with the aspects together. This paper, therefore, used exploratory research approach to evaluate the performances and applied features of BREP to gain insights and lessons from this program. This paper evaluated the performances of BREP in terms of progress and growth of village coverage, line constructed, and connection established. The driving and hindering factors behind the performance of BREP were derived from the insights gained from this program and literatures on successful cases.

3. Rural electrification status in Bangladesh and its position within developing countries

Bangladesh is a country of 162 million people; 73% of the people live in rural areas. Of 117 million rural people, only 35% of them (41 million) had access to electricity as of December 2010. Bangladesh set the target to provide electricity to everyone by the year 2020. Until the year 2006, the country had every year provided electricity to an additional 4.4 million rural people by expanding the grid. The government's study finds that grid extension alone will not be sufficient to achieve the target of providing electricity to everyone. Thus, Bangladesh has taken serious efforts to disseminate renewable energy technologies, and consequently, it now hopes to bring 10 million rural people under renewable-based, off-grid electrification systems by 2012. If the trend continues, the country would achieve electrification for everyone by 2020. However, since 2006 there have been doubts that the grid-based rural electrification program will achieve its targets.

From a developing country perspective, the majority (64%) of the people who do not have access to electricity live in South Asia and Sub-Saharan Africa (Table 1). Among the major countries that are greatly facing challenges in providing access to electricity, Bangladesh is one of the top-ranked countries in terms of the number of people with and without electricity. In South Asia, 493 million people do not have access to electricity, and Bangladesh is the second largest country after India in terms of the number of people who do not have access to electricity.

The number of people who are gaining access to electricity each year is quite remarkable, but the population growth rates are even higher than the electrification rates in many developing countries. In its new policy scenarios of 2010,[1] the IEA predicts that 1.2 billion people will still lack access to electricity in the year 2030 and most (87%) of them will be living in rural areas. Though the progress of rural electrification is on course, there is still a long way to go and further dedicated efforts are required to provide

[1] The 2010 edition of the world energy outlook sets out three policy scenarios for the year 2035. According to these definitions, the new policy scenario takes into account the broad policy commitments that were already announced in June 2010.

Table 1
Electricity access in selected developing countries, 2009.*Source*: (IEA, 2011).

Country	Electrification rate (%)	Population with electricity (millions)	Population without electricity (millions)	Share of global total population without electricity (%) [a]
Angola	26.2	4.9	13.7	1.04
Burkina Faso	14.6	2.2	12.6	0.961
DR Congo	11.1	7.3	58.7	4.46
Ethiopia	17.0	14.1	68.7	5.22
Kenya	16.1	6.41	33.4	2.54
Nigeria	50.6	78.2	76.4	5.80
Mozambique	11.7	2.7	20.2	1.53
Uganda	9.0	2.8	28.1	2.14
Zambia	18.8	2.4	10.5	0.80
Tanzania	13.9	6.1	37.7	2.86
Sub-Saharan Africa (SSA)				27.34
Bangladesh	41.0	66.5	95.7	7.27
India	75.0	866.5	288.8	21.93
Nepal	43.6	12.8	16.5	1.26
Pakistan	62.4	105.9	63.8	4.85
Afghanistan	15.5	4.4	23.8	1.81
South Asia (SA)				37.11
SSA and SA				64.45

[a] This represents the percentage share of the respective countries from the global total un-electrified population.

electricity coverage to all people within a reasonable amount of time (IEA, 2010; UN, 2010; Winkler et al., 2011).

4. Challenging features of rural electrification (presented in generic form for developing countries, but equally applicable for Bangladesh)

Rural areas are attributed with many characteristics that makes it more challenging to provide electricity to them compared to urban areas (ARE, 2008; Barnes, 2007). Agricultural activities are dominant in rural areas, the ratio of labor to capital is high, and income is on average quite low. Power consumption is also quite low because of the low number of connections per km of power line and the low load per connection. At the same time, the costs per connection and per supplied kW h are significantly higher. Due to poor communication and bad terrain, operation and maintenance are more problematic and costly, and the quality of the power supply is often quite low (Mohan, 1988).

Rural electrification program usually requires some form of subsidy from the government so that program can cope with the high capital cost (ARE, 2011). The subsidy, if not administered properly, causes problems; for instance, it can create opportunities for politicians to intervene, which destroys impartial management practices. The subsidy often makes the program prone to unfair practices for restoring connections that have been cut off due to a lack of payment, to stealing power or other illegal activities, and to people bypassing the criteria for the selection of areas. Also, poorly designed subsidies divert the distribution company from customer services. This causes the rural electrification program to alienate the customer and the compromise the quality of its service (Barnes, 2007).

The idea of right-of-way[2] access also causes problems in rural areas where the overhead lines crisscross croplands, houses, or land reserved for future households. The local community may also seek compensation against the right-of-ways, which is usually not budgeted into rural electrification schemes. The load factor in rural areas is quite low and demand is generally only concentrated at the evening peak times. This requires high peak capacity for the conductors and other equipment, which leads to higher costs. Another challenge in rural electrification has to do with the grid expansion versus off-grid dilemma. Many politicians have a strong preference for extending the national grid irrespective of its viability, while communities with an off-grid electricity supply will continue to aspire for a grid connection (ARE, 2010; Rahman et al., 2013).

Besides the above challenges, some low-lying countries also face a few exceptional challenges. Bangladesh, for example, has almost 800 rivers and tributaries that crisscross and pass through the country. Most of the country's rivers originate in the Himalayas and flow into the Bay of Bengal, and they are characterized by massive land erosion and changing water courses every year. This means that many rural areas face the challenge of removing the grid lines and expanding the grid. The massive river erosion also causes new areas to form, which are called “chars” (islands), through silt deposition within the water course. Although thousands of people may live on the newly formed ‘chars', extending the grid lines to the chars is both unfeasible and impractical.

[2] The idea of “right-of-way” is the right to build the distribution infrastructure across someone's property without expecting any legal challenge in the future.

5. Rural electrification overview of Bangladesh

5.1. Policy on technology options

Bangladesh has been considering two technical options for bringing electricity to rural areas: (i) extending and intensifying the central grid, and (ii) deploying off-grid technologies (in the form of a standalone option or a mini grid). Bangladesh, according to rural electrification policy, has aimed at grid expansion to all areas that are feasible based on presumed techno-economic criteria. Grid expansion in many areas is unfeasible and impractical; therefore, renewable-based, off-grid options are considered as an alternative to the grid in the classified areas. The areas that belong to any one of the following categories are endorsed as classified areas for renewable based off-grid alternatives:

(a) The areas which are isolated from the national grid network.
(b) The areas where electricity supply system does not exist.
(c) The areas where existing electricity supply system is inadequate, and coverage is very low.

Small-scale renewable energy options, such as a solar home system (SHS) and biogas plants, have evolved as promising alternative for providing electricity to these disperse areas (World Bank, 2008b). Other renewable energy options, such as wind energy and hydro power, have little potential to contribute to rural electrification in Bangladesh. Among the renewable technologies, the SHS option has accounted for the major share (80%) of off-grid technologies in Bangladesh (Islam et al., 2006; Mohammad Ziaur, 2012; Rahman and Paatero, 2012; REIN, 2011).

5.2. Institutional overview

5.2.1. Brief institutional overview: On-grid program

Bangladesh started its intensive rural electrification program[3] in 1977 when only 10% of its total population was connected to a

[3] Before 1977, the government-owned Power Development Board (PDB) was the sole organization providing electricity throughout the country, without there being any special emphasis on rural areas. This actually left rural areas very little chance to get access to electricity, and so, given this situation, the country launched the Rural Electrification Program (REP), which exclusively targets rural areas.

grid. The country adopted a rural electric cooperative (REC) concept from the National Rural Electric Cooperative Association (NRECA), which had successfully electrified rural America in the 1930s (NRECA, 2004). To implement the rural electric cooperative concept in Bangladesh, a central statutory agency called the Rural Electrification Board (REB) was formed by the government. The REB was given the responsibility of organizing the rural electric cooperatives (Palli Bidyut Samity, PBS); it employed managers to oversee the financial and administrative activities of the cooperatives (Fig. 1) (NRECA, 2005). The cooperative is a consumer-owned autonomous organization that constructs, operates, and manages its own electricity distribution system in the area under its jurisdiction. Consumers elect a board of directors, which formulates the cooperative's policy and implements the policies through managers. The success of the rural electrification program served a model for other developing countries facing electricity access challenges (Nathan, 2006; NRECA, 2005; Taniguchi and Kaneko, 2009).

5.2.2. Institutional overview: Off-grid program

In Bangladesh, numerous rivers crisscross the country and make grid electrification in many areas nearly impossible. Given this situation, off-grid renewable energy is emerging as a potential alternative to the grid for remote and riverine areas. The government has set up an institution and formulated policies with the aim of bringing electricity to the entire country. The government established the Infrastructure Development Company Limited (IDCOL) in 2002 as an umbrella organization to oversee the overall implementation and operation of renewable energy projects. IDCOL has been working as a market-oriented finance and training facilitator and has implemented and been overseeing the program through 30 Partner Organizations (POs). The POs are mostly non-government organizations (NGOs) and they physically bring the materials and services to the clients' premises. IDCOL arranges the following support services: Selection of POs, preparation of technical specifications for the materials, selection of suppliers, capacity building training for the POs, and monitoring the performance of the POs (Fig. 2).

5.3. Financing policy overview

5.3.1. Financing policy: On-grid program

It is well recognized that a rural electrification program has high start-up costs and therefore requires substantial financial support during its initial years. During this initial period, program organizers need to concentrate on developing the infrastructure without expecting to produce sufficient revenues. Demand

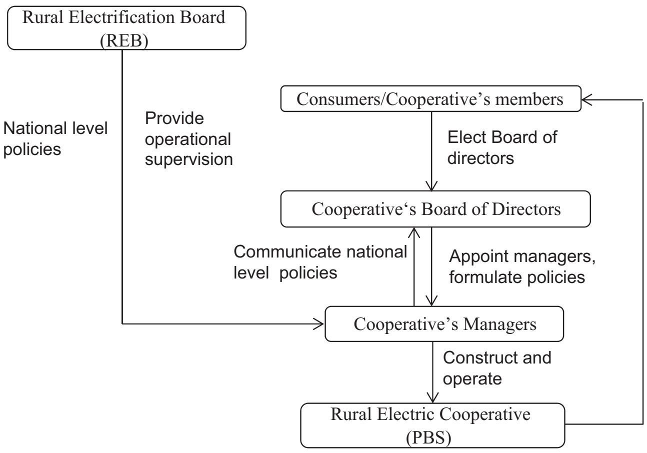

Fig. 1. Institutional framework for grid based rural electrification program.

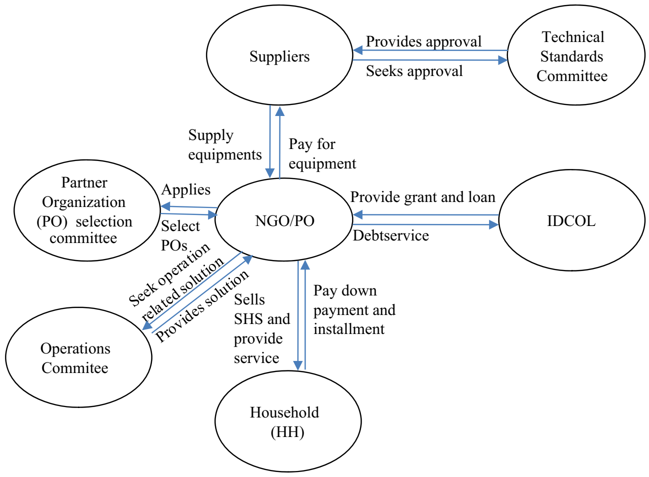

Fig. 2. Institutional framework for off-grid program.

matures slowly, and after a few years of being in this development phase, the program usually begins to generate revenues. The start-up funding for the rural electrification program in Bangladesh has been obtained mainly from two sources-from the government and from development partners. The program did not acquire any remarkable direct subsidies—rather, it received funding with favorable terms and conditions (instead of a subsidy). To channel the funding from donors and the government to the cooperatives, the REB acted as a conduit. Loans are channeled by the government to the REB with a 2% interest rate, which, in turn, channels resources to the cooperatives in the form of materials and services with a 3% interest rate. The loan repayment period for both the REB and the cooperatives is 33 years, with an initial 8-year grace period (Fig. 3). The 8-year grace period aims to gain the cooperatives some form of financial maturity, and thus, to put them in a position to begin repaying the loan.

5.3.2. Financing policy: Off-grid program

The IDCOL receives equity funds from the government, and grants and loans from multiple donor agencies (Fig. 4). The IDCOL provides soft loans (at a 6% interest rate with a 2-year grace period and a 10-year maturity period) to the POs and channels grants to reduce the cost of systems as well as to support the institutional development of the POs (IDCOL, 2011). The customers have to pay 15% of the total cost of the system as a down payment and the POs provide the remaining cost as credit to the customers. The customers have to repay the credited amount to the POs with a 12% service charge in monthly installments. The service charge covers the maintenance of the systems (Urmee et al., 2009).

6. Rural electrification performance in Bangladesh

6.1. Service in place: On-grid mode

This section discusses the progress of on-grid rural electrification to show the extent to which the program has been successful. From its inception, the REB has looked forward to providing electricity to rural Bangladesh by progressively laying distribution lines and other infrastructure components. Of a total 84,323 villages that were selected for grid coverage, 48,682 of them (57.7%) had access to electricity by June 2010 (Fig. 5). The Bangladesh's REP acquired the capability to provide an average of five villages per day with electricity between 1980 and 2010, and the number reached a peak of 9.5 villages per day in the year 2000. Bangladesh's REP constructed 233,367 km of distribution

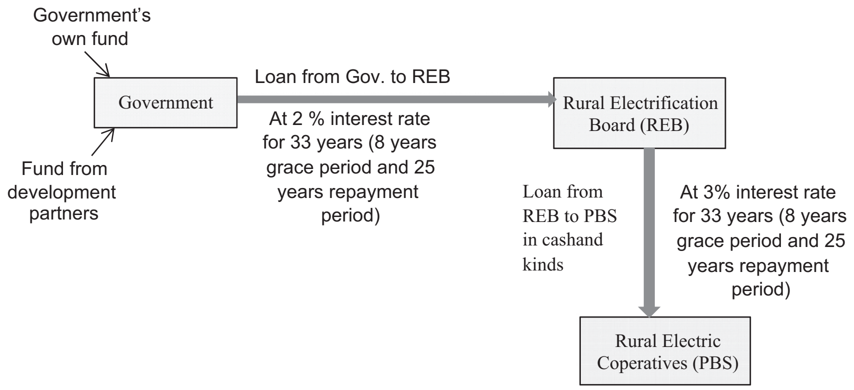

Fig. 3. Financing model for on-grid rural electrification program in Bangladesh (Chowdhury, 2010).

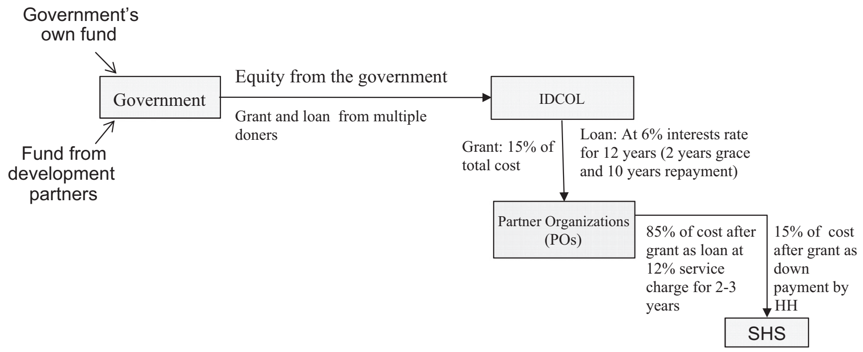

Fig. 4. Financing model for off-grid system.

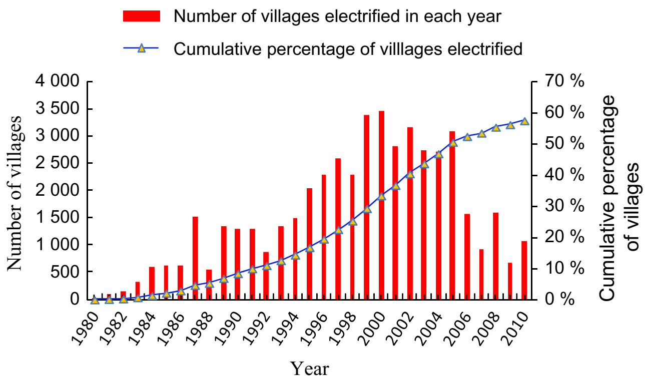

Fig. 5. Yearly village electrification progress, 1980–2010.

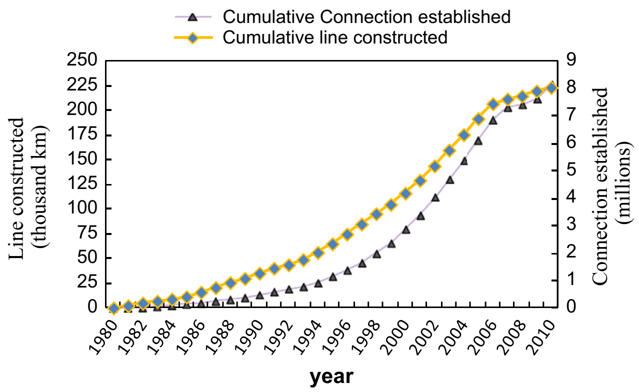

Fig. 6. Cumulative lines constructed and connections established, 1980–2010.

lines and 433 sub-stations (33/11 kV) and it established eight million electric connections. The cumulative progress of the distribution lines and electric connections built between 1980 and 2010 can be seen in Fig. 6. The construction rates for the distribution lines and electric connections totaled 7700 km and 700,000 per year, respectively, in the year 2005. Since 2006, however, the total number of villages receiving electricity and the amount of lines and connections established has been declining every year (Figs. 5 and 6).

6.2. Services in place: Off-grid mode

This section examines the success of off-grid rural electrification in Bangladesh. The major share in off-grid rural electrification has been achieved by building SHSs (Solar Home Systems). Other types of off-grid electricity include a solar photovoltaic mini grid, a bio-digester, a small wind generator, and micro-hydro electricity. Renewable technologies other than SHS have not yet been widely accepted on the market and their contribution to rural electrification has not been remarkable; therefore, this study considers the SHS's performance as part of the overall progress of off-grid rural electrification. The IDCOL

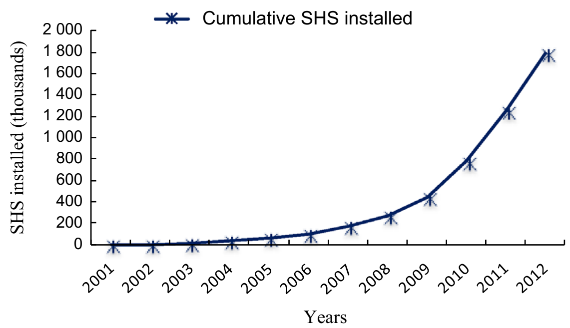

Fig. 7. SHS installation progress under IDCOL, 2001–2009.

has been strongly promoting the dissemination of SHS since 2003. The IDCOL initially proposed to install 50,000 SHSs by June 2008: it achieved the target in 2005, 3 years ahead of schedule. From then on, the IDCOL continuously installing SHSs at an accelerated pace, and it reached an installation rate of 40,000 SHSs per month in 2011. The IDCOL aims to install five million SHSs by the year 2015; it had already installed one million SHSs by December 2011. The cumulative progress of IDCOL's SHS program is presented in Fig. 7. The SHS program can be considered quite successful in terms of its growth rate and volume.

6.2.1. Performance in terms of load growth

This section explores the difficulty posed by the load characteristics of Bangladesh's rural electrification program. Bangladesh's REP connection data shows that the majority (86%) of the connections are households, which account for less energy consumption than industrial and commercial connections. The annual load served per km of rural line is 43 MW h, which is several times smaller than that of the average demand of lines serving urban areas (Fig. 8). Moreover, the household connections account for only 51% of the annual consumption, whereas the industrial connections (only 1.7% in total) account for 28.79% of the load consumed (Fig. 9).

7. Factors contributing to success

7.1. Success factors: On-grid

The growth of this program has been remarkable and Figs. 5 and 6 show that the BREP as in a healthy position in terms of its progress until 2006. The key factors that contribute to the success of BREP are discussed below.

7.1.1. Prioritized system investment

Maintaining a priority to extend distribution lines is one of the challenges for a rural electrification program. Local areas that would appear to produce better revenues should be given priority for the financial viability of the program. Every year, sections of distribution line are built because of political motives and not justified on the grounds of revenue. This misallocation has been kept low by adopting a master-planning system, which governs system expansion. Master planning is a clearly defined prioritizing process for line expansion on the basis of anticipated revenue generation. By sticking with this priority model, BREP has been able to expand the distribution lines without undermining revenue preferences. Though political pressure has influenced the selection of some projects, some of which have eventually resulted in poor performance, nevertheless it has not caused major damage to the implementation of the overall program.

7.1.2. Community involvement

Community participation has been an important factor contributing to the success of rural electrification. Every electricity user is a member of a rural cooperative and has the right to be involved in the decision-making and policy-making practices of the cooperative through their elected representatives, which are called directors. This membership practice gives the electricity users a feeling of ownership in the cooperative and encourages them to protect the assets from thieves and abuse. Electricity users have been educated by arranging village meetings and training programs about their responsibilities and the limitations of the power system. Meetings with community leaders are also held to disseminate information on the key rights and responsibilities of the elected directors. Rural industries, farming groups, and

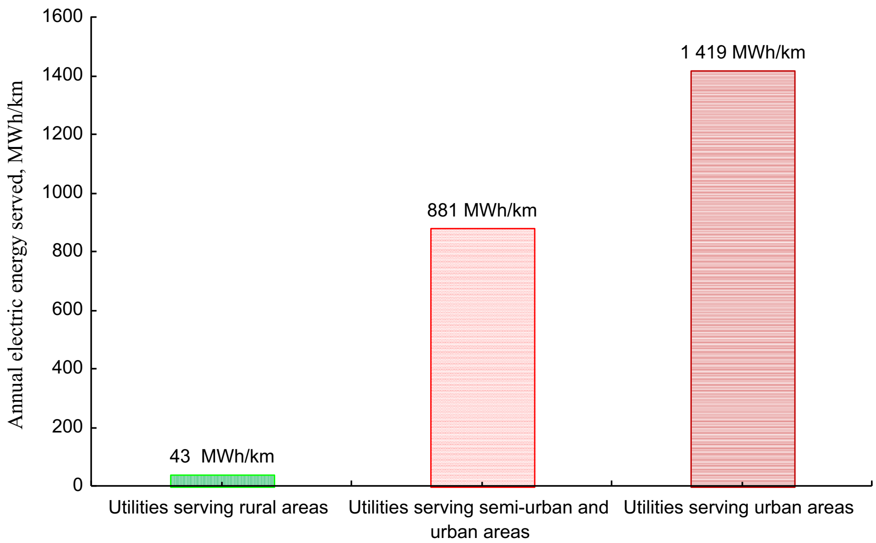

Fig. 8. Annual electricity served by utilities working in rural, semi-urban, and urban areas of Bangladesh.

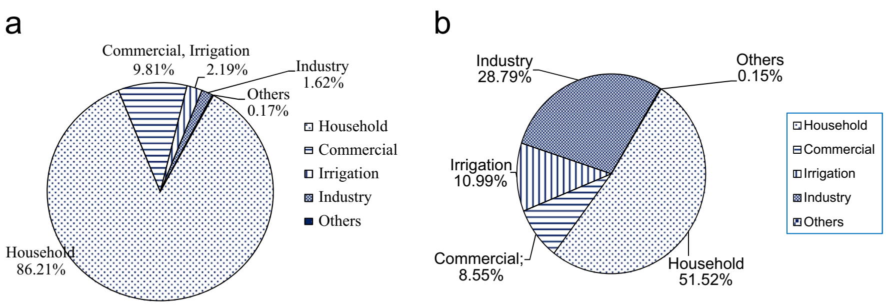

Fig. 9. Category wise (a) percentage of connection and (b) percentage of load consumption in BREP, 2010.

commercial leaders are also invited to the meetings to ensure that their interests are not ignored. House-wiring technicians are also selected from the local community so that they are easily available and trusted; this also helps reduce their wiring cost.

The village advisors (those selected from the local community) meet periodically with members to share views on how cooperative management can most effectively address customer concerns. Cooperative management also arranges communication between them and their members through meetings with focus groups (who are assigned to advise them on specific problems, such as load shedding and power quality).

7.1.3. Anti-corruption features

Anti-corruption features are another successful tool of Bangladesh's rural electrification program. Meter reading and bill collection are the major areas where there is the chance for corruption and for people trying to undermine the success of the electricity distribution systems (Nathan, 2006). The anti-corruption mechanism is equipped with selection, training, job contract, and cross-checking processes for meter reading and billing operations. Meter readers are carefully selected and trained before being put on a master roll contract by cooperatives. Meter readers are employed for a fixed-term contract, and after that they are barred from employment by the same cooperative. The service areas for each meter reader must be changed every 6 months.

The meter reader's reports are entered by billing assistants into a system and they are used to prepare the electric bills. The billing supervisors prepare a meter report register and cross-check the entry made by the billing assistants. The meter reader's reports are also cross-checked by the bill deliverers, who deliver the monthly bills. The number of bills and the kW h recorded in the electric bills must agree with the number of accounts read and the kW h posted on the meter book control sheet (Nathan, 2006).

7.1.4. Performance based incentives

In order to improve the technical, operational, and financial efficiencies and the quality of the services, a performance measure tool is introduced in the cooperatives. The tool is called the Performance Target Agreement (PTA), which consists of clearly stated set of goals. The agreement is also meant to guide the cooperatives to become more self-sufficient and to provide better customer services. As a reward for reaching the targets, employees of the cooperatives get a bonus. Cooperatives that fail to achieve the target have to face financial penalties. The PTAs are set by considering the overall status of the cooperatives. The PTA contains parameters that measure financial performance as well as technical and operational competencies.

7.1.5. System loss monitoring

System loss monitoring is another important feature enacted to improve the cooperative's technical performance. This measure enables the cooperative to make individual employees liable for the losses incurred at sub-stations, feeders, or line sections. The managers of the cooperatives are required to visit the meters on a regular basis and take readings from the substation power meters. All meters for industrial and other large-scale consumers must be read within 3 days of the substation reading. In addition to the substation meters, the cooperatives must place meters at all feeder outgoings and at intermediate positions for long feeders. These readings make it possible to monitor system losses and make the managers more accountable for carrying out their responsibilities.

7.1.6. Disconnection for nonpayment (DNP)

Payments and bills are quickly reconciled by billing systems. Meters are to be disconnected after 2 months of nonpayment. The finance section of the cooperative prepares account lists for those who need to be disconnected. The disconnection teams promptly carried out the disconnection. To restore the service after disconnection, the charges along with all unpaid bills have to be paid (Nathan, 2006).

7.1.7. Centralized supervision, decentralized operations

The BREP is characterized by centralized planning, design, and construction and decentralized operational responsibility. Centralized supervision enables the REB to monitor and evaluate the cooperatives' performance using standardized and objective tools. Decentralized operational responsibility through the cooperatives ensures that the right personnel are empowered to make day-to-day operational decisions (Barnes, 2007).

7.1.8. Standardized procedures and practices

The REB has introduced a series of instructions on planning, engineering, administrative, and business procedures. They have consistently been put into practice throughout the entire program, covering all aspects of the development and operations of the electricity distribution system. Standardization ensures the quality of the operations and accelerates their growth, while giving operation engineers the opportunity to share technical resources (NRECA, 2005).

7.1.9. Exclusion of political parties

To be an eligible candidate for being a representative in a cooperative (e.g., a director), one must not be an office bearer in any political party. This requirement has helped isolate the rural electrification cooperatives from general politics. This feature enables them to focus on economic, commercial, and technical criteria for determining new connections and limits the scope for political intervention (Nathan, 2006).

7.1.10. Prohibition of unions (CBA), and hiring and firing

A law prohibits unions (although staff welfare organizations exist) from becoming involved in cooperatives. Unions involved in many other organizations in Bangladesh have the painful history of diminishing the performance of those organizations and offering shelter for corrupt staff and practices. This factor prompted rural cooperatives to offer no mercy for wrongdoers or bad practices and instead to encourage good performance. The message “perform or be fired” sets the standard that employees must work hard and abide by the cooperative's principles.

7.2. Success factors: Off-grid

Off-grid rural electrification in the Bangladesh case includes some key factors that help to enhance the program's success; these factors are highlighted below.

7.2.1. Ownership

Renewable-based electrification systems are often in theory owned by the initial funding agencies, but in point of fact they are owned by the end users. This type of confused ownership arrangement can swiftly lead to people taking shortcuts on operational practices and long-term maintenance work (ARE, 2008). The private ownership practice of the systems reduces maintenance cost, overcomes the chances for tampering with the system, reduces overuse, and maximizes benefits (Asif and Barua, 2011; Urmee and Harries, 2011; Urmee et al., 2009).

7.2.2. Internalize social benefit

Renewable energy technology is still perceived as a high-cost option, and therefore private investment is limited. This is because of the fact that the social and environmental costs of conventional energy are not weighed in comparison to renewable energy technology. An appropriate support framework, which can internalize the social and environmental benefits of renewable energy sources, will enhance the renewable technology business (ARE, 2008; Mohammad Ziaur, 2012).

7.2.3. Institutional framework for sound financial management

A supportive institutional framework is necessary for ensuring a speedy fund flow from donors and the government to the implementing agencies, the efficient signing of agreements, proper supervision, and the accountability of the parties. It is essential to introduce fund flow tracking and a loan recovery monitoring mechanism to enhance the financial gains (World Bank, 2010a). Obtaining physical verification for the materials before opening up the fund to POs (participating organizations) and close inspections and monitoring of the delivered equipment can decrease misappropriation.

7.2.4. Affordable and customer-friendly size and design

Designing the system according to public needs is essential. This practice increases system reliability and the life of the system, and it also increases the number of users that are able to purchase or pay for the systems (Urmee and Harries, 2011; Urmee et al., 2009).

7.2.5. Innovative financing mechanism

Having an innovative financing mechanism and smart subsidies will improve the affordability of the systems for users and help scale up the program. The subsidies need to be structured in such a way that they will assist low-income households in affording the systems, but at the same time all users should contribute to the systems (Mondal et al., 2010; Asif and Barua, 2011; Urmee and Harries, 2011; Urmee et al., 2009).

7.2.6. Donor satisfaction

The extent to which international investors distrust developing countries remains a challenge that needs to be overcome. Donor satisfaction with the renewable energy program will attract more investment and thereby be a way of overcoming the shortage of funding (ARE, 2008; World Bank, 2010a).

7.2.7. Standardization of equipment and availability of spare parts

It is necessary to standardize equipment and spare parts so that unreliable and inferior equipment does not enter the systems. Supplying proper spare parts should be an integral part of the renewable dissemination program, one that will help make the program sustainable (ARE, 2008).

8. Factors hampering the success of the on-grid program in recent times

Once a successful example of rural electrification, since 2006 the performance of the Bangladesh rural electrification program has been deteriorating. The issues accounting for the program's deteriorating performance have been outlined in various studies (Barnes, 2007; Nathan, 2006; Taniguchi and Kaneko, 2009; World Bank, 2010a). The major issues include institutional weakness, power supply shortages, unrealistic power tariffs, and a shortage of funding.

8.1. Institutional issues

The institutional issues are the major reason for the program's deterioration and they even enhance the other issues, too. The NRECA International, previously a vocal supporter of the program, is now critical of this system and is suggesting institutional reforms that will promote increased autonomy or result in privatization. According to the association, the main factors accounting for the setback are that the institutional structure makes the cooperatives unfit to defy political influence and maintain autonomy for the REP. Due to the institutional issues, major donors are reluctant to provide funding for this program until a credible reform has been made (World Bank, 2010a). Bangladesh's REP has been enjoying a certain measure of autonomy by making the cooperative the operational unit, but is has failed to defend the cooperative from political pressure in many ways, such as by allowing it to defy master planning, to refuse to purchase nonstandard materials, and to refuse to protect thieves and stamp out corruption.

8.2. Power supply shortages

Bangladesh lacks the capacity for sufficient electricity generation, and thus there has been a huge gap between demand and supply. Although only 35% of the rural population is connected to the grid, the demand is still largely unmet due to supply shortages. During the summertime, the total peak demand usually remains at around 2500 MW, whereas the grid can only supply around 1200 MW (Fig. 10). Rural clients in Bangladesh face a huge amount of load shedding within the range of 10–18 h a day during the hot summer days due to national-level power generation shortages. Whereas at one time rural people had been quite supportive of the rural electrification program and had helped it to successfully overcome many challenges, the load shedding issue has made many of them reluctant to support it any longer. Vigorous load shedding also results in other problems, such as (i) decreases in the collection rates, (ii) increases in power theft, (iii) lower staff morale, (iv) decreasing public interest, and (v) a diminished reputation for the program. The power shortage problems are one of the main causes jeopardizing the progress of Bangladesh's rural electrification program (World Bank, 2010a).

8.3. Unrealistic power tariffs

The BREP purchases power from the Bangladesh Power Development Board (BPDB) to serve its rural clients. The BREP enjoys

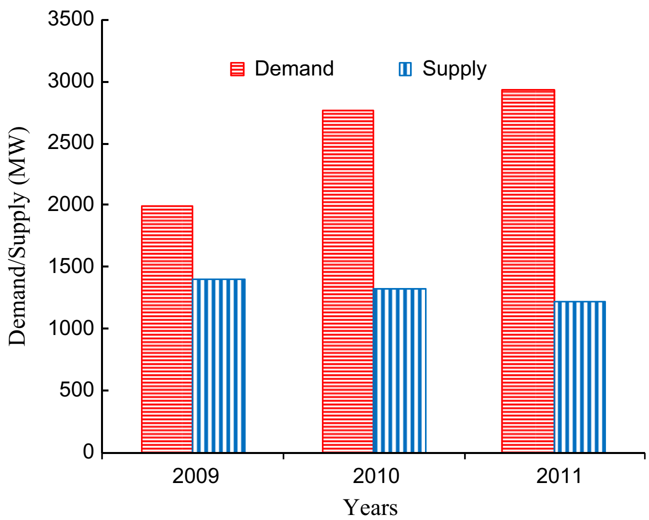

Fig. 10. Demand and supply for BREP's clients, 2009–2011.

preferential bulk power tariffs while purchasing power from the BPDB because of governmental tariff regulation. The BREP has negotiated a system price of US$ 0.039 from the BPDB, while the BPDB's true supply cost remains at US$ 0.038 (BPDB, 2010). The selling tariffs for the BREP are also regulated by the government. Different cooperatives under the BREP enjoy different selling tariffs according to their load condition and geographic disparity. The selling tariffs are guided by a constitutional mandate to promote rural economic development by encouraging agriculture and industrial production, and to provide electricity access to as many rural households as possible. The tariffs for each load category are set in such a way that, on the one hand, mass numbers of people can afford the price and, on the other hand, cooperatives can gain financial strength through expanding their services to industrial and commercial clients (NRECA, 2005). Considering the affordability of the tariffs, the tariffs for the domestic loads are artificially low. The higher percentages of domestic loads with a low price prevent the BREP from achieving financial stability. With the current tariffs schedule, the BREP incurred huge losses in 2010, which amounted to US$179 million in a single year (Table 2). Moreover, if the BREP has to buy bulk power from the BPDB at more realistic prices, the program will face further financial losses. The BREP proposed a new tariffs schedule to the government that would be effective for cooperatives aiming to prevent such financial losses. According to the proposed tariffs (Fig. 11), the maximum increase (43%) will stem from residential connections, which will to some extent affect their affordability for poor rural households.

However, studies have found that if the electricity price increased according to the new schedule, the households would still not be spending that much more money than they would for kerosene for lighting. Several studies of rural households have found that each household without electricity on average spends $2.85 to $5 US per month for lighting (Asaduzzaman et al., 2010; Komatsu et al., 2011; Urmee and Harries, 2011). The average household's electricity consumption in Bangladesh per month is 64 kW h, which corresponds to $3.5 US per month with proposed tariffs settings.

Table 2
Costs and revenues against current and proposed tariffs setting, 2010.*Source*: (BERC, 2011).

Components	Amount (million US$)
Distribution cost (a)	35.9
Consumer sales expenses (b)	40.6
Administrative costs (c)	34.9
Taxes (d)	2.6
Depreciation (e)	67.1
Interest for long term loan (f)	47.0
Power purchase cost (g)	467.4
Total costs (h)=(a+b+c+d+e+f+g)	695.5
Revenue at present tariffs (i)	516.6
Revenues at proposed tariffs (j)	687.3
Financial loss has to incur at present tariffs (k)=(h–i)	179.0
Financial loss has to incur at proposed tariffs (l)=(h–j)	8.2

Note: 1US$=70 BDT (Bangladesh Taka), 2010.

8.4. *Shortage of funding*

Rural electrification in Bangladesh is primarily supported by donor agencies. Of a total US$ 2470 million in investments, US$ 1338 million has been acquired from international donor agencies. The International Development Association (IDA) is the key investor: by 2006, it had provided US$ 413 million. However, the IDA suspended its support in 2006 due to institutional reforms issues (World Bank, 2010a). Other major donor agencies are also reluctant to provide funding for the on-grid rural electrification program (REB, 2012). As the development budget is hugely dependent on donors' loans, the donors' reluctance to invest in the program has meant that the annual budget has been cut, slowing growth.

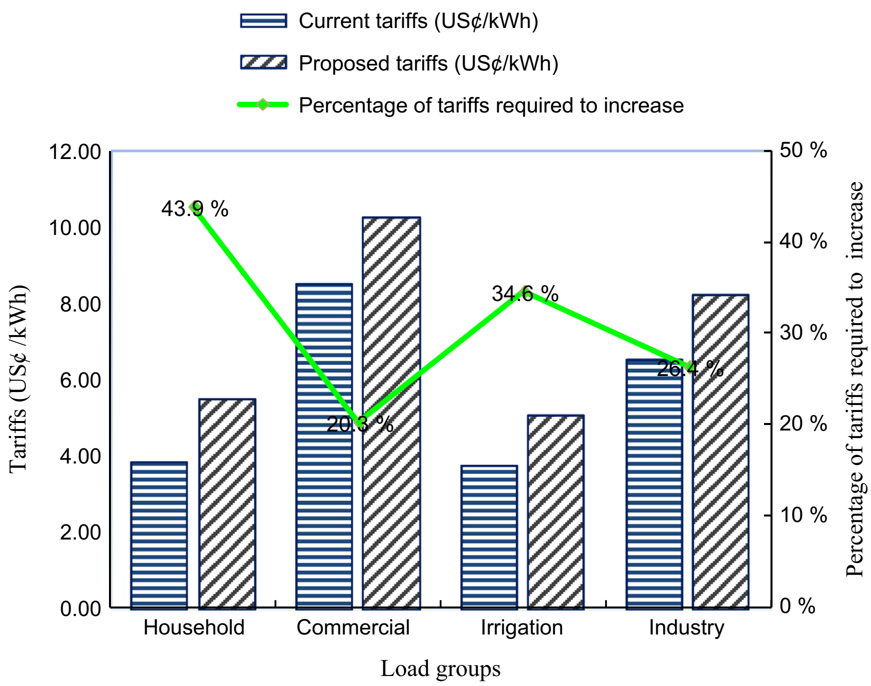

Fig. 11. Current and proposed tariffs for different load groups, 2010.

Table 3
Example of some successful countries that tackled the few issues.*Source*: (Barnes, 2007).

Issues	Countries						
	Costa Rica	Philippines	Thailand	Mexico	Tunisia	Chile	China
Organizational	Private companies	USA REC's Cooperatives model	USA REC's Cooperatives model	Public company assign to rural areas	Decentralized municipal and community based utilities	Government and private agencies	Private utilities
Realistic tariffs	Tariffs are charged based on full recovery of the costs	Tariffs are charged based on full recovery of subsidized costs	National tariffs based on costs recovery	Tariffs based on subsidized costs	Tariffs are charged based on subsidized full costs	Tariffs based on full costs recovery	Tariffs based on costs recovery
Private funding	Yes	Yes	No	Yes	No	Yes	Yes

9. Suggested measures for overcoming the current setbacks to the on-grid program

Successful rural electrification is a dynamic process where the nature of problems changes over the course of time. Some solutions employed in the early stages of the Bangladesh rural electrification program later turned into problems. The recommended actions for tackling the current setbacks are summarized below. These same issues have been successfully handled in other developing countries (Table 3).

9.1. More autonomy or privatization

Private participation together with competition and the providing of incentives can result in cost efficiency, lower prices, reduced system losses, and improved revenue collection for the utilities (Jamasb, 2006). Community participation and some degree of autonomy have been embedded in Bangladesh's REP through the formation of cooperatives; however, the partial autonomy of the cooperatives has not succeeded in bypassing the political influence (Nathan, 2006). Bangladesh's REP is often under strong political influence, meaning, for example, that new electric lines need to be constructed in areas of interest to the politicians irrespective of predetermined master plans (Taniguchi and Kaneko, 2009). The privatization of these cooperatives can bring more autonomy and the ability to defy external interference. The private and cooperative utilities in countries like China and Chile have been highly successful in electrifying both their urban and rural areas. In these two countries, subsidies were not used as a tool for political influence; rather, they have been used successfully as incentives for the private sector to promote electrification in rural areas (Barnes and Foley, 2004; Jamasb, 2006).

9.2. Funding from the connection seekers

The international community prefers to support the renewable-based rural electrification program overly much (UNCTAD, 2010). Many developing countries are also experiencing a lack of funding from international and private sources (Jamasb, 2006). The REP should be capable of finding funds from its own sources for long-term financial sustainability. The connection density and load growth in Bangladesh have increased to such an extent that the revenue versus cost ratio is attractive if the tariffs would be set at a realistic level. Private funding is already in the works to a limited degree in the form of “deposit-work.” Under the deposit-work option, an interested individual or party can get connected by paying the full costs and by fulfilling the minimum revenue criteria (REB, 2011). This policy can be expanded in the annual development plan and a major portion of the funding can be sought from interested connection seekers. The rural electrification program in Costa Rica successfully incorporated connection seekers' funding into their financial budget (Barnes and Foley, 2004).

9.3. Realistic tariffs

Rural electrification is only accessible where there is already a demand for electricity or where a demand will be created once a power supply has been secured. In the absence of grid electricity, the current load or prospective load causes people to spend money on such things as kerosene, LPG, or dry cell batteries; all of these options are expensive in comparison to the per unit price of the electricity that is supplied. Therefore, rural electrification tariffs set at a realistic level would not prevent people from staying within their energy budget and they would provide improved services. Charging the right prices sends a positive signal to the participant company and makes it possible for them to provide electricity in an effective, reliable, and sustainable manner to an increasing number of satisfied consumers (Jamasb, 2006). In Costa Rica, however, the price of electricity is set by means of a regulatory process: the price is high enough for the cooperatives to make a modest profit (Barnes and Foley, 2004). Surveys done in regions without electricity indicate that there is a willingness to pay for electricity, and in some cases, rural people are already spending as much as US $5 per month on other energy sources (World Bank, 2010b). Setting realistic tariffs will mean that Bangladesh's REP will receive its main source of revenues from clients rather than from donor funding.

9.4. Renewable energy to reduce grid dependency

Expanding the mini grid with renewable-energy based distributed generation and standalone renewable energy are the most viable alternatives to the grid in many remote and isolated areas (Mondal and Islam, 2011). A certain amount of the Bangladesh's geography is not suitable for grid expansion (World Bank, 2010a). The BREP, though, has already launched an SHS and battery charging program; it may also incorporate renewable energy sources into the grid or mini-grid to reduce the burden on conventional power generation. The country already benefitted from a hugely successful off-grid SHS program, however, the lending term is somehow beyond the affordability of many poor households. The off-grid SHS program of Bangladesh permits only 2–3 years period to pay back the full cost of the system in a monthly installment. For example, a modest size SHS (20 W) costs 110 US$, every month the client has to repay 5 US$ for a period of 2 years which is beyond the affordability of many rural households. The economic life of the major component of off-grid technologies (e.g. PV panel) is more than 20 years. If the costs are spread out over a period of around 20 years, more rural residents can afford and further speed up the dissemination the off-grid system (Asaduzzaman et al., 2010).

10. Conclusions

Among the major developing countries who are facing electricity access challenges, Bangladesh is one of the top-ranked countries in terms of the number of people with and without electricity. The country started an intensive rural electrification program in 1977 when only 10% of its total population was connected to the grid. Since the program was initiated, it has brought large number of rural villages under electric coverage and constructed huge amounts of distribution lines every year. The program reached a construction capacity of 7700 km of distribution lines and installed 700,000 connections per year in 2005. Bangladesh's REP connection data shows that the majority (86%) of the connections are households, which account for smaller energy consumption compared with industrial and commercial connections. The higher percentage of household load at an artificial low price was one of the major reasons for the program's financial incompetence.

The IDCOL, the overseer of the renewable-based, off-grid program, continuously installs SHSs at an accelerated pace, and it reached a capacity of 40,000 SHS installations per month in 2011. The SHS program in Bangladesh has been one of the most successful cases in terms of its growth rate and volume. However, the country is experiencing continuously declining numbers for the on-grid rural electrification program in terms of the number of villages electrified, the total km of lines installed and the number of connections established after 2005. Thus, it is clear that the on-grid mode of BREP had been performing quite well until 2006; later, the same began to decline in performance.

Community involvement, anti-corruption features, standardized practices, and the banning of bargain agents are the notable positive factors that have proved worthwhile; other countries can certainly learn from them. The major factors for the deterioration of the program were found in the form of institutional weaknesses, power supply shortages, unrealistic power tariffs, and a shortage of funding. By deriving lessons from other successful cases, we suggest that institutional reform, private funding, realistic tariffs setting, and renewable-based supplemental power can potentially resolve the current setbacks. Other countries can seek lessons from the factors that accounted for the success of the program and that are still an effective part of Bangladesh's rural electrification program. However, Bangladesh, for its part, should keep the winning features intact and concurrently update its policies and strategies to tackle the present issues so that it can bring the derailed on-grid electrification program back on track.

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