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Disseminating Renewable Energy Products in Bangladesh: Implications of Solar Home System Adoption in Rural Households

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Abstract

The electricity sector of Bangladesh suffers from acute problems in terms of insufficient power generation and a lack of distribution infrastructure. In this context, the present study explores the renewable energy interventions to promote rural electrification through Solar Home Systems. By conducting key informant interviews and filed observations, this paper sheds light on the distribution of Solar Home Systems in rural households, most of which have been installed through micro-finance schemes provided the by Government and Non-government organizations. In addition to this, the paper also calls for research attention on the fact that even though the SHS program is commercially viable and socially acceptable, there exits some technical and managerial constraints which should be brought under attention of the policy makers and stakeholder institutions for ensuring the advancement of SHS usage in the rural market. With this backdrop, the research adds value to the present literature in the field of improving rural electrification.

Key Words: Renewable Energy Technology, Solar Home System, Microfinance, Rural Electrification, Rural Households.

1. Introduction

Lack of access to electricity is a major obstacle to development, especially in rural areas of developing nations. The richest 20% of the world's population consume 58% of total energy, while the poorest 20% consume less than 4% and the majority of those underserved are the poor in Sub-Saharan Africa and South Asia (MAH Mondal, 2010). Bangladesh, a South Asian country, is no exception from this situation where despite the rapid economic growth (more than 6 percent growth in GDP), the overall prevalence of electrification for households is 60 percent for the nation but much lower for rural areas at only 42.5 percent (BBS, 2012). The resulting electricity shortages are expected to impede sustainable economic growth and are considered urgent issues in Bangladesh's energy sector. Hence, rural electrification is an essential concern for making the development process inclusive and sustainable (Islam M.S. et al., 2012). Consequently, several developing countries are implementing various policies for promoting research, development, demonstration, deployment and commercialization of new and renewable sources of energy (Pode, 2013).

As electrification in rural Bangladesh has lagged behind than in urban areas, the country has been experiencing a gradual shift towards exploring renewable energy resources as a driving force to meet the unprecedented energy demand (Hasanuzzaman M. et al., 2015). Bangladesh is a subtropical country with an average daily solar radiation of 4–6.5 kW h m−2, with highest amount in April and lowest amount in December (Hossain M. F. et al., 2017). It is found that 94% of the land area in Bangladesh has such radiation which is sufficient for appropriate utilization based on available renewable energy technology (RET) like Solar Home System (SHS) (Mondal & Denich, 2010). Solar Home Systems are small photovoltaic systems that transform solar energy into electricity, which does not require any kind of conventional fuels. The major components of SHS are solar panels, batteries, charge controllers, and some electric appliances (e.g., lamps, small fans, or televisions) which can be operated with minimum training (Rabbani & Ahsan, 2012).

SHS programs have been implemented in the country by the state-owned Infrastructure Development Company Limited (IDCOL) established in 1997 by the Government of Bangladesh. IDCOL operates the SHS program with 56 Partner Organizations (PO), mostly NGOs like Grameen Shakti, Rural Services Foundation, BRAC Foundation, Bengal Solar etc. (IDCOL 2017). The POs utilize their expertise in micro-finance to have greater reach in the rural community for making renewable energy

applications affordable to the users. Thus, supply of electricity and its affordability can be significantly improved if people in rural communities are provided with financial services to purchase the solar energy technologies to cater their household and commercial needs (Morris Ellen et al., 2007).

The lessons derived from different demonstrations of RET projects, particularly, Solar Home System (SHS) programs reveal that with vigilant frontward planning, renewable energy can provide far-reaching economic, environmental, and social benefits to people living in remote rural areas in Bangladesh (Sovacool and Drupady, 2011). However, there exists a substantial research and policy making gap to determine the mass distribution and commercialization of solar electrification. Despite the significant potential of RET, Lack of technical know-how, awareness, financial constraints and stakeholder collaboration are the barriers for sustainability of SHS in the rural areas of Bangladesh. Therefore, this paper aims to shed light on the financing the access to RET for accelerating the distribution of SHS in rural Bangladesh (Mondal M.A.H, 2010)

The next sections of the paper are organized as follows: Section two presents the problem statement of the study, section three comprises of the research methodology. Section four presents review of related literature on the topic and subtopics of the study. Section five explores the SHS dissemination process and resulting implications. Section six contains the prevailing challenges and a proposed framework on stakeholder collaboration for accelerating RE usage in rural Bangladesh. Lastly, conclusion and forward research from this study have been highlighted in section seven followed by list of reviewed papers for this research.

2. Research Context

In Bangladesh, about 80% of the population lives in rural areas. Data from the Household Income and Expenditure Survey revealed that 44% of the rural population was classified as poor and a vast majority of them remain without connection to the national electricity grid (BBS, 2012). The substantial number of rural citizens without access to electricity is one of the primary challenges in the socio-economic development of the country (Khan and Mahmood, 2009). From the perspective of resource endowments and user acceptance, solar PV energy is the most viable electrification option in the country relative to the other renewable energy sources (Islam and Rahman, 2006). However, at present, renewable energy remains a small portion, 2.70%

(installed RE generation capacity is currently 419 MW) of Bangladesh's electricity generation portfolio (SREDA, 2016).

Nevertheless, rural electrification in Bangladesh through SHS is receiving attention among the researchers as well as policy makers by yielding positive outcomes, including improvements in quality of life, increasing income and employment opportunities (Sovakool and Drupady, 2011). In this regard, the study makes an attempt to explore the proliferation of RET and calls for attention on multi-lateral collaborations among the stakeholders in the sector.

With this background, the study calls for research attention on the following issues:

- Current state of rural electrification by using SHS
- The microfinance interventions for disseminating SHS in the target market
- The need for multilateral collaboration for the sustaining the growth of RE industry.

3. Research Methodology:

To explore the implementation of SHS programs in rural communities, this study is characterized as qualitative in nature. The primary data has been collected by field observations and key informant interviews (KII). The location for field observation was the villages of Maona and Fulbaria from Gazipur District in the month of July 2017. From the perspective of this study, visiting the study locations include observing the rural communities using SHS to comprehend the benefits and constraints of renewable energy adoption. In this regard, extensive field notes have been taken which were subsequently coded and analyzed to address the research objectives.

The KII had been conducted from August to September, 2017 with the participants mentioned in Table 1 (along with the topics of investigation during the interview sessions). These topics for interviewing the respondents were designed based on the insights gathered from field observations and scrutinizing the research objectives and findings from the pertinent literature (Hossain M. F. et al., 2017, Sovacool and Drupady, 2011). The information and viewpoints derived from the interviews were recorded and analyzed based on the research aims and objectives, to comprehend the implications of solar electrification in rural households.

Table 1: Participants & discussion topics in Key informant Interview

Participants in KII	Topics of investigation
• Renewable Energy Program Managers of Grameen Shakti • Solar energy technicians and officials of regional branch (Maona, Gazipur), Grameen Shakti. • Renewable Energy Consultant from private sectors in Bangladesh • Advisor for Sustainable Energy for Development (SED) Programme, GIZ	• Overview on RE program in Bangladesh • Dissemination of SHS in rural communities • Microfinance schemes for addressing the affordability of SHS installation • Challenges in promoting solar electrification

4. Literature Review:

4.1 Renewable Energy

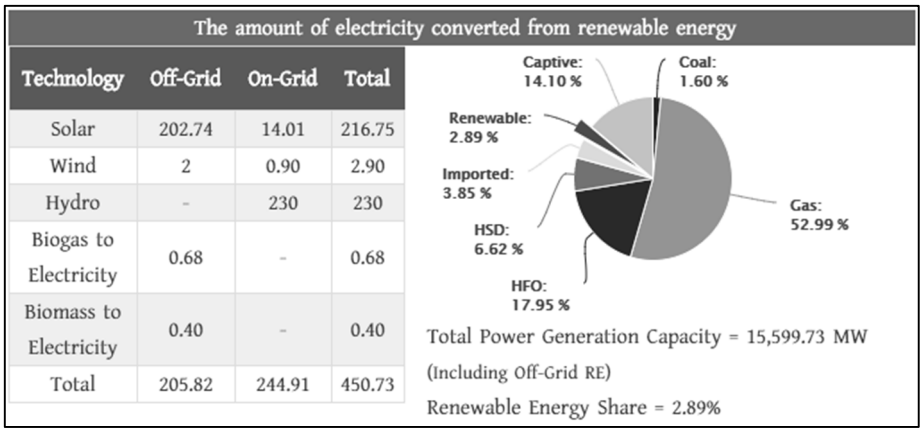
Two of the most significant challenges prevailing in Bangladesh energy sector are provision of electricity access to the rural population and improving energy security. Diffusion of RE along with the mainstream energy mix could potentially address both these challenges (Rahman M.S.et al., 2013). Renewable energy sources are known as those that are ample in nature and derived from natural process with no depletion in the course of utilization (*Ellabban O. et al., 2014*).

In Bangladesh, the potential renewable source of energies that are obtainable include the solar, biogas, hydropower and wind which can be harnessed to deliver an environmentally sustainable energy security to the off-grid rural areas of the country (Islam M.T. et al., 2014). As per the renewable energy (RE) statistics 2015, reported by International Renewable Energy Agency, more than half of all new electricity capacity installed worldwide, was renewable. Globally, there are an estimated 7.7 million jobs linked with the renewable energy industries, with solar energy being the largest employer in the renewable sector (IRENA, 2017).

4.2 The potential of Solar Energy

Technology that is widely used to harness solar energy potential is commonly known as photovoltaic (PV). The word "photovoltaic" can be divided into two parts: "photo" and "voltaic." The term "photo" comes from the Greek word for light, whereas a "volt" is a unit of measure for electric current. Thus

"photovoltaic" literally means "electricity from light." That is exactly what the word describes: capturing solar energy in the form of light and transforming it into electricity (Michel Carrara, 2017). In PV system, solar cells transform light energy into electric current that has been illustrated in figure 2.



The amount of electricity converted from renewable energy

Technology	Off-Grid	On-Grid	Total
Solar	202.74	14.01	216.75
Wind	2	0.90	2.90
Hydro	-	230	230
Biogas to Electricity	0.68	-	0.68
Biomass to Electricity	0.40	-	0.40
Total	205.82	244.91	450.73

Figure 1: Current scenario of renewable energy and energy efficiency in Bangladesh (SREDA 2017)

Several researches have been conducted by the academicians, researchers and industry experts on the prevailing energy scenario and scope of the renewable energy sources in Bangladesh (Islam M.T. et al., 2014; Rahman M.S. et al., 2013; Ullah M.H. et al., 2012; Islam M.R. et al., 2008). As illustrated in these studies, utilizing the solar PV technology, SHS achieved remarkable success in off-grid power generation for domestic and commercial purposes at rural and remote areas of the country (Ahammed & Taufiq, 2008; Hossain M.F. et al., 2017). Hence, the growth of solar energy industry has significant long-term benefits as it improves country's energy security and contributes in sustainable development (Khan and Arsalan, 2016).

4.3 The implications of solar home system in Rural Development

A growing body of research studies in the field of renewable energy paid attention on the SHS impact assessment in promoting rural electrification. From the background of development studies, researchers well documented the relationship between the improvement of energy services and socio-economic development. These literature identified the benefits derived from

SHS by highlighting the reduction in monthly energy expenditures, better health conditions, access to information, increased business and household productivity, thus accelerating the usage of RET (Ahammed and Taufiq, 2008; Kurschner E. et al., 2009; Sovacool and Drupady, 2011; Momotaz and Karim, 2012; Komatsu et al., 2013; Asaduzzaman et al., 2013; Das D., 2013; Azimoh et al., 2015; Mishra and Behera, 2016). Along with these findings, the current status of SHS installation across the country acknowledges that the adoption of RET usually gives favorable outcomes for upgrading the living standard of rural households.

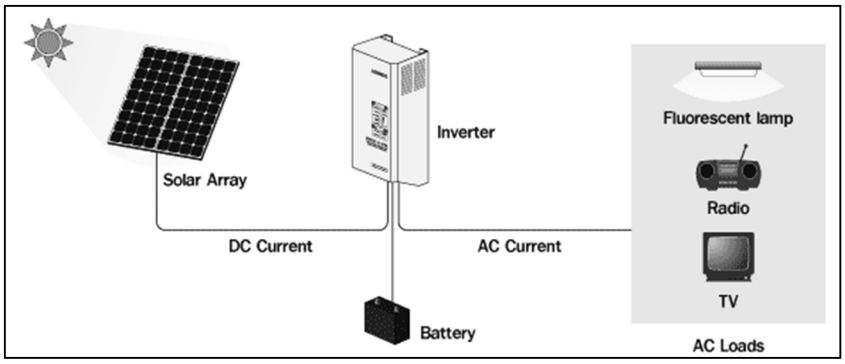


Figure 2: Electricity Generation and application of SHS (Source: Wahi & Ahsan, 2012)

In Addition, from the experience of developing nations in Sub-Saharan Africa and Asia, it has been observed that SHSs are economically feasible for rural electrification program in remote regions which improves the socio-economic condition of underprivileged population. As discussed in the prevailing literature, the rural electrification program in Bangladesh has already witnessed with manifold and far-reaching socioeconomic impact in the electrified areas. This is also evident in the Government publications through Bangladesh Rural Electrification Board (BREB, 2017). BREB reveals USAID report's findings and assessments about the outcomes of the rural households (HHs) electrification program in Bangladesh, as outlined below:

- 93.7% of the electrified HHs reported a decrease in fuel cost
- 78.2% reported an increase on working hours
- 62.0 % HHs reported an increase in family income

- 94% reported an increase in children's study time
- Literacy rate in the electrified families is 71%, whereas 54% in the non-electrified HHs
- 94.7% reported an improvement in security
- The annual infant mortality rate in the electrified HHs is 42.7/1000 live births, in the non-electrified HHs 57.8/1000. Thus annual number of infant deaths that could be saved will be around 36818, i.e., a saving of 101 infant deaths every day.

Furthermore, the deployments of SHSs do not only provide sustainable electricity, it serves as a stimulant for other development activities. This industry showed promising impact in employment generation and local entrepreneurship development. The domestic production of SHS components like solar lamps and charge controllers creates job opportunity for technicians and local youth in solar industries which has employed more than 75,000 people in a green industry (IDCOL, 2017). Besides, researchers in environmental economics also emphasized the significance of solar energy usage that has so far saved consumption of 1.14 million tons of kerosene (worth USD 411 million approximately) which is one of the primary sources of greenhouse gas emissions in developing nations (IDCOL, 2017).

5. Microfinancing the Dissemination of SHS for Improving Rural Electrification

This section of the paper highlights the diffusion of SHS across the country through Microfinance schemes which are primarily contributing to the success of SHS program and important for acquiring it by the rural population. Microfinance can be conceptualized as the provision of financial services to low-income poor and very poor self-employed people (Otero 1999, p.8). Generally these financial services consist of savings and credit but can also include other financial services such as insurance and payment terms (Ledgerwood, 1999). Hence, microfinance involves the setting up of financial services such as savings, loans and insurance to poor people living in both urban and rural locations who are unable to attain such services from the formal financial sector. Worldwide, the microfinance industry is estimated at $60 -100 billion. The rapid growth of the industry over the past 15 years has reached approximately 130 million clients according to recent estimates. Yet microfinance still reaches less than 20 percent of its potential market among the world's three billion or more poor (MIX, 2017; IFC, 2016).

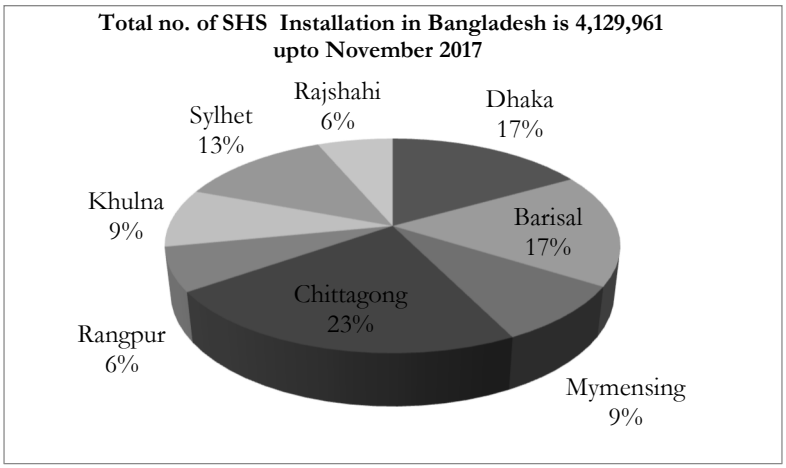


Figure 3: Status of SHS installations in eight divisions of Bangladesh

To fulfill basic electricity requirement of the off-grid rural people of Bangladesh as well as supplement the Government's vision of ensuring access to electricity for all citizens of Bangladesh (MoPEMR 2008a), Infrastructure Development Company Limited (IDCOL) started the SHS program in January 2003. IDCOL initially received credit and grant support from the World Bank and GEF to start the program. Later, other international funding agencies like GIZ, ADB, IDB, JICA, USAID and DFID came forward with additional financial support for expansion of the SHS Program.

Under IDCOL SHS Program, IDCOL does not provide any loan directly to the end users. All loans are being channeled through the Partner Organizations (PO) as per the terms set the Government regulatory body. At present, 56 PO are implementing the program. IDCOL provides grant and soft loans as well as necessary technical assistance to the POs. POs select customers, extend loan, install the systems, and provide after sale service. IDCOL's total investment under the program is BDT 52,240 million (USD 696 million) out of which loan USD 600 million and grant USD 96 million (IDCOL 2017).

Although investment costs of solar electrification are generally higher compared to fossil fuel alternatives, this option becomes economically viable when all externalities (e.g. environmental cost, health hazards etc.) and lower operating cost are taken into consideration (Hamid M.R., 2013). The Government of Bangladesh has goals to provide universal access to electricity by 2021. In this regard, the country has attained global attention in the field of rural electrification by SHS. The solar industry has grown at a rate of 35% per year over the last ten years (Biswas MM et al., 2011). The program has

been acclaimed as one of the largest and the fastest growing off-grid renewable energy program in the world (SREDA, 2017). Under the supervision of state owned IDCOL, up to June 2017, about 4.12 million SHS have been installed in the off-grid rural areas of Bangladesh, mostly by microfinance interventions.

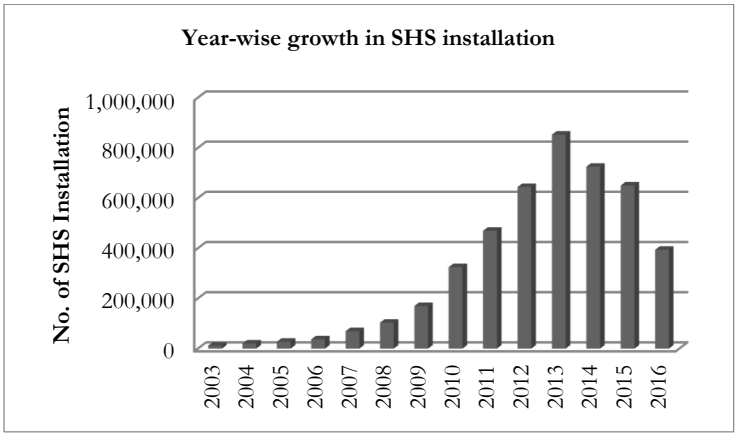


Figure 4: Growth in number of SHS installation in the previous years

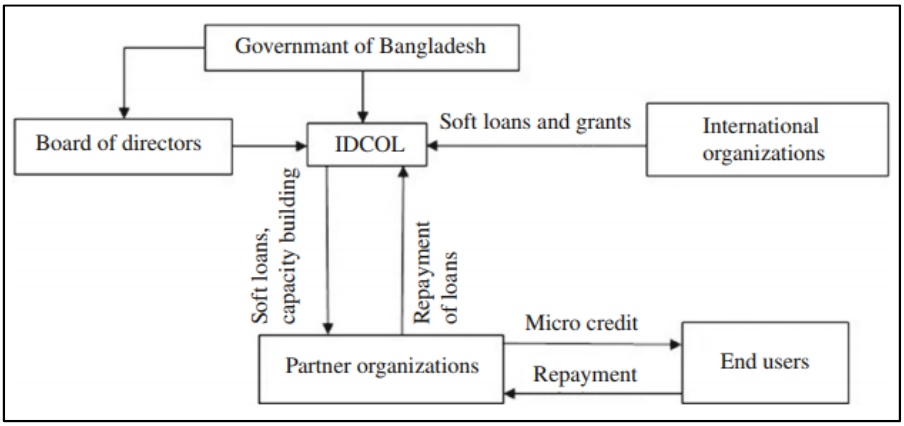


Figure 5: Implementation approach of the IDCOL SHS program (Source: Islam Sharif, 2013)

Hence, the study concedes that, to address the prevailing electricity crisis in rural Bangladesh with solar energy, a critical barrier is high installation cost in comparison to the income of poor households

(Assaduzzaman et al., 2013). Under these circumstances, The 56 POs of IDCOL have implemented a purchasing option for the potential users where the clients of SHS can make an initial down payment and pay the rest of the money in installments under specific micro-finance scheme that suits the users' financial capacity and usage needs. As identified in the Government reports with the interventions of MFIs and NGOs under IDCOL, around 18 million beneficiaries are provided with solar electricity which is around 12% of the total population of Bangladesh (IDCOL, 2017). Thus, the solar energy projects initiated by the Government are helping private sector, NGOs, and MFIs expand the solar energy technologies, both in terms of sustainability and commercial viability (Hossain M. F. et al., 2017)**.**

6. Prevailing Constraints and Proposed Framework for Stakeholder Collaboration

Despite the appealing features, solar PV systems do not yet have broad market acceptance due to the existence of barriers arising from the need for large-scale implementation. Furthermore, researchers (Sovacool and Drupady, 2011; Komatsu et al., 2011; Asaduzzaman et al., 2013) also identified certain constraints regarding difficulty in matching the output of SHS with customers' electricity requirements. The amount of sunshine combined with the relatively small size of SHS at the household level poses a limitation on the electricity generating capacity. Consequently, as the production of electricity is typically in the range 30–130 Watt peak (Wp), SHS would normally allow households to use only low-powered electrical appliances such as electric lamps, radios and televisions, and mobile phone rechargers.

Despite the significant potential in the commercialization of solar energy, some limitations like higher investment costs, lack of awareness and multilateral collaboration, and program monitoring process need to be taken care of in the development of rural electrification through renewable energy (Hossain M. F. et al. 2017, Mondal M.A.H. et al., 2010, Friebe C.A. et al., 2013). This suggests that further research should attempt to analyze how to synthesize policy tools with the aim of mitigating the challenges and capitalizing on the development opportunities derived from SHS to meet the energy needs in rural households.

The study is expected to imply the fact that awareness building programs and financial incentives like providing SHS with tailored financing schemes will encourage the adoption of SHS, and thus the rural households

can avail the development opportunities through solar electrification. Additionally, the research calls for attention of the target audience of RE Policy makers and stakeholders, on the need to promote multilateral collaboration in RE industry. This mutual cooperation is essential to formulate relevant strategic mechanisms for accelerating the dissemination of the RET to the underprivileged rural communities (Najmul H. & Kumar D., 2013, Tahsina k. 2017). In doing so, the proposed study provides significant insight in the expansion of renewable energy usage; and thereby contributes in achieving the national vision of universal access to electricity in the country. In order to give an illustration of the proposed support network, the following participants and beneficiaries have been considered as the major stakeholders in RE dissemination:

Policy makers

- Sustainable & Renewable Energy Development Authority (SREDA), Power Division, Ministry of Power, Energy & Mineral Resources, Government of the Peoples' Republic of Bangladesh.
- Rural Electrification Board

Funding agencies

- World Bank, GIZ, KfW, ADB, IDB, GPOBA, JICA, USAID and DFID

Regulatory Institution

- Infrastructure Development Company Limited (IDCOL)

Partner Organizations

- 56 NGOs and MFIs distributing SHS across the country

Renewable Energy Forums

- Renewable energy research center (RERC), Dhaka University
- Bangladesh Solar and Renewable Energy Association

End users

- Domestic usage for rural Households
- Commercial usage by small & micro enterprises

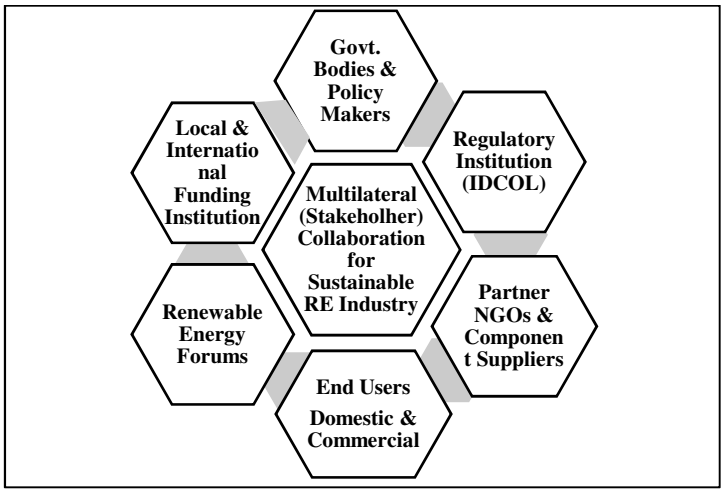


Figure 6: Stakeholders in the multilateral collaboration framework for RE Industry

7. Concluding remarks:

This study is intended to address the diffusion of renewable energy technology in the form of SHS, other types of solar energy like concentrated solar power (CSP) and grid-connected solar PV system are not discussed in the present study due to the less prevalence of such practice in the research context. However, an emerging distribution of the solar electricity in the national grid is evident through the Government interventions. The renewable energy statistics highlighted in this study is limited to the field of solar electricity generation. With this backdrop, this research investigates microfinancing the access to electricity for facilitating the dissemination of SHS in rural Bangladesh. In doing so, the study reveals that rural electrification can be accelerated by devising customized financial schemes to address the affordability of RET among the rural population. Furthermore, the paper also suggests a framework on multilateral collaboration to address the challenges in this regard. This unveils the scope of further research to assess the sustainability of solar energy ventures in addressing the development goals of the country.

References

Ahammed, F. and Taufiq, D.A. (2008), "Applications of solar PV on rural development in Bangladesh", *Journal of Rural and Community Development*, Volume 3, Number 1, pp. 13-20.

Asaduzzaman, M., Yunus, M., Haque, A.E., Azad, A.A.M., Neelormi, S. and Hossain, M.A. (2013), "Power from the sun: An evaluation of institutional effectiveness and impact of solar home systems in Bangladesh", *Final Report submitted to the World Bank, Bangladesh Institute of Development Studies, Dhaka, Bangladesh*.

Azimoh, C.L., Klintenberg, P., Wallin, F. and Karlsson, B. (2015), "Illuminated but not electrified: An assessment of the impact of Solar Home System on rural households in South Africa", *Applied energy*, Volume 155, pp. 354-364.

Bangladesh Rural Electrification Board, Socio Economic Impact, Retrieved from, http://www.reb.gov.bd/site/page/b36a45d6-6ed2-4477-9cb1-831bd0b13d90/Socio-Economic-Impact, accessed on August 2, 2017.

BBS, Bangladesh Bureau of Statistics (2012): Report of the Household Income & Expenditure Survey, Statistics and Information Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

Biswas, M.M., Das, K.K., Baqee, I.A., Sadi, M.A. and Forhad, H.M.S. (2011), "Prospects of renewable energy and energy storage systems in Bangladesh and developing economics", *Global Journal of Researches in Engineering (GJRE)*, Volume 11, Number 5, pp. 23-31.

Das, D. (2013). "Is solar electrification a sustainable solution for rural electrification? Learning from field experience". *Indian Journal of Energy*, Volume 2, Number 5, pp. 121-128.

Ellabban, O., Abu-Rub, H. and Blaabjerg, F. (2014), "Renewable energy resources: Current status, future prospects and their enabling technology", *Renewable and Sustainable Energy Reviews*, Volume 39, pp. 748-764.

Friebe, C.A., von Flotow, P. and Täube, F.A. (2013), "Exploring the link between products and services in low-income markets—Evidence from solar home systems", *Energy Policy*, Volume 52, pp. 760-769.

Hamid, M.R. (2013), "Photovoltaic Based Solar Home Systems: Current State of Dissemination in Rural Areas of Bangladesh and Future Prospect", *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, volume 2, Number (2), pp. 745-749.

Hasanuzzaman M, Abul Q. A., Shamsunnahar K., and Hosenuzzaman M. (2015), "Photovoltaic power generation and its economic and environmental future in Bangladesh", *Journal of Renewable and Sustainable Energy*.

Hossain, M.F., Hossain, S. and Uddin, M.J. (2017), "Renewable energy: Prospects and trends in Bangladesh", *Renewable and Sustainable Energy Reviews*, Volume 70, pp. 44-49.

IDCOL, Infrastructure Development Company Ltd, Renewable Energy, Solar Map, Retrieved from http://www.idcol.org/, accessed on 30th March, 2016.

International Finance Corporation (IFC), Microfinance, Financial Institutions. (2016). retrieved from http://www.ifc.org/wps/wcm/connect/Industry_EXT_Content/IFC_External_Corporate_Site/Industries/Financial+Markets/MSME+Finance/Microfinance/, accessed on 6ht February 2017

International Renewable Energy Agency (IRENA). 2017. Renewable energy and jobs, Annual review 2015, retrieved from, http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=585, accessed on 12th September 2017.

Islam, A.S., Islam, M. and Rahman, T. (2006), "Effective renewable energy activities in Bangladesh", *Renewable Energy*, Volume 31, Number 5, pp. 677-688.

Islam, M.R., Islam, M.R. and Beg, M.R.A. (2008), "Renewable energy resources and technologies practice in Bangladesh", *Renewable and Sustainable Energy Reviews*, Volume 12, Number 2, pp. 299-343.

Islam, M.S., Khan, A.M.H.R., Nasreen, S., Rabbi, F. and Islam, M.R. (2012), "Renewable energy: the key to achieving sustainable development of rural Bangladesh", *Journal of Chemical Engineering*, Volume 26, Number 1, pp. 9-15.

Islam, M.T., Shahir, S.A., Uddin, T.I. and Saifullah, A.Z.A. (2014), "Current energy scenario and future prospect of renewable energy in Bangladesh", *Renewable and Sustainable Energy Reviews*, Volume 39, pp. 1074-1088.

Khan, J. and Arsalan, M.H. (2016), "Solar power technologies for sustainable electricity generation–A review", *Renewable and Sustainable Energy Reviews*, Volume 55, pp. 414-425.

Khan, M.F. and Khan, M.M. (2011), "Prospect of PV home system for promoting and stimulating economic development of rural Bangladesh", *Journal of Electrical Engineering*, Volume 36, Number 2, pp. 39-42.

Komatsu, S., Kaneko, S. and Ghosh, P.P. (2011), "Are micro-benefits negligible? The implications of the rapid expansion of Solar Home Systems (SHS) in rural Bangladesh for sustainable development", *Energy policy*, Volume 39, Number 7, pp. 4022-4031.

Komatsu, S., Kaneko, S., Ghosh, P.P. and Morinaga, A. (2013), "Determinants of user satisfaction with solar home systems in rural Bangladesh". *Energy*, Volume 61, pp. 52-58.

Kürschner, E., Diehl, E., Hermann-Friede, J., Hornikel, C., Rosenbusch, J. and Sagmeister, E. (2010), "Impacts of Basic Rural Energy Services in Bangladesh".

Ledgerwood, J. (1999), "Sustainable banking with the poor microfinance handbook".

Michel Carrara, Solar Impulse, SOLAR CELLS From light to electricity, retrieved from, https://www.solarimpulse.com/img/pdf/CELLS.pdf, accessed on, September 5, 2017.

Mishra, P. and Behera, B. (2016), "Socio-economic and environmental implications of solar electrification: Experience of rural Odisha", *Renewable and Sustainable Energy Reviews*, Volume 56, pp. 953-964.

MIX Outreach report. (2014), Microfinance Information Exchange, retrieved from http://www.themix.org/mixmarket, accessed on 26th August, 2017.

Momotaz, S.N. and Karim, A.M. (2012), "Customer satisfaction of the solar home system service in Bangladesh". *World Journal of Social Sciences*, Volume 2, Number 7.

Mondal, M.A.H. and Denich, M. (2010), "Assessment of renewable energy resources potential for electricity generation in Bangladesh", *Renewable and Sustainable Energy Reviews*, Volume 14, Number 8, pp. 2401-2413.

Mondal, M.A.H. (2010), "Economic viability of solar home systems: Case study of Bangladesh", *Renewable Energy*, Volume 35, Number 6, pp. 1125-1129.

Mondal, M.A.H., Kamp, L.M. and Pachova, N.I. (2010), "Drivers, barriers, and strategies for implementation of renewable energy technologies in rural areas in Bangladesh—An innovation system analysis", *Energy Policy*, Volume 38, Number 8, pp. 4626-4634.

Morris E., Winiecki J., Chowdhary S., and Cortiglia K. (2007), "Using Microfinance to Expand Access to Energy Services, Summery of findings", *U.S. Agency for International Development (USAID),* Washington.

Najmul Hoque, S.M. and Kumar Das, B. (2013), "Present status of solar home and photovoltaic micro utility systems in Bangladesh and recommendation for further expansion and upgrading for rural electrification", *Journal of Renewable and Sustainable Energy*, Volume 5, Number 4, pp. 288-301.

Otero, M. (1999), "Bringing development back, into microfinance", *Journal of Microfinance/ESR Review*, Volume 1, Number 1, pp. 8-19.

Pode, R. (2013), "Financing LED solar home systems in developing countries", *Renewable and Sustainable Energy Reviews*, Elsevier, Volume 25, pp. 596-629.

Rahman, M.S., Saha, S.K., Khan, M.R.H., Habiba, U. and Hosse, S.M. (2013), "Present situation of renewable energy in Bangladesh: renewable energy resources existing in Bangladesh", *Global Journal of Research In Engineering*.

Renewable Energy Policy of Bangladesh, Power Division, Ministry of Power, Energy and Mineral Resources, Government of The People's Republic Of Bangladesh, pp.1,3 , November 2008, [MoPEMR 2008a].

Roth, C. and Glemarec, Y. (2012), "Microfinance opportunities for a Clean Energy Future", *UNDP, United Nations Conference on Sustainable Development*, Rio de Janeiro.

Socio-economic Impact, Bangladesh Rural Electrification Board, Retrieved from, http://www.reb.gov.bd/, accessed on September 5, 2017.

Sovacool, B.K. and Drupady, I.M. (2011), "Summoning earth and fire: The energy development implications of Grameen Shakti (GS) in Bangladesh". Energy, Volume 36, Number 7, pp. 4445-4459.

Sustainable & Renewable Energy Development Authority (SREDA). (2016), Renewable Energy, Power Division, Ministry of Power, Energy and Mineral Resources, Government of the Peoples' Republic of Bangladesh, retrieved from http://www.sreda.gov.bd/index.php/site/re_present_status, accessed on 5th February, 2017.

Tahsina K. (2017), "Microfinance Interventions in Renewable Energy: Enhancing the Living Standard of Rural Households", *International Journal of Business and Management Study*, Volume 4, Number 1, pp. 45-49.

Trochin W. M. (2002), "Research Methods Knowledge Base", *Cornell University Publications*.

Ullah, M.H., Hoque, T. and Hasib, M.M. (2012), "Current status of renewable energy sector in Bangladesh and a proposed grid connected hybrid

renewable energy system", *International journal of advanced renewable energy research*, Volume 1, Number 11, pp. 618-627.

Wahi, R.R.H. and Ahsan, N.U. (2012), "December. Feasibility study of solar home system in rural areas of Bangladesh: Prospect, progress and challenges", In Proceedings *of the Global Engineering, Science and Technology Conference*.