Sustainable Energy for Rural Development in Bangladesh

- *Economic, Social and Environmental Benefits of Renewable Energy*

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Abstract

Bangladesh has a population of 161 million, nearly 75% of the population lives in rural areas and only about 30% of the rural households in Bangladesh have access to grid electricity. In developing countries (Asia and Africa), especially in rural areas, 2.5 billion people rely on biomass, such as fuelwood, charcoal, agricultural wastes and animal dung, to meet their energy needs for cooking. Biomass accounts for 55% of total energy source in Bangladesh. Lacking access to electricity are forcing rural people of Bangladesh to continue to use kerosene, agricultural residues (rice and wheat plants; paddy husk and bran; bagasse, jute sticks; twigs, leaves and fuel/forest wood), charcoal, and cattle dung for cooking and lighting, predisposing them to hazards associated with smoke and fumes. Both population and economy in Bangladesh are growing at a rapid pace; therefore Bangladesh would be in need of more and more energy to accommodate better life style and to grow more food (agriculture, livestock, fisheries and aquaculture).

Current electric supply in Bangladesh using the fossil fuel-natural gas is expected to be exhausted very soon and therefore, Bangladesh would be in need of alternative and sustainable energy sources such as renewable energy (RE) which are low or zero polluting. Bangladesh has plenty of sunshine and has huge opportunities to use solar energy (solar photovoltaic or PV). Cattle dung, poultry droppings, and agricultural residues that are available in plenty in rural Bangladesh can be used to produce biogas. There is strong wind power potential flow in particular during the months of April to September in costal Bangladesh. Due to relative flatness of the country, Bangladesh has limited hydro power potentials. Government of Bangladesh (GoB) has already prioritised the development of renewable energy and identified renewable energy as one of the most important programmes of Bangladesh Climate Change Strategy and Action Plan (note: Bangladesh is one of the most vulnerable countries in the world to climate change). GoB has also established a Sustainable and Renewable Energy Development Authority (SREDA) to promote renewable energy and achieve energy efficiency.

Bangladesh has set a target of achieving 10% power from RE by 2020, Australia sets its target of achieving 20% RE by 2020, New Zealand has 90% of RE achievable target by 2015 and many countries have even higher RE targets such as Small Island Developing States (SIDS) in the Pacific region including the Cook Islands (100% RE by 2020); Tokelau (100% RE by 2012), Tuvalu (100% RE by 2020; Fiji (100% by 2020). RE technologies are essential for energy access, energy security, reduce dependency on fossil fuels, mitigating climate change (reducing emissions of greenhouse gases) and sustainability and socio-economic benefits (low-carbon economic growth and prosperity). RE such as solar, wind energy can be used and extended in remote areas where it is too expensive to extend the electricity power grid. RE offers significant public health benefits to rural people, would facilitate educational and livelihoods activities at nights in rural areas; would reduce time consuming firewood and water collection by women for cooking and drinking; help reduce environmental degradation such as desertification/deforestation and biodiversity depletion (by preventing use of forest woods for fuel). Overall, RE would alleviate rural poverty, improve quality of life of rural women, men and children, reduce air pollution, create local employment, and enhance food production in Bangladesh.

1. Introduction

Bangladesh is one of the world's poorest and most densely populated nations (161 million), where nearly 75% of the population lives in rural areas [1,2] and only about 30% of the rural households have access to grid electricity [3]. Lacking access to electricity (Figure 1) are forcing rural people to continue to use kerosene, agricultural residues (rice and wheat plants; paddy husk and bran; bagasse, jute sticks; twigs, leaves and fuel/forest wood), charcoal, and cattle dung) for cooking and lighting [4,5,6] predisposing them to hazards associated with smoke and fumes (see section 2 for threats and risks associated with smoke and fumes). There is frequent load shedding and power outages in Bangladesh since energy supplies by using mainly fossil fuel-natural gas (natural gas accounts for 79.33% of electricity supplies) [7] are not sufficient. It is reported that existing natural gas reserve is expected to be exhausted very soon [8] and therefore, Bangladesh would be in need of alternative and sustainable energy sources such as renewable energy (RE) which are low or zero polluting (see section 6).

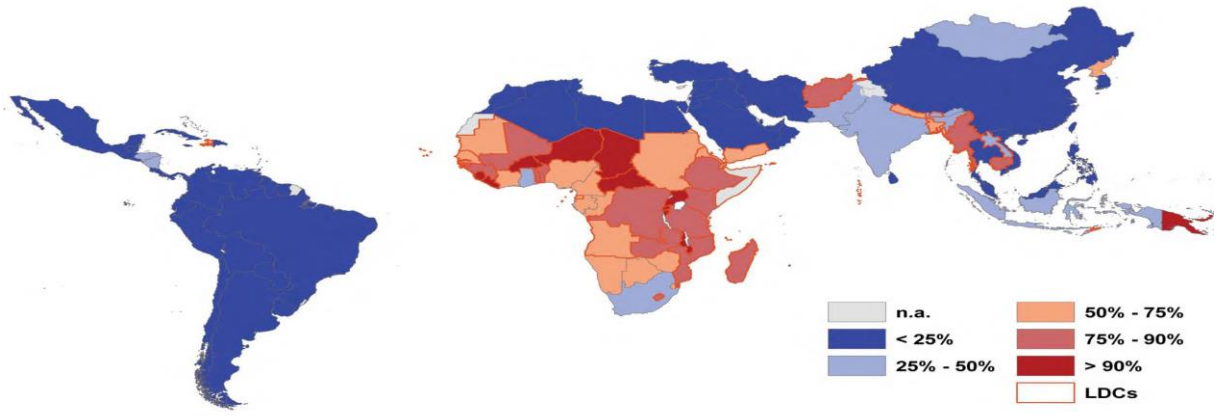

Figure 1: Share of people without electricity access for developing countries, 2008 [9]

2. Why need sustainable energy?

In developing countries (Asia and Africa), especially in rural areas, 2.5 billion people rely on biomass, such as fuelwood, charcoal, agricultural wastes and animal dung, to meet their energy needs for cooking. In many countries, these resources (biomass) account for over 90% of household energy consumption [10]. About 77% and 61% of population use solid fuels (wood, charcoal) for cooking in Africa and South east Asia respectively (Figure 2). Biomass (rice and wheat plants, paddy husk and bran, bagasse, jute sticks; twigs, leaves and fuel wood; charcoal; and cattle dung) accounts for 55% of total energy source in Bangladesh [5]. Use of biomass for energy (to cook meals and heating homes), exposes rural people and their families to hazards of smoke and fumes. About 1.3 million people, mostly women and children, die prematurely every year because of exposure to indoor air pollution from biomass [10]. In fact, the indoor air pollution associated with biomass use is directly responsible for more deaths than malaria (Figure 3). Fuel wood, roots, agricultural residues and animal dung are responsible for high emissions of carbon monoxide (CO), hydrocarbons and particulate matter. Hydrocarbon emissions are highest from burning of animal dung for fuel, while particulate emissions are highest from agricultural residues [10]. Inhaling of biomass smoke may put people at a high risk of contracting diseases like

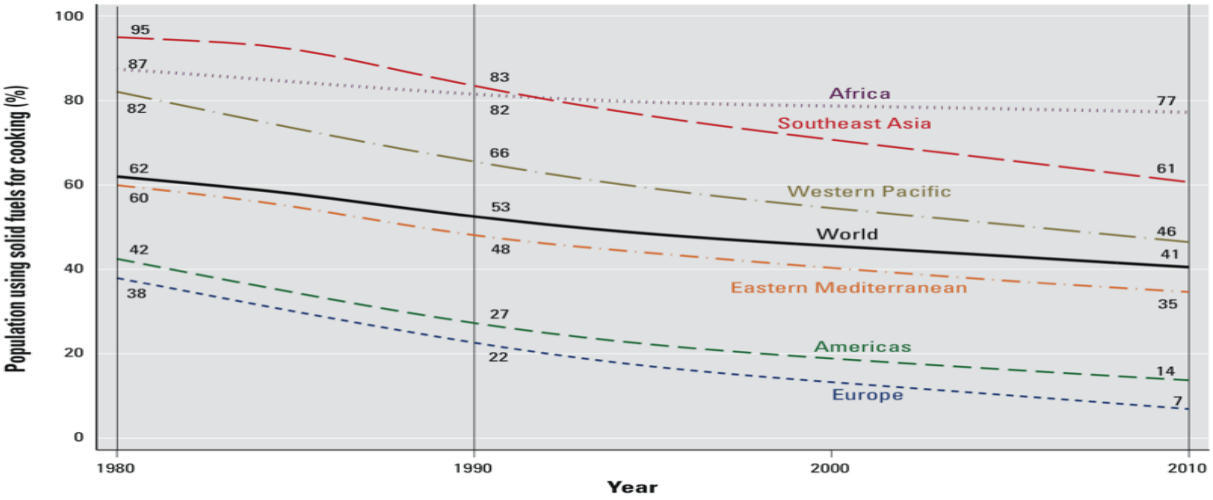

Figure 2: Regional trends for the percentage of population using solid fuels as the main cooking fuel in LMICs (low- and middle-income countries), 1980–2010 [11,page 787].

asthma, tuberculosis and cancer [12]. It has been estimated that 46,000 women and children die each year in Bangladesh and millions more suffer from respiratory diseases, tuberculosis, asthma, cardiovascular disease, eye problems, and lung cancer due to direct exposure to indoor air pollution [6]. Both population and economy in Bangladesh are growing at a rapid pace and increasing numbers of people aspire to have higher standards of living. It means Bangladesh would be in need of more and more energy to: **(a)** accommodate better life style (use of electrical appliances, cars, new and modern houses/buildings, working during nights); **(b)** grow more food (agriculture, livestock, fisheries and aquaculture). These can only be possible by producing energy and food in a sustainable way that creates less waste and pollution such as less or zero CO_2 pollution (note: elevated CO_2 means climate change which is already threatened biodiversity, ecosystems, water, food and livelihoods of poor; [see 1]. Therefore, we need energy sources which are sustainable that will not lead to further increase in the CO_2 in the earth's atmosphere. Sustainable energy is the form of energy obtained from non-exhaustible resources (renewable resources that can be replenished naturally). Provision of this form of energy serves the needs of the present without compromising the ability of future generations to meet their needs. Sustainable energy include renewable energy sources, such as solar energy, wind energy, biogas, hydroelectricity, geothermal energy, bioenergy, tidal power [13].

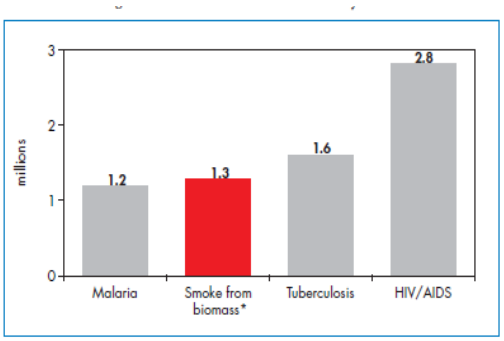

Figure 3: Annual deaths caused by smoke from biomass compared to malaria and other diseases [10, page 425].

3. Potential of renewable energy in Bangladesh

Bangladesh has plenty of sunshine (average daily solar radiation is 4-6.5 kWh/m^2) [14], and has huge opportunities to use solar energy (solar photovoltaic or PV). Most of the rural areas where people are suffering

from energy crisis or where it is too expensive to extend the electrical power grid, solar energy could be best the solution. Solar PV would be a viable option in supplying electricity to rural homes, rural markets, rural health clinics, rural street lighting, rural food production, irrigation, water delivery and telecommunication in Bangladesh. Furthermore, there is a strong potential for biomass gasification based electricity production. Abundant quantities of rice husks, crop residues, woods, jute sticks, animal wastes, municipal wastes are available in rural areas. Similarly, cattle dung, poultry droppings, and agricultural residues that are available in plenty in rural Bangladesh can be used to produce biogas. Biogas can be used for household works, cooking, harvesting, lighting, irrigation etc. Furthermore, there is strong wind power potential flow in particular during the months of April to September in costal Bangladesh. Wind electricity produced by windmills can be utilised for water pumping, power generation through Wind-Diesel-hybrid systems, small battery charging, shrimp farming, fish/poultry farming, salt/ice production, poultry fish-mill feed industries, hatcheries, domestic applications and vegetable irrigation. Due to relative flatness of the country, Bangladesh has limited hydro power potentials (such as micro-and mini hydropower) though country receive significant amount of rain fall (average 2,347 mm/annum). Nonetheless, micro-hydropower can support electricity at rural schools, households, mosques, small industries, and village markets. There is some scope for geothermal energy in northern Bangladesh. In addition, there is a 'hot salt water spring' known as Labanakhya at Sitakunda (30 km from Chittagong) which could be a good location to extract the geothermal energy [8].

4. Initiatives by government and non-government organisations on renewable energy supplies in Bangladesh

The following sections briefly discuss about initiatives taken/being taken by various private companies, national and international NGOs and Government of Bangladesh (GoB) on three important RE sectors viz solar, biogas and wind power.

4.1: Solar power: In solar technology, mainly private organizations (NGOs) are working such as Infrastructure Development Company Limited (IDCOL), Grameen Shakti (GS), Bangladesh Rural Advancement Committee (BRAC), Rural Electrification Board (REB), Bangladesh Power Development Board (BPDB), Centre for Mass Education in Science (CMES), Local Government and Engineering Department (LGED), Rahimafroz and Energypac who are promoting solar technology for power generation. GS, a non-profit village renewable energy scheme, linked to the micro-credit lender Grameen Bank, has pioneered in promoting 'green energy', since 1996 as a lone player and today is the largest distributor of Solar home service (SHS). Around over 700,000 units, out of a total of about 1.1 million in the country– contributing to the daily generation of about 60 MW of solar power. Since November 2010, the GoB has mandated the installation of roof-top solar panels on all new high-rise buildings, and it currently has other solar power projects under development with a total capacity of 35 MW. Under the plan, 340 MW of electricity would be generated from systems installed on residential, commercial and industrial buildings, as well irrigation pumps, mini-grid systems and solar parks. IDCOL, funds 90 % of Bangladesh's 1.1 million SHS – mostly in partnership with GS, but also in association with other companies and NGOs. It is envisioned that seven city corporations will get solar street lights by 2015, which will ensure persistent light on city streets during night-time and will eventually increase the security of city-dwellers [8,15]. So far a number of private companies have installed valuable solar systems in the rural areas of Bangladesh including GS (81%), BRAC (11%); REB (3%); BPDB (2%), CMES (2%), LGED (1%) [7,8]. From the government perspective, the GoB is encouraging private companies to invest in renewable energies through providing incentives/concessions who are willing to set up solar plants in Bangladesh . These includes: **(i)** a 15-year tax holiday and exemption from paying import duty on equipment; **(ii)** exemptions of foreign investors on royalties, technical knowhow, technical assistance fees and facilities for their repatriation of profits; **(iii)** foreigners working in solar energy projects do not need to pay income tax for the first three years of their stay in Bangladesh [15].

4.2: Biogas: Different institutions and organisations such as the Institute of Fuel Research and Development (IFRD) of Bangladesh Council of Scientific and Industrial Research (BCSIR), Universities [Bangladesh University of Engineering & Technology (BUET), Dhaka University (DU), Rajshahi University of Engineering & Technology (RUET), Khulna University of Engineering & Technology (KUET), Jahangirnagar University (JU), Bangladesh Agricultural University (BAU)], LGED, and GS etc. are working on biogas projects in Bangladesh [8]. BAU and (BCSIR) launched biogas technology in the country in early 1970s. LGED constructed its first biogas plant at Kurigram, in 1992. A biogas plant of 85 cubic meter digester volume was built at Dholpur, Dhaka to produce 200 cft biogas from city garbage. By 2004, about 17194 biogas plants were established under a project of IFRD. Tapping potentials of biomass, two rice husk-based power plants of 250 kW at Gazipur and 400 kW at Thakurgaon, and seven poultry waste-based power plants at different sites with aggregated capacities exceeding 1.0 MW, have been established at the initiative of private sector with support

from IDCOL. Against an estimated potential of 4 million biogas plants, about 70,000 plants have been established so far throughout the country [8,16].

4.3: Wind: Bangladesh's first-ever generation of electricity from wind at a 900-kilowatt plant is located near the Muhuri Dam in south eastern Feni district, which have four separate wind turbines of 225 kw each. The electricity generated from wind, supplies electricity to the Muhuri Irrigation Project and the national grid. Beside several small wind generators have been installed by BRAC (11 small wind turbines in various coastal sites) and GS (two wind generators of 300 W and 1 KW at its Chakoria Shrimp Farm). GS has also installed 4 small wind generators (3xl.5KW + ONE 10 KW) in coastal Barguna district. GS is also planning to develop these stations into hybrid systems, first with diesel and then with solar PV, to maximize energy output and to evaluate the economics of cost [8,15]. GS has also set up 4 of its wind generators to power cyclone shelters along the coast. GS has a plan to develop micro-enterprise zones around the cyclone shelters in the coastal areas. The wind generators will provide electricity to buildings targeting micro-enterprises/small businesses lead by rural women (e.g. to run electric sewing machine, making ice and husking rice etc.). Thus wind energy will help in the growth of small enterprises and create self-employment opportunities in rural Bangladesh. By providing a reliable source of electricity, wind energy can also lead to an extension of average working hours resulting in added income and improvement in the quality of life for micro-entrepreneurs in the future. Wind energy also holds promise for the fishing and shrimp industries, especially for small-scale fishermen in the coastal regions of Bangladesh. Due to the scarcity of ice in rural Bangladesh, a significant percentage of fish caught by small-scale fishermen get rotten. Decentralized electricity from wind, used in making ice as well as in salt production, could aid fish preservation and hence, increase incomes of fishermen and intermediary vendors. Further, it is not possible to apply modern methods of shrimp cultivation in Bangladesh due to shortage of electricity. With the influx of electricity, application of semi-intensive methods of shrimp and fish farming can increase production by 25-30 times, resulting in the creation of new jobs in the farming and processing industries. GS has already started providing electricity to fish and prawn farms in Cox's Bazar (an important coastal fishing port). The BPDB Board has estimated that wind energy can contribute to 10% of the energy needs of the country [7,8,15].

5. Renewable energy targets by country

A number of Governments have adopted renewable energy targets (see Table 1) to meet multiple social, economic and environmental objectives. For example, in 2005, there were only 43 countries with RE targets, but by mid-2015, the number of countries had grown to 164. Bangladesh has set a target of achieving 10% power from RE by 2020, Australia sets its target of achieving 20% RE by 2020, New Zealand has 90% of RE achievable target by 2015 and many countries have even higher RE targets (see Table 1, reference 17-IRENA 2015). On the other hand Small Island Developing States (SIDS) in the Pacific region (who will be most affected due to climate change) have adopted highly ambitious renewable energy targets, including the Cook Islands (100% renewable energy sources of electricity (RES-E) by 2020; Tokelau (100% RES-E by 2012 - achieved), Tuvalu (100% RES-E by 2020) and Fiji (100% RES-E by 2020) [17]. In order to keep pace with the global trend, GoB has already prioritised the development of renewable energy and identified renewable energy as one of the most important programmes of Bangladesh Climate Change Strategy and Action Plan- BCCSAP (note: Bangladesh is one of the most vulnerable countries in the world to climate change; ranks #1; see 1,2]. To achieve this, the government has established a Sustainable and Renewable Energy Development Authority (SREDA) to promote renewable energy and achieve energy efficiency [18].

Table 1: Renewable energy targets of different countries [19; accessed 28 August 2015].

Country	Current Share %	Target %	Year		Country	Current Share %	Target %	Year		Country	Current Share %	Target %	Year
Argentina	1.3%	8%	2016		Greece	13	20.1	2010		Nigeria		7%	2025
Australia	9.15%	20%	2020		Hungary	4.4	3.6	2010		Pakistan		10%	2015
Austria	62	78	2010		India	4%	35%			Poland	2.6	7.5	2010
Bangladesh	5% (2015)	10%	2020		Indonesia	4%	15% (inc. nuclear)	2025		Portugal	32	45	2010
Belgium	2.8	6.0	2010		Ireland	10	13.2	2010		Russia		4.5%	2020

Country	Current Share %	Target %	Year	Country	Current Share %	Target %	Year	Country	Current Share %	Target %	Year
Brazil	5%			Israel	0%	5%	2016	Slovak Republic	14	31	2010
Canada	59%	90% (non-emitting sources)	2020	Italy	16	25	2010	Spain	19	29.41	2010
Chile	9%	20%	2025	Japan	0.4%	1.63%	2014	Sweden	49	60	2010
China	8%	15%	2020	Korea		6.08%	2020	Switzerland	52%		
10Czech Republic	4.2	8.0	2010	Luxembourg	6.9	5.7	2010	Taiwan	6%	12%	2020
Denmark	26	29	2010	Malaysia	0%	5%	2005	Thailand	7%	20%	2022
Egypt	15%	20%	2020	Mexico	16%	40%	2014	The Philippines		100% increase from 2005	2015
Finland	29	31.5	2010	Morocco	10%	20%	2012	United Kingdom	4.1	10	2010
France	10.9	21	2010	Netherlands	8.2	9.0	2010	United States	9.2%		
Germany	11.5	12.5	2010	New Zealand	6%	90%	2025	Vietnam		5%	2020

6. Economic, social and environmental benefits of renewable energy

RE technologies are essential for energy access, energy security, reduce dependency on fossil fuels, mitigating climate change (reducing emissions of greenhouse gases) and sustainability and socio-economic benefits (low-carbon economic growth and prosperity) [17,19]. The possible economic, social and environmental benefits of renewable energy in Bangladesh are highlighted below:

- REs are a clean and green sources of energy; have a much lower environmental impact than conventional energy (fossil fuels-coal, petrol, diesel, natural gas; see Table 2)
- REs sources have very little contribution to the anthropogenic carbon dioxide emissions (compare CO_2 emissions by fossil fuels vs renewable energy; see Table 2)
- Unlike fossil fuels, RE is sustainable and will never run out
- RE would help reduce fossil fuel imports (saving foreign exchange)
- RE such as solar, wind energy can be used and extended in remote areas where it is too expensive to extend the electricity power grid
- RE projects in rural areas of Bangladesh will bring economic benefits (revenue from selling energy, creating local jobs-so far RE sectors has created 114,000 jobs in Bangladesh, Figure 4)

Table 2: Life cycle emissions from various energy sources [20,21].

Energy sources	Green-house gas emission		
	CO_2 g/kWh	SO_2 g/kWh	NO_x g/kWh
Fossil fuels			
Coal (best practice)	955	11.8	4.3
Coal (NOx) and FGD	987	1.5	2.9
Oil (best practice)	818	14.2	4.0
Diesel	772	1.6	12.3
Natural gas (CCGT)	430	-	0.5
Renewable energy			
Large hydro	3.6–11.6	0.009–0.024	0.003–0.006
Wind	7–9	0.02–0.09	0.02–0.06
Geothermal	7-9		
Small hydro	9.0	03	0.07
Energy crops (biomass) – current practice (Likely to improve)	17–27	0.13–0.27	0.06–0.13
Solar thermal electric	26–38		
Solar photovoltaic	98–167	0.2–0.34	0.18–0.30

- Generating electricity from RE offers significant public health benefits to rural people (e.g. reducing premature child mortality and preventing exposure to harmful pollutants associated with use of fuel wood, cow dung, kerosene for cooking and lighting)
- RE would facilitate educational and livelihoods activities at nights in rural areas (e.g. increased indoor reading by children and sewing activities by women, running business at nights)
- Availability of RE in rural areas would reduce time consuming firewood and water collection by women for cooking and drinking
- RE technologies can help reduce environmental degradation such as desertification/deforestation, biodiversity depletion (by preventing use of forest woods for fuel)
- RE would help recycle waste for energy (biogas) thereby, would reduce waste, cost of waste treatment, reduce environment risks, surface and groundwater pollution, bad smell, health and sanitary problems
- RE such as solar PV would be a viable option in supplying electricity for rural homes, rural markets, rural health clinics, rural street lighting, rural food production (irrigation pumping, agriculture, livestock, and aquaculture/fisheries production) and telecommunication in Bangladesh.
- RE (wind) can be used for water pumping, power generation through Wind-Diesel-hybrid systems, small battery charging, shrimp production, fish/poultry firming, salt/ice production, poultry/fish-feed industries, hatcheries, domestic applications and vegetable irrigation etc.
- RE (biogas) can be used for household works, cooking, harvesting, lighting, irrigation
- Overall, RE would alleviate rural poverty, improve quality of life of rural women, men and children, reduce air pollution, create local employment, and enhance food production in Bangladesh.

Figure 4: Renewable energy employment in selected countries [22]

7. Conclusion

RE is green, clean and can play a significant role in energy access, energy security, rural development, rural employment, and climate change mitigation (reducing carbon footprint). It will also help to prevent rural people from exposing to hazardous substances which can impair lung functions and increase risks to tuberculosis, asthma, and cancer (associated with using kerosene, candle, cow dung and straw, dry leaves, wood for cooking and lighting). Moreover, RE technologies can help reduce environmental degradation such as desertification/deforestation. To eradicate poverty in third world countries (such as in Bangladesh) and save the planet from the effects of climate change and greenhouse gases, we need investments in renewable technologies. In this regard, the developing countries, have the opportunity to leapfrog conventional energy options in favour of cleaner energy alternatives (such as renewable energy) that will drive growth and enhance economic and social development.

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