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# Drivers, barriers, and strategies for implementation of renewable energy technologies in rural areas in Bangladesh—An innovation system analysis

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## ABSTRACT

Bangladesh has good potential for harnessing renewable energy sources such as solar, biomass, wind, and mini-hydropower. The country has been experiencing a gradual shift towards exploring renewable energy resources as a driving force for rural development. A few public sector and non-government organizations have started to develop renewable energy technology (RET) projects in rural areas. The lessons learnt from different demonstrations of RET projects reveal that with careful forward planning renewable energy can provide far-reaching economic, environmental, and social benefits to people living in remote rural areas in Bangladesh. This paper identifies some of the barriers that need to be overcome for the successful development of renewable energy technology sector and betterment of rural livelihoods. It does so through a critical review of policy and institutional settings, as well as present status and lessons learnt from pilot demonstration of a number of RET projects undertaken by different organizations. The study highlights policy implications of the review with the aim of supporting decision makers in formulating renewable energy policies and future plans for Bangladesh.

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## 1. Introduction

Bangladesh has a rural economy based on agriculture. Out of 130.1 million people, an estimated 77% of the population lives in rural areas (BBS, 2001). The rural majority uses mainly traditional energy sources—nearly 70% of total energy consumption comes from traditional biomass sources (Khan, 2003). People in rural areas do not have access to sufficient commercial energy and electricity, which is needed for economic growth. Per capita consumption of energy, which is a measure of the physical quality of life, is very low in Bangladesh. In 1997, it was only 8.83 GJ/person/year (Islam, 2001).

Furthermore, the gap between demand and supply is gradually increasing, as is the dependence on imported fuel oil. The rural population, which uses a fair amount of imported diesel and kerosene, is largely disadvantaged because of its low purchasing power (Sarkar et al., 2003). Also, efficiency of energy utilization is generally poor.

For lighting, many people in rural areas use kerosene based devices, many of which constitute serious fire hazards. Cooking is mainly done using unsustainable biomass fuels. Hence, biomass

resources are being rapidly exhausted. Rural women and children are the primary collectors of wood and crop residues. Women cook three times a day on wood, crop residues, tea leaves, and dung and therefore have high exposures to indoor air pollution, which can cause acute infections, chronic lung diseases, low birth weight, cancer, and eye problems (Sarkar et al., 2003).

Grid-based rural electrification in Bangladesh is increasing. However, per capita generation of electricity is still very low at about 170 kWh/year in 2006 (Mondal and Denich, 2010). In 2006, still over 58% of the total population was not connected to the unreliable electricity grid (Jamaluddin, 2008). The reason is that it is not economical to extend grid access to lowly populated areas. Electricity supply to low-load rural and remote areas is characterized by high transmission and distribution losses, and heavily subsidized electricity pricing.

In 2005, the government of Bangladesh announced its ambitious goal to provide electricity for all by the year 2020 (PSMP, 2005). The government targets of electricity generation by renewable energy technologies (RETs) are 5% of the total power generation by 2015 and 10% by 2020 (REP, 2008). The use of solar, biomass, hydro, and wind energy technologies are planned to play a major part in meeting this target. Reaching these ambitious targets will be a major challenge. This paper aims to contribute to reaching these targets by identifying drivers and bottlenecks for implementation of RETs in rural Bangladesh and proposing implementation strategies.

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Already since the 1970s, attempts have been made to implement RETs in rural areas of Bangladesh (REIN, 2010). In the last decade both public and private sectors have carried out a number of projects for promoting RETs in Bangladesh. Their experience entails valuable information that could support national policy makers in their on-going attempts at integrating RETs in the power sector of Bangladesh through national energy planning and policies. No integrated review of those experiences, however, exists so far.

This paper addresses this gap by providing an overview of the current state of implementation of those projects, analyzing their experiences through the theoretical lens of innovation systems and appropriate technology, identifying barriers and drivers to the successful implementation of RETs in rural areas in Bangladesh, and highlighting the policy implications and strategic directions for future work.

## 2. Theoretical framework: innovation systems and appropriate technology

### 2.1. Innovation systems

Innovations are not developed and implemented in isolation. They are developed and implemented within a socio-cultural context. In the literature, this innovation context is coined by different terms: socio-technical system (see e.g. Geels, 2005), technological system (Carlsson and Jacobsson, 1997), or innovation system (see e.g. Edquist, 1997). Because these terms all come down to the same, we choose to use the term 'innovation system'. Innovation systems are commonly defined as (Freeman, 1987)

'systems of innovation are networks of institutions, public or private, whose activities and interactions initiate, import, modify, and diffuse new technologies'.

An innovation system consists of three building blocks (Malerba, 2005):

1. technology and related knowledge and skills,
2. networks of actors, and
3. institutions (defined broadly as 'rules of the game').

Networks of actors develop and implement new knowledge and technology, within their institutional context. These actors can be subdivided into technology developers, technology end users/owners, policy makers/government institutes, knowledge providers, entrepreneurs, service and maintenance providers, non-government organizations (NGOs), etc., Knowledge consists of 'hard' technical knowledge but also 'soft' knowledge or skills, e.g. on how to use technology properly, or on which governmental agencies or NGOs to ask for subsidies. Institutions involve formal institutions like laws, government regulations and organizations, and technical standards and norms; and informal institutions like common law, cultural aspects, tradition, norms, codes of conduct, practices, etc. (North, 1990).

For an innovation system to be successful in developing and implementing technologies, these three building blocks need to be aligned (Malerba, 2005). Furthermore, these three building blocks co-evolve in time. Actors enter or exit networks, new technologies and knowledge are developed or discarded, and also institutions can change over time. A successful innovation system requires a fit in this co-evolution (Malerba, 2005).

### 2.2. Appropriate technology

Another research field is called 'appropriate technology'. This starts from a similar notion as the above described innovation

system framework, namely that technology that is implemented in a developing country should be appropriate to the local circumstances. For implementation of RETs in a rural area in a developing country, several requirements have been derived in literature, e.g. they must be simple, but give a comfortable life, save human energy and time, increase income generation and other activities. Furthermore, according to Schumacher (in Biswas et al., 2001) "the 'non-violence' of a technology is an essential part of its appropriateness, suggesting that an appropriate technology is completely under human control, has no unintended side effects and in particular social or environmental disruption" (Biswas et al., 2001). The RETs should be technically feasible considering technical resources and operating characteristics, and also financially viable and preferably sustainable. Also, the technologies should be socially equitable and culturally acceptable. Institutional capacity to implement RET projects properly is also needed. Furthermore an adequate availability of different resources from a combination of public, private organizations and initiatives, and natural resource potential is also required. For RETs, this would include a policy framework, financial viability of the technology, institutional arrangements, resources, technical education and information dissemination, and supply of material and hardware (Huque, 2002). Each of these components forms a link in the chain to success of renewable energy services (Painuly, 2001; Yu, 2003).

This paper will use a combination of these theoretical frameworks. It will analyze the current status of RETs in Bangladesh and investigate the fit between the three innovation system building blocks: (1) technology and related knowledge and skills, (2) networks of actors, and (3) institutional aspects. It will also investigate the presence of requirements listed in the appropriate technology literature, most of which can be regarded as institutional aspects.

## 3. Current status of RETs in Bangladesh

### 3.1. Potential of RET applications

**Biogas:** An agriculture-based country like Bangladesh has huge potential for utilizing biogas technologies. Animal dung available from 24.48 million cattle and buffalo is nearly 186,000 tons/day (Islam et al., 2008). One kg of dung can produce 0.037 m<sup>3</sup> of biogas. Available dung can produce about 2.5 billion m<sup>3</sup> of gas, which is equivalent to 1.28 million tons of kerosene or 2.56 million tons of coal. Besides, a substantial amount of biogas can be produced from poultry droppings, waste, garbage, and water hyacinth (Islam et al., 2008).

**Solar:** Bangladesh is situated between 20.30° and 26.38° north latitude and 88.04° and 92.44° east longitude with an area of 147,500 km<sup>2</sup>, which makes it an ideal location for solar energy utilization. Daily average solar radiation varies between 3 and 6.5 kWh/m<sup>2</sup> (Sarkar et al., 2003; Islam et al., 2006). The Asian Development Bank (2003) estimated that 50,463 MW could be generated from solar PV (ADB, 2003).

**Hydropower:** Due to the country's flat terrain and potentially high social and environmental impacts of large-scale hydropower, further expansion of this technology is expected to be limited (Uddin and Taplin, 2006). The estimated exploitable capacity for hydropower generation is estimated to be 745 MW, of which around 200 MW can be produced by small and mini-sized hydropower plants (Wazed and Ahmed, 2008).

**Wind:** Wind energy potential is not encouraging except in coastal areas (Islam et al., 2006). Several locations in the coastal region of the country have already been assessed to determine the wind energy potential. The Asian Development Bank (2003)

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