SREDA
Sustainable and Renewable Energy Development Authority

SREP

(Scaling-Up Renewable Energy Program in Low Income Countries)

SREP seeks to demonstrate the economic, social and environmental viability of low carbon development pathways in the energy sector. It does this by supporting the deployment, in low income countries, of renewable energy technologies such as solar, wind, bio-energy, geothermal and small hydro. The support is intended to have a transformative impact on the country, leveraging SREP funds to remove barriers to renewable energy and lead to the replication of renewable energy investments through other sources of financing.

Bangladesh has been selected as one of the 14 countries eligible for SREP funding. The objective of the SREP is to pilot and demonstrate the economic, social and environmental viability of development pathways in the energy sector by creating new economic opportunities and increasing energy access through the use of renewable energy. In January 2015, the SREP approved the indicative allocation of US$ 75 million for Bangladesh.

SREDA has engaged consultants DH Infrastructure and PSL to prepare a “renewable energy investment plant (IP)” to demonstrate how SREP and other funding resources could be used to overcome current obstacles to the wider penetration of renewable energy in Bangladesh. The consultants’ work was assessing the potential and costs of applicable renewable energy technologies and prioritizing potential interventions. The draft investment plan prepared to prioritize the renewable energy investments in Bangladesh.

Please send your valuable opinion & suggestions on this Report before ***September 15, 2015***

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Investment Plan for Bangladesh

Under

Scaling Up Renewable Energy Program in Low Income Countries (SREP)

DRAFT

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1 Investment Plan Summary

This document contains the Investment Plan (IP) for Bangladesh. The IP is the result of extensive analysis by the Sustainable & Renewable Energy Development Authority (SREDA), and a wide-reaching internal and public consultation process, also led by SREDA, to identify priorities in the development of renewable energy technologies for electricity generation. The consultations included a wide range of government agencies, as well as representatives from the private sector, civil society, and academia.

The Investment Plan, if implemented, will be transformational for Bangladesh, launching an aggressive drive toward the integration of renewable energy generation into the grid, and a continued expansion of the off-grid electrification programs with which Bangladesh has had so much success in the past.

1.1 Context

Bangladesh is a low lying country located on the Ganges Delta. Seventy-five percent of the country is less than 10 meters above sea level and more than 700 rivers run through its borders. Approximately 144 million people live in a total area of 147,500 square kilometers, giving it the highest population density in the world among large countries, and twelfth highest overall (976 people per km^2). About 23 percent of the population is urban, with the remaining 77 percent living in rural areas.

Poverty in Bangladesh is widespread, but on the decline. In 2010, about 32 percent of the population lived below the national poverty line, down from 49 percent in 2000. Despite this considerable improvement, Bangladesh still has substantially higher poverty rates (in terms of purchasing power parity, or PPP) than other countries in the South Asia region. Using this indicator, Bangladesh has a poverty rate of 43.3 percent, while the regional average is just 24.5 percent. The incidence of poverty in Bangladesh is highest in the Rangpur and Barisal administrative divisions and northern Dhaka.

Nationwide, 55 percent of the population has access to electricity (up from only about 20 percent in 1990). Electrification rates are highest in urban areas, where only 12 percent lack access to electricity. In rural areas, 57 percent do not have electricity. Electrification rates have improved in recent years with the installation of solar home systems—since 2003, over 3.5 million solar home systems have been installed, benefiting about 13 million people.

The majority of electricity is supplied through gas-powered thermal generation. Rental power producers (RPPs) using diesel generators have been contracted to meet peak demand in the summer. Electricity has also been imported from India since September 2013. In terms of renewable energy (RE), hydropower is the primary grid-connected RE source.

1.2 The Context for SREP Involvement

The energy sector in Bangladesh faces important challenges which include limited availability of indigenous hydrocarbon resources, limited access to the electricity network, and climate change.

Access to Electricity

The vast number of citizens without access to electricity is the primary challenge in the Bangladesh energy sector. The lack of service has economic consequences for some of the poorest regions in the country. According to the 2010 Household Income and Expenditure Survey, Barisal and Rangpur divisions—the divisions with the highest incidence of poverty—have the lowest percentage of rural households with access to electricity, at 32 and 24 percent, respectively. Rangpur division also has the lowest urban electrification rate, at just 69 percent, compared to the national rate of 90 percent.

Energy Security

Bangladesh faces challenges in the form of natural gas depletion and biomass availability. It has been estimated that Bangladesh's natural gas reserves will be depleted before 2020. The uncertainty about reserves has limited the development of gas-based power generation programs. Biomass is becoming scarcer and more expensive, which negatively impacts poor households that rely on this fuel source. More than 90 percent of Bangladesh households use traditional biomass for cooking, and biomass accounts for 50 percent of Bangladesh's total energy supply. The common fuels used are rice husks, jute sticks, cow dung and wood.

Declining indigenous resources and increasing demand has caused Bangladesh to increasingly depend on imported fuel oil. The increase in fuel oil consumption has been driven by BPDB reliance on fuel oil QRPPs, RPPs and diesel IPPs to mitigate energy shortages. From 2009 to 2015, the share of oil-fired electricity has increased from 5 to 20 percent. This increase in oil-fired electricity contributed to the fuel cost per kWh generated going from 1.1 to 3.42 taka/kWh (US$0.014 to US$ 0.04) over the same period. This leaves Bangladesh's energy sector vulnerable to political and economic instability in nations from which it imports fuel, as well as rising prices generally.

Climate Change

Bangladesh is one of the world's most vulnerable countries to climate change. As a low-lying country with many rivers, Bangladesh has a very high flood risk, both due to monsoons and sea-level rise associated with climate change. Rising temperatures have already begun to shorten the growing season for rice; low crop production could increase poverty up to 15 percent by 2030. Higher water levels could lead to higher incidence of waterborne disease, such as cholera, and result in forced migration due to flooding.[1]

The World Bank has noted that Bangladesh is particularly vulnerable to an increase in poverty headcount rate and risk of chronic poverty as a result of different

[1] IPCC, 2014, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Malch, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, New York.

warming scenarios. Climate change could also reduce the availability of clean water supply and sanitation.[2]

The World Risk Report ranks Bangladesh as the fifth most vulnerable country in the world to climate change.[3] In addition, the Climate Change Vulnerability Index rates Dhaka as one of the five most climate-vulnerable cities in the world. Bangladesh addresses climate change issues through the Bangladesh Climate Change Strategy and Action Plan, which is implemented through the donor-funded Bangladesh Climate Change Resilience Fund.

1.3 Renewable Energy in Bangladesh

Bangladesh has considerable renewable energy potential, and significant past experience developing renewable energy projects. Most of the existing RE investment has been in off-grid technologies such as solar home systems (SHS), solar microgrids, and solar irrigation pumps. The GoB has set several investment targets for grid-connected technologies including utility-scale solar, wind, and waste-to-energy. Despite significant potential the development of these grid-connected renewable energy technologies, however, has been slow to materialize.

There are a number of regulatory, financial and technical barriers that if addressed could accelerate renewable energy investment in Bangladesh. Improved regulations, such as establishment of a formal feed-in tariff and set provisions for compensating minigrid investors after transmission expansion, would reduce risk and send strong signals to investors. Grant funding and low income financing can help address concerns about affordability for both grid-connected and off-grid projects. Reduced financing costs can also offset the high cost of procuring land for projects, land scarcity one of the key barriers to investment. Overall the paradox of the investment situation is that increased experience with renewable energy projects will lead to increased investment. Successful renewable projects will provide better access to data on renewable energy; demonstrate successful business models that can be replicated by local banks; and allow local workers the opportunity to learn the necessary technical skills.

The GoB has two sets of directives for renewable energy investment. The first is the 500 MW Solar Program, developed in 2012. The objective of the program is to add 500 MW of solar generation capacity by 2016 through financing and implementing solar-powered projects in both the public and private sectors.The GoB has also set renewable energy development targets for several technologies for each year from 2015 to 2021 ("RE Development Targets"). The RE Development Targets call for an additional 3,100 MW of RE capacity to be installed by 2021. Most of the new capacity will be provided by solar (1,676 MW, or 54 percent) and wind (1,370 MW, or 44 percent). There are also targets for waste-to-energy (40 MW), biomass (7 MW), biogas (7 MW) and hydro (4 MW).

SREP could play a major role in addressing some of the investment barriers and support the GoB's renewable energy goals. SREP funds would be used to kick-start

[2] World Bank, "Turn Down the Heat: Confronting the New Climate Normal," 2014.

[3] Alliance Development Works, "WorldRiskReport 2012."

investment in the government priority areas of utility-scale projects and off-grid solar. Grants and low cost financing can be used to attract early investors into an unproven market and keep the cost of energy more affordable for off-grid customers. The successful projects developed using SREP funds will then demonstrate the potential for utility-scale projects and attract other investors into the market.

1.4 The Proposed Investment Program for Bangladesh

Each of the potential renewable energy resources were evaluated against national and SREP criteria, and prioritized accordingly. The criteria reflect the Government's strategic objectives, and the clear recognition that SREP funding should be used to overcome barriers to technologies that will have the potential to have a transformative impact on the energy sector. The criteria considered included: scalability (the amount of developable resource potential relative to other technologies), availability of sites, unexploited market potential, readiness for implementation and financial viability.

The prioritization exercise has led to the selection of three areas where Government will request SREP support:

- Grid-connected renewable energy, which includes utility-scale solar PV and grid-connected rooftop solar PV. If wind resources prove to be sufficient, and there is private sector interest, the SREP funds could also be used for a grid-connected wind project
- Off-grid solar PV, which includes solar irrigation, and mini/microgrids
- Transaction advisory assistance in preparing a municipal waste-to-energy project.

Table 1.1 presents a plan for financing the projects described in Section5. It shows the proposed credits and grants from SREP as well as estimates of the amounts anticipated from MDBs and the private sector.

As the table shows, roughly US$ 75 million of SREP funding is expected to catalysemore than seven times as much investment, most of it from the private sector (as equity or debt), and the public sector lending windows of the MDBs.

The exact financing modalities will be determined at the time of appraisal, but it is expected that:

- Roughly US$ 42 million of SREP contributions would be used to leverage blended financing for utility-scale renewable energy plants (primarily solar but possibly also wind), and rooftop solar. The blended financing would include US$ 100 million in IDA financing from the World Bank, US$100 million in a partial risk guarantee (PRG) or similar instrument, US$ 30 million in investment from IFC, and roughly US$ 100 million from the private sector. IFC's assistance would be sought for transaction advisory on structuring of the PPP arrangement under which private operators would be selected.

- Roughly US$ 30 million of SREP grant funding would be used to leverage US$ 140 million in concessional financing from ADB for solar irrigation and hybrid minigrid projects.
- IFC's assistance would be sought for assistance with an assessment of technical and commercial feasibility and for transaction advisory on the structuring of a municipal waste-to-energy project.

The Government of Bangladesh will contribute by waiving VAT (15%) on all capital expenditure and services associated with the financing plan.

Table 1.1: Financing Plan—Phase 1

SREP Project	**SREP**	**MDB Respon-sible**	**Government of Bangladesh**	**MDBs**	**Private Sector (Equity or Debt)**	**Total before government contribution**	**Total**
Grid-Connected Renewables	**(Million US$)**						
Investment in utility-scale solar and wind, and rooftop solar	42.0	WB	55.8	200.0*	100.0	372.0	**427.8**
Investment in utility-scale solar and wind, and rooftop solar		IFC		30.0			
Project preparation (including feasibility studies)	2.0	WB				2.0	**2.0**
Transaction advisory	0.8	IFC	0.4		1.8	2.6	**3.0**
Subtotal: Grid-connected renewables	**44.8**		**56.2**	**230.0**	**101.8**	**376.6**	**432.8**
Off-grid solar PV	**(Million US$)**						
Investment in mini-grids	5.0	ADB	18.8	120.0		125.0	**143.8**
Investment in solar irrigation	24.0		6.6	20.0		44.0	**50.6**
Project preparation	1.0					1.0	**1.0**

Subtotal: Off-grid solar PV	**30.0**		**25.4**	**140.0**	**0.0**	**170.0**	**195.4**
Development support for Waste-to-Energy	**(Million US$)**						
Transaction advisory for WtE plant (including feasibility study)	0.2	IFC	0.2		0.9	1.0	**1.2**
Subtotal: Development support for Waste-to-Energy	**0.2**		**0.2**	**0.0**	**0.9**	**1.0**	**1.2**
Grand Total	**75**		**81.6**	**370.0**	**102.7**	**547.6**	**629.3**
SREP Leverage	**7.4**						

Notes: All amounts in this table are preliminary estimates and are subject to availability of funds.

*Roughly $100 million of this amount could be IDA financing and $100 million could be in the form of a partial risk guarantee (PRG) or similar guarantee instrument.

The investments associated with the SREP investment prospectus represent the first phase of two-phase investment program planned by Government. Support for Phase II will be sought from the Green Climate Fund (GCF). The second phase will include a continuation of the grid-connected renewable energy projects, clean cookstoves program, and the waste-to-energy project launched as part of Phase 1, with SREP assistance.

2 Country Context

Bangladesh is a low lying country located on the Ganges Delta.Seventy-five percent of the country is less than 10 meters above sea level and more than 700 rivers run through its borders. The Chittagong Hill Tracts, Low Hills of Sylhet and the highlands in Rangpur are the highest points of elevation. Bangladesh has more than 580 km of coastline, and 32 islands in the Bay of Bengal and Padma River.

According to the 2011 census, approximately144 millionpeople live in a total area of 147,500 km^2, giving it the highest population density in the world among large countries, and twelfth highest overall (976 people per km^2). Roughly23 percent of the population is urban, with the remaining 77 percent living in rural areas. The largest cities are Dhaka, the capital (7.03 million), and Chittagong (2.59 million). Population density of the administrative divisions ranges from a low of 630 people per km^2 in Barisal Division to a high of 1,521 people per km^2 in Dhaka Division. Figure 2.1below shows the administrative divisions of Bangladesh, along with relevant population statistics.

Figure 2.1: Administrative Divisions of Bangladesh

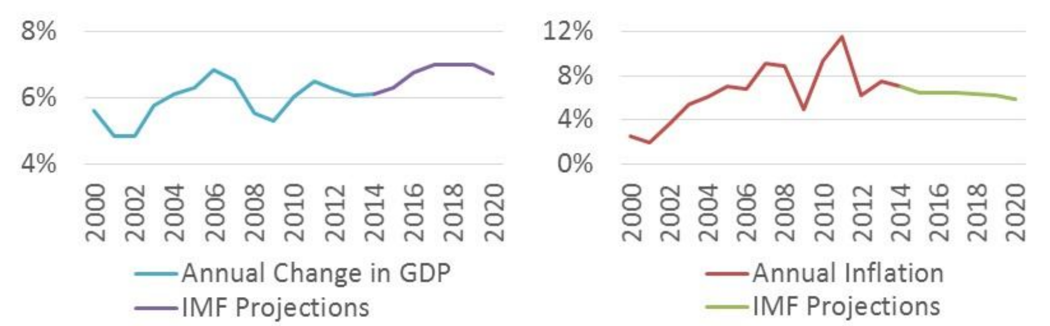
Division	Population (Millions)	Pop. Density (per km^2)	Urban Pop. %	Rural Pop. %
Barisal	8.325	630	16.4%	83.6%
Chittagong	28.423	838	24.3%	75.7%
Dhaka	47.424	1,521	32.9%	67.1%
Khulna	15.687	704	18.0%	82.0%
Rajshahi	18.484	1,018	17.9%	82.1%
Rangpur	15.787	975	13.3%	86.6%
Sylhet	9.910	784	14.8%	85.2%
Total	**144.043**	**976**	**23.3%**	**76.7%**

Source: 2011 Census, Bangladesh Bureau of Statistics.

2.1 Economy

Bangladesh is classified as a developing economy by the IMF. Its economic growth has averaged nearly six percent per year since 1996. Bangladesh's GDP was US$ 196.6 billion in Fiscal Year 2014-2015, with manufacturing (17 percent), motor vehicles (13 percent), service (13 percent), and agriculture (12 percent) being the largest value-added sectors.[4]The economy lost about US$ 2.2 billion (about 1 percent of GDP) as a result of political unrest in 2013 and January 2015, but economic growth in Bangladesh has largely been resistant to political instability, natural disasters, poor infrastructure and global shocks.[5] Bangladesh was less affected by the global financial crisis because of increased international demand for low-cost exports, and remittance growth of 22.5 percent in 2008-2009.[6]Figure 2.2 below shows the annual change in real GDP and annual inflation from 2000 to 2020. Inflation in Bangladesh has been constrained by reduced global oil prices and conservative monetary policies.

Figure 2.2: Annual Change in Real GDP and Inflation, 2000-2020



Source: IMF World Economic Outlook (April 2015).

The economy added 1.3 million jobs per year from 2010 to 2013. The national unemployment rate is five percent, but underemployment rates are much higher. Important employment sectors include agriculture (54 percent);trade, hotel and restaurant (16 percent); and manufacturing (12 percent). About 86 percent of employment is informal.[7]

2.2 Poverty

Poverty in Bangladesh is widespread, but on the decline. In 2010, about 32 percent of the population lived below the national poverty line, down from 49 percent in 2000. Despite this considerable improvement, Bangladesh still has substantially higher poverty rates (in terms of purchasing power parity, or PPP) than other countries in the South Asia region. Figure 2.3 shows poverty rates in South Asia in terms, where the poor are defined as those who earn less than US$ 1.25 per day PPP. The horizontal line represents the regional average of 24.5 percent. Using this indicator, Bangladesh has a poverty rate of 43.3 percent. The incidence of poverty in Bangladesh is highest in the Rangpur and Barisal administrative divisions and northern Dhaka.

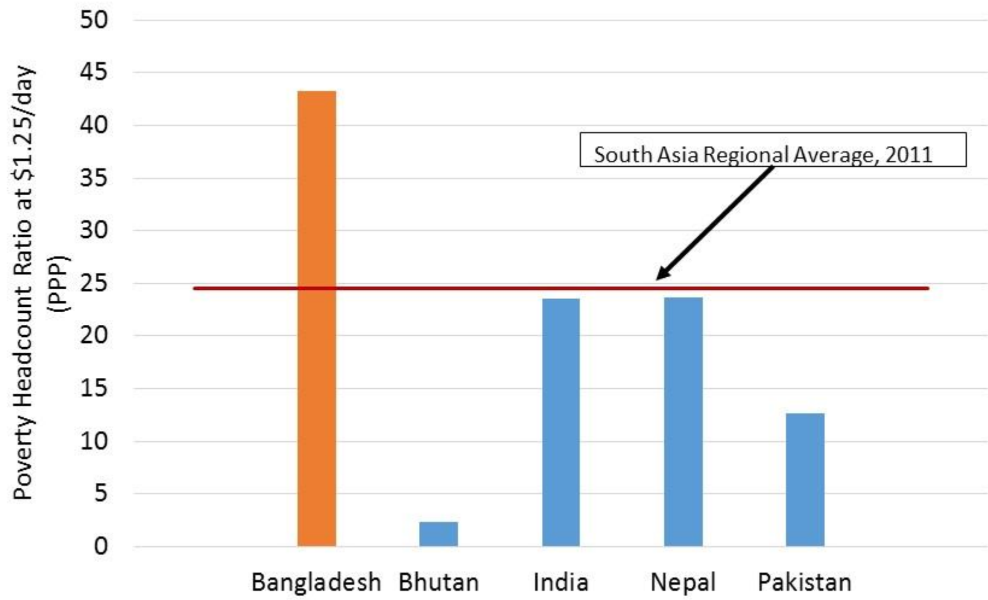
[4] Bangladesh Bureau of Statistics (2015)

[5] World Bank, Bangladesh Development Update, April 2015.

[6] World Bank, “Impact of the Global Financial Crisis in South Asia’s Electric Power Infrastructure.”

[7] BBS Labour Survey, 2010.

Figure 2.3: Poverty Rates in South Asia (at US$ 1.25 per day PPP)



Note: Country data is from 2010 for Bangladesh, Nepal and Pakistan; 2011 for India; and 2012 for Bhutan. No data was available for Afghanistan or Maldives. The only data available for Sri Lanka was from 2002, so it was excluded.

Source: World Bank Development Indicators.

2.3 Energy Supply and Demand

Indigenous fuel supply in Bangladesh is comprised of natural gas, coal and oil products. There are 21 natural gas fields in Bangladesh, operated by three national and two international companies.[8] There are five coalfields in Bangladesh, in Barapukuria, Khaspir, Jamalganj, Fulbari and Digipara.[9] In 2012, Bangladesh struck its first oil in two fields in Sylhet.[10]In 2013, Bangladesh produced 21,000 ktoe of natural gas (up from 18,000 ktoe in 2010), 400 ktoe of coal and 200 ktoe of oil.[11]

Natural gas and biofuels are the main sources of energy in Bangladesh. Primary energy consumption increased 74 percent from 2000 to 2012, with natural gas and coal consumption growing at the fastest rates (seeFigure 2.4).

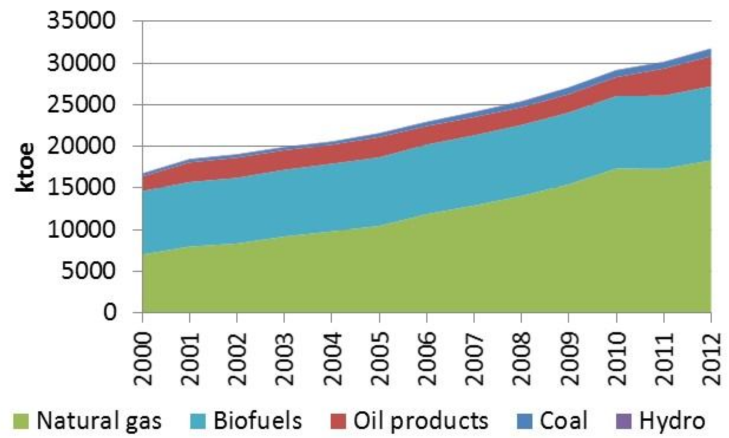
[88]http://www.petrobangla.org.bd/daily%20gas%20product.pdf

[9]http://www.bcmcl.org.bd/index.php?page=development_of_coal_mining

[10]http://www.aljazeera.com/news/asia/2012/05/2012520163618865961.html

[11] United States Energy Information Association.

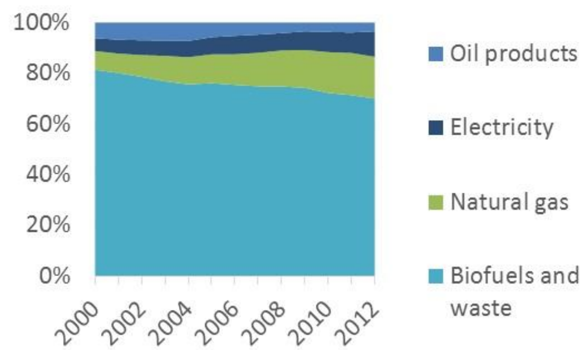
Figure 2.4: Primary Energy Consumption, 2000-2012



Source: IEA Energy Balances (2014).

Biofuels remain the main source of energy for residential consumers; however consumption patterns have changed in recent years. Biofuels as a percentage of total residential consumption decreased from 81 to 70 percent between 2000 and 2012. Electricity increased from five to ten percent of consumption, and natural gas increased from seven to 16 percent of consumption, replaced the consumption of biofuels (see Figure 2.5).

Figure 2.5: Residential Energy Consumption, 2000-2012



Source: IEA Energy Balances (2014).

2.4 Policies and Plans

The following sub-sections provide a summary of important characteristics of the national and international policy frameworks of Bangladesh's energy sector, as well as Government plans for RE development.

2.4.1 Strategic Objectives of the Government of Bangladesh

Table 2.1provides an overview of GoB's policy objectives for the energy sector.

1 **Table 2.1: Policy Framework for the Energy Sector**

Policies	Overview
Private Sector Power Generation Policy (1996)	▪ Plan to attract private sector investments in the energy sector to meet energy sector growth targets
National Energy Policy (2004)	▪ Strive to have energy meet the needs of economic growth in Bangladesh, and meet the needs of all the zones and socio-economic groups ▪ Optimum development of indigenous energy sources ▪ Promote sustainable utility operations ▪ Rational use of energy sources and environmentally friendly development of renewable energy ▪ Promote public and private participation in the sector, and develop a regional energy market to ensure energy security ▪ Goal of total electrification by 2020 ▪ Ensure reliable and affordable energy supply
Private Sector Infrastructure Guidelines (2004)	▪ Established procedures to identify Private Infrastructure Projects ▪ Set guidelines for private sector investors and the GoB for the procurement and implementation of Private Infrastructure Projects ▪ Set guidelines for monitoring and expediting the implementation of Private Infrastructure Projects
Policy Guidelines for Power Purchase from Captive Power Plant (CPP) (2007)	▪ Plan to lessen the gap between supply and demand for energy by utilizing the surplus capacity of CPPs and allowing electric utilities to purchase electricity from CPPs
Remote Area Power Supply System (RAPSS) Guidelines (2007)	▪ Guidelines for the implementation of the RAPSS program, in which private investors are given an area (either on-grid or off-grid) to develop an electricity generation and distribution system, which they then utilize as a utility operator for up to 20 years
Policy Guidelines for Small Power Plants (SPP) (1998, Revised 2008)	▪ Guidelines to allow for fast-track private sector establishment of SPPs for their own electricity needs, and to sell the surplus to others ▪ SPPs are to be developed with a capacity of 10MW or less (larger plants are possible with government permission), and are to be established on a build-own-operate basis.

Renewable Energy Policy of Bangladesh (2008)	▪ Goal of renewable energy constituting 5% of total generation by 2015 and 10% by 2020 ▪ GoB committed to facilitating public and private sector RE investments ▪ Scale up RE contributions to electricity and heat energy, and substitute RE for indigenous non-renewable energy supplies ▪ Facilitate RE use at every level of energy usage ▪ Develop legal environment that promotes RE use ▪ Encourage efficient and environmentally-friendly use of renewable energy, and promote clean energy
Policy Guidelines for Commercial IPP (2008, Amended 2010)	▪ Goal of promoting private sector participation, competition, efficient use of natural gas, and the development and revitalization of power plants through PPPs. ▪ Established guidelines for establishing and enhancing PPPs in the power sector
Guidelines for the Implementation of Solar Power Development Program (2013)	▪ Goal of enhancing and improving solar technology, and attracting donor organizations and private investors ▪ Established guidelines for implementing solar parks, solar minigrids, solar rooftop systems and solar irrigation pumps

2.4.2 National and International Policy Frameworks

Japan International Cooperation Agency (JICA) is currently supporting an update of the 2010 Power Sector Master Plan. The 2010 Master Plan set several plans and corresponding targets, summarized in Table 2.2.

Table 2.2: 2010 Power Sector Master Plan Targets

Plan	Target
▪ To actively develop primary energy resources	▪ To maintain domestic primary energy supply over 50% – Domestic natural gas development – Domestic coal development
▪ To establish the power system portfolio by fuel diversification	▪ Fuel composition ration in 2030: 50% coal, 25% natural gas, 25% others – Construction of imported coal power station – Introduction of LNG facilities – Construction of oil-fired power station – Import electricity generated by hydropower from neighboring countries (or joint development) – Development of domestic renewable energy (wind and solar power)

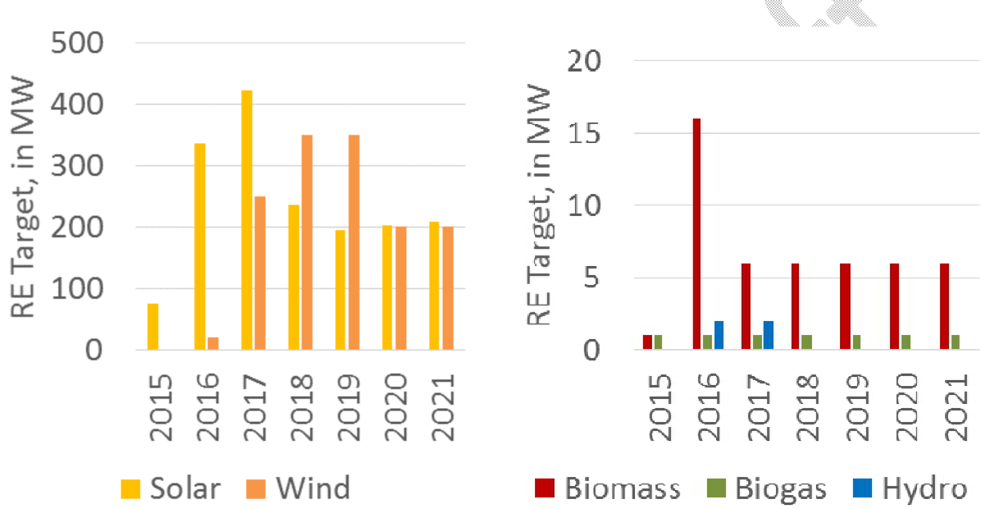
▪ To realize a low-carbon society by introducing a high-efficiency power supply and low CO_2	▪ Improve thermal efficiency by 10 points on average – High-efficiency gas power station – Development of domestic coal power station – Review of operations and maintenance schemes – Energy conservation and demand-side management
▪ To build an infrastructure necessary for stable power supply under joint multi-sector coordination	▪ Jointly build a deep sea port facility (power, industry, and commercial sectors) – Construction of deep sea port – Improvement of power transmission system – Enhancement of gas transmission line – Construction of fuel center – Strengthen domestic waterways – Strengthen railway system
▪ To build efficient and effective mechanisms, organizations and regulations for stable power supply	▪ Establish an organization for long-term stable fuel supply security – Organization for coal procurement ▪ Formulate regulations for compulsory regular inspection of power stations ▪ Revise the tariff structure to recover maintenance costs and provide for future investment in plants and equipment – Introduction of Power Development Surcharge into the power tariff – Promotion of private investment to realize the Master Plan – Create an effective and efficient power market
▪ To reduce poverty through socio-economic growth	▪ Promote local communities and mutual collaboration – Spread stable and sustainable power supply – Promote rural area electrification – Promote local industry, associated employment opportunities and income increases – Promote mutual collaboration between the power station and the local community

Source: Ministry of Power, Energy and Natural Resources and Japan International Cooperation Agency, Power System Master Plan 2010, February 2011.

2.4.3 Government Plans

The GoB has two sets of directives for renewable energy investment. The GoB has set renewable energy development targets for several technologies for each year from 2015 to 2021 (“RE Development Targets”). The RE Development Targets call for an additional 3,100 MW of RE capacity to be installed by 2021. Most of the new capacity will be provided by solar (1,676 MW, or 54 percent) and wind (1,370 MW, or 44 percent). There are also targets for biomass (47 MW), biogas (7 MW) and hydroelectricity (4 MW). Figure 2.6 shows the RE development targets for each technology from 2015 to 2021.

Figure 2.6: RE Development Targets, 2015-2021



Source: Based on information provided by SREDA.

The RE Development Targets propose three models for investment in utility-scale solar parks and wind farms: GoB investment on government owned land; independent power producer (IPP) investment on government land; and private investment on private land. The current plan for procuring the private sector projects is to hold auctions for IPP investment on government land and to negotiate fixed tariffcontracts for private investment on private land.Feed-in-tariffs are an option that may be considered for these projects but are currently being considered just for small-scale generation and microgrid projects. Table 2.3 shows the targets for new capacity of solar parks and wind farms (in MW) via each of these implementation models from 2015 to 2021.

Table 2.3: New Solar Park and Wind Farm Capacity (in MW) by Implementation Model

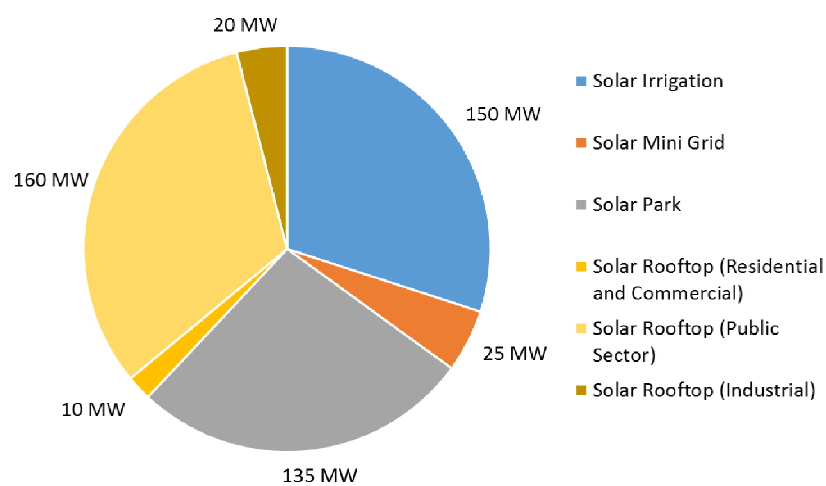
		2015	2016	2017	2018	2019	2020	2021	Total
GoB on government land	Solar park		68	40	50	30	40	45	273
	Wind farm			100	150	150	100	100	600
IPP on	Solar park	3	85	50	50	50	50	50	338

government land	Wind farm			50	100	100	50	50	350
Private on private land	Solar park		100	100	100	100	100	100	600
	Wind farm		20	100	100	100	50	50	420
Total		3	273	440	550	530	390	395	2,581

Source: Based on information provided by SREDA.

The second directive is the 500 MW Solar Program, developed in 2012. The objective of the program is to add 500 MW of solar generation capacity by 2016 through financing and implementing solar-powered projects in both the public and private sectors. The program will help the GoB achieve the goals set out in its Renewable Energy Policy (2008) for the percentage of electricity to be generated from renewable sources (five percent by 2015 and 10 percent by 2020). Figure 2.7 shows a breakdown of the installation goals of the program by application.

Figure 2.7: 500 MW Solar Program Installation Goals (MW)



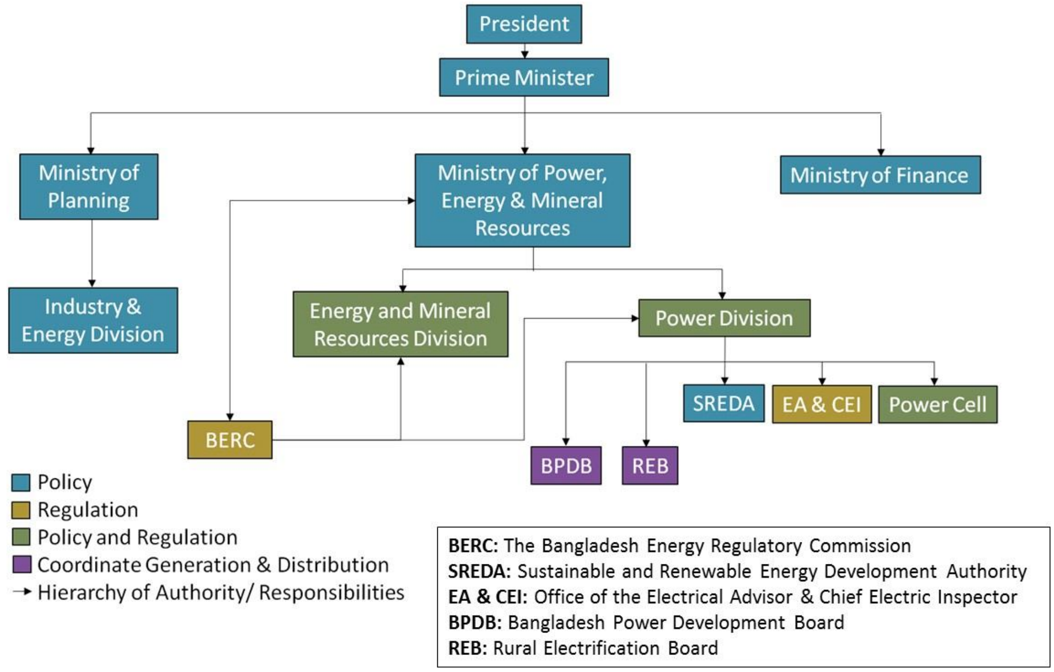
2.5 Legal, Regulatory and Institutional Framework

The following sub-sections provide a summary of important characteristics of thelegal, regulatory, and institutional framework of Bangladesh's energy sector. Section 2.5.1 provides information on important institutions in the energy sector, including generation, distribution and transmission companies and their assets. Section 2.5.2 summarizes the legislative and regulatory framework in the energy sector in Bangladesh.

2.5.1 Institutional Framework in the Energy Sector

There are several important institutions responsible for energy policy and regulation in Bangladesh. Figure 2.8 below shows their responsibilities and the relationships between the institutions.

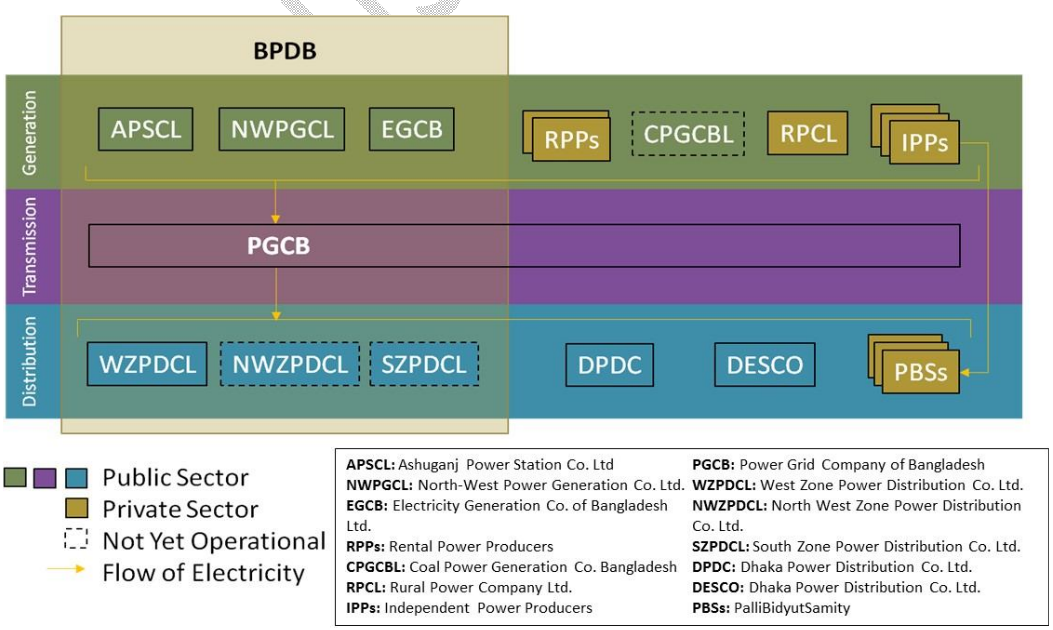
Figure 2.8: Energy Policy and Regulatory Entities



Adapted in part from:http://www.usea.org/sites/default/files/event-file/493/overviewofbpdb.pdf
and http://www.powercell.gov.bd/index.php?page_id=216

Figure 2.9 shows the energy utility companies in Bangladesh, including generation, transmission and distribution companies, which are further described below.

Figure 2.9: Energy Utility Companies in Bangladesh

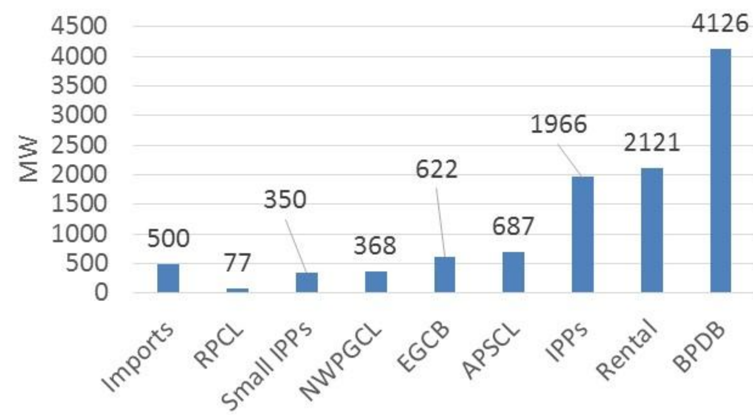


Note: Although NWZPDCL and SZPDCL are not yet operational, BPDB is still providing distributional services to customers in the Northwest and Southwest zones. Those distribution duties and assets will later be transferred to the individual entities.

Generation

The Power Development Board (BPDB) and its affiliates operate 5,803 MW (about 53 percent) of installed capacity. Rental power producers (RPPs) have been contracted on three-, five- and 15-year contracts to address power shortages. Figure 2.10below shows installed grid-connected capacity by owner.

Figure 2.10: Installed Capacity by Owner, 2015



Source: PGCB; BPDB SREDA.

Installed off-grid capacity includes solar home systems (150 MW), electricity from biogas and biomass (6 MW), wind (2 MW) and rooftop solar PV (14 MW).

Transmission

The Power Grid Company of Bangladesh (PGCB) owns the national power grid, the only high voltage power transmission network in Bangladesh. Table 2.4 summarizes information about the length and capacity of the transmission network.

Table 2.4: Key Information about Transmission Grid System

Transmission Lines	
400 kV	164.70 km
230 kV	3044.45 km
132 kV	6263.63 km
Substations	
400 kv	1 (500 MW HVDC, B2B)
230/132 kv	18

132/33 kv	150
Performance Metrics	
Transmission Losses	2.90%
No. of grid Failures (Time)	94* (14 hours 32 minutes)

Note: * Grid failures: 84 due to power generation failure; four due to substation failure; one due to lightning; and one partial grid failure.

Source: BPDB Annual Report FY2013-2014.

Distribution

There are five distribution companies, operating in separate service areas:

- **BPDB:** Urban areas in their six zones—Northern Zone (Rajshahi), Comilla, Mymensingh, Sylhet, Rangpur and Chittagong. BPDB's distribution responsibilities will eventually be transferred to NWZPDCL and SWZPDCL.
- **WZPDCL:** West zone—Khulna Division, Barisal Division and Greater Faridpur, comprising 21 districts and 20 upazilla, excluding REB area.
- **DPDC:** Southern part of Dhaka and Narayanganj.
- **DESCO:** Dhaka Mega City Area.
- **REB:** Collective of 72 PBSs serving 52,714 villages in rural areas. Approximately 13 million rural households still do not have access to electricity.[12]

Table 2.5 below provides details on the networks, substations, connections and system losses for each distribution company.

Table 2.5: Key Information on Distribution Companies in Bangladesh

Distribution Company	Network (km of lines)	33/11 kV Substations	Connections	System Losses (FY13-14)
BPDB	38,934	153	2,901,235	11.89%
WZPDCL	10,526	63	790,080	10.98%
DPDC	4,266	42	925,437	9.76%
REB	277,037	664	11,375,908	12.72%
DESCO	4,074	29	641,187	8.41%

Source: Company websites, FY2013-2014 Annual Reports.

Table 2.6 below summarizes the roles and responsibilities of each entity of Bangladesh's energy sector.

[12] World Bank, "Project Signing: Bangladesh Receives US$ 600 Million to Improve Rural Electricity Supply for 25 Million People." 19 July 2014.

Table 2.6: Roles and Responsibilities of Energy Sector Entities

Entity	Roles and Responsibilities
Ministry of Planning, Industry and Energy Division	▪ Coordinate national new and renewable energy projects and coordinate between ministries for cross-ministry energy projects
Ministry of Finance	▪ Develop energy sector documents, such as the Power Energy Sector Road Map (2011)
The Ministry of Power, Energy & Mineral Resources (MPEMR)	▪ Consists of the Energy and Mineral Resources Division and the Power Division
The Energy & Mineral Resources Division, under MPEMR	▪ Policies related to petroleum, natural gas, mineral resources, and geological surveys ▪ Administration of Geological Survey of Bangladesh, Bureau of Mineral Development, Department of Explosives, Bangladesh Petroleum Institute, Hydrocarbon Unit, Bangladesh Oil, Gas and Mineral Corporation and Bangladesh Petroleum Corporation ▪ Inquiries and statistics ▪ Fees for subjects allotted to this division
Power Division , under MPEMR	▪ Consists of the Power Cell, EA & CEI, and SREDA
Power Cell, under the Power Division, MPEMR	▪ Develop and implement reform programs that improve the sector's performance, increase consumer satisfaction, and maintain sector viability ▪ Promote sector development and optimum resource utilization ▪ Strategize for corporatization of sector entities, and develop financial/business plans and HR/D plans ▪ Establish distribution areas ▪ Develop and implement the MIS & IT system of the power sector ▪ Capacity building for system improvement, tariff calculation, and cash flow studies ▪ Development of the power sector Master Plan ▪ Develop a communication system between the utilities

Office of the Electrical Advisor & Chief Electric Inspector (EA & CEI), under the Power Division, MPEMR	▪ Inspect installations, substations and lines ▪ Grant licenses for high tension and medium tension consumers, electrical contractors, engineers and electricians ▪ The Energy Monitoring Unit (a subdivision of EA & CEI) ensures that industries are using energy efficiently and energy is being conserved were possible.
Sustainable and Renewable Energy Development Authority (SREDA), under the Power Division, MPEMR	▪ Coordinate between ministries and departments concerned with sustainable and renewable energy ▪ Executive members are responsible for duties involving renewable energy, energy efficiency, finance, administration, policy and research. ▪ Assist in the achievement of renewable energy goals, such as the plan to increase renewable energy's share of generation to 5 percent in 2015 and 10 percent in 2020.
Bangladesh Power Development Board (BPDB), under the Power Division, MPEMR	▪ Generation ▪ Distribution, mainly in urban areas (except for Dhaka and the area covered by WZPDC), and also some rural areas not covered by REB ▪ Installed generation capacity of 10868 MW (as of April 2015) ▪ 2,901,235 consumers (as of the end of the 2014 fiscal year)
Rural Electrification Board (REB), under the Power Division, MPEMR	▪ Electrifying rural Bangladesh through the management and regulation of electricity cooperatives or "Palli Bidyut Samity" (PBSs) ▪ Use electricity to facilitate socio-economic development and improve agriculture in rural areas ▪ 11,375,908 consumers served (as of April 2015)
The Bangladesh Energy Regulatory Commission (BERC)	▪ Enforcement of codes, standards and existing laws on environmental energy standards ▪ Dispute resolution ▪ Set performance targets and encourage a competitive market ▪ Set standards for energy operations and supply ▪ Determine tariffs ▪ Issue licenses and license exemptions, and approve schemes based on those licenses ▪ Develop the methodology for performance rating for all licensees ▪ Collect, review, maintain, and publish energy statistics ▪ Audit machinery and appliances that utilize energy and determine their efficiency level

2.5.2 Legal and Regulatory Framework in the Energy Sector

Table 2.7 provides an overview of energy sector legislation in Bangladesh.

Table 2.7: Legal Framework for the Energy Sector

Laws	Overview
Electricity Act (1910, Amended 2012)	▪ Set standards for electricity supply, transmission, and distribution ▪ Stipulates that the GoB will encourage power generation utilizing renewable and non-conventional energy ▪ Set guidelines for private sector participation, policy formation, reform, and reorganization
BERC Act 2003 (Amendments 2005 & 2010)	▪ Established the Bangladesh Energy Regulatory Commission
Power and Energy Fast Supply Enhancement (Special Provision) Act (2010)	▪ Simplified power project approval processes, to allow for a fast increase in supply to the national grid
Sustainable & Renewable Energy Development Authority (SREDA) Act	▪ Established the Sustainable and Renewable Energy Development Authority, and set its responsibilities and authorities

Table 2.8 below summarizes important regulations and codes in the energy sector in Bangladesh.

Table 2.8: Regulatory Framework for the Energy Sector

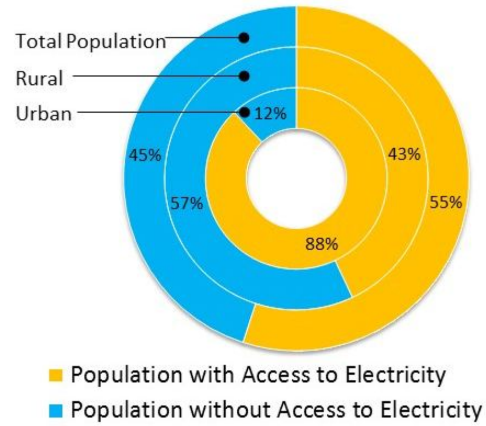
Regulations and Codes	Overview
BERC License Regulations (2006, Amended 2011)	▪ Set regulations for licenses issued by BERC for energy generation, transmission, distribution and marketing
BERC Electricity Generation Tariff Regulations (2008)	▪ Sets regulations for generation bulk supply tariffs (BST), transmission wheeling charges, and retail distribution tariffs
Draft Feed-In Tariff (FIT) Regulations (2015)	▪ Set regulations for wind and solar tariff structure and design
Electricity Grid Code (2012)	▪ Set responsibilities of involved entities ▪ Established rules for safety and technical standards ▪ Regulations for investment and operational planning ▪ Established commercial operating guidelines

Electricity Distribution Code (2012)	▪ Assigned Distribution Licensees the responsibility of maintaining an efficient and economical distribution system, and supplying energy in accordance with the BERC Licensing Regulation and the Distribution Licensee Standards of Performance

2.6 Access to Electricity

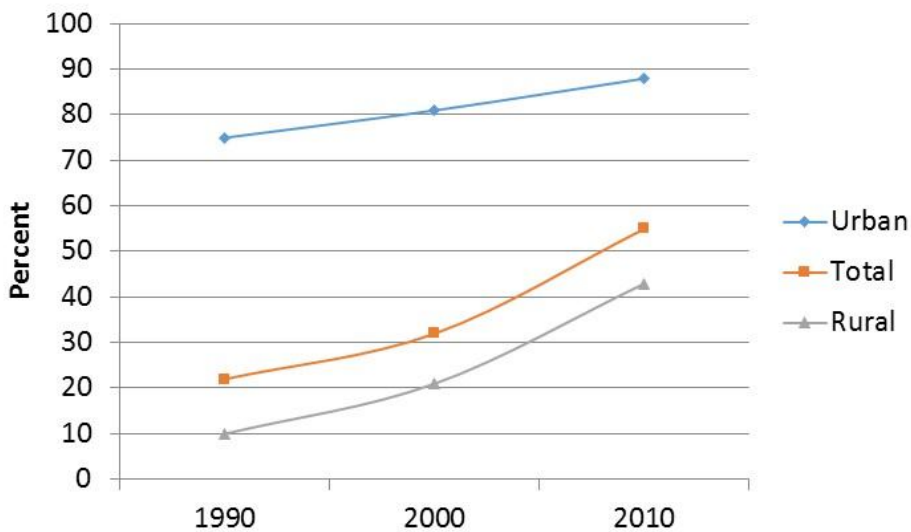
Rapid urbanization is causing demand growth, but supply is not keeping up. Only 12 percent of the urban population has no electricity access. In rural areas, 57 percent do not have electricity. Nationwide, 55 percent have access to electricity, up from about 20 percent in 1990.Figure 2.11shows electricity access rates for the urban, rural and total population in 2010. Figure 2.12 presents the change in access to electricity from 1990 to 2010.

Figure 2.11: Access to Electricity, 2010



Source: World Bank Development Indicators.

Figure 2.12: Change in Access to Electricity, 1990-2010

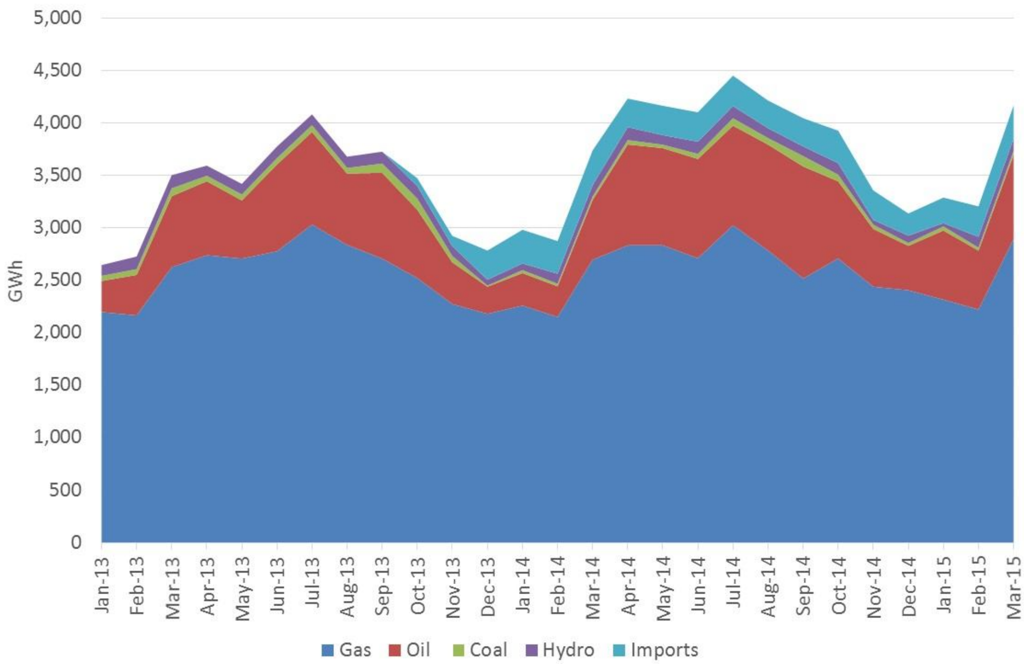


Source: World Bank Development Indicators.

2.7 Electricity Supply and Demand

Natural gas fueled turbines make up62 percent of Bangladesh’s installed generation capacity, these plantsrepresented 70 percent of electricity production in 2014. Rental power producers (RPPs) using diesel generators have been contracted to meet peak demand in the summer. Electricity has also been imported from India since September 2013. In terms of renewable energy (RE), hydropower is the primary grid-connected RE source (see Figure 2.13).

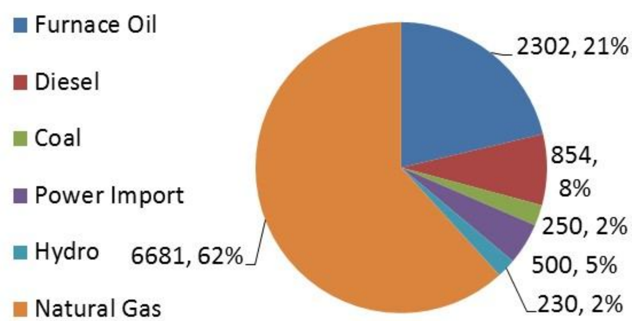
Figure 2.13: Monthly Electricity Generation Mix, 2013-2015



Source: PGCB Monthly Reports

The most common fuel type for generation in Bangladesh is natural gas, which makes up 62 percent of total-grid connected capacity. This is followed by furnace oil (21 percent) and diesel (8 percent). Figure 2.14 shows the installed grid-connected capacity by fuel type.

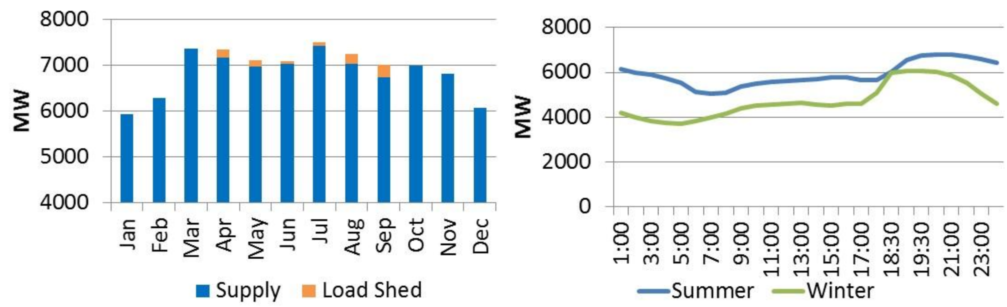
Figure 2.14: Installed Grid-Connected Capacity by Fuel Type, 2015



Source: PGCB; BPDB SREDA.

Electricity demand peaks in the summer months, at over 7,000 MW (see Figure 2.15). The system load factor is 0.71. Daily demand typically peaks between 5PM and 11PM.

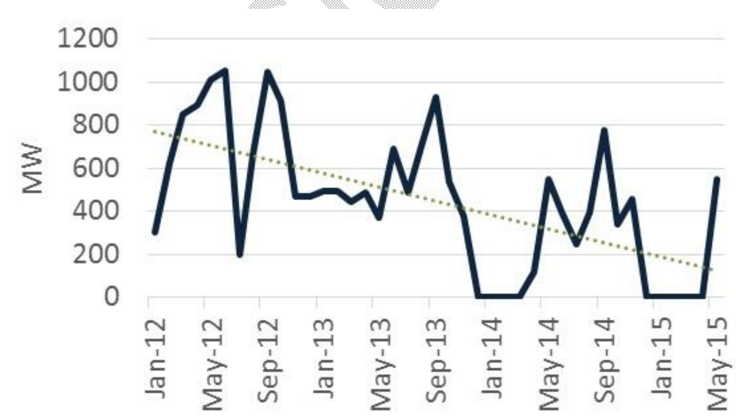
Figure 2.15: Peak Demand by Month and Average Demand by Hour, 2014



Source: PGCB

New capacity from IPPs and RPPs have improved power supply over the last 18 months. Maximum load shed has declined since May 2012, and total load shed days has decreased (see Figure 2.16). Despite the decline in load shed, unserved energy from transmission failures has increased 61 percent—a 2,155 MW jump—from 2013 to 2014. Unserved energy has continued to rise in the first five months of 2015, increasing nine percent over the same period in 2014. While RPPs have added much-needed capacity, they do not represent a sustainable long-term solution to energy shortfalls. Their ability to meet energy shortfalls quickly makes them an attractive option, but not a long-term solution. Moreover, RPP costs increase with the price of imported oil.

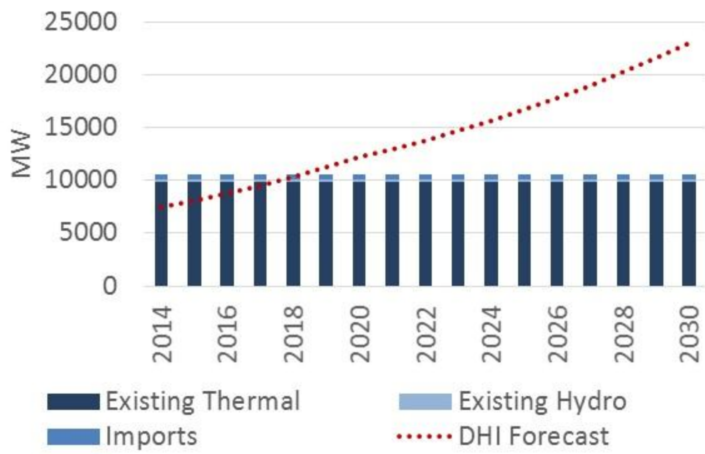
Figure 2.16: Maximum Load Shed by Month,2012-2015



Source: PGCB Monthly Reports

Additional capacity investments are neededfor supply reliability to continue to improve. SustainedGDP growth of six percent per year could lead to an increase in annual demand of 62 percent by 2020 and 207 percent by 2030. If power demand continues to grow at the projected rate, an average of 829 MW per year needs to be installed over the next 15 years to meet peak demand in 2030 (see Figure 2.17).

Figure 2.17: Projected Supply-Demand Balance, 2015-2030



Source: DHInfrastructure projections

2.8 Electricity Tariffs

The approach for setting electricity tariffs was established in the Bangladesh Energy Regulatory Act (2003). The Act calls for BERC to set tariffs, tariff policy and methodology in consultation with GoB. As part of this role BERC has established procedures for the following tariffs:

- **BPDB Bulk Supply**. BERC sets the price BPDB uses to sell energy to the distribution companies. The tariff is supposed to cover the expenses for the expenses incurred by BPDB in operating their own power plants and also the cost of procuring energy from IPPs and RPPs. Procurement and price negotiations between IPPs, RPPs, and developers of publically-owned power plants must be in line with Public Procurement Rules (PPR) (2008). Procurement processes under the PPR are summarized in Box 2.1.
- **PGCB Wheeling Charges**. Price paid by distribution companies to PGCB for delivery over the high-voltage transmission network.
- **End-User Tariffs**. BERC also sets tariffs for the distribution companies. BERC reviews tariffs quarterly at open public hearings, but is only obligated to adjust tariffs annually. In other words, the companies may requires quarterly changes, but BERC is not obliged to grant them.The distribution companies can also request BERC to revise tariffs. Distribution companies and other stakeholders can make recommendations which BERC will consider when making tariffs.

Box 2.1: Public Procurement Rules in Bangladesh

Bangladesh's Public Procurement Rules (2008) provide for several methods of procurement:

- **Open tendering:** competition open to all interested firms via public advertisement;
- **Limited tendering:** competition limited to those directly invited to tender;
- **Two-stage tendering:** open, publicly advertised tendering in which an initial unpriced technical proposal is submitted and evaluated for compliance and responsiveness; all

responsive tenderers from the first stage are invited to submit priced tenders;

- **Single stage two envelope tendering:** similar to two-stage tendering, but technical and financial proposals are submitted simultaneously in separate envelopes;
- **Request for quotation (RFQ):** simplified tender, advertised on company website, requesting quotations for low-value goods and services;
- **Direct procurement:** procuring entity requests a priced offer, subject to negotiation, from a tenderer directly, without competition, for proprietary, exclusive or urgently needed goods and services;
- **Request for proposals (RFP):** technical and financial proposals used for procurement of intellectual and professional services, sent to short-listed applicants and evaluated based on specific experience of the applicants, adequacy of methodology and work plan proposed, and qualification of key staff. Applicants meeting a minimum technical score are then evaluated on their financial proposals, and technical and financial scores are combined to select an Applicant for further negotiations.

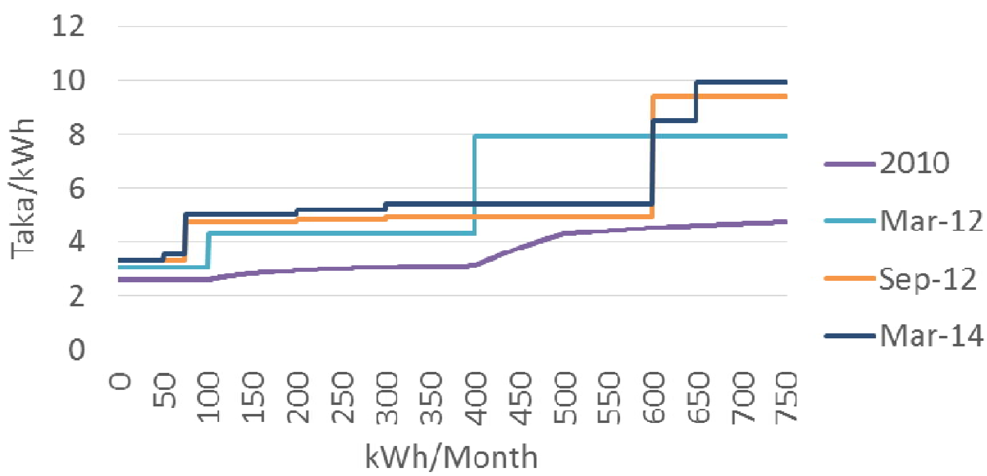
Recent BPDB projects (for their own plants) have been procured through either open tender or single-stage two envelope processes. IPPs tend to be procured using an RFP under a Build-Own-Operate (BOO) model. IPPs involve three contracts: (i) a power purchase agreement (PPA) with BPDB where BPDB is required to purchase the power produced by the IPP; (ii) a fuel supply agreement with the fuel supplier guaranteeing uninterrupted fuel supply; and (iii) an implementation agreement with GoB that backstops BDPB's payment commitment and provides fiscal incentives to facilitate the project. IPP tenures range from seven to 22 years. RPPs follow a competitive bidding process, but QRPPs are awarded based on negotiation. RPP contracts range from three to 12 years. RPPs operate under a "must dispatch" obligation up to their declared capacity.

The Power Pricing Framework (2004) established the distribution tariff-setting methodology. According to the Framework, the average end-use tariff for each customer category[13] should cover the costs of supplying power to those customers, including generation, distribution, transmission and maintenance costs. It should also provide some extra funding for coverage expansion and quality improvement. Any subsidies for consumer types are to be taken directly from the budget. In addition, tariffs should incentivize technological improvement and efficiency. Rates are different for peak and off-peak hours. For BPDB's generation, a two-part tariff will be introduced—one to cover fixed costs and the other to cover variable costs.

End-user tariffs vary by customer category. Domestic consumers have incremental block tariffs (IBT) that increase based on kWh increments or "slabs." Since 2013, they pay the rate of their highest slab. A lifeline tariff was introduced in 2014 for residential consumers using less than 50 kWh per month. Figure 2.18 shows the average residential tariff by monthly consumption from 2010 to 2014.

[13] Customer categories include domestic, agriculture, small industry, non-residential, commercial, medium voltage, high voltage, extra high voltage and street lights and pumps.

Figure 2.18: Average Residential Tariff by Monthly Consumption, 2010-2014



Source: BERC

Agricultural pumps, non-residential customers, street lights and pumps all have a single rate. Small industry, commercial and medium/high/extra-high voltage have flat, off-peak and peak rates. Rural rates through REB vary from those for urban customers.

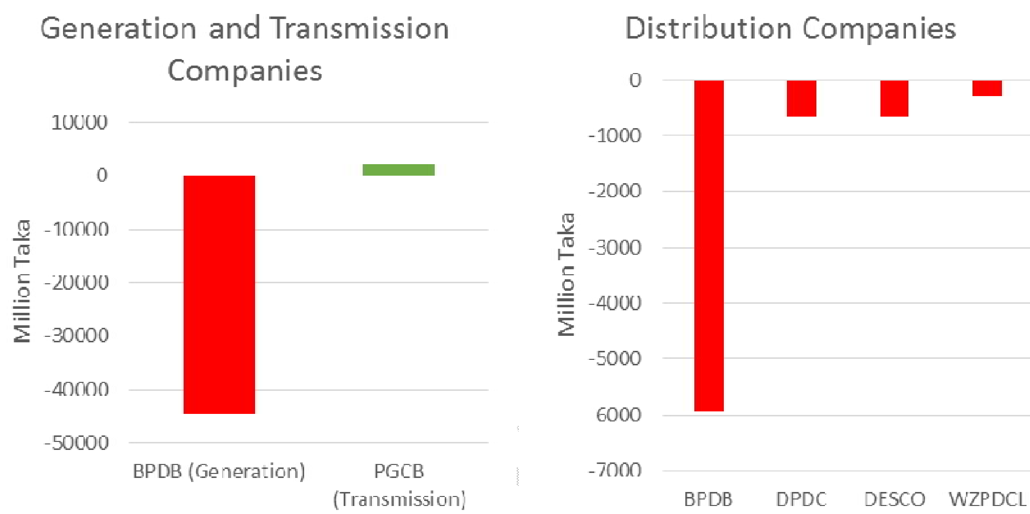
Tariffs are set such that commercial and industrialcustomers(C&I) and high use residential customers subsidizelow use residential and agricultural users. Figure 2.19 shows BPDB's tariffs versus the actual cost of delivery by consumer group.

Figure 2.19: BPDB Tariffs vs. Delivery Cost, FY2013-2014

*Generation (6.42 taka/kWh) + Transmission (0.22 taka/kWh) + Distribution (0.6 taka/kWh)

Cross-subsidies are not enough to coverthe lost revenue for selling the majority of electricity at below-cost recovery. The average retail tariff (6.2 taka/kWh) in FY 2013-2014 was 16.7 percent below the total delivery cost (7.25 taka/kWh). As a result only PBDB operated with a net operating profit over that fiscal year. BPDB suffered high losses for both generation and distribution services, while the distribution only companies had moderate losses. Figure 2.20 presents the net operating profit (loss) for the power sector companies in FY 2013-2014.

Figure 2.20: Operating Net Profit (Loss) in FY 2013-2014



Source: Company annual reports.

Note: Annual reports were not available for individual PSBs under the REB.

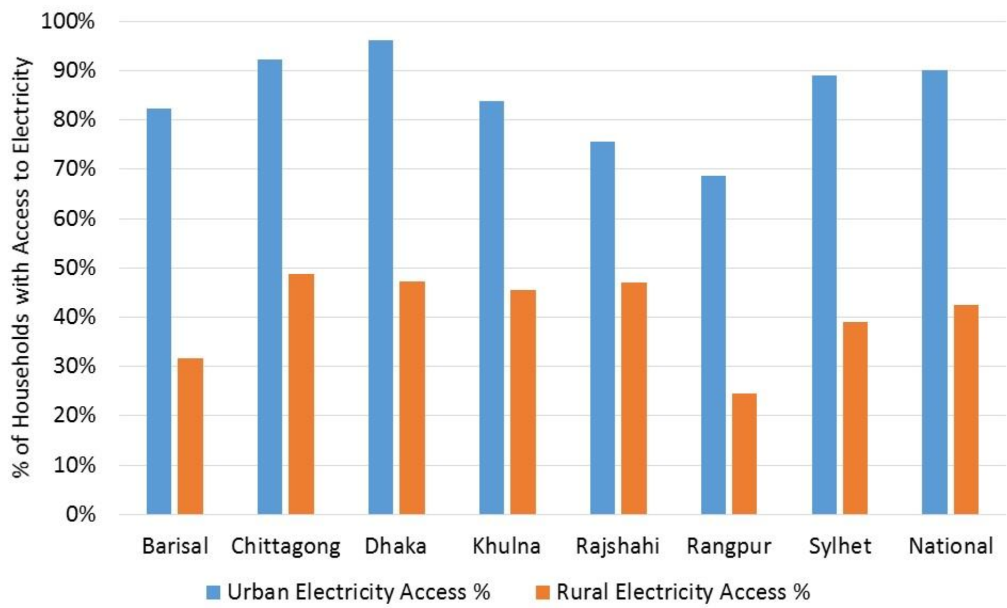
2.9 Sector Challenges

The energy sector in Bangladesh faces important challenges which include limited availability of indigenous hydrocarbon resources,limited access to the electricity network, and climate change.

2.9.1 Challenge #1: Access to Electricity

The vast number of citizens without access to electricity is the primary challenge in the Bangladesh energy sector. The lack of service has economic consequences for some of the poorest regions in the country. According to the 2010 Household Income and Expenditure Survey, Barisal and Rangpur divisions—the divisions with the highest incidence of poverty—have the lowest percentage of rural households with access to electricity, at 32 and 24 percent, respectively. Rangpur division also has the lowest urban electrification rate, at just 69 percent, compared to the national rate of 90 percent. Figure 2.21 shows the percentage of urban and rural households with access to electricity by division.

Figure 2.21: Percentage of Urban and Rural Households with Electricity by Division



Source: Bangladesh Bureau of Statistics, "Report of the Household Income & Expenditure Survey 2010".

2.9.2 Challenge #2: Supply Reliability and Energy Security

Bang

Bangladesh also faces challenges in the form of natural gas depletion and biomass availability. It has been estimated that Bangladesh's natural gas reserves will be depleted before 2020. The uncertainty about reserves has limited the development of gas-based power generation programs. Biomass is becoming scarcer and more expensive, which negatively impacts poor households that rely on this fuel source. More than 90 percent of Bangladesh households use traditional biomass for cooking, and biomass accounts for 50 percent of Bangladesh's total energy supply. The common fuels used are rice husks, jute sticks, cow dung and wood.

Declining indigenous resources and increasing demand has caused Bangladesh to increasingly depend on imported fuel oil. The increase in fuel oil consumption has been driven by BPDB reliance on fuel oil QRPPs, RPPsand diesel IPPs to mitigate energy shortages. From 2009 to 2015, the share of oil-fired electricity has increased from 5 to 20 percent. This increase in oil-fired electricity contributed to the fuel cost per kWh generatedgoing from 1.1 to 3.42 taka/kWh (US$ 0.014 to US$ 0.04) over the same period. This leaves Bangladesh's energy sector vulnerable to political and economic instability in nations from which it imports fuel, as well as rising prices generally.

2.9.3 Challenge #3: Climate Change

Bangladesh is one of the world's most vulnerable countries to climate change. As a low-lying country with many rivers, Bangladesh has a very high flood risk, both due to monsoons and sea-level rise associated with climate change. Rising temperatures have already begun to shorten the growing season for rice; low crop production could increase poverty up to 15 percent by 2030. Higher water levels could lead to higher incidence of waterborne disease, such as cholera, and result in forced migration due to flooding.[14]

The World Bank has noted that Bangladesh is particularly vulnerable to an increase in poverty headcount rate and risk of chronic poverty as a result of different warming scenarios. Climate change could also reduce the availability of clean water supply and sanitation.[15]

The World Risk Report ranks Bangladesh as the fifth most vulnerable country in the world to climate change.[16] In addition, the Climate Change Vulnerability Index rates Dhaka as one of the five most climate-vulnerable cities in the world. Bangladesh addresses climate change issues through the Bangladesh Climate Change Strategy and Action Plan, which is implemented through the donor-funded Bangladesh Climate Change Resilience Fund (See Table 3.16 for more details).

[14] IPCC, 2014, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Malch, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, New York.

[15] World Bank, "Turn Down the Heat: Confronting the New Climate Normal," 2014.

[16] Alliance Development Works, "WorldRiskReport 2012."

3 Renewable Energy Sector Context

Bangladesh has substantial technical potential for renewable energy generation. Resource assessments indicate that Bangladesh could realize over 6,000 GWh of generation from renewable technologies annually. The Government has ambitious targets for renewable development, and a robust and active private sector has substantial experience increasing access of off-grid solutions to commercial and residential customers.

However, renewable energy remains a small portion of Bangladesh's generation portfolio. Barriers preventing the scale-up of RE in Bangladesh include affordability and a lack of available commercial financing; the lack of a comprehensive legal and regulatory framework for RE; and a lack of feasibility and technical potential data.

This section describes Bangladesh's renewable energy sector, and includes an assessment of the potential for different renewable energy options, a description of the business environment for renewable energy, as well as a description of the barriers facing renewable energy development in Bangladesh.

3.1 Assessment of Electricity Generating RE Technologies

An assessment of available data on the use of REin Bangladesh was carried out to support the preparation of the IP. This section details the results of theassessment and describes progress to date on deploying RE technologies in Bangladesh.The results of the resource assessment are shown in Table 3.1.

Table 3.1: Summary Renewable Energy Technical Potential

Technology	Resource	Capacity (MW)	Annual Generation (GWh)
Solar Parks	Solar	1400*	2,000
Solar Rooftop	Solar	635	860
Solar Home Systems	Solar	100	115
Solar Irrigation	Solar	545	735
Wind Parks	Wind	637**	1250
Biomass	Rice husk	275	1800
Biogas	Animal waste	10	40
Waste to Energy	Municipal Waste	1	6
Small Hydropower Plants	Hydropower	60	200
Mini and Microgrids***	Hybrid	3***	4
	Total	**3,666**	**7,010**

*Case 1 estimate**Case 2 estimate***Based on planned projects only, not a theoretical maximum potential, because there is potential overlap with off-gridsolar systems. Either could be used to serve off-grid demand.

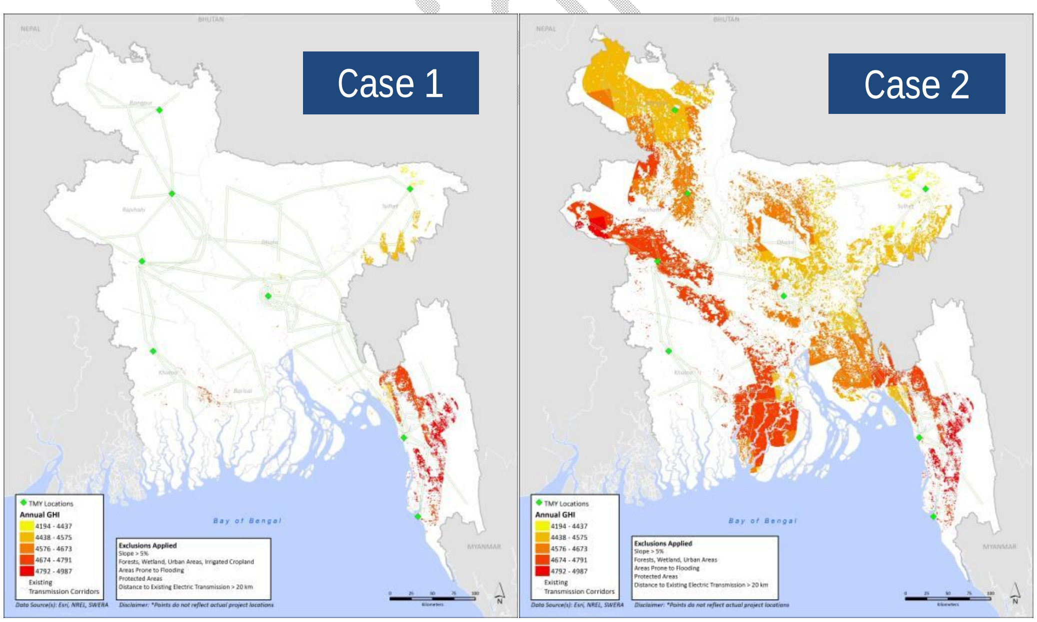
3.1.1 Solar Parks

There are currently no complete solar park projects in Bangladesh, but five projects with a total installed capacity of 44.9 MW are currently under construction or have financing committed.

Data on solar radiation were from a Solar Wind Energy Resource Assessment (SWERA) that had been completed by the United Nations Environment Program (UNEP) and the Global Environment Facility (GEF) in 2007.[17]The technical potential of solar parks was determined by first evaluating the overall resource potential, in terms of solar radiation, and then applying exclusions to limitthis potential to only areas practical for development. Solar park locations were required to be within 20 km of a transmission line and could not be located on land with a slope greater than five percent, forest land, wetland, urban areas, historical flood areas, military bases,or protected areas.[18]

The GoB has stipulated that solar parks should only be developed on government-owned non-agricultural land or privately-owned uncultivable land. Two cases were developed to show the resource potential when agricultural land is excluded (Case 1) and when it is included (Case 2). In both cases only two percent of the eligible land was assumed to be suitable for development, in order to take into account potential land obstructions. Figure 3.1 below shows the resource locations identified; the results of the resource assessment are presented in Table 3.2.

Figure 3.1: Solar Park Resource Maps



[17] SWERA data consisted of Typical Meteorological Year (TMY) data filesfor eight locations, shown as green dots on the resource maps.

[18] Land exclusions were applied using GIS data. Land gradient, forest, wetland, protected areas, and urban areas data were from the National Renewable Energy Laboratory's (NREL) Geospatial Toolkit for Bangladesh. Historical flood information for 2000-2014 was from the Bangladesh Water Development Board.

Table 3.2: Solar Parks Technical Potential

Admin. Division	Capacity Factors (%)**	Case 1			Case 2		
		Land (km^2)	Capacity (MW)	Annual Generation (GWh)	Land (km^2)	Capacity (MW)	Annual Production (GWh)
Barisal*	17.2	116	14	20.4	8,136	2,034	2,953.4
Chittagong	17.2	4,200	1,050	1,524.6	13,666	3,416	4,960
Dhaka	16.7	74	18	25.4	13,472	3,368	4,748.2
Khulna	16.8	200	50	71	964	2,420	343.2
Rajshahi	16-16.9	4	0	0	11,692	2,922	4,057.6
Rangpur	16.0	4	2	2.8	15,378	3,844	5,192
Sylhet	15.4	1,094	274	356.2	3,900	974	1,266.2
	Total	**5,692**	1,408	2,000.4	67,028	18,978	23,520.6

*Capacity factors calculated using PVsyst modeling software

**Barisal Division is assumed to have the same resource as the Chittagong site due to proximity.

3.1.2 Solar Rooftop

Solar rooftop systems are grid connected systems that provide onsite power at the point of installation and then feed excess power to the grid. BPDB has installed solar rooftop systems on several Government buildings, such as a 21.6 kW system on the Prime Minister's Office, a 32.75 kWp system on the WAPDA office building, and a 37.5 kWp system on the Bidyut Bhaban building.

The SWERA solar radiation data were again used to assess solar resources. Availability of land was assessed using two existing studies on rooftop space available for solar PV in parts of Dhaka and Chittagong. Box 3.1summarizes the approach and results of these studies.

Box 3.1: Rooftop Availability Studies

The following studies on available rooftop space for solar PV were used in the technical analysis:

- **CEPZ Study (2014).** The Chittagong Export Processing Zone (CEPZ) is a 183.37 hectare trade zone with 501 industrial plots ranging from 718 to 2,350 m^2. Researchers at Go for Green and Bangladesh University of Engineering and Technology divided CEPZ into six zones and used Google Earth line measurement tools to estimate the approximate area of roof space in each zone. Roofs were categorized as either south facing, west facing, or flat; and roofs covered by obstacles were excluded. Total available rooftop for solar PV system in the CEPZ was estimated as 170,810 m^2 (0.17km^2).
- **Dhaka City Study (2010).** Researchers in the Department of Geography at Humboldt-University of Berlin estimated the potential sunlit rooftop area within the high building density areas of the Dhaka City Corporation (now Dhaka City North and Dhaka City South). The study used Object-based Image Analysis (OBIA) on a high-resolution satellite image taken in 2006 to estimate rooftop area with bright sunlight. In other words, the researchers set color, shape, and scale parameters representative of a bright rooftop that OBIA software used to analyze the image and report the total area meeting those parameters. The results indicate that there are 10.554 km^2 of bright rooftop space in the Dhaka City North and Dhaka City South combined. There are limitations to this approach-- the study excluded rooftops in informal settlements, but there were no other restrictions on the type of building or roof.
- **Dhanmondi Study (2014).** Researchers from American-International University-Bangladesh and the Asian Institute of Technology (Bangkok) refined the results of the Dhaka City Study by manually measuring (using Google Maps and ArcGIS software) bright rooftops in a 9.83 km^2 area around the Dhanmondi neighborhood in southern Dhaka City. The researchers considered several factors for excluding rooftops, such as construction and design constraints; shade from trees and nearby buildings; obstacles on the rooftop; and rooftop orientation. Approximately 50 percent of the bright rooftop area found using the Dhaka City Bright Rooftop Study approach was found to actually be suitable for solar rooftop systems in the Dhanmondi area.

Source:

Chakraborty, Sanjib et al. "Possibilities and potentialities of roof top solar PV system within Chittagong export processing zone (CEPZ), Bangladesh." *Proceedings of5th International Conference on Environmental Aspects of Bangladesh*, 2014.

It was assumed that 50 percent of bright rooftop area found in the Dhaka Rooftop Study (5.277 km^2)are buildings that would be available for housing a rooftop system, combining the results of the Dhaka study and the assumptions of the Dhanmondi study. Because the CEPZ results include a more comprehensive analysis of the structures, the entire estimated area (0.17 km^2) is included. A total of 5.447 km^2 roof space is assumed to be available.The technical potential was calculated by treating the estimated areas as one large rooftop covered with 1,000 W solar modules that take up approximately 9.29 m^2 (100 ft^2). The technical potential also includes an additional 81 MWs from three national programs targeting (i) installation of solar rooftop systems on schools (41 ME), (ii) railroad stations (30 MW), and (iii) commercial and industrial buildings (10 MW).[19]In order to calculate potential

[19] It is assumed these targets were based on estimates of actual rooftop availability.

generation, the capacity factors used for solar parks were modified to take into account the potential suboptimal location of a rooftop system compared to a solar park.Table 3.3 shows capacity factors for solar rooftop systems and solar home systems.

Table 3.3: Capacity Factors for Rooftop Solar and Solar Home Systems

Rajshahi	Chittagong	Dhaka	Khulna	Sylhet	Rangpur	Barisal*	National
15.4-15.7%	16.0-16.1%	15.6%	15.6%	14.2%	14.9%	16.0%	15.5%

Note: Rajshahi includes measurements for Bogra and Ishurdi; Chittagong includes measurements for Chittagong City and Cox's Bazaar. *Barisal is based on Chittagong City measurements.

3.1.3 Solar Home Systems

Solar home systems (SHS) are low capacity solar PV-battery units that provide electricity to individual or clustered off-grid customers. SHS installation has already been one of the most successful RE initiatives in Bangladesh, with around 4 million units installed since 2003.[20] IDCOL has set a target to fund 6 million SHS units by 2017.

IDCOL's installation targets are used as a basis for estimating the SHS market. Given the 4 million IDCOL-funded installations that have already been completed, this leaves 2 million more SHS units that need to be installed to achieve the 2017 target. The installation target was allocated among the 11 SHS size options offered by IDCOL, with more units being allocated to the most commonly sold sizes. Table 3.4 shows the number of SHS units by sizeincluded in the technical potential.

Table 3.4: Allocation of SHS Units in Technical Potential

SHS Size	% of Installation Target	SHS Units	Total Capacity (MW)	Annual Production (GWh)*
20 Wp	5.0%	100,000	2	2.72
30 Wp	25.0%	500,000	15	20.37
40 Wp	20.0%	400,000	16	21.72
50 Wp	15.0%	300,000	15	20.37
60 Wp	10.0%	200,000	9	16.29
65 Wp	5.0%	100,000	6.5	8.83
75 Wp	5.0%	100,000	7.5	10.18
85 Wp	5.0%	100,000	8.5	11.54
90 Wp	5.0%	100,000	9	12.22
100 Wp	2.5%	50,000	5	6.79
130 Wp	2.5%	50,000	6.5	8.83
Totals	**100%**	**2,000,000**	**100**	**139.86**

*Assumes capacity factor of 15.5%

[20] As of March 2014 IDCOL had installed 2.9 million SHS units. If installation from April 2014 to July 2015 averaged 62,342 units per month—as it did from 2012-2013—then current installations stand at around 3.96 million.

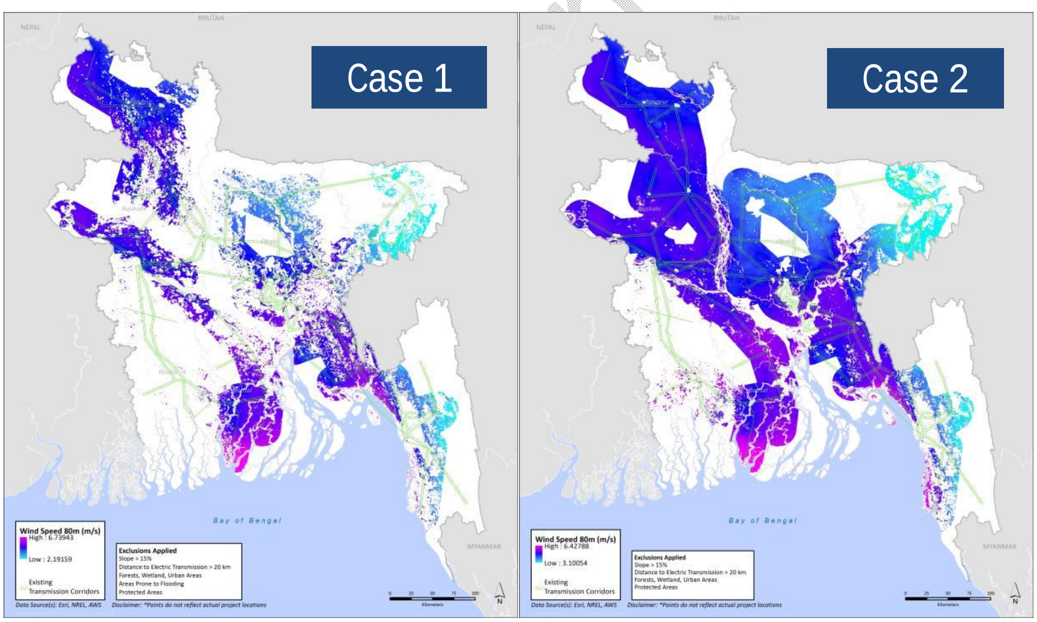
3.1.4 Wind Farms

A 900 kW plant at the Muhuri Dam and a 1000 kW plant on Kutubdia remain the only grid-connected wind farms currently in operation.

Wind speed and land availability werethe determining factors in assessing the technical potential. Wind resources were evaluated using AWS Truepower's WindNavigator data that provide estimates of wind speed, wind speed distribution, wind direction, and diurnal patterns at a height of 80 m above ground level.For a location to be considered a viable site it was required to be located within 20 km of a transmission line. Land not suitable for wind farm installation was excluded from the assessment.[21]

Flooding is a concern for wind farms because softening of the soil could compromise the foundation of the turbines. Two cases were developed by combining the AWS data with GIS flood data, showing the resource potential when flood prone land is excluded (Case 1) and when it is included (Case 2). The AWS data were also used to evaluate the resource potential according to capacity factor. In both cases, fifty percent of the eligible land was assumed to be suitable for development,in order to take into account potential land obstructions. The results of the resource assessment are presented in Table 3.5 .

Figure 3.2: Wind Park Resource Potential Maps



[21]Land excluded from the technical assessment included slopes greater than or equal to 15%; forests; wetland; and urban areas.

Table 3.5: Wind Farms Technical Potential

	Case One		Case Two	
	20-25% Capacity Factor	25-30% Capacity Factor	20-25% Capacity Factor	25-30% Capacity Factor
Buildable MW	624	13	996	37

3.1.5 Biomass

Rice byproducts, particularly rice husk and rice straw, are the most readily available biomass feedstock for power generation. Because rice straw is more beneficialleft in the field as fertilizer or for use as a direct cooking fuel, only rice husk is viewed as a viable feedstock option.Other options, such as wood biomass, are limited because 37 of 63 districts partially or completely protect local forests from deforestation, and what resources are available are used for residential cooking. There is currently a 250 kW off-grid rice husk plant in the Kapasia upazlia and a 400 kW rice husk plant proposed for Thakurgaon.

An estimated 10.13 million tons of rice husk are produced annually in Bangladesh.[22]It is assumed that that only 50 percent of rice husk is available for electricity generationand that only 10 percent of the gross resource potential is located at a sufficiently large commercial rice operation to host a digester for electricity production. The energy content of rice husk is assumed to be 16 MJ/kg and that the biomass plant has a heat rate of 13,648 btu/kWh. The technical potential results are shown in Table 3.6.

Table 3.6: Biomass Technical Potential

Annual Rice Husk Crop (tons)	HHV (MJ/kg)	Gross Energy Potential* (mmBTU)	Gross Electricity Potential (MWh)	Net Electricity Potential (MWh)**	Potential Capacity (MW)
10,130,000	16	139,363,715	4,084,514	2,042,258	274

*Based on heat rate of 13,648 btu/kWh

**Assume 50 % of Rice Husk is available for electricity generation

3.1.6 Biogas

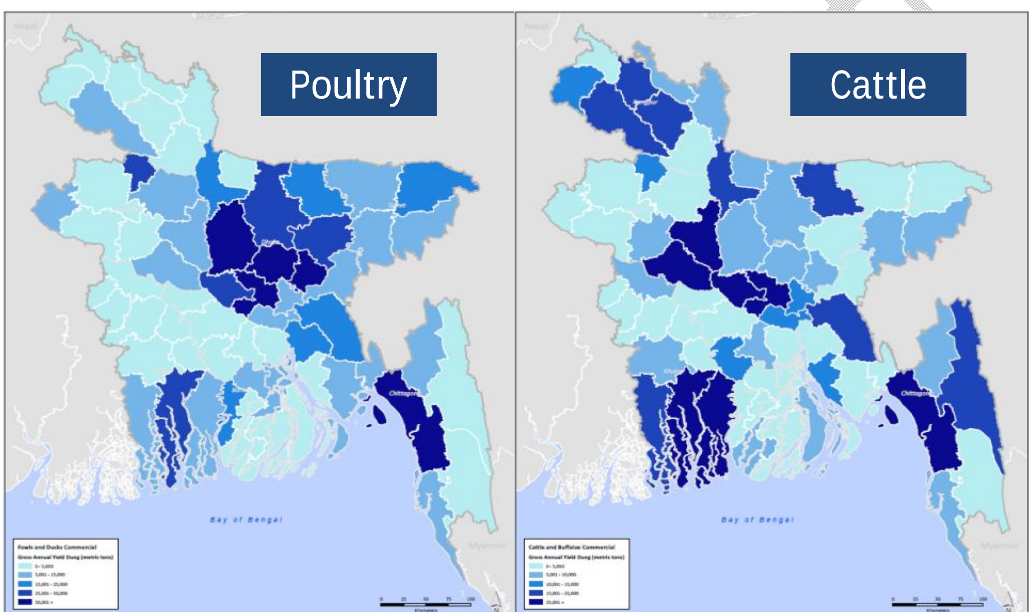
Farms in Bangladesh are installing small-scale biogas plants that use animal waste to produce power for own-use purposes. There are currently two IDCOL-funded plants—400 kW and 50 kW—in operation with four more plants ranging in size from 25 to 100 kW under construction. Cow manure is also a possible fuel option at large commercial operationswhere the manure is less likely to be needed for domestic cooking purposes. GIZ has provided technical assistance and some fundingto poultry

[22]Das, Barun Kumar, and S. M. Hoque. "Assessment of the Potential of Biomass Gasification for Electricity Generation in Bangladesh." Journal of Renewable Energy 2014 (2014).

and dairy farms that have installed an aggregate of 1,200 kW in small- to medium-sized engine biogas fueled generators (5 kW to 50 kW).[23]

Resource potential was determined by estimating the amount of animal waste available for electricity generation. Only livestock at commercial farms were considered because animal waste at subsistence farms has other uses, such as cookstove fuel and fertilizer. Agricultural statistics from the Bangladesh Bureau of Statistics (BBS) were used to determine the number of poultry and cattle at commercial operations. Yield of waste per animal head was assumed to be 0.01 ton per cattle and 0.12 kg per bird.[24]Between these two waste-to-energy options, poultry is more viable because it is a local product, while cows are imported from India. Figure 3.3 shows the resource potential by location for poultry and cattle waste.

Figure 3.3: Commercial Farming Animal Waste Resource Maps



It was assumed that only 10 percent of the resource potential is located at commercial operations large enough to host a digester. The technical assessment from this potential assumes that conversion of waste to biogas is 47m^3/ton of cattle manure and 200 m^3/ton for chicken waste, and that biogas consists of 50 percent methane. The biogas plant is assumed to have a reciprocating engine efficiency of 10,000 kWh/btu and capacity factor of 50 percent. The technical potential results are shown in Table 3.7.

[23] "Meeting Energy Needs with Biogas Technology," *GIZ*, accessed April 16, 2015, https://www.giz.de/en/downloads/giz2012-en-biogas-technology-bangladesh.pdf.

[24]Netherlands Development Organization, Domestic Biogas in Bangladesh, 2005

Table 3.7: Biogas Technical Potential

Division	Technical Potential (MWh)*		Estimated Capacity Potential (kW)**	
	Commercial Cattle & Buffalo	Commercial Fowl & Duck	Commercial Cattle & Buffalo	Commercial Fowl & Duck
Barisal	1,989	16,189	45	370
Chittagong	11,364	69,243	259	1,581
Dhaka	18,452	188,138	421	4,295
Khulna	11,095	26,983	253	616
Rajshahi	15,999	33,193	365	758
Sylhet	1,383	18,946	32	433
Total	**60,282**	**352,692**	**1,376**	**8,052**

*Based on a heat rate of 10,000 btu/kWh.

**Determined by assuming a capacity factor of 50%

3.1.7 Waste-to-Energy (Electricity)

Waste-to-energy plants use municipal household waste for power production. Approximately 13,383 tons of solid waste are produced daily in Bangladesh;more than 4,379 tons come from Dhaka alone. As part of a solid waste management (SWM) technical assistance project,JICA set target goals for advancing SWM in Dhaka, including the development of plans for waste-to-energy.[25]In 2012, Dhaka North City Corporation and Dhaka South City Corporation announced plans to build two waste-to-energy plants: an incineration plant in Matuali and an anaerobic digester in Aminbazar. The plans intended for the plants to be commissioned with a combined capacity to process 1,000 tons of waste and produce 10 MW of power, and then increase capacity to process 6,000 tons of waste and 50 MW of power within three years.[26] Despite a successful bidding process, the construction of the plants has been delayed several times and has not yetstarted.[27]One reason construction has been delayed is the fact that the city governmentshave had problems developing processes for waste collection.

Despite vast resource potential (in terms of daily municipal waste production), the actual technical potential cannot be estimated without established procedures for delivering the waste to a power plant. The GoB now intends to start a 1 MW pilot

[25] Project for Strengthening of Solid Waste Management in Dhaka City (Extension). JICA Terminal Evaluation Report. 2013.

[26] Alam, Helemul. “Power from garbage: Govt-run plant to generate 50MW electricity using garbage of Dhaka city.” The Daily Start, 18 August 2012. < http://archive.thedailystar.net/newDesign/news-details.php?nid=246632>

[27] Mahmu, Abu Hayat. “Waste-fueled power plant dream yet to come to life in 15 years.” Dhaka Tribune, 24 September 2014. <http://www.dhakatribune.com/bangladesh/2014/sep/24/waste-fuelled-power-plant-dream-yet-come-life-15-years>

waste-to-energy project that will be used to establish waste collection practices. The technical potential is set at the proposed pilot plant size. The capacity factor is assumed to be 80 percent.

3.1.8 Small Hydropower

The only existing hydropower plants in Bangladesh are the 230 MW Kaptai Hydropower Plant and a 10 kW Micro-hydropower plant in Bamerchara. A 2014 study by Stream Tech (a US-based engineering firm) for The Ministry of Power, Energy and Mineral Resources identified potential hydropower sites at different locations along the Sangu, Matamuhuri, and Bakkhali Rivers, as well as the Banshkhali Eco-park stream. The technical assessment only includes the sites from this study because other studies on potential hydropower sites were either outdated or provided inadequate information for a technical assessment.

The technical assessment consisted of an estimate of the generation potential at each site. Topographic analysis was performed using GIS-based Digital Elevation Model (DEM) data to determine the available gross hydraulic head at each site. A hydrologic model was developed to simulate the river flows at the selected sites over a 15-year period based on observed stream flow data (2003-2012) from the Bangladesh Water Development Board (BWDB).

Hydropower has limited potential in Bangladesh due to concerns about land use and flooding. The construction of the Kaptai dam in 1961 displaced about 100,000 people from the Chittagong Hills Tracts due to flooding caused by the dam's reservoir.[28]

3.1.9 Microgrids/Minigrids

Microgrids are autonomous grids used to deliver power to customers in remote areas. Microgrid activity in Bangladesh involves the use of solar minigrids between 100-500 kWp. The firstminigrid in Bangladesh was commissioned on Sandwip Island in 2010. Since then, three other minigrids have been installed in Kutubdia (100 kWp); Rajshahi (141 kWp); and Narsingdhi (141 kWp). Another 12 projects ranging from 100 to 228 kWp have been approved for IDCOL financingand are at various stages of development.

IDCOL currently has a list of 20 minigrid projects for which private companies have submitted initial requests for funding. The assessment assumes these 20 projects encompass the current minigrid technical potential.

3.1.10 Solar Pumps

Solar pumps use solar energy to pump water. The systems are primarily used for irrigation purposes but can also provide pumping for domestic water or fish pond aeration when the pumps are not in use for irrigation. There are approximately 1.34 million diesel irrigation pumps in operation in Bangladesh. Because each solar irrigation pump could replace three to four diesel pumps, there is potential to replace these pumps with 335,000 to 450,000 solar pumps. Currentlyonly large 11 kWp systems installed on three- to four-crop per year land are assumed to be viable projects. IDCOL has plans toinstall 50,000 of these 11 kWp systems by 2025. As of

[28] http://www.internal-displacement.org/south-and-south-east-asia/bangladesh/2015/bangladesh-comprehensive-response-required-to-complex-displacement-crisis

June 2015, 156 pumps have been installed and an additional 149 pumps have been approved for installation. The resource potential included in the IP is set based on the remaining pump installations needed to reach IDCOL's 2025 goal.Power generation potential was estimated using the same capacity factors used for solar parks.

3.1.11 Geothermal

There are several locations in Bangladeshwith potentialgeothermal resources but due to a lack of additional technical information on these sites no technical potential can be confirmed. A study of Bottom Hole Temperature (BHT) of 13 deep wells drilled for petroleum exploration in northeastern part of Bangladesh measured temperature gradient in each well at depths of 3000 to 15,000 m.[29] The results show that 11 of these locations have temperature gradients of at least 30°C per km. Extensive investments in studies and well drilling are necessary to confirm the resource adequacyof these sites.

3.1.12 Hydrokinetic Generation

Hydrokinetic generating units are turbines installed in river beds. Technology is being developed for the purpose of harnessing river flows without reservoir impoundments. When determining the technical potential the effects of river morphology must be considered, as well as impacts on river navigation. Hydrokinetic generation could be considered for Brahmaputra and Meghna river basins. In these areas more than 100MW of installed capacity could potentially be possible with lower impact compared to conventional hydro.

However, this technology is still immature with only a few MWsof capacity deployed worldwide. Project costs are currently not well understood and the technology is not considered a feasible option at the present time. Hydrokinetic generation may be well suited for future application in Bangladesh if viability is proven over the next ten years.

3.1.13 Tidal Power

Tidal power is another emerging renewable energy technology. Dams or barrages with water turbines can be built across river mouths or inlets to generate electricity from the movement of tides. The benefit of tidal power is that power production is more predictable and consistent than either wind or solar. The amount of electricity generated depends on the range of the tide. Bangladesh has a tidal range of 2-8 meters, which may be too low for tidal power to be a viable option. In addition to the low resource potential, limited international experience—only seven tidal power stations are in operation—make this technology impractical for Bangladesh at this time.

3.2 Assessment of Other RE Technologies

As discussed in Section 2.3, biomass is the main source of energy for domestic consumers and cooking is the primary use of fuel. RE technologies are being introduced in Bangladesh that allow for more efficient use of biomass or aim to

[29] Khandoker, R.A. and M. Haque. "Temperature Distribution and its Relation to Hydrocarbon Accumulation in Sylhet Trough, Bangladesh." Bangladesh Journal of Geology, 1984.

provide an alternative to biomass-based cooking. The follow sub-sections describe the potential for these technologies.

3.2.1 Solar Water Heating

Solar water heating systems (SWHS) have potential commercial and industrial uses in Bangladesh. For example, the tanning industry has been identified as an industry with great potential for solar water heating. UNIDO has already installed three pilot SWHS systems on tanneries. If SWHS were installed to meet the 120 million liters of hot water required by the 200 tanneries in Bangladesh each year, more than 2.67 m^3 of natural gas could be replaced annually. Textile factories are also considered locations where SWHS can be used to heat water for dying purposes. A GIZ study estimates that there is the potential for some 10,000 SWHS to be installed for providing 5 million liters of hot water daily to textile factories.[30]

3.2.2 Improved Cookstoves (ICS)

Traditional cookstoves used in Bangladesh are inefficient and release smoke into homes. Newer biomass-based cookstoves have been developed that use fuel up to 50 percent more efficiently and emit less smoke.ICS projects have been some of the most successful energy initiatives in Bangladesh, with more than1.5 million ICS installed since 1989.[31]

The market remains extremely strong;the existing penetration rateof ICS was only three percent in 2013. The GoB's Country Action Plan for Clean Cookstoves (November 2013) set a target to reach 100 percent market penetration by 2030, a goal that will require the dissemination of 30 million ICS. As many as 67 percent of households use more than one stove; if these are taken into account, there could be demand for an additional 20 million.[32]

3.2.3 Biogas for Domestic Cooking

Another alternative to traditional cookstoves is to deliver biogas to residential homes for cooking purposes. Domestic biogas plants are small-capacity (2.4 to 4.8 m^3) anaerobic digesters designed for individual household use.[33] There have also been a few medium-capacity systems installed to serve clusters of homes. Digesters are fed mostly with cattle and poultry waste,though kitchen and household waste and human excreta are also used. More than 33,000 domestic biogas plants have been installed using IDCOL funding, with Grameen Shakti implementing the majority of the projects as a partner organization. Due to the interchangeability between ICS and biogas plants it is difficult to determine the demand for domestic biogas plants. A 2005 study produced by SNV Netherlands and IDCOL suggests the market potential

[30]

[31] Md Raisul Alam Mondal, Department of Environment, Government of Bangladesh "Mitigation of Short Lived Climate Pollutants (SLCPs) in Bangladesh and Integration in National Policies and Strategies", Climate and Clean Air Coalition (CCAC) Agriculture Side Event, Lima, 11 December 2014. Available: http://www.unep.org/ccac/Portals/50162/COP20/docs/11Dec_Agriculture_side_event/Raisul_Alam_Mondal_Bangladesh_Presentation_CCAC_COP20_11_Dec_Agriculture.pdf

[32] Government of Bangladesh. Ministry of Power, Energy, and Mineral Resources. Power Division. Country Action Plan for Clean Cookstoves. November 2013.

[33] Kabir, H., M. S. Palash, and S. Bauer. "Appraisal of domestic biogas plants in Bangladesh." Bangladesh Journal of Agricultural Economics 35, no. 1-2 (2012).

could be as high as 950,000 domestic biogas plants.[34] IDCOL has set a target to install just 100,000 domestic biogas plants by 2018. As a conservative assumption, the current IDCOL target is used as the assumed market potential.

3.2.4 Waste-to-Energy (Natural Gas)

In addition to generating power, municipal waste can also be used as a source of natural gas. Producing gas from municipal waste faces the same waste collection issues faced by waste-to-power projects;therefore,more studies would be needed to estimate technical potential for producing gas from waste. The GoB, however, has proposed the Clean City Clean Fuel project as a pilot project to demonstrate the potential of municipal waste for gas production. The Clean City Clean Fuel project plans to install anaerobic digesters in 20 municipalities that each generate around 20-100 tons of solid waste per day. Natural gas would either be piped to residential houses or picked up by customers at fill stations. Assuming a yield of 367 m^3 per ton of waste[35], this project could produce 146.8 to 731 TCM of natural gas daily. In addition, the byproduct from the anaerobic digester could eventually be sold as fertilizer following a three-year composting period.

3.3 Cost of RE Technologies

The comparative cost of renewable energy technologies is an important factor when determining their viability and attractiveness for inclusion in Bangladesh's electricity development plan.[36] This section includes supply curves which show the levelized energy costs (LECs) of the various grid-connected and off-grid renewable energy technologies assessed in Bangladesh for the preparation of the Investment Plan, as well as the estimated production of each of those technologies.

The LECs of the various grid-connected renewable energy technologies were assessed on an economic and financial basis. The purpose of economic analysis is to understand which supply options are the best option for Bangladesh, irrespective of the actual cost of financing that would be used for the projects. A social discount rate is used for economic analysis, where the rate (10 percent) reflects an estimate of the social opportunity cost of capital for the country. Concessional financing terms are used to evaluate financial viability in order to demonstrate the potential for each technology to attract private investment. The assumptions used for the viability analysis are shown inTable 2.1.

[34] Ghimire, Prakash C. "Final Report on Technical Study of Biogas Plants Installed in Bangladesh." National Program on Domestic Biogas in Bangladesh. SNV and IDCOL, December 2005.

[35] US Environmental Protection Agency. "Turning Food Waste into Energy at the East Bay Municipal Utility District (EBMUD)." < http://epa.gov/region9/waste/features/foodtoenergy/ebmud-study.html> Accessed on 15 July 2015.

[36] The cost of renewable energy was not, however, the only criterion used for selecting project to be included in the Investment Plan. It is only one of a number of factors that was considered in the course of developing this investment plan. Section **Error! Reference source not found.** describes the other criteria used to select the projects for which SREP funding is requested.

Table 3.8: Economic and FinancialViabilityAssumptions

	Financial	Economic
Debt/equity split (%)	70/30	100
Debt rate (%)	13.00	10.00
Equity return (%)	20.00	N/A
Debt term (years)	7	Life of the asset
VAT (15%)	Yes	No

Section 3.3.1 shows the LECs for grid-connected technologies and Section 3.3.2 shows the LECs for off-grid technologies. A summary of the costs of the other renewable energy technologies (non-electricity) considered for the IP are presented in Section 3.3.3.

3.3.1 Grid-Connected

Cost assumptions for each RE technology are based on costs of existing projects in Bangladesh; IDCOL reference data; and generic international costs adjusted for the Bangladesh context. Assumptions used for each grid-connected project are presented in Table 3.9.

Table 3.9: Cost Assumptions for Grid-Connected RE Technologies

Technology	Capital Cost ($/kW)	Fixed Cost O&M (US$/ kW-year)	Variable O&M[A] ($/kWh)	Heat Rate (BTU/kW h)	Capacity Factor (%)
Solar Parks	$1551	$26	----	----	16-17.3%[C]
Solar Rooftop	$1561	$130[B]	----	----	15.5-16.7%[C]
Wind Farm	$1625-$2000	$35	----	----	21-25.63%[C]
Small Hydro	$2090-$6080	$57-$111	----	----	40%
Biomass (Rice Husk)	$2059	$125	$0.06	13,648	75%
Biogas (Animal Waste)	$6100	$125	$0.02	12,000	50%
Waste to Energy	$2995	$115	$0.02	18,000	70%

Notes:

(A) Includes cost of fuel

(B) Includes roof lease payment

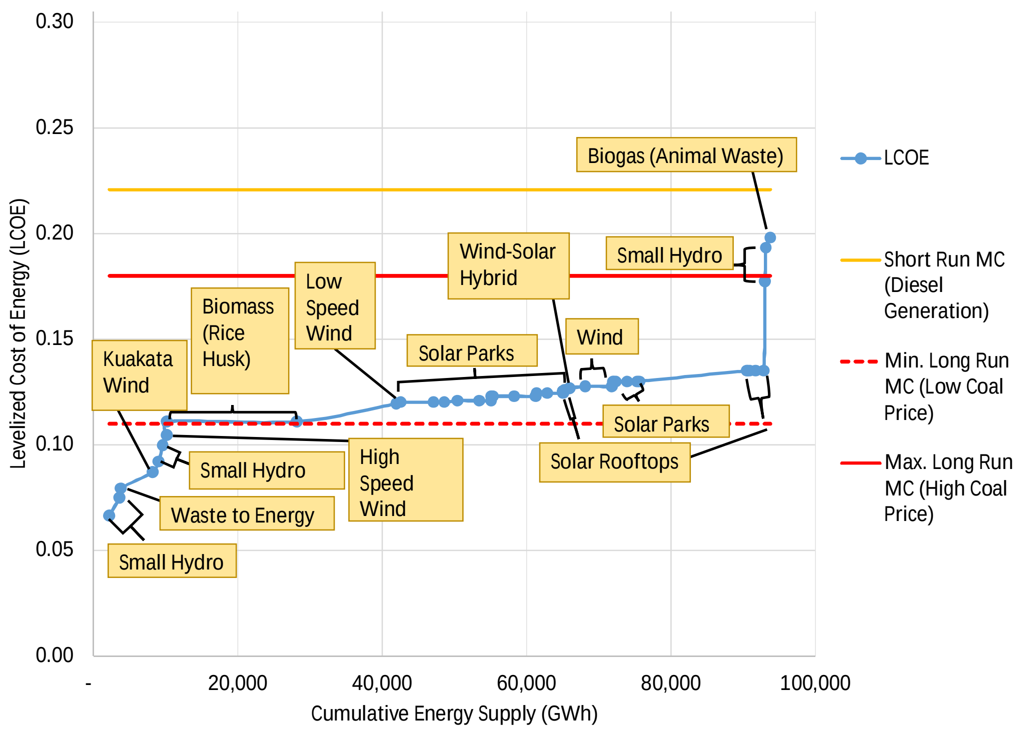
(C) Capacity factor ranges by location

Figure 3.4 and Figure 3.5show the supply curves for the various grid-connectedprojects under the described economic and financial viability scenarios. For purpose of comparison each figure has a horizontal line (yellow, solid lines) with the current price of diesel generation[37] and two horizontal lines (red, solid and hash-

[37] Cost of diesel is the average cost of rental power diesel generators in 2014.

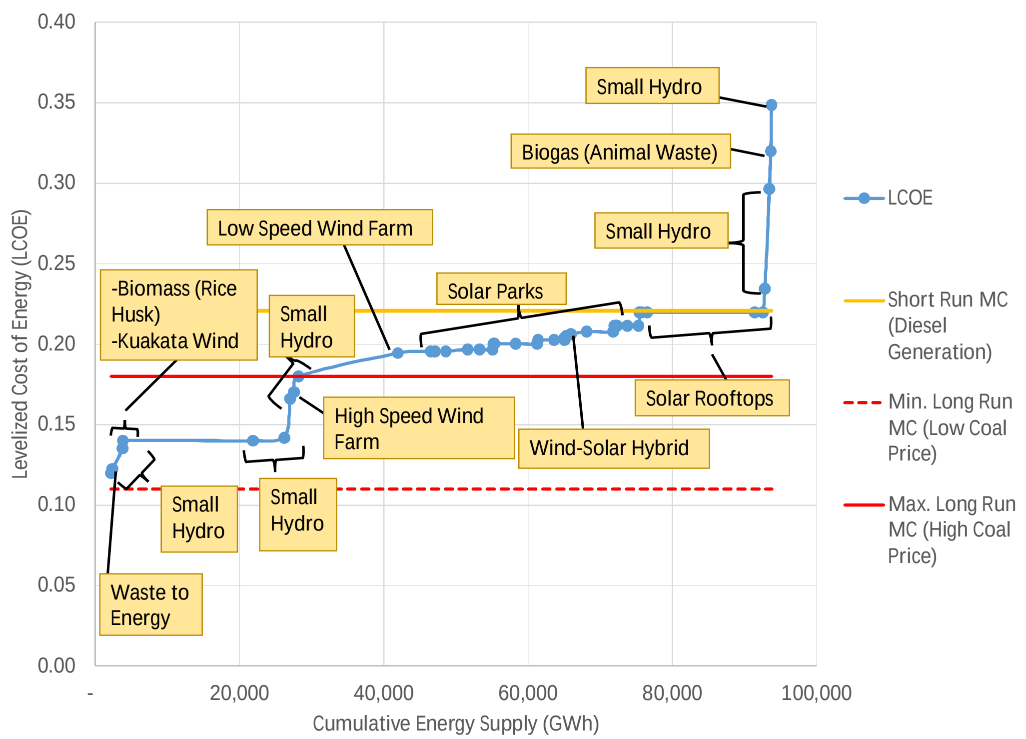
marked lines) representing the rangein LEC of a new coal plant[38]. The price of diesel is meant to demonstrate the competiveness of RE options with RPPs, the short run power supply option. The price of coal generation represents a likely long run power supply option given the projected depletion of domestic natural gas reserves.

Figure 3.4: RE Supply Curves for Grid-Connected Electricity (Economic Viability)



[38] LEC of coal range assumes a low coal price of US$ 138/ton; high import price of US$ 300/ton; and $1,600/kW capital cost. The coal price includes the cost of CO2 emissions as listed in the most recent WB Guidance Note.

Figure 3.5: RE Supply Curves for Grid-Connected Electricity (Financial Viability)



3.3.2 Off-Grid Electricity

Similar to grid-connected technologies, the cost assumptions for each off-grid technology are based on costs of existing projects in Bangladesh; IDCOL reference data; and generic international costs adjusted for the Bangladesh context. Assumptions used for each off-grid technology are presented in Table 3.10.

Table 3.10: Cost Assumptions for Off-Grid RE Technologies

Technology	Capital Cost ($/kW)	Fixed Cost O&M (US$/ kW-year)	Variable O&M[A] ($/kWh)	Heat Rate (BTU/kWh)	Capacity Factor (%)
SHS	$3555-$6547	$245-$456	----	----	13.18%
Microgrid[A]	$5000	$255[B]	----	----	15.41-16.4%
Solar irrigation pumps	$3273	$150	----	----	15.43%
Small Hydro	$2090-$6080	$57-$111	----	----	40%

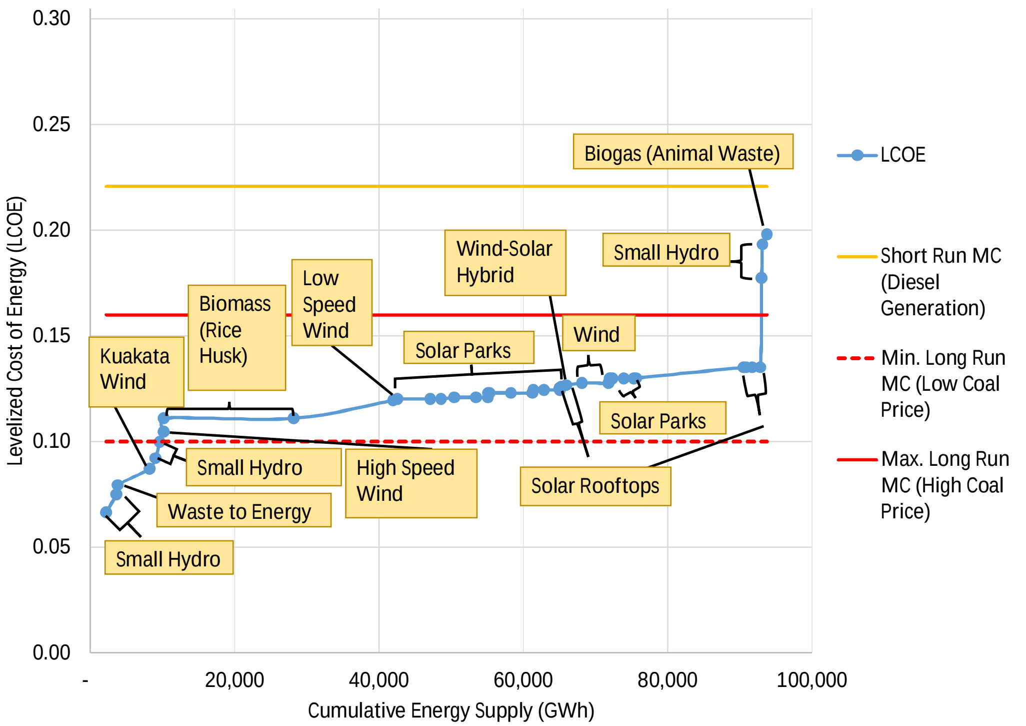
Note:

(A) Cost of microgrid includes investment for backup generation.

(B) Fixed O&M includes fuel costs for diesel generator, assuming: 12,000 btu/kWh; US$ 25/mmBTU cost of diesel; and a diesel generator capacity factor of two percent.

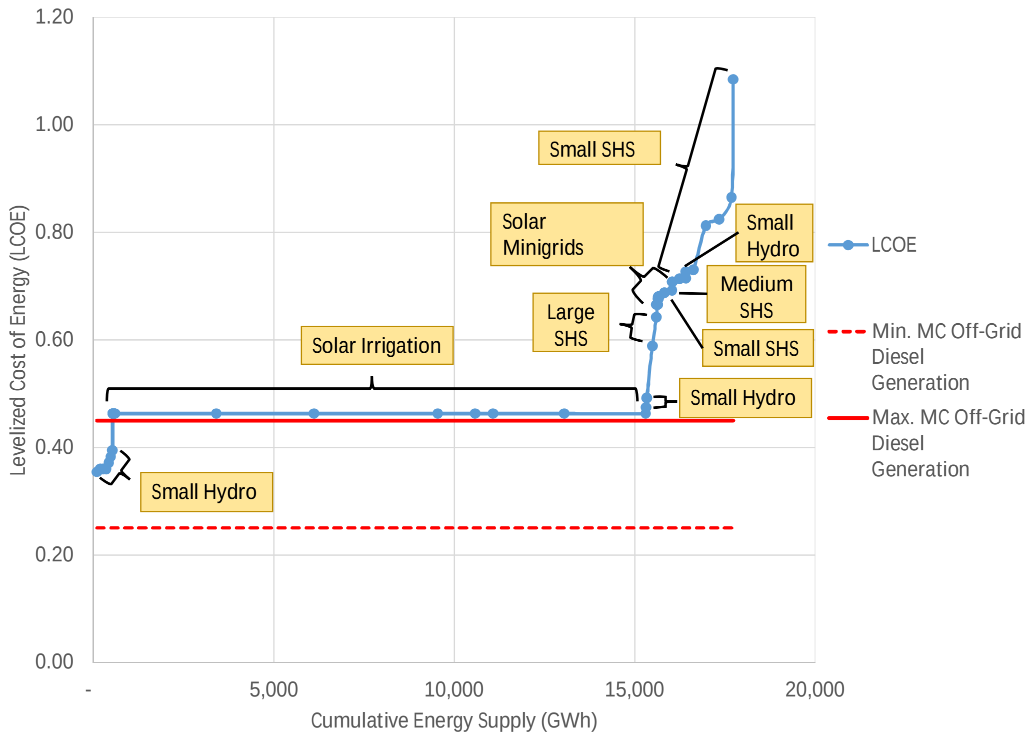
Figure 3.6 and Figure 3.7show the supply curves for the various off-gridprojects under the economic and financial viability scenarios. The figures in this section also include two horizontal lines (red, solidand hashed-mark lines) representing a range in theoff-grid diesel generation cost[39], for the purpose of comparison with renewable energy options.

Figure 3.6: RE Supply Curves for Off-Grid Electricity (Economic Viability)



[39] Assumes low diesel price of US$ 22/mmBTU; high price of US$ 28/mmBTU; and diesel generator efficiency of 16,000 btu/kWh.

Figure 3.7: RE Supply Curves for Off-Grid Electricity (Financial Viability)



3.3.3 Cost of Other RE Technologies

This section presents a summary of the costs of the other RE technologies considered in the IP. Due to the limited details on the specifics of the Clean City Clean Fuel project costs could not be estimated for the provision of gas services from municipal waste.

ICS

The most common biomass based ICS is the chulha model. The cost of a chulha stove ranges depending on region and material. Concrete models ($10-23) can be built in 1-2 hours and last approximately three years. Clay models ($10-19) are built in 5 to 7 days and last more than five years.[40] The payback period for ICS is 2-3 months due to around 50 percent savings in fuel compared to traditional stoves.

Biogas for Domestic Cooking

A biogas cooking system includes both an aerobic digester and a biogas cookstove. The system costs range from US$330-$615.[41]

Solar Water Heating

A SWHS systems consists of a solar water heating panel and an adjoining water tank. The cost of a 1,000 liter SWHS is approximately US$ 8,974.

[40] Accenture Development Partners. Sector Mapping Analysis, Bangladesh Market Assessment. Global Alliance for Clean Cookstoves, 2012.

[41] Ibid.

3.4 Barriers to RE

Table 3.11 describes some of the most significant barriers hindering the development of renewable energy in Bangladesh.

Regulatory barriers include (i) the absence of a comprehensive legal and regulatory framework for renewable energy, particularly with regard to feed-in tariffs; and (ii) incomplete coordination between involved ministries, agencies and institutions which leads, in particular, to the threat of transmission expansion “stranding” investments in off-grid renewable energy.

Financial and economic barriers include (i) limited fiscal space, as renewable energy is not the only important sector with funding needs; (ii) affordability of off-grid technologies, particularly solar home systems and microgrids; (iii) limited availability of commercial funding, as banks have little experience making renewable energy loans; (iv) high import tariffs that restrict competition in supply; (v) limited land availability, with high market prices; and (vi) seasonal demand, as some renewable energy technologies depend on agricultural activities.

Technical barriers include (i) a lack of data and information on renewable energy feasibility and experience in Bangladesh, as well as on technical potential of wind and solar rooftops; (ii) a lack of skilled labor for maintenance and repair of renewable energy technologies; (iii) seasonal flooding; (iv) poor domestic technical standards compared to imported components that comply with international standards; and (v) weak capacity of end-users for operation and maintenance, leading to misuse and damage.

Table 3.11: Barriers to Renewable Energy Development and Mitigation Options

Barrier	Solar Park	Solar Rooftop	Solar Home System	Wind Farm	Bioenergy	Small Hydro	Microgrid	Solar Irrigation
Financial and Economic								
Limited fiscal space, as RE is not the only important sector with funding needs.	✓	✓	✓	✓	✓	✓	✓	✓
Affordability of off-grid technologies, including initial investment in SHS and cost recovery tariff for microgrids, as end-users lack income.			✓				✓	
Limited availability of commercial funding, as banks do not have experience making RE loans and so view these investments as risky. Where available, there are high financing costs and short loan tenors.	✓	✓	✓	✓	✓	✓	✓	✓
High import tariffs restrict competition in supply.					✓			
Limited land availability, with high market prices.	✓			✓				
Seasonal demand, as some RE technologies depend on agricultural activities and thus have low capacity and high LEC.					✓			✓
Policy								
Few policy incentives for RE.	✓	✓	✓	✓	✓	✓	✓	✓
Absence of comprehensive legal and regulatory framework for RE, including lack of feed-in tariffs for grid-connected RE generation; no standardized process for procuring IPPs; no standardized PPA for sale of RE generation intro grid; and no rules governing extension of grid to areas already served by microgrids.	✓	✓	✓	✓	✓	✓	✓	✓

Barrier	Solar Park	Solar Rooftop	Solar Home System	Wind Farm	Bioenergy	Small Hydro	Microgrid	Solar Irrigation
Incomplete coordination between involved ministries, agencies and institutions. For example, the promise of grid connection to certain areas may inhibit investment in microgrids or other technologies.	✓	✓	✓	✓	✓	✓	✓	✓
Technical								
Lack of data and information on RE feasibility and RE experience in Bangladesh, and technical potential for wind and solar rooftops.	✓	✓	✓	✓	✓	✓	✓	✓
Lack of skilled labor for maintenance and repair of certain RE technologies. Installations may be improperly sized, use poor quality components, and be done under inappropriate conditions.	✓	✓	✓	✓	✓	✓	✓	✓
Seasonal flooding.	✓			✓	✓	✓	✓	✓
Poor domestic technical standards compared to imported components that comply with international standards.	✓	✓	✓	✓	✓	✓	✓	✓
Weak capacity of end-users of off-grid technologies for O&M due to lack of training, leading to customer misuse and prematurely damaged units.			✓				✓	

3.5 Role of Private Sector

The private sector in Bangladesh has been very active in the renewable energy sector and has helped increase access of off-grid solutions to commercial and residential customers through financing mechanisms such as microloans, low interest loans, retail sales, and some generation investment. The GoB has played a substantial role in incentivizing private sector participation by creating a commercially viable market for the uptake of RE technology, using guaranteed refinancing schemes delivered through IDCOL and the Bangladesh Bank.[42] The most common types of private sector players include: private commercial banks, foreign commercial banks, non-governmental organizations (NGO), and retailers.[43]

Commercial banks

The Bangladesh Bank Refinancing Scheme for Renewable Energy is a revolving refinancing mechanism that provides loans for RE and energy efficiency projects such as biogas, solar, bio-fertilizer plants, SHS, solar irrigation pumps, and hybrid Hoffman kilns at low interest rates.[44]Domestic and foreign commercial banks have been the leading participants. In 2014, Domestic commercial banks on-lent US$ 287.57 million to finance RE projects, 90 percent of the total amount disbursed by the revolving scheme. Foreign commercial banks on-lent US$ 8.05 million to finance RE projects, 3 percent of the total amount disbursed by the revolving. Table 3.12 shows the types of RE projects which received financing at reduced rates in 2014 under the Refinancing Scheme for Renewable Energy.

Table 3.12: RE Projects Financed under the Refinancing Scheme for RE in 2014

	Biogas Plant	Solar Panel/Renewable Energy Plant	Bio-fertilizer Plant	HHK	Others
	Million US$				
Private Commercial Banks	5.16	19.00	0.02	45.68	214.70
Foreign Commercial Banks	0.00	8.05	0.00	0.00	0.00

Source: Bangladesh Bank, "Sustainable Banking" in *Annual Report 2014,* 2014.

Non-governmental organizations

Non-governmental organizations play an important role in expanding the uptake of RE technology in Bangladesh. As partner organizations (PO) of IDCOL's SHS, and domestic biogas programs, NGOs serve as important intermediaries between IDCOL

[42] The GoB established the Infrastructure Development Company (IDCOL) in 1997 as an implementing agency which on-lends grants and loans to partner organizations who in turn procure, install, and often times refinance loans to households.

[43] The link provides a list of private sector organizations that are active in the power sector. https://energypedia.info/wiki/Bangladesh_Energy_Situation#Private_Sector_.28enterprises.2C_NGOs.29

[44] The SREDA page on financing schemes provides further detail on the types and terms of loans provided under this scheme. http://www.sreda.gov.bd/index.php/investment/financing-schemes

and customers by directly procuring RE technology components from suppliers, installing SHS, and on-lending micro loans to customers (see Figure 3.8). Since 2003 when the SHS program started, 3 million SHS systems have been installed and currently serve about 9 percent of the Bangladeshi population. The domestic biogas program which was initiated in 2006 has since financed more than 33,000 biogas plants in Bangladesh. Table 3.13 summarizes the achievements of the IDCOL SHS and Domestic Biogas Programs to date.Box 3.1Box 3.1 describes how IDCOL's SHS, solar irrigation, and solar minigrid programs are financed.

Figure 3.8: SHS Program by IDCOL

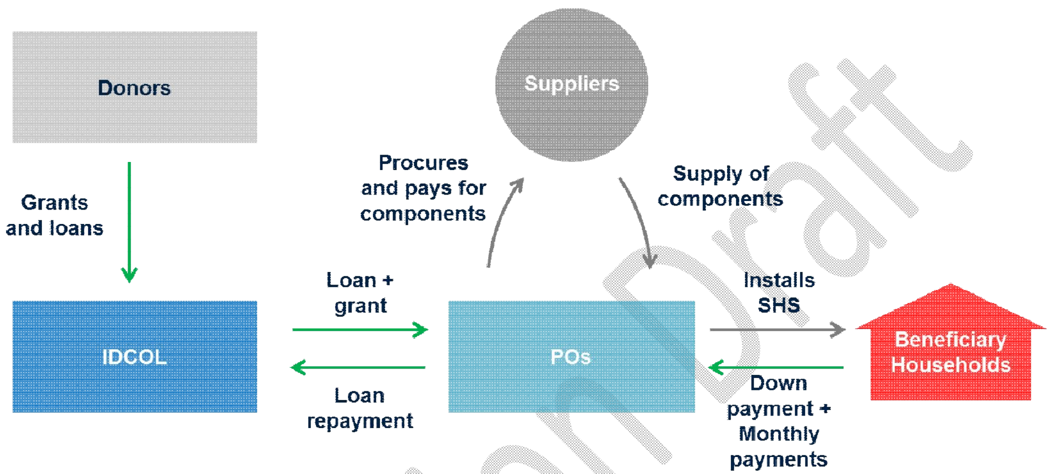


Table 3.13: Achievements of the IDCOL SHS and Domestic Biogas Programs

Program	Program start year	No.of partner organizations (2014)	Achievements to date (2014)	Energy/fuel savings	Savings in Million US$
SHS	2003	47	3 million systems installed	180 kilotons of kerosene	225
Domestic Biogas	2006	24	33,000 biogas plants	28 kilotons chemical fertilizer; 1,000 kiloton of kerosene	20

Source: IDCOL, "Domestic Biogas Program", Accessed July 9, 2015. IDCOL, "SHS Program", Accessed July 9, 2015.

Box 3.2: Financing of IDCOL Projects

Solar Home System (SHS)

The Solar Home System (SHS) program was started by IDCOL in 2003, with credit and grant support from the World Bank and GEF. The program was later expanded with additional financing from GIZ, KfW, ABD, IDB, GPOBA, JICA, USAID and DFID. IDCOL offers refinancing, grant support, and technical assistance to 47 Partner Organizations (POs)who implement the program.[45] The major POs include Grameen Shakti, Rural Services

[45] IDCOL. "Solar Home System Program." Accessed July 15, 2015. http://idcol.org/home/solar.

Foundation, Srizony Bangladesh, and BRAC Foundation. POs purchase the system components from suppliers (who receive approval from the Technical Standards Committee) and install the systems and provide service to households.[46]

Households pay the POs 10-15 percent of the SHS price at installation, and pay the rest of the cost over a 3-year micro-credit period at a flat interest rate of 12 percent. When the life of a battery is over, households have a buy-back and replacement option. Households are also offered a discounted price if they accept a shorter repayment period and also have the option to buy the SHS outright in cash.[47]

After making an installation, POs apply for refinancing of the micro-credit and a capital buy-down grant from IDCOL. The refinancing from IDCOL covers 80 percent of the micro-credit extended to households, and has a 6 percent flat interest rate for a period of 6-8 years. The capital buy-down allows POs to reduce the costs of SHS to households. The grant, which was initially set at US$ 90 per SHS, is now US$ 20 per SHS. A US$ 3 per SHS institutional development grant is also provided to new POs to assist with up-front costs of setting up their establishments.[48]

Solar Irrigation Program

IDCOL runs the Solar Irrigation Program with financing from The World Bank, KfW, GPOBA, JICA, USAID, ADB and Bangladesh Climate Change Resilience Fund (BCCRF).[49] This program has two business models: the fee for service model, which is currently in use, and the proposed ownership model, which IDCOL is trying to introduce.[50]

In the fee for service model, the development partners offer grants to IDCOL, which in turn provides grants to sponsors for 40 percent of the pump cost, at a 6 percent interest rate, over a period of 8 years. There are currently 17 sponsor organizations which have implemented projects under this model. These sponsors purchase TSC-approved equipment (pumps and PV panels) from suppliers, who install the equipment and provide after-sale service. The sponsors own the pumps and sell water to farmers who pay an irrigation charge. Payments are collected by pump operators.[51]

The ownership model functions in a similar way for donors, IDCOL, and suppliers, but has POs (instead of sponsors) who sell the pump on cash/credit to farmers. Under this model farmers pay 60 percent of what the pump would cost without a grant. They make a 20 percent down-payment and pay the rest in yearly installments for 5 years, at a 15 percent interest rate.[52]

Solar Minigrid Projects

IDCOL runs the solar minigrid projects with financing from The World Bank, KfW, GPOBA, JICA, USAID, ADB and DFID.53 The projects are implemented through sponsors, who contribute 20% of projects costs from their own sources and receive 50% grant financing and 30% concessionary financing from IDCOL. The concessionary loans have a 6 percent

[46] Asaduzzaman, M., Mohammad Yunus, AK Enamul Haque, AKM Abdul Malek Azad, Sharmind Neelormi, and Md Amir Hossain. "Power from the sun: An evaluation of institutional effectiveness and impact of solar home systems in Bangladesh." *Bangladesh Inst. Dev. Stud.(BIDS), Dhaka, Bangladesh, Final Rep. to the World Bank Report* (2013).

[47] Ibid

[48] Ibid

[49] IDCOL. "Solar Irrigation Program." Accessed July 15, 2015. http://idcol.org/home/solar_ir.

[50] Rahman, Farzana. "IDCOL Solar Irrigation Projects." February 19, 2015.

[51] Rahman, Farzana. "IDCOL Solar Irrigation Projects." February 19, 2015.

[52] Rahman, Farzana. "IDCOL Solar Irrigation Projects." February 19, 2015. Accessed July 15, 2015.

[53] IDCOL. "Solar Mini Grid Projects." Accessed July 15, 2015. http://idcol.org/home/solar_min.

interest rate and are paid in quarterly installments over a maximum of 10 years, with a 2 year grace period.54 Sponsors include NGOs, micro-finance institutions and private sector companies.55 Sponsors hire O&M contractors, which provide O&M solutions, and EPC contractors, which purchase equipment from suppliers and provide turnkey solutions. The sponsors provide grid connections to customers (including small shops, health centers, schools, etc.), who pay tariffs to the sponsors.56 Tariffs are US$0.38 per kWh, and customers must also pay a one-time connection cost of US$38-64 and monthly line rent of US$1-2.57 After the project implementation, minigrids are monitored by IDCOL's monitoring team and environmental consultant. Suppliers also provide after-sale service.[58]

The largest partner organization by market share participating in the IDCOL SHS program is Grameen Shakti (GS). As of March 2014, GS installed 60 percent of SHS systems under the program, while the second largest partner organization, Rural Services Foundation installed 20 percent of SHS. BRAC installed 11 small wind turbines of 300 watt capacity each across various coastal sites of Bangladesh.

RE technology retailers

There is also substantial private sector participation in the retail market for RE technology. As of September 2014, local manufacturers made up at least 89 percent of approved vendors under IDCOL’s SHS program (see Table 3.14).

[54]IDCOL. "Invitation for Proposal Submission Under IDCOL Solar Mini-Grid Project." Accessed July 15, 2015. http://idcol.org/notice/feead32c0c458badcc023e78e18f649a.pdf.

[55] IDCOL. “Expression of Interest: Scaling Up Renewable Energy Program (SREP) under Climate Investment Funds." April 24, 2014. https://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/Bangladesh_EOI.pdf

[56]Haque, Nazmul. “Renewable Energy Initiatives by Infrastructure Development Company Ltd. (IDCOL)." March 5, 2012. Accessed July 15, 2015. http://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/IDCOL%20Renewable%20Energy%20Initiatives%20-%20Nazmul%20Haque.pdf.

[57]Formanul Islam, S.M. "Financing, Policy & Regulatory Issues of Mini-grid." November, 2014. Accessed July 15, 2015. http://www.esi-africa.com/wp-content/uploads/2014/11/Formanul-Islam-grid.pdf

[58] IDCOL. “Expression of Interest: Scaling Up Renewable Energy Program (SREP) under Climate Investment Funds." April 24, 2014. https://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/Bangladesh_EOI.pdf

Table 3.14: Number of Domestic and International Vendors of Solar Products (2014)

	Local Manufacturers	Vendors of Imported Equipment	Proportion of Local Production
Batteries	16	2	89%
Large batteries	22	1	96%
Charge Controller	34	3	92%
Large Charge Controller	50	3	94%
LED Lamps	62	5	93%
Photovoltaic Modules	15	55	21%
Large photovoltaic Modules	23	89	21%
Inverter Circuit/Fluorescent Luminaire	22	1	96%

Source: IDCOL

Private investments in RE generation

There has been growing private sector activity in off-grid RE technologies for electricity generation. Much of this investment is for own use purposes, at dairy farms or poultry farms where dung or litter is fed into a biogas digester. The bio gas which is produced is used as cooking fuel or for power generation. Table 3.15 lists proposed and completed biogas projects funded by IDCOL from 2010 – 2015.

Table 3.15: Proposed and Completed Biogas Projects

Name of the project	Location	Capacity (kW)	COD
Rashid Krishi Khamar Ltd.	Raimony, Trisal	50	June 2010
Phenix Agro Ltd.	Member Bari, Gazipur	400	June 2013
Kazi & Kazi Tea Estates Ltd.	Rowshanpur, Tetulia	100	*September 2015
Zubaida Poultry Ltd.	Shashanpara	25	*September 2015
Ummi Kulsum Agro Ltd.	Bhuapur	25	*September 2015
United Integrated Agro Ltd.	Bangahati, Sreepur	60	*September 2015

More recently, Purobi Green Energy Limited (PGEL) and Prokaushali Sangsad Limited (PSL) invested and installed the country's first solar minigrid on Sandwip Island. Purobi Green Energy Limited funded 20 percent of the total project costs, while the remaining amount was financed through a grant and loan from IDCOL. The minigrid is the first utility of its kind in Bangladesh and has a capacity of 100kW, and a 40kW back up diesel generator.

There is also some private sector participation in the RE generation investment. In December 2011, BPDB signed a power purchase contract with Solarium Power Ltd. The 18MW solar farm was initiated in 2014, and the BPDB will purchase power from the firm at TK 5.50 per kWh.[59] In addition, Parasol Energy, a subsidiary of the poultry conglomerate Paragon Group, has proposed to build a solar park on one of its poultry farms.

3.6 Investments by Development Partners

A number of multilateral and bilateral donors are actively involved in promoting renewable energy in Bangladesh.

[59] http://www.bpdb.gov.bd/bpdb/images/Planning/new_generation_planning.pdfhttp://archive.thedailystar.net/newDesign/news-details.php?nid=215047

Table 3.16 describes the involvement for each of the donors in Bangladesh's energy sector.

Table 3.16: Development Partner and Donor Supported Projects and Technical Assistance

Agency	Projects
ADB	▪ **Grid-Connected Solar PV.** The GoB is currently implementing a number of grid-connected Solar PV Projects, including a 7.4 MW solar PV plant at the Kaptai Hydro Power Station in Rangamati and a 4.2 MW (2.2 MW solar +2 MW diesel) solar-diesel based hybrid power plant in Hatiya. These projects are being constructed on a turnkey basis, with assistance from ADB.
Gesellschaft für Internationale Zusammenarbeit (GIZ)	▪ **Sustainable Energy for Development (SED) Program.** This program works to promote the efficient use of renewable energy in Bangladesh through clean cookstoves, biogas digesters, and solar power. – **Clean Cookstoves.** GIZ has installed more than 400,000 new domestic cookstoves and 3,000 commercial cookstoves. – **Biogas.** GIZ has supported the installation of about 1,500 biogas plants in slaughterhouses, and on dairy and poultry farms. These now produce biogas on a commercial scale, which is used for cooking and generating electricity. By December 2013, about 5 GW of power was being generated with biogas digesters.SED is also working with a tea garden in the Tetulia area of Panchagar District to explore the possibility of using biogas powered heaters to dry harvested tea leaves. This would replace/save the diesel fuel the garden presently uses for this purpose. – **Solar Photovoltaic Pumping (PVP) Systems.** In 2010, GIZ started installing Solar Photovoltaic Pumping (PVP) Systems for drinking water supply. The program has installed over 100 systems since 2010, with a total installed capacity of 92.32 kW and a total pumping capacity of 2,209,000 L/day. Additional support for SED is provided by the Ministry of Power, Energy, and Mineral Resources.
The World Bank	▪ **IDCOL Biomass Based Power Project**. IDCOL has created a rice husk-based power plant (250 kW at Gazipur), built by Dreams Power Private Limited (DPPL). The plant is connected to a minigrid with the capability of delivering power to 200 households and 100 small commercial businesses. However, the plant's current operating capacity is limited to 56 kW allowing it to serve only 50 houses. ▪ **Bangladesh Climate Change Resilience Fund.** The Fund was established in 2010 for the implementation of the Bangladesh Climate Change Strategy and Action Plan (2009), which calls for the development of renewable energy, improvement to energy efficiency, and improvements in the energy consumption patterns of the transport sector. The fund is managed and implemented by GoB, with ongoing temporary assistance from the World Bank. Energy projects supported by the fund

Agency	Projects
	include the Solar Irrigation Program and the Rural Electrification and Renewable Energy Development II Project, both implemented by IDCOL. The fund is financed through development partners, including Denmark, the European Union, Sweden, the United Kingdom, Switzerland, AusAID, and USAID. ▪ **IDCOL Biogas-Based Power Projects.** Seven poultry waste-based power plants at different sites with capacity over 1 MW, have been established under IDCOL initiatives. IDCOL plans to finance 450 biogas projects with an average of 50kW. Funding is also provided through KfW, USAID, and JICA. ▪ **IDCOL Solar Irrigation Program.** IDCOL has a target to finance 1,550 solar irrigation pumps by 2017. IDCOL has so far approved114 solar irrigation pumps, with 41 of these already in operation. Funding is also provided by KfW, GPOBA, JICA, USAID, ADB and Bangladesh Climate Change Resilience Fund (BCCRF). ▪ **IDCOL Solar Mini Grid Projects.**IDCOL has a target to finance 50 microgrids around the country by 2017. In 2010, IDCOL financed a 100 kW solar microgrid project on Sandwip Island. The pilot minigrid project is currently supplying electricity to a 250 neighboring shops, 5 health centers and 5 schools. Funding for these projects is also provided byKfW, GPOBA, JICA, USAID, ADB and DFID. ▪ **IDCOL Solar Home System Program.** The program began in 2003 and works in line with the GoB's vision of ensuring 'Access to Electricity for All' by 2021. IDCOL had installed 3.5 million SHS and reports that 13 million beneficiaries are getting solar electricity as a result of the installations in off-grid rural areas. More than 65,000 SHSs are now being installed every month under the IDCOL program, with average year to year installation growth of 58%. The program replaces 180,000 tons of kerosene (traditionally used for lighting) having an estimated value of US$ 225 million per year. Funding for this program is also provided by GEF, GIZ, KfW, ADB, IDB, GPOBA, JICA, USAID, and DFID.
USAID	▪ **Market Analysis and Development for Improved Cookstoves (ICS).** USAID'sCatalyzing Clean Energy in Bangladesh (CCEB) funds the project, which began in 2013, and aims to develop a framework to facilitate the installation of 350,000 improved cookstoves by 2017. ▪ **Enhancing Capacity for LowEmission DevelopmentStrategies (EC-LEDS).**Wind resources assessment is currently occurring at 5 sites and assessments of another 4 sites will be starting very soon. Funding for this wind mapping is also provided by NREL. ▪ **Bangladesh Cookstoves Market Assessment.** This market assessment on clean cookstoves estimates that only 2 percent of

Agency	Projects
	households in Bangladesh have a clean cookstove, leaving a potential market of more than 29.4 million households.
UNDP	▪ **Sustainable Rural Energy (SRE)Project.**The Local Government Engineering Department (LGED) successfully completed the first micro-hydro power unit at Bamerchara, Chittagong. Its installed capacity was 10 kW but due to inadequate water head falling, only about 4 kW of power was generated.
Sustainable Energy for All (SE4ALL)	▪ **Investment Prospectus.**SE4ALL is coordinating with the GoB, IDCOL, and donors to provide a pipeline for energy projects and match investors to investment opportunities in the sector. Current projects under consideration include two clean cooking projects, third generation SHS upgrades, and threeminigrid projects ranging from 3kW to 100kW, a waste-to-energy project, an LED manufacturing facility, and brick kiln technology upgrades.
SNV Netherlands	▪ **IDCOL Domestic Biogas Program.**IDCOL plans to install 100,000 biogas plants in Bangladesh by 2018, and has financed the construction of 33,000 as of April 2014. Additional funding for this program is also provided byKfW and the World Bank.

1

4 Prioritization of Renewable Energy Technologies

Many of the technologies described in Sections3.1and 3.2are important for Bangladesh, but some are better candidates for SREP support than others. This section prioritizes projects based on criteria identified by stakeholders in preparatory workshops and one-on-one consultations.

Hydrokinetic power and tidal power are not considered because the technologies are only on the cusp of commercial viability, and because the potential resources in Bangladesh have not yet been studied in much detail. Geothermal power is not considered because substantial additional work will be needed to verify whether the resource is worth investigating further. These resources and technologies may at some point make important contributions to Bangladesh's energy mix, but they were not considered as viable candidates for SREP support.

Criteria for prioritization

The criteria reflect a consideration of criteria important to SREP as well as criteria considered by stakeholder to be specifically important for Bangladesh. The criteria are:

- **Scalability.**The amount of developable resource potential relative to the other technologies, as measured by production potential (GWh). Resources with higher production potential were given higher priority. Scalability is an important component of the *transformation impact* SREP seeks to achieve with its funding, as well as to one of SREP's expected program outcomes, *increased supply of renewable energy*.
- **Availability of sites.** As described in Section 3.4 availability of land is an important barrier to the development of renewable energy in Bangladesh. Land has high value for agricultural use, an important driver of Bangladesh's economy. Land suitable for the development of utility-scale plants is scarce, also because of seasonal variations in water levels and the longer-term effects of climate change.
- **Unexploited market potential.** The extent to which the technology is used or the resource is already exploited in Bangladesh. Resources or technologies which already have financing available through IFI programs or through the private sector were given lower priority. Resources or technologies which are lesser known, with little or no support, were given higher priority.
- **Readiness for implementation.** Technologies were ranked higher if there was reasonably good data on resource availability and potential sites or projects. Options without good resource data were ranked lower.
- **Financial viability.** Technologies were ranked higher if they were determined in Section 3.3 to be close to being cost-competitive with diesel generation and therefore less dependent on subsidies. Technologies were ranked lower if it was determined that they would need substantial subsidies.

Table 4.1 shows the rankings assigned to each technology under each criterion, and provides a brief explanations for why each technology received a particular ranking on each criterion. A distinction is made between grid-connected and off-grid projects.

The ranking criteria were used as rough guides and not absolute decision criteria. In the final evaluation, other factors (such as co-benefits) were also considered by Government in developing the list of priority projects.

It is important to note that projects not put forward for SREP funding will be considered for a second phase (Phase II) investment plan, with funding to be sought at a later stage from the Green Climate Fund (GCF), MDBs, and other sources. Section 5 describes the investments to be included in both the Phase I investment plan (with SREP support), and Phase II investment plan (where additional support will be sought).

Summary of Rankings

The on-grid projects ranked with highest priority were utility-scale solar, and rooftop solar. The principal reasons are:

- There is abundant solar potential in Bangladesh, and an abundance of sites, despite the limited availability of non-agricultural land.
- Few projects have yet broken ground, despite the potential. Some type of support is clearly needed to show that such projects can be done successfully on a larger scale.
- Few specific sites have yet been identified, but solar data in Bangladesh are of relatively good quality and reliability.
- Utility-scale and rooftop solar are now close to parity, on an LCOE basis, with the cost of diesel generation from the PPAs emergency diesel generators in Bangladesh.

Utility-scale wind projects ranked nearly as well. Their viability as potential projects will depend critically on the wind mapping exercise currently being undertaken by the Government of Bangladesh and USAID. If there proves to be a good number of sites with good resource profiles, such projects could also be considered for SREP support under the umbrella of utility-scale renewable energy projects.

Waste-to-energy did not rank as high as utility-scale renewable energy, but was included because of the substantial co-benefits it could have for Bangladesh's highly populated urban areas in terms of waste collection and management, and as a further consequence, public health.

Grid-connected hydropower was not considered for SREP funding, because of the lack of reliable data on sites and because of the social and environmental problems Bangladesh has had in the past with hydropower projects. Hydropower projects will, however, be studied further for possible inclusion in a Phase 2 investment plan.

Theoff-grid projects ranked with highest priority were solar irrigation and minigrids. These projects were selected because:

- The resource potential and number of sites is high.

- Data on the resource potential are good and IDCOL have identified a number of potential projects in need of funding.
- The technologies are competitive with the cost of off-grid diesel generation, especially in rural areas where the price of diesel is likely to be higher than in urban areas.

Solar home systems were not prioritized because they have become commercially viable to many households in Bangladesh. Private sector operators are SHS without subsidies or concessional financing. The use of solar irrigation and minigrids, in contrast, are not yet as widespread, and still require considerable concessional financing or grant funding to be financially viable.

Solar cookstoves, biomass and biogas projects were reserved for Phase II of Bangladesh's investment plan. Solar cookstove programs were viewed by stakeholders as already having sufficient support from donors, and therefore not in need of additional funding at this stage. Biomass and biogas projects were viewed as having sufficient support, given the current understanding—still incomplete—of their potential. Such projects would be considered (as described in Section 5) for the Phase II investment plan.

Table 4.1: Ranking of Renewable Technologies against Selection Criteria

RE Technologies		Criteria: Scalability	Criteria: Availability of sites	Criteria: Unexploited Market Potential	Criteria: Readiness for implementation	Criteria: Financial Viability
Grid-Connected	**Utility-scale solar**	**High** Large resource potential throughout Bangladesh	**Medium** Land is expensive to acquire, but potential for projects on publicly owned-land or on land already owned by project developers	**High** Considerable developer interest; schemes to promote utility scale solar still in development	**High** Only a few specific sites identified, but quality of solar resource data is good	**High** Competitive with diesel generation and likely future sources of baseload power (imported coal and LNG)[60]
	Rooftop Solar (electric)		**Medium** Substantial rooftop potential in Dhaka and Chittagong but may compete with other uses	**High** Unknown developer interest; loosely defined policy to promote solar development		
	Solar water heating		**Low** Substantial rooftop potential, but interest may be limited to industrial customers	**High** So far, little uptake of solar thermal	**Medium** Some pilots completed but limited data on potential uses	

[60] Solar water heating is typically used by industrial facilities to replace natural gas used for heating.

RE Technologies	Scalability	Availability of sites	Unexploited Market Potential	Readiness for implementation	Financial Viability
	Criteria				
Utility-scale wind	**High** Capacity factors higher than solar but wind speeds relatively low	**Medium** Most wind in coastal areas, which are prone to flooding or have soil which makes construction difficult	**High** Some developer interest; no existing schemes to promote utility-scale wind	**Medium** Comprehensive wind mapping to be completed in 2015	
Hydropower	**Low** Resource potential appears to be limited; sites are low head	**Low** Substantial social and environmental difficulties associated with siting in Bangladesh	**High** Very little small hydropower development in Bangladesh to date	**Medium** Some sites have been identified, and flows measured, but no engineering site visits have been made	**Low-High** Cost is highly site dependent
Waste-to-Energy (Electricity)	**Medium** Sufficient resources in major cities only	**Medium** Substantial potential in urban areas, but better schemes needed for collection and management	**High** Some developer interest; no existing schemes to support waste-to-energy	**High** Technology well-developed globally but collection and management critical	**High** Initial levelized cost estimates are among the lowest

RE Technologies		Criteria				
		Scalability	**Availability of sites**	**Unexploited Market Potential**	**Readiness for implementation**	**Financial Viability**
Off-grid	**Solar Home Systems (incl. Pico solar)**	**High** Large solar resource potential throughout Bangladesh	**High** More than half of rural population does not have access to electricity	**Low** Rising market demand since 2003; IDCOL has well developed program. Private sector is becoming active without IDCOL support.	**High** Well-developed pipeline of potential customers	**High** Compares well to off-grid diesel; sales of panels happening without IDCOL support
	Solar Pumps		**High** Large potential to replace solar pumps	**Medium** IDCOL has a well-developed program but needs additional funding to reach targets		
	Mini and Microgrids	**Medium** Resource potential in off-grid areas is high, but SHS systems may be sufficient for most residential needs.	**Medium** Many potential sites, lack of clear plans on transmission expansion may limit future interest	**Medium** IDCOL has a program for micro and minigrids but existing projects have run into regulatory and operational problems	**High** IDCOL has a pipeline of 21 projects with investor interest	**Medium** Financially viable with subsidies only
	Biomass and biogas (electric)	**Medium** Biomass is most used	**Low** Only large commercial operations have sufficient	**Medium** IDCOL has an	**Medium** Some projects in	**Medium** Cost

RE Technologies		Criteria				
		Scalability	**Availability of sites**	**Unexploited Market Potential**	**Readiness for implementation**	**Financial Viability**
		source of fuel, but there are issues of resource scarcity	resource potential	established track of funding both animal waste and rice husk gasifiers	IDCOL's pipeline. Limited data available on biomass potential; Study to be completed by SREDA in 2015	competitive with offgrid diesel but feedstock cost may be too low
	Improved Cookstoves		**High** Market penetration rate of ICS is still low; More than 30 million traditional cookstoves could be replaced	**Low** ICS market has been around for nearly 30 years and is therefore one of the most mature in Bangladesh; IDCOL has established funding program	**High** 30+ partner organizations are using IDCOL model	**Medium** Constraints on biomass availability prevent long-term financial viability
	Domestic Biogas Plants		**Medium** Alternative to ICS; adopters tend to be on larger cattle farms with higher incomes[61]	**Medium** Moderate investor interest; IDCOL has established funding program	**High** 40+ partner organizations are using IDCOL model	**Medium** High upfront cost, lower operating cost than ICS; uses

[61] Kabir, Humayun. "Growing popularity of small scale biogas plants in Bangladesh." Volunteer research study submitted to the Food and Agriculture Organization of the UN, < http://tinyurl.com/oqtypny>

		Criteria				
RE Technologies		**Scalability**	**Availability of sites**	**Unexploited Market Potential**	**Readiness for implementation**	**Financial Viability**
						biomass more efficiently
	Waste to Energy (Natural Gas)	**Unknown**	**Unknown** Some sites have to be identified.	**Unknown** Unknown developer interest	**Medium** Technology is common, but unproven domestically.	**Unknown**

5 Program Description

The prioritization exercise described in Section 4 has led to the selection of threeareas where Government will request SREP support:

- Grid-connected renewable energy, which includes utility-scale solar PVand grid-connected rooftop solar PV. If wind resources prove to be sufficient, and there is private sector interest, the SREP funds could also be used for a grid-connected wind project
- Off-grid solar PV, which includes solar irrigation, and mini/microgrids
- Transaction advisory assistance in preparing a municipal waste-to-energy project.

This section describes the projects proposed for SREP support, the delivery models that may be used for each project, the priority activities envisioned for each project, and the expected co-benefits and environmental and social risks associated with the proposed projects.

5.1 Grid-Connected Renewable Energy

SREP contributionswould be used to leverage financing forthe development of 200-300 MW of utility-scale solar or grid-connected rooftop solarin major urban areas.[62] The rapid decline in solar PV and battery costs in recent years has made utility-scale solar PV more affordable and more competitive with the other power generation options available to Bangladesh, but few projects have yet gone forward. SREP support would help catalyze private investment in a first round ofground- or roof-mounted solar PV plants, and show the potential for deploying solar PV on a commercial basis.

5.1.1 Utility-scale solar PV

SREP contributions would be used to finance Bangladesh's first utility-scale solar plant, through a public private partnership (PPP) modality. The project would benefit from a mix of concessional finance from SREP and the MDBs,as well as commercial finance from IFC and other private sector investors.The plant would be tendered through a reverse auction, under which Government issues a tender for a given capacity (some number of MW) of new grid-connected solar. The tender may be site-specific or not. A site-specific tender would identify a specific site, on publicly-owned land, for construction of the new plant or plants. As an alternative to a site-specific tender, Government could tender a request for a given capacity of solar, leaving it to the developers the responsibility of acquiring the land. This model would allow for bidding by private sector developers who have their own land at the time of bidding, as well as other developers who do not yet have land at the time of bidding. There is considerable flexibility on how responsibilities can be allocated under a PPP contract, but contracts giving the design, build, operate, and finance (DBOF) functions to the

[62] "SREP contributions" refers to the concessional loans available through SREP. "SREP grants" refer to grant funding available through SREP. It is anticipated that roughly 55 percent of the support provided by SREP will be in the form of SREP contributions, and 45 percent will be in the form of SREP grants.

private sector are most common in such tenders. These contracts are typically known as Build-Own-Transfer (BOT) or Build-Own-Operate (BOO) transactions.

Priority activities for utility-scale solar

The utility-scale solar PV project wouldinclude the following activities:

- **Project preparation, feasibility studies, site measurement and monitoring.** If a site-specific tender is used, or the plant is to be publicly owned and operated,SREP grant funds could first be used to fund more detailed resource assessments, and identification of possible sites and possible projects. Existing data are generally acceptable for understanding the nature of the resource and conducting a high-level financial analysis. However, a feasibility study will be needed to characterize the solar resource potential in the areas targeted for solar development in more detail. Furthermore, it will be necessary to evaluate the potential for grid interconnection at the chosen site, and whether or not grid upgrades will be necessary before the project is interconnected. The feasibility study will also reaffirm the economic and financial viability, compliance with environmental and social safeguards, and to complete legal and regulatory due diligence.

- **Investment in project or projects.**SREP support would be used to offer blended finance to private bidders. For example, US$ 15 million of SREP contributions could be blended with US$100 million of IDA financing, and US$30 million of IFC financing to attract an additional US$100 million of private sector investment for a project. A benefit of using IFC financing is that no sovereign guarantees are required.

- **Transaction advisory.** Transaction advisors would be hired to help government tender for the projects identified in the feasibility studies. As described above, private operators would be procured through competitive tender. Bidders would be selected based on technical and financial criteria, the financial criteria being the level of tariff required or, alternatively, the level of concessional support required. Developers offering lower tariffs or requiring less concessional support would receive higher scores.

- **Partial Risk Guarantees.** If desired by private bidders SREP contributions could also be used to provide guarantees to investors in utility-scale solar. The best form and purpose of the guarantee will need to be determined in parallel with the feasibility studies and market sounding (part of the transaction advisory) but guarantees could conceivably be used to reduce private investors risk related to regulatory changes, or changes in macro-economic variables that are difficult or unusually expensive to hedge (currency fluctuation, for example) for government and the private sector.

5.1.2 Rooftop Solar

Two delivery models are suitable for grid-connected rooftop solar in Bangladesh:

- **Private ownership and operation.** Private developers could be incentivized to own and operate a collection of rooftop solar arrays through two possible arrangements:

– Feed-in-tariffs. Potential investors could be offered a fixed fee per kWh of solar production, with guaranteed offtake for the life of the plant. This arrangement would likely be most suitable for rooftop solar arrays on large privately-owned roof areas, such as industrial or large commercial buildings

– Power purchase agreements awarded through competitive tender. This is similar to the PPP arrangement described above for utility-scale solar PV projects. Box 5.1 summarizes the successful rooftop solar program in Gujarat, has used a PPParrangement that could be considered for Bangladesh. This arrangement may be more suitable than a feed-in-tariff for projects requiring the aggregation of multiple publicly- or privately-owned rooftops.

- **Public ownership and operation.** The public sector could install and operate rooftop solar arrays on public buildings, including publicly-owned industries and other parastatals. SREP contributions and MDB financing could be used to invest in such projects.

Box 5.1: Gujarat Rooftop Solar Program

In 2010, the Government of Gujarat launched its pilot solar rooftop program in the city of Gandhinagar, the state's capital. The IFC, serving as transaction advisor, helped Gujarat innovate a 5 MW solar rooftop public-private partnership (PPP) project to add power generating capacity, develop contractual models for further solar projects, and demonstrate the technical and economic feasibility of rooftop-based solar power. Under the PPP model used to finance Gujarat's solar rooftop program, two private firms,Azure Power and SunEdison, each won 25-year concessions for 2.5 MW solar rooftop projects. The two developers will install solar photovoltaic panels on the rooftops of public buildings and private residences and connect them to the grid in Gandhinagar. The 5 MW of power is saving over 7 million metric tons of greenhouse gas emissions annually.

Azure Power and SunEdison will lease rooftop space from government and residential buildings. The building owners will receive Rupees (Rs) 3 (or US$0.05) for every unit of power generated. The private operators are responsible for installing the panels and connecting them to the grid, for which they will receive a feed-in-tariff of Rs 11.21 ($0.18) per unit.

One of the greatest successes of the pilot program has been its replicability for other cities in the state of Gujarat. The solar rooftop concept is being replicated in five other cities in Gujarat. A 25-year concession to implement Gujarat's second solar rooftop PPP was signed in Vadodara in June 2014. IFC is helpingimplement similar PPP policy to finance rooftop solar programs in four other cities in Gujarat – Bhavnagar, Mehsana, Rajkot, and Surat.

Sources: "Replicating Success in Vadodara: Rooftop Solar PPPs in India," *The World Bank Group*, last modified September 25, 2014, http://www.worldbank.org/en/news/feature/2014/09/25/replicating-success-in-vadodara-rooftop-solar-ppps-in-india.

"Public-Private Partnership Stories India: Gujarat Solar," *International Finance Corporation*, last modified April 2012, http://www.ifc.org/wps/wcm/connect/d0a75c804b077348b4acfe888d4159f8/PPPStories_India_GujaratSolar.pdf?MOD=AJPERES.

Priority activities for rooftop solar

The rooftop solar PV projects would include the following activities:

- **Project preparation, feasibility studies, site measurement and monitoring.** The studies identified in Box 3.1are not sufficient for an investment-grade estimate of technical potential. A more detailed mapping exercise is needed to determine all the suitable rooftops in the largest urban areas. As would be the case for utility-scale solar PV, the feasibility study would also reaffirm the economic and financial viability, compliance with environmental and social safeguards, and to complete legal and regulatory due diligence. Rooftops on existing private buildings, for example may not all be suitable for rooftop solar, as residents use them for other purposes which range from drying laundry, socializing or other recreational activities.
- **Transaction advisory or technical assistance on FiTs.**The private sector transaction advisory arms of the MDBs could fulfill the transaction advisory role IFC fulfilled in Gujarat. If, instead of a tender, feed-in-tariffs are used, a small amount of SREP funding could be used to advice BERC and Government on the level, structure, and terms of feed-in tariffs. This would include advice on the level of feed-in-tariff, eligibility for the tariff, and other conditions (for example, how long the feed-in-tariff is valid, and how it changes over time, if at all).
- **Investment in projects.**As for utility-scale solar, SREP contributions would be used to leverage additional IDA financing, financing from IFC and from the private sector.

5.1.3 Utility-Scale Wind

If the current wind mapping exercise shows a sufficient resource, and if there is private sector interest, SREP funding could be used to support wind projects. The delivery model and priority activities for utility-scale wind would be the same as for utility-scale solar.

5.2 Off-grid Solar PV

Bangladesh has ample, and successful experience with off-grid solar PV. As described in Section 3.1, solar home systems, solar irrigation pumps, and hybrid minigrids have already enjoyed considerable success.

As described in Section 4, the dissemination of solar home systems program is well advanced and has begun to attract substantial private sector interest without the need for concessional financing. There is still room, however, for concessional financing to facilitate scale-up of the solar irrigation and mini-grid programs.SREP grant funding would therefore be used to leverage concessional financing from the MDBs to support the scale-up of solar irrigation technologies and hybrid minigrids.

Financing would be on-lent through the Ministry of Finance and Bangladesh Bank to a financial intermediary. The financial intermediary would make grant funding or low-cost financing available to investors, developers or end-users. The models currently used for these technologies are described in detail in Box 3.2. Similar models would be considered to deliver projects supported by SREP.

Box 5.2: Current Business Models for Solar Irrigation and Minigrids

IDCOL currently finances solar irrigation pumps and hybrid minigrids in the following ways:

- **Solar irrigation.** This program has two business models: the fee for service model, which is currently in use, and the proposed ownership model, which IDCOL is trying to introduce. In the fee for service model, the development partners offer grants to IDCOL, which in turn provides grants to sponsors for 40 percent of the pump cost, at a 6 percent interest rate, over a period of 8 years. There are currently 17 sponsor organizations which have implemented projects under this model. These sponsors purchase TSC-approved equipment (pumps and PV panels) from suppliers, who install the equipment and provide after-sale service. The sponsors own the pumps and sell water to farmers who pay an irrigation charge. Payments are collected by pump operators. The ownership model functions in a similar way for donors, IDCOL, and suppliers, but has POs (instead of sponsors) who sell the pump on cash/credit to farmers. Under this model farmers pay 60 percent of what the pump would cost without a grant. They make a 20 percent down-payment and pay the rest in yearly installments for 5 years, at a 15 percent interest rate.
- **Solar minigrid projects.** The projects are implemented through sponsors, who contribute 20% of projects costs from their own sources and receive 50% grant financing and 30% concessional financing from IDCOL. The concessional loans have a 6 percent interest rate and are paid in quarterly installments over a maximum of 10 years, with a 2 year grace period. Sponsors include NGOs, micro-finance institutions and private sector companies. Sponsors hire O&M contractors, which provide O&M solutions, and EPC contractors, which purchase equipment from suppliers and provide turnkey solutions. The sponsors provide grid connections to customers (including small shops, health centers, schools, etc.), who pay tariffs to the sponsors.

Priority activities

The off-grid solar PV projects would include:

- **Investments in solar irrigation, or solar minigrids.** Financing would be on-lent to a financial intermediary and then on-lent to various partner organizations, developers, sponsors or end-users.
- **Technical assistance in minigrid business models and regulation.**Minigrids have, as noted in Section 3.4, experienced a number of challenges in Bangladesh, related to how they are planned, regulated and operated as business. SREP funding would be used, as part of the project preparation to fund a studyaimed at diagnosing the problems experienced with minigrids in Bangladesh and identify possible improvements to the regulatory environment or possible alternative business models for the MDBs or IDCOL to consider.

5.3 Waste to Energy

SREP support would be used to support the development of a municipal Waste-to-Energy (WtE) project for Bangladesh. As noted in Section3.1.7, the challenges to WtE are more managerial than technological. The principal challenges to WtE project in the past have been primarily in the waste management functions required to provide feedstock for a WtE plant.

Priority Activities

SREP support would be used for transaction advisory, which would identify the technical and commercial options for developing a WtE plant. The work completed under the transaction advisory would include the development of a feasibility study and “business case” to consider optionsfor ownership and operation. Such options would include a purely public arrangement (government owned and operated); and various types of PPP arrangements (for example, management contracts, leases, or concessions).

5.4 Environmental, Social and Gender-Related Co-Benefits

Utility-scale solar, off-grid solar PV, utility-scale wind, and waste-to energy all have potential environmental, social, and gender-related co-benefits. Sections 5.4.1 to 5.4.5describe potential co-benefits from these technologies.

5.4.1 Labor and working conditions

- Some opportunities for local employment (paid and voluntary) and ‘on-the-job’ training in relation to the preparatory works and deployment of these power sources (for example fixing of roof-mounted solar PV panels; clearance of trees and vegetation; and, erection of electricity distribution poles under skilled supervision). Depending on the business models, this may also be likely to provide employment opportunities in sales, maintenance and fee collection roles.
- Opportunities for skills training, educational events or mechanisms for encouraging jobs for women and marginalized communities. This could lead to poverty alleviation, increased average earnings and increased GVA per capita.
- Utility-scale projects, and some off-grid projects offer the promise of transport infrastructure improvements, as better roads will be needed to provide maintenance access to sites required for utility-scale RE sites. Transport infrastructure improvements result in secondary benefits to local residents, businesses, and tourists.
- Grid-connected projects can improve the reliability of energy supply, benefitting a wide range of economic sectors and encouraging new and existing businesses.
- A waste-to-energy project may also (depending on the plant design) offer heat as an important by-product. The heat could be used by industrial customers near the plant.

5.4.2 Resource efficiency and pollution prevention

- The grid-connected projects can improve resource efficiency and prevent pollution by providing better reliability of supply, reducing the use of back-up diesel generators, and thus reducing the NO_x, SO_x and carbon dioxide emissions resulting from diesel combustion.
- The off-grid technologies will reduce the use of traditional fuels, thereby reducing air pollution from combustion of these fuels, but also reducing

the river sedimentation and marine and coastal pollution arising from deforestation.

- Utility scale solar, off-grid solar PV, and utility-scale wind have the potential to reduce water resource usage compared to fossil fuel technologies, which require the abstraction of water for cooling. They also have the potential to improve surface water quality compared to fossil fuel technologies, which require discharge of treated effluents.
- Waste-to-energy has an added benefit from production, because by-products (e.g. bottom-ash and residual metals) have market value.

5.4.3 Community health and safety

- Electricity from off-grid technologies may partially replace the use of indigenous fuels, which produce harmful indoor pollutants.
- Potential to improve access to, or reliability of electricity supply for hospitals, health centers, and clinics. This is especially true for hybrid minigrid projects where the combination of solar and diesel can provide 24-hour electricity service suitable for refrigeration, sterilization, and the offering of nighttime medical services.
- Utility-scale solar can be designed to alleviate the impacts of climate change events locally by incorporating sustainable drainage into sites, as a way of mitigating flood risks
- Waste-to-energy can stimulate improvements in waste management and recycling/disposal, sanitation and quality of life.There is also potential to improve community-level materials handling/ waste recycling facilities as part of a waste management regime for solar PV (especially batteries and solar PV panels).

5.4.4 Indigenous people and cultural heritage

- For utility-scale projects, there would be the opportunity to use cultural heritage surveys, as part of the ESIA process, to identify, document and protect culturally important areas/artefacts for the long-term benefit of Affected Communities.
- Off-grid solar PV provides an opportunity for the empowerment of indigenous people, by providing them with energy sources they did not have before, and allowing them to manage or own energy sources.

5.4.5 Gender

- Better quality lighting, and additional hours of lighting have security benefits (especially when public areas are lit).
- Solar lighting has educational benefits, allowing for longer hours of study in brighter light, while solar home systems allow more homes to have a television and benefit from educational and health programming.
- Women, children, and the elderly benefit relatively more from lower use of traditional fuels, as they are typically at risk of higher exposure to indoor pollutants associated with burning of wood, dung or garbage.

- Potential for operational agreements for the renewable energy projects to target the encouragement of jobs for women.

5.5 Environmental and Social Risks

Utility-scale solar, off-grid solar PV, utility-scale wind, and waste-to energy all have environmental and social risks. Many of these risks are the same across the RE technologies, but each technology also has its own unique risks to be considered. Sections 5.5.1 to 5.5.7 describe some of the risk related to these technologies.

5.5.1 Labor and working conditions

- Lack of locally trained professionals could give rise to the need for either local professionals to travel overseas for training or for imported technical expertise. This could result in the displacement of the local population, as well as an increased cost-of-living
- Unsafe or unhealthy working conditions and poor health of workers can arise if measures are not in place to promote safe and healthy working conditions, especially for vulnerable categories of workers such as children, workers engaged by third parties and workers in the supply chain.
- For waste-to-energy and utility-scale projects, transportation of people and equipment might impact traffic patterns during construction near the project site.

5.5.2 Resource efficiency and pollution prevention

- Potential for air emissions during the construction stage(vehicle emissions, particulate matter and dust), due to material transportation and on-site plant movements
- Waste-to-energy plants cause air quality emissions from flue gas (including CO2, sulphur dioxide, nitrogen oxide and nitrogen dioxide amongst many others).These emissions can give rise to risks of acidification of soils and water bodies.
- Utility-scale solar and solar PV have a risk of pollution from the generation, handling and disposal of waste during construction, maintenance and decommissioning. This is a special risk for solar PV because there may be hazardous materials in solar PV panels (such as gallium arsenide, copper-indium-gallium-diselenide and cadmium-telluride). Lead-sulfate dust from lead-acid batteries, and mercury from compact florescent lightingare alsopollution risks.
- Off-grid solar PV, and utility-scale projects have a risk of polluting water bodies due to potential erosion and mobilization of sediments by the construction of the plant and inappropriate storage of polluting materials.

5.5.3 Community health, safety and security

- Risk of detrimental health effects on local communities through dust and other particulate matter during construction.

- Waste-to-energy health concerns include odor, litter, flies/vermin/birds and noise emissions.
- Unauthorized access to utility-scale structures is a safety concern (for example, unauthorized climbing of turbine structures).
- Risk of damage to the RE infrastructure due to increased frequency and severity of floods, tropical storms, storm surges and sea level rise associated with climate change.
- Utility-scale solar and minigrids have the potential for increased flood risk in high-risk flood areas due to clearing of vegetation for the generation plant, materials holding and storage areas.
- Utility-scale projects andminigrids may cause disturbances to communities, arising from construction (including vibration, blasting, clearing and grading site), operation and decommissioning such as noise, traffic, vibration, odor, shadow flicker and blade glint.
- Utility-scale wind has the risk of electromagnetic interference with aviation radar and telecommunication systems (including microwave, radio and television).[63]

5.5.4 Land acquisition and involuntary resettlement

- Utility-scale projects and off-grid solar PV have the potential risk of sunk cost in infrastructure if poorly planned and located in high-risk flood areas or in the path of sea level rise.
- Utility-scale projectsand waste-to-energy present possible conflicts with land owners as a result of the need for loss of existing land (such as temporary or permanent loss of farmers' croplands), resettlement or displacement of other economic activities. In particular, conflict could arise in areas of community land ownership, where cultural sensitivities and landowner negotiations can be particularly difficult.

5.5.5 Biodiversity conservation and sustainable management of living natural resources

- Utility-scale projects and waste-to-energyhave the potential for construction works and operational equipment to result in the loss of habitat, habitat fragmentation and impacts on ecosystem services.
- Utility-scale projects have the risk of soil erosion and degradation as a result of stripping the working area for infrastructure during construction.
- Utility-scale solar could cause ecological impacts in local water bodies as a result of sediment deposition from storm water runoff.

[63] As cited in the World Bank's Environmental, Health and Safety Guidelines for wind Energy: http://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/ifc+sustainability/our+approach/risk+management/ehsguidelines

- Utility-scale wind could impact populations of bird species due to strikes associated with turbines or transmission lines, and could impact bats due to vibration and noise.
- Utility-scale wind has a risk of harm to fauna arising from partial decommissioning, and leaving residual infrastructure or polluting materials in place.
- Utility-scale wind construction and maintenance activities for land grading, foundations and in-ground equipment could cause disturbances of contaminated soils and sediments.

5.5.6 Indigenous peoples and cultural heritage

- Ethnic disputes over placement of energy generating equipment and ancillary infrastructure
- Potential loss or damage to cultural and natural sites due to construction or operation of schemes, including nationally and regionally registered areas, unknown or unregistered cultural heritage sites and intangible cultural and heritage assets
- Visual impacts of RE generation infrastructure upon the landscape, with potential impacts on the scenic value of Reserves, Sanctuaries and National Parks (For example, the stack of a waste-to-energy plant)

5.5.7 Other cross-cutting topics

- Utility-scale projects have a risk of pollution to water bodies (including surface water and groundwater supplies) arising from construction activities.
- Off-grid solar PV has a risk of sulfate contamination in surrounding lands and water bodies (including groundwater) due to improper disposal and recycling of lead-acid storage batteries.
- Waste-to-energy has a risk to water resource availability, surface water quality and aquatic ecology (likely abstraction and cooling water discharge requirement).
- Utility-scale projects and minigrids have a risk of localized geological damage as a result of creating foundations for RE generation infrastructure and laying transmission networks.

6 Financing Plan and Instruments

Table 6.1 presents a plan for financing the projects described in Section5. It shows the proposed credits and grants from SREP as well as estimates of the amounts anticipated from MDBs and the private sector.

As the table shows, roughly US$ 75 million of SREP funding is expected to catalysemore than seven times as much investment, most of it from the private sector (as equity or debt), and the public sector lending windows of the MDBs.

The exact financing modalities will be determined at the time of appraisal, but it is expected that:

- Roughly US$ 42 million of SREP contributions would be used to leverage blended financing for utility-scale renewable energy plants (primarily solar but possibly also wind), and rooftop solar. The blended financing would include US$ 100 million in IDA financing from the World Bank, US$100 million in a partial risk guarantee(PRG) or similar instrument, US$ 30 million in investment from IFC, and roughly US$100 million from the private sector.IFC's assistance would be sought for transaction advisory on structuring of the PPP arrangement under which private operators would be selected.
- Roughly US$ 30 million of SREP grant funding would be used to leverage US$ 140 million in concessional financing from ADBfor solar irrigation and hybrid minigrid projects.
- IFC's assistance would be sought for assistance with an assessment of technical and commercial feasibility and for transaction advisory on the structuring of a municipal waste-to-energy project.

The Government of Bangladesh will contribute by waiving VAT (15%) on all capital expenditure and services associated with the financing plan.

Table 6.1: Financing Plan—Phase 1

<table>
<tr><th><u>SREP Project</u></th><th>SREP</th><th>MDB Respon-sible</th><th>Government of Bangladesh</th><th>MDBs</th><th>Private Sector (Equity or Debt)</th><th>Total before government contribution</th><th>Total</th></tr>
<tr><td>Grid-Connected Renewables</td><td colspan="7">(Million US$)</td></tr>
<tr><td>Investment in utility-scale solar and wind, and rooftop solar</td><td rowspan="2">42.0</td><td>WB</td><td rowspan="2">55.8</td><td>200.0*</td><td rowspan="2">100.0</td><td rowspan="2">372.0</td><td rowspan="2">427.8</td></tr>
<tr><td>Investment in utility-scale solar and wind, and rooftop solar</td><td>IFC</td><td>30.0</td></tr>
<tr><td>Project preparation (including feasibility studies)</td><td>2.0</td><td>WB</td><td></td><td></td><td></td><td>2.0</td><td>2.0</td></tr>
<tr><td>Transaction advisory</td><td>0.8</td><td>IFC</td><td>0.4</td><td></td><td>1.8</td><td>2.6</td><td>3.0</td></tr>
<tr><td>Subtotal: Grid-connected renewables</td><td>44.8</td><td></td><td>56.2</td><td>230.0</td><td>101.8</td><td>376.6</td><td>432.8</td></tr>
<tr><td>Off-grid solar PV</td><td colspan="7">(Million US$)</td></tr>
<tr><td>Investment in mini-grids</td><td>5.0</td><td rowspan="3">ADB</td><td>18.8</td><td>120.0</td><td></td><td>125.0</td><td>143.8</td></tr>
<tr><td>Investment in solar irrigation</td><td>24.0</td><td>6.6</td><td>20.0</td><td></td><td>44.0</td><td>50.6</td></tr>
<tr><td>Project preparation</td><td>1.0</td><td></td><td></td><td></td><td>1.0</td><td>1.0</td></tr>
</table>

Subtotal: Off-grid solar PV	**30.0**		**25.4**	**140.0**	**0.0**	**170.0**	**195.4**
Development support for Waste-to-Energy	**(Million US$)**						
Transaction advisory for WtE plant (including feasibility study)	0.2	IFC	0.2		0.9	1.0	**1.2**
Subtotal: Development support for Waste-to-Energy	**0.2**		**0.2**	**0.0**	**0.9**	**1.0**	**1.2**
Grand Total	**74.5**		**81.6**	**370.0**	**102.7**	**547.1**	**628.8**
SREP Leverage	**7.4**						

Notes: All amounts in this table are preliminary estimates and are subject to availability of funds.

*Roughly $100 million of this amount could be IDA financing and $100 million could be in the form of a partial risk guarantee (PRG) or similar guarantee instrument.

As described in Section 4, the investments associated with the SREP investment prospectus represent the first phase of two-phase investment program planned by Government. Support for Phase II will be sought from the Green Climate Fund (GCF). The second phase will include a continuation of the grid-connected renewable energy projects, clean cookstoves program, and the waste-to-energy project launched as part of Phase 1, with SREP assistance.

Table 6.2 shows financing plan for Phase II of Bangladesh's investment plan. The numbers are meant for the purposes of rough illustration only, and do not imply any commitment made by GCF, the Government of Bangladesh, the MDBs or any other parties.

More specifically, the Phase 2 program would include:

- **Grid-Connected Renewables II**. This project will be an expanded version of the project from Phase 1 with the aim of supporting the GoB's RE Development Targets for 2021 (see Section 2.4.3). The financing plan for this project includes more than US$3.5 billion in funds for:
  - Utility-scale solar. The plan for Phase 2 would be to achieve the goal of having 1,221 MW of utility-scale solar by 2021 through the financing of approximately 1,050 MW. The focus in this phase would be to reduce the role played by MDBs and increase private sector activity.
  - Utility-scale wind. A major emphasis of Phase 2 would be to kick-start the expansion of utility-scale wind. MDBs would provide the majority of financing in order to support wind similar to how utility-scale solar would be supported in Phase 1. The plan provides total financing sufficient to achieve the 637 MW technical potential for utility-scale wind found in Section 3.1.4. This installed capacity is nearly half of the GoB's 2021 target.
  - Rooftop solar. The target for 2021 is to have 48 MW of rooftop solar. Financing in Phase 1 would cover approximately 32 MW. The plan for Phase 2 is for MDB support to contribute to the remaining 16 MW and have an additional 110 MW (approximately 25 percent of technical potential found in Section 3.1.2) in private sector investment.
  - Small hydropower. GoB has a target to install 4 MW in small hydropower by 2021. The plan includes sufficient financing to cover installation of 3-4 small HPPs at sites with 1-2 MW in technical potential.
- **Clean Cookstoves**. The clean cookstove project includes US$519.2 million in funds for the installation of ICS and biogas plants. Existing MDB programs have sufficient funds for these technologies through 2018. The financing plan in this project would aim to continue these existing programs in order to support the nationalgoals of installing 30,000 million ICS and 100,000 biogas plants. ICS support would be provided through the provision of low cost financing to the POs that are installing ICS. Biogas plants would be supported through a mix of capital buy down grants and

concessional grants. In total, this Phase 2 project would cover the financing of approximately 20 million ICS and 65,000 biogas plants.

- **Waste to Energy Program**. Thisproject supports the GoB's goals to have the installed capacity to generate 40 MW from municipal waste; 7 MW from biomass; and 7 MW from biogas by 2021. The municipal waste to energy project would be developed based on the results of the feasibility study in Phase 1. The biomass and biogas financing plan follows the existing models to use a mix of grants, concessional loans, and private equity for these projects.

Table 6.2: Financing Plan—Phase 2

SREP Project	GCF or others	Government of Bangladesh	MDBs	Private Sector (Debt or Equity)	Total
Grid-Connected Renewables II			**(Million US$)**		
Investment in utility-scale solar	100.0	283.5	550.0	925.0	**1805.4**
Investment in utility-scale wind	55.0	228.6	940.0	275.0	**1498.6**
Investment in rooftop solar	9.0	35.4	17.5	170.0	**231.9**
Investment in small hydro power	1.0	2.9	10.0	5.0	**18.9**
Project preparation (including feasibility studies)	10.0				**10.0**
Subtotal: Grid-connected renewables	**175.0**	**550.4**	**1517.5**	**1375.0**	**3617.9**
Clean Cookstove			**(Million US$)**		
Investment in cookstoves	0.0	72.0		400.0	**472.0**
Investment in biogas plants	10.0	7.2	16.0	14.0	**47.2**
Financing for POs	15.0		85.0		
Subtotal: Clean Cookstove	**25.0**	**79.2**	**101.0**	**414.0**	**519.2**
Waste to Energy Program			**(Million US$)**		
Investments in Municipal Waste-to-Energy	20.0	21.6	70.0	30.000	**141.6**
Investments in Biomass to Electricity	3.0	2.5	5.0	6.000	**16.5**
Investments in Biogas to Electricity	7.0	7.6	25.0	10.000	**49.6**
Subtotal: Waste to Power	**30.0**	**31.7**	**100.0**	**46.0**	**207.7**
Grand Total	**230.0**	**661.2**	**1718.5**	**1,835.0**	**4344.7**

7 Responsiveness to SREP Criteria

The Investment Plan developed for Bangladesh is responsive to all of the SREP criteria. Table 7.1 summarizes how each of the projects responds to SREP Criteria.

Table 7.1: Summary of Projects' Responsiveness to SREP Criteria

Criteria	Grid-connected solar	Grid-connected wind	Off-grid solar PV	WtE
Increased installed capacity from renewable energy sources	SREP resources would be used to finance the development of 170 MW of utility-scale solar PV and 32 MW of grid-connected rooftop PV in major urban areas.	SREP resources could be used to finance the development of ZZ MW of utility-scale wind via private investment (through a feed-in tariff or reverse auctions) or public investment (via on-lending from MoF to BPDB).	SREP resources could be used to finance the development of 12.5 MW of solar irrigation (through a fee-for-service or an ownership model) and 30 MW of minigrids (through sponsors, grant financing and concessional financing).	SREP support could be used to support the development of municipal WtE schemes, through financing a feasibility study and business case, providing viability-gap funding and lending to (or investment in) the WtE PPP company.
Increased access to energy through renewable energy sources			Microgrids can provide groups of up to 1000 customers with close to 24 hr power services and solar irrigation pumps can offer surrounding residents access to electricity when not being used for pumping purposes.	

Criteria	Grid-connected solar	Grid-connected wind	Off-grid solar PV	WtE
Low Emission Development	Grid-connected solar produces no emissions and will displace diesel powered generation.	Grid-connected wind produces no emissions and will displace diesel powered generation.	Off-grid solar produces no emissions and willdisplace kerosene currently used by households for lighting and diesel currently used for existing water pumps.	WtE leads to air quality emissions from flue gas (including CO_2, sulphur dioxide, nitrogen oxide and nitrogen dioxide among many others) but will displace diesel powered generation.
Affordability and competitiveness of renewable resources	The rapid decline in solar PV and battery costs in recent years has made utility-scale solar more affordable and more competitive with diesel generation and likely future sources of baseload power (e.g., imported coal and LNG).	Grid-connected wind is competitive with diesel generation and likely future sources of baseload power (e.g., imported coal and LNG).	Off-grid solar could provide power for irrigation at cheaper rates than diesel, though only replacement of large diesel pumps on 3-4 crop land are considered viable. Concessional financing makes minigrids and solar irrigation competitive with diesel generation.	The cost of WtE schemes depend on the introduction of efficient waste collection processes. With efficient collection, WtE is competitive with diesel and coal.
Productive use of energy	Grid-connected technologies increase access to energy supply and could lead to an increase in new businesses, supplying new development and workforce, increasing local tax returns and diversifying local business base.		Off-grid solar can lead to an increase in new businesses, supplying new development and workforce, increasing local tax returns and diversifying the local business base. Children's education benefits from lighting that allows them to study longer in brighter light.	WtE provides more reliable electric power supply, and can also provide heat energy to local businesses if so designed. By-products of WtE (e.g., bottom-ash and residual metals) have market value.

Criteria	Grid-connected solar	Grid-connected wind	Off-grid solar PV	WtE
Economic, social and environmental development impact	The development of these projects has a number of economic, social and environmental benefits, which are described in detail for each technology in Section 5.			
Economic and financial viability	The supply curves shown in Section 3.3confirm that grid-connected solar, with either concessional or private financing, is considerably lower cost than diesel or coal generation.	The supply curves shown in Section 3.3confirm that grid-connected wind (including high speed and low speed wind farms and wind-solar hybrids), with either concessional or private financing, is considerably lower cost than diesel or coal generation.	The supply curves shown in Section 3.3confirm that off-grid solar is financially viable with concessional financing.	The supply curves shown in Section 3.3confirm that WtE, with either concessional or private financing, is low cost compared to diesel and coal generation.
Leveraging of additional resources	Investments from the private sector, MDBs, and government are estimated to leverage 7.4 times the amount contributed by SREP.			
Gender	Grid-connected technologies create the potential for skills training and education for the empowerment of women.		Off-grid solar can lead to skills training and education, and the empowerment of women through better lighting and longer hours of electricity and associated security benefits at night. Off-grid solar also reduces air pollution compared to use of fossil fuel technologies, improving respiratory health in women.	WtE could provide vocational skills training and educational opportunities which could benefit women.

Criteria	Grid-connected solar	Grid-connected wind	Off-grid solar PV	WtE
Co-benefits of renewable energy scale-up	There are a number of co-benefits associated with each technology. These are described in more detail in Section 5.			

8 Implementation Potential with Risk Assessment

The implementation risk of the IP in Bangladesh is moderate. The main risks are regulatory and financial.

For the on-grid projects, it is not yet clear how rights to own and operate grid-connected RE plants will be awarded and how the investors and operators will be remunerated. The financial risks are related to the fact that end-user tariffs are still well below the cost of supply, meaning that fiscal subsidies are required to cover the difference between utility revenue and the cost at which a private bidder would be willing to sell power to the grid.

For the off-grid project, the biggest risk is one of stranded assets. There is a risk that transmission expansion or customer anticipation of grid expansion, will stifle interest in investment in off-grid technologies, as rural areas await electricity connections instead of investing in their own sources of supply. Off-grid RE also requires a large upfront investment which, while on a levelized basis may be cheaper than using a diesel generator, can require substantial upfront payments.

Most of these risks can be mitigated by project preparation, as can environmental and social risks. The GoB has well-established processes for mitigating social and environmental issues associated with the proposed projects, and ensuring that these be managed in accordance with World Bank and/or ADB safeguard requirements as applicable.Legislation for environmental impact assessments (EIAs) in Bangladesh is provided by the Environmental Policy (1992), Environmental Conservation Act (ECA, 1995) and the Environmental Conservation Rules (ECR, 1997). The ECA requires all industrial units and projects to receive Environmental Clearance Certificates (ECCs) from the Department of Environment. The ECR describes the processes and requirements for obtaining ECCs, and classifies projects into four categories of environmental impact and location: Green, Orange A, Orange B and Red. Projects with low environmental impact are issued a Green ECC. All other projects must receive a site clearance certificate before obtaining an ECC. Applications for Orange B and Red projects must be accompanied by a feasibility report on initial environmental examination, EIA and an environmental management plan. Once granted, the ECC must be renewed every three years for Green projects, and every year for other categories. Figure 8.1 below lays out the procedure for obtaining an ECC.

Figure 8.1: Procedure for Obtaining Environmental Clearance Certificates

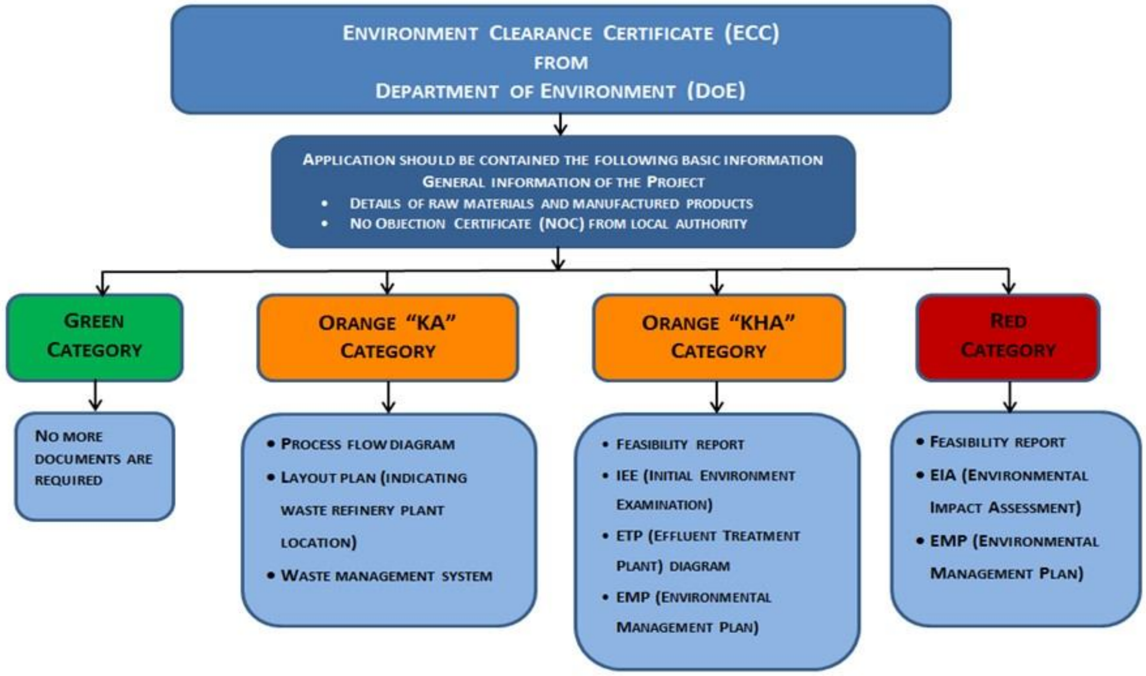


Table 8.1describes the principal risks associated with Bangladesh's IP, describes how to mitigate those risks, and evaluates the residual level of risk after the proposed mitigation measures are implemented.

Table 8.1: Risk Assessment of the SREP Programme in Vanuatu

Risk	Description	Mitigation	Residual Risk
Legal and regulatory risks	A number of gaps and inconsistencies have been identified in Bangladesh's regulatory framework. The grid-connected RE projects could be affected by the absence of a clear policy on remuneration for utility-scale RE or rooftop solar, and the absence of a standardized process for entering into PPP arrangements. The risks to the waste-to-energy project are limited as the project involves technical assistance only. The principal risks to the off-grid projects are the risk of expansion of the transmission network into areas which have	Project preparation grant from SREP will include TA for advice on procurement modalities and (where appropriate, for example, industrial rooftops) feed-in tariffs. IFC will provide transaction advisory services to ensure high quality of bidding documents and tender process which will serve as the basis for future power sector PPPs. Project preparation grant from SREP will provide TA (using international experience) on best models for coordinating grid	**Moderate**

Risk	Description	Mitigation	Residual Risk
	made investments in off-grid technologies; stranding those investment. A related risk is the *perception* of customers in off-grid areas that the grid will expand to their areas, and their consequent reluctance to invest in off-grid technologies.	expansion with uptake of off-grid technologies.	
Institutional capacity risks	The Government of Bangladesh, through BPDB, has extensive experience negotiating power purchase agreements for grid-connected diesel. However, the commercial terms of these PPAs have not necessarily been as advantageous to Bangladesh as they could have been. For example. "take or pay" arrangements with private operators leads to non-economic dispatch in which lower cost, government-owned gas plants sit idle while higher-cost privately-owned diesel plants run. The Government of Bangladesh and several of its financial intermediaries have extensive experience with off-grid technologies. The business models are well-known and have proven successful.	As noted above, IFC will provide transaction advisory services to ensure that Government receives favourable terms from private investors. Where possible, SREP funds will be disbursed through the financial intermediaries that have proven track records investing in off-grid renewable energy in Bangladesh.	**Moderate**
Technology risks	Most of the proposed projects relate to technologies that are well-known globally. Many of the technologies (especially the off-grid technologies) are also well-known in Bangladesh.	Project preparation will include feasibility studies with detailed technical specifications.	**Low**
Environmental risks	Environmental risks include pollution and threats to biodiversity and natural resource management. Pollution could be a serious risk for both solar and waste-to-energy projects, while pollution remains a lesser issue for utility-scale wind projects. Utility-scale projects (both solar and wind) present environmental risks in the form of disruption to	Site-specific environmental impact assessments (or project specific, in the case of the individual solar systems) will be carried out for all projects implemented under SREP. These assessments will ensure that the projects comply with Government policies as well as World Bank and/or ADB safeguards requirements as applicable.	**Moderate**

Risk	Description	Mitigation	Residual Risk
	biodiversity and natural resource management, with utility-scale wind presenting the widest range of issues.		
Social risks	Social risks include the threat of poor working conditions, community health, safety and security, land acquisition/resettlement, and risks to indigenous peoples and their cultural heritage. Poor working conditions could be a problem with any of the selected technologies. Community health, safety and security impacts are also overarching concerns, but have particular significance for utility-scale projects and minigrids. Challenges arising from the necessity of land acquisition and voluntary resettlementcould likely arise for utility-scale and waste-to-energy projects. Each technology also poses risks to the indigenous peoples of Bangladesh and their cultural heritage.	Site-specific social impact assessments will be carried out for all projects implemented under SREP. These assessments will ensure that the projects comply with Government policies as well as World Bank and/or ADB safeguards requirements as applicable. In relation to hydro and microgrid projects where this risk is considered high, Free, Prior and Informed consultation (FPIC) among other social assessment and consultation methodologies will be used to address any issues of land disputes. Strong community ownership and buy in will be sought to mitigate these risks.	**Moderate**
Financial risks	The transmission company, PGCB, receives subsidies from GoB and in 15 years has never missed a payment to power producers. However, the end-user tariff for grid-connected generation is well-below the cost of supply, meaning that subsidies from GoB will need to continue. The upfront capital cost of off-grid RE options is difficult for many rural users to afford.	For grid-connected projects, GoB will consider working with MDBs to offer guarantees which cover regulatory risk (tariffs not being increased as agreed) or payment risk. The business model envisioned for the off-grid technologies will provide CAPEX subsidies or low cost financing which will make the technologies affordable.	**Moderate**

1

9 Monitoring and Evaluation

The investments proposed in this plan has the potential to transform grid-connected electricity generation in Bangladesh, moving the country from a dependence on emergency, thermal generation to utility-scale solar, wind, and waste-to-energy.It would also expand the use of promising off-grid technologies for households and agriculture, building on the success of existing programs.

A monitoring and evaluation (M&E) system will be established by the Government, in cooperation with the MDBs and other donor partners, for the purpose of tracking and reporting on progress in reaching SREP impacts and outcomes. The M&E framework will be coordinated by SREDA.

Table 9.1 summarizes the proposed monitoring and evaluation (M&E) framework for Bangladesh's SREP IP.

Table 9.1: Results Framework for the SREP Programme in Bangladesh

Result	Indicators	Baseline (2014)	Targets (2020)	Means of Verification
SREP Transformative Impact Indicators				
Support low carbon development pathways by reducing energy poverty and/or increasing energy security	Percentage of total households with access to electricity[64]	XX%	XX%	SREDA/SREP Project's M&E system
	Percentage of off-grid households with access to electricity*	<XX%	XX%	SREDA/SREP Project's M&E system
	Annual electricity output from RE	XX%	XX%	SREDA/SREP Project's M&E system
SREP Outcomes				
Increased supply of renewable energy	Increased annual electricity output (GWh) as a result of SREP interventions	XX	TBD	SREDA/SREP Project's M&E system
Increased access to modern energy services	Number of women and men, businesses and community services benefiting from improved access to electricity and fuels as a result of SREP interventions	XX connected	XX men, women, connected through off-grid projects	SREDA/SREP Project's M&E system

[64] The Revised SREP results framework (2012) says that this indicator should be a "National measure of 'energy poverty' such as the Multi-dimensional Energy Poverty Index (MEPI), or some equivalent mutually agreed measure." Energy poverty is indeed a multi-dimensional problem which includes problems associated with a lack of access to sufficient energy supply, a lack of access to clean energy, and a lack of access to affordable energy. The principal problem in Vanuatu is a lack of access to any energy supply whatsoever. Access indicators are therefore used to measure energy poverty.

New and additional resources for renewable energy projects	Leverage factor: US$ financing from other sources compared to SREP funding	0	7.4	SREP Project's M&E system

Appendix A: Assessment of Bangladesh's Absorptive Capacity

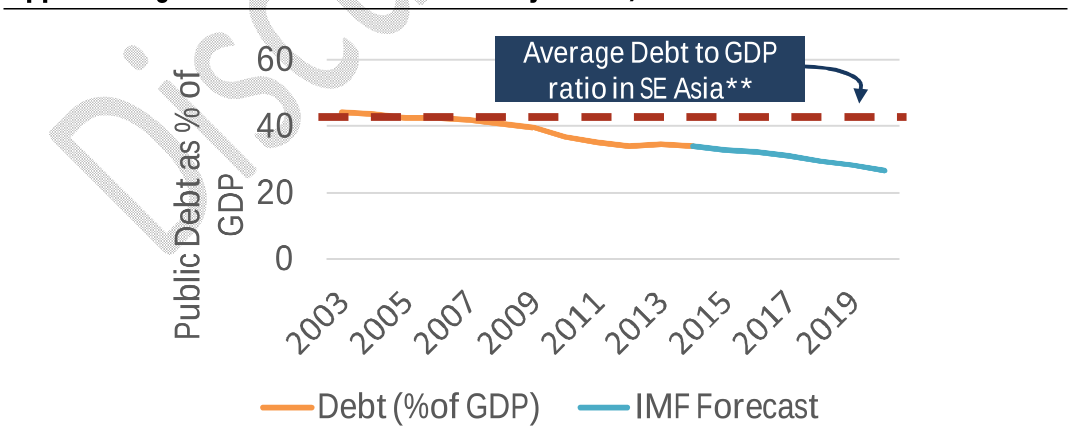
This appendix contains an assessment of Bangladesh's ability to absorb the financing envisioned as part of Phase I of the investment plan and the ability of relevant government agencies to implement the projects identified.

A.1 Debt Sustainability

The amount of Bangladesh's debt has increased over time, but its debt-to-GDP ratio has decreased. Economic expansion and consistent annual growth has put Bangladesh at a low risk of debt distress, with a debt-to-GDP ratio below the 42.8 percent regional average.[65]

According to recent International Monetary Fund (IMF) analysis, when subject to multiple macroeconomic shocks, there is a 50 percent chance that Bangladesh's debt-to-GDP ratio would stay between 36 and 40 percent (and thus a 50 percent chance the debt-to GDP ratio would be either above 40 percent or below 36 percent). Even if Bangladesh experienced a combination of negative macro-economic shocks, with no positive macroeconomic shocks, the debt-to-GDP ratio would still remain below 42 percent. Appendix Figure 9.1 shows Bangladesh's recent debt-to-GDP ratios, along with IMF projections up to the year 2019.

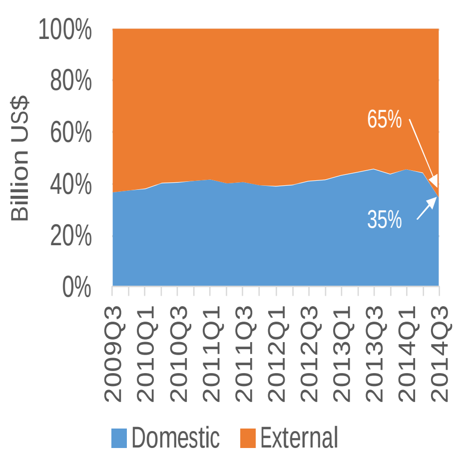
Appendix Figure 9.1: IMF Debt to GDP Projections, 2003-2019



[65] Leandro Medina. "Assessing Fiscal Risks in Bangladesh." IMF (2015).

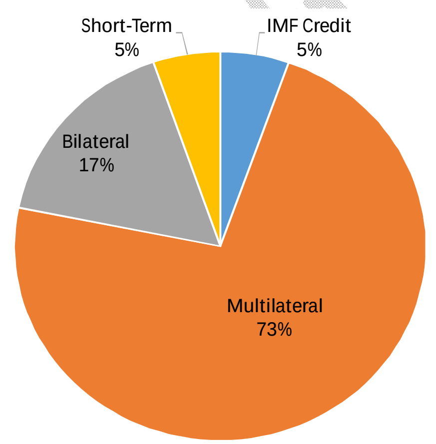
As of the third quarter of FY 2014, the composition of Bangladesh's public debt was 65 percent external and 35 percent domestic (see Appendix Figure 9.2).[66] According to the Ministry of Finance, the cost of external debt has been low for Bangladesh, since most of this debt is in the form of concessional loans from IDA, ADB and Japan. Recently, external borrowing has been increasing, partially due to Bangladesh receiving a smaller share of grant aid in the external aid package. These external loans have an average 10-year grace period and an average 20 year repayment period. [67]Appendix Figure 9.3 shows Bangladesh's funding sources for public external debt, with multilateral donors offering the majority of funding.

Appendix Figure 9.2: Composition of Public Debt (2009-2014)



Source: World Bank Quarterly Public Sector Debt (2015)

Appendix Figure 9.3: Public External Debt by Funding Source (2013)



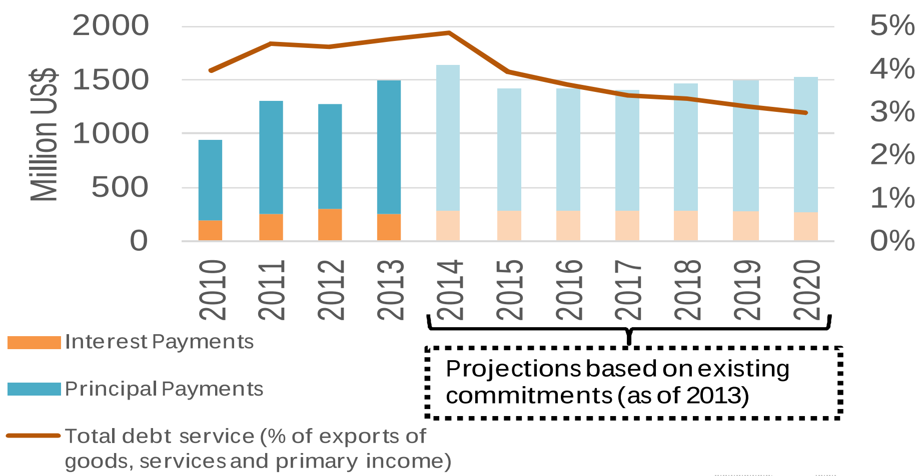
Source: World Bank International Debt Statistics (2015)

The Ministry of Finance acknowledges a concern that interest rate payments are a "substantial burden on the budget". Appendix Figure 9.4 illustrates a projection of external debt service payments, showing both principal and interest payments. By continuing its efforts to maximize its share of grant aid and seek low interest concessional loans (such as those provided by SREP and as leverage from MDBs), Bangladesh can minimize the burden that interest rates have on the budget, while still obtaining the financing needed to meet development goals.

[66]World Bank."Quarterly Public Sector Debt." (2015).

[67] Bangladesh Ministry of Finance. "Budget Financing and Debt Management." (2008).

Appendix Figure 9.4: External Debt Service Payments (2010-2020)



Source: World Bank International Debt Statistics (2015)

Note: Exports and income assumed to grow 7% annually from 2014 to 2020

In accordance with the National Strategy for Accelerated Poverty Reduction (NSAPR), the Bangladesh Ministry of Finance has taken on debt management reform measures, and has developed strategies for public debt management.[68] This strategy includes pursuing stable and low-cost financing, developing a well-functioning government securities market, and minimizing the risks involved with debt management, in order to promote debt sustainability in the medium-term.

A.2 Implementing Agency Capacity

Financing will be channelled through the Economic Relations Division (ERD) of the Ministry of Finance and Bangladesh Bank. SREDA will be the principal coordinating agency for the projects, and will be responsible for applying the monitoring and evaluation framework outlined in Section 9. These institutions have extensive experience implementing and coordinating programs financed by the MDBs.

A number of non-bank financial intermediaries (NBFIs) may be involved in various aspects of the investment program.[69] It is expected that the financial intermediary most appropriate for each investment will be selected in conjunction with the MDBs responsible for each particular project.

The financial intermediaries which may be involved in various aspects of this investment plan include:

- **The Infrastructure Development Company (IDCOL)**, described in earlier sections. IDCOL was established in 1997 as an implementing agency which on-lends grants and loans to partner organizations who in turn procure, install, and often times refinance loans to households.

[68] Bangladesh Ministry of Finance. "Budget Financing and Debt Management." (2008).

[69] As of December 2012, 48 commercial banks and 28 Non-Banking Financial Institutions (NBFIs) are active in the financial sector.

- **The Bangladesh Infrastructure Finance Fund Limited (BIFFL)**, incorporated on 21 March 2011 as a public limited company with capital of roughly US$200 million. The fund is licensed by Bangladesh Bank to operate as an NBFI under the Financial Institutions Act, 1993. BIFFL's objective is to provide predominantly long-term financing for PPP projects through the issuance of bonds, debt instruments, and equity offerings.
- **Investment Promotion and Financing Facility (IPFF).** IPFF is a financing facility at Bangladesh Bank. IPFF finances PPP projects. Its objective is to accelerate private sector-led growth by providing term financing for infrastructure development and promoting domestic infrastructure finance capacity. IPFF can work through a range of participating NBFI's including, for example, IFDC (Industrial and Infrastructure Development Finance Company, Ltd).IIFDC is a participating non-bank financial institution of IPFF, with the objectives are to finance investments in infrastructure and industrial sector.

Appendix Table A.1 compares the financial intermediaries described above in terms of their experience as implementing agencies for MDB financing, as well as their experience in the energy sector.

Appendix Table A.1: Comparison of Financial Intermediaries

NBFI	Relevant Experience
IDCOL	As described in Section3.5, IDCOL has extensive experience appraising and on-lending to MDB financing to energy sector projects, including off-grid RE projects and traditional, thermal power plant projects (IDCOL was instrumental in financing for the Meghnaghat and Haripur combined cycle gas turbine (CCGT) projects
BIFFL	BIFFL has not yet financed any projects in the power sector or worked as an intermediary for MDB financing.
IPFF	Roughly US$ 60 million of power sector projects have been financed through IPFF, adding 178 MW of electricity to the national grid. An additional $300 million in MDB financing has been allocated for on-lending in the 2nd Phase of IPFF, extending the project tenure up to 31 December 2015.
IIDFC	

Direct on-lending to commercial banks may also be an alternative to working through NBFIs, but commercial banks in Bangladesh are typically conservative in their lending because of a lack of capacity for appraisals and risk assessment, and, to some extent, regulatory requirements for liquidity. Lending to RE projects may look risky in comparison to their traditional markets in corporate and consumer lending.

Appendix B: Project Concept Briefs

[To be developed after current draft is approved.]

Appendix C: Stakeholder Consultations

Bangladesh's SREP Investment Plan is the result of an extensive internal and public consultation process, led by the Government of Bangladesh and represented by the Sustainable Renewable Energy Development Authority (SREDA) to identify priorities in the development of renewable energy technologies. The consultations included a broad range of government agencies, as well as representatives from the private sector, civil society organizations (CSOs) and donors. Feedback was sought through one-on-one meetings and group workshops with stakeholders.

Scoping Mission

A World Bank Group and Asian Development Bank team Joint SREP Scoping mission took place between January 26 and 28, 2015. Participants in the stakeholder meeting included representatives from: Power Division; SREDA; Economic Relations Division of theMinistry of Finance; Infrastructure Development Company Limited; USAID; Department for International Development (DFID); and Japan International Cooperation Agency (JICA).

Inception and Data Collection Phase (April 2015)

The inception phase of the project took place in April 2015. As part of this phase members of SREDA's consultant team collected any readily available data and studies on renewable energy technology in Bangladesh. Datasets on resource availability for wind and solar were collected from the Solar Wind Energy Resource Assessment (SWERA) that had been completed by the United Nations Environment Program (UNEP) and the Global Environment Facility (GEF) in 2007. Other information on renewable energy projects was found in academic papers and reports from donor banks, power companies, and local financial institutions.

As a next step, members of the consultant team met with stakeholders to gather anecdotal information and any additional studies on ongoing and proposed renewable energy projects. A list of the organizations and agencies contacted by the consultants is presented in Appendix Table C.1.

Appendix Table C.1: Stakeholders Contacted during Inception Phase

Government Agencies		
▪ Local Government Engineering Department (LGED)	▪ Bangladesh Council of Scientific and Industrial Research (BCSIR)	▪ Power Division (BPD)
Utility Companies		
▪ Bangladesh Power Development Board (BPDB)	▪ Rural Electrification Board (REB)	
Financial Institutions		
▪ Infrastructure Development Company Limited (IDCOL)	▪ Grameen Shakti	
Multilateral and Bilateral Agencies		
▪ kfW ▪ USAID Dhaka ▪ World Bank Group	▪ Japan International Cooperation Agency (JICA) ▪ GIZ Dhaka	▪ Asian Development Bank (ADB) Dhaka
Academic and Research Institutions		
▪ Bangladesh University of Energy and Technology (BUET), Centre for Energy Studies (CES)	▪ Renewable Energy Research Center (RERC), Dhaka University	

First Technical Mission (May-June2015)

The purpose of the first technical mission was to solicit feedback from stakeholders on the technical and financial evaluations completed for the draft IP. The mission included discussions between SREDA, its consultants, the MDB team working on SREP, and other key stakeholders.

The analytical work completed in preparing the IP included a comprehensive assessment of renewable energy technologies identified during the data collection phase. The technologies included: solar parks, rooftop solar, solar home systems, wind parks, biomass for electricity, biogas for electricity, small hydropower, microgrids, solar irrigation, geothermal, and improved clean cook stoves.

The mission included an open stakeholder consultation workshop to get feedback on the analysis. This was held by SREDA on June 8, 2015 and included representatives from the government, utility companies, civil society organizations, private sector, and donor organizations (see Appendix Table C.2). SREDA opened the workshop by discussing ongoing projects and Government plans for renewable energy investment. Recent work highlighted included a PPA agreement for utility-scale solar and a study on biomass for electricity. The SREDA representative then discussed the Government's 500 MW solar target for 2015 and another plan to install 3,016 MWs of RE capacity by 2021, in order to achieve the goal of 10 percent generation from renewable resources. SREDA outlined three models to be used for procuring utility-scale wind and solar: (1) Public Land + Public Ownership; (2) Public land + Private Ownership; and (3) Private land + Private Ownership. SREDA discussed the

Government's plan to have project developers operate for 20 years with a tariff to cover the levelized cost. SREDA noted that technical and economic consideration will be needed if the company has the capability to carry out the project.

Appendix Table C.2: Attendees of Stakeholder Meeting

Government Agencies

- Local Government Engineering Department (LGED)
- Bangladesh Energy Regulatory Council (BERC)
- Bangladesh Council of Scientific and Industrial Research (BCSIR)
- Power Division (BPD)
- Power Cell

Utility Companies

- Bangladesh Power Development Board (BPDB)
- Dhaka Electric Supply Company
- West Zone Power Distribution Company
- Electric Generation Company of Bangladesh
- Rural Electrification Board (REB)
- Dhaka Power Distribution Company
- Northwest Power Generation Company
- Power Generation Company Ltd.
- Rural Power Company

Financial Institutions

- Infrastructure Development Company Limited (IDCOL)
- Grameen Shakti
- Bangladesh Infrastructure Finance Fund Limited (BIFFL)
- Bangladesh Bank

Multilateral and Bilateral Agencies

- kfW
- World Bank Group
- SNV Netherlands
- GIZ Dhaka
- UNDP
- IFC
- JICA

Academic and Research Institutions

- Ahsanullah University of Science & Technology
- Institute of Energy Economics-Japan

Private Companies

- Bangladesh Biogas Development Foundation
- Bright Green Energy Foundation
- Bangla German Solar Power Plant Development Company
- Gazi Associates
- Greenergy Solutions Ltd
- Green Power Electrical & Electronics
- Solar Electro Bangladesh Ltd
- Solaren Foundation
- Solaric
- Bangladesh Organic Products Manufacturers Association
- Bangladesh Solar & Renewable Energy Association
- East Coast Group
- Filament Energy Ltd
- Global Green Energy Ltd
- Keystone Business Support Ltd
- Rahimafrooz Renewable Energy Ltd.
- Saif Powertech Ltd
- Wind Resources Mapping Project

Civil Society Organizations

- Dhaka Ahsania Mission

Following a presentation by SREDA's consultants on the renewable energy assessment, stakeholders were asked to provide feedback.Appendix Table C.3 below summarizes the comments received at the meeting.

Appendix Table C.3: Co-Benefits Associated with SREP Impacts and Outcomes

Category	Comments
Comments on barriers/solutions to RE investment	▪ Recovery rate for RE is discouraging considering the high investment costs ▪ Private sector investment should be encouraged with better lending rates, bank financing at nine percent is too high ▪ Biogas is not a realistic option because gasification process takes too long ▪ Regional cooperation with Nepal or India could benefit hydropower projects ▪ It is important to take into consideration land availability ▪ Grid expansion is a risk to private investors of minigrids ▪ Small hydropower not feasible due to social impacts, this should be included in assessment ▪ Situation for tariff for renewable energy is unclear ▪ Information needs to be better disseminated to the private sector ▪ Category of land influences cost of project.
Recommendations on other technologies or projects to consider	▪ Waste-to-energy project, Clean City Clean Fuel, should be included ▪ Canals for fish culture and solar on top should be considered ▪ Tidal power and hydrokinetic energy should be considered ▪ Solar home systems are already successful, medium size systems should be focus of future programs, can be used in nanogrid applications ▪ Waste to energy power plant should be considered
Suggestions on different biofuel and biomass feedstocks to consider	▪ Post harvesting agro-waste (like Maize) can be used for power generation ▪ Water hyacinth can be used as biomass ▪ Castoroil, jatropha, and maize plants are potential feedstocks for biofuel ▪ Sludge from textile mills could be used for biogas production ▪ Biomass pellets should be used as an alternative to twigs for ICS
Comments on the cost analysis	▪ Comparison of off-grid levelized cost should be to LNG/Diesel ▪ Overall cost assumptions are too high
Comments on the technical assumptions	▪ The technical potential for rooftop solar needs to be higher, try to base it on rooftop availability ▪ Potential mentioned in the presentation is not enough.

Another goal of this mission was to get feedback on the set of criteria to be used to evaluate and prioritize projects for the IP. During the stakeholder meeting participants were asked to complete a survey in which they ranked various National and SREP criteria in order of importance. The results of the survey indicated that the

Second Technical Mission (July 2015)

An MDB team consisting of the World Bank, International Finance Corporation (IFC), and Asian Development Bank (ADB) visited Bangladesh in the period July 27-30, 2015 to conduct a Joint Mission. The main objectives were (a) to discuss progress on the preparation of the SREP Investment Plan (IP) with the Government and the main stakeholders; (b) to discuss with the Government and agree on the prioritization of renewable energy projects to be supported under the SREP; and (c) to agree on the next steps and the timetable to finalize the investment plan and to submit it to the SREP Sub-Committee for approval in November 2015.

As part of the mission SREDA and the Government agreed with the key stakeholders and the MDB team on a set of criteria for prioritization of renewable technologies. Based on the agreed upon priorities, the Government identified the following renewable energy technologies to be supported with a combination of SREP funds (subject to approval of SREP IP), public financing, and private sector investments:i) utility-scale solar PV and wind; ii) grid-connected solar rooftop; iii) solar irrigation; iv) solar/hybrid mini-grids, and v) waste-to-energy development support.The Government also agreed to include in the IP a broader set of renewable energy priorities to help access other sources of climate finance, such as the Green Climate Fund (GCF). These included utility-scale wind and other renewable energy, scaling up solar irrigation, biogas for household and commercial use, scaling up improved cookstoves, waste-to-energy investment, and grid integration of renewable energy.

In addition, SREDA and its consultants held two workshops to solicit feedback from stakeholders on substantive portions of the draft IP, which had been circulated in advance.First, a briefing for the MDB team and representatives from KfW, GiZ, USAID, DFID, and UNDP was held on July 28, 2015. Second, a workshop was held for representatives of private sector, civil society organizations (CSOs), research institutions and academia (see Appendix Table C.4) on July 29, 2015.

Appendix Table C.4: Attendees of Private Sector Stakeholder Meeting

Academic and Research Institutions	
▪ Dhaka International University ▪ Bangladesh University of Energy and Technology (BUET)	▪ Institute of Energy Economics-Japan
Private Companies	
▪ Bangladesh Solar & Renewable Energy Association (BSREA) ▪ Mars Renewable	▪ Maxtech Ltd. ▪ Rehimafrooz Renewable Energy Ltd.
Civil Society Organizations	
▪ Practical Action Bangladesh	▪ Dhaka Ashania Mission

Appendix D: Co-Benefits

Section 5 highlighted some of the environmental, social and gender co-benefits likely to result from Bangladesh's SREP IP. This section focuses specifically on the co-benefits tracked under SREP's Revised Results Framework (as of June 1, 2012). Appendix Table D.1 lists the co-benefits considered under SREP's Revised Results Framework, and describes how those co-benefits will be achieved in Bangladesh.

Appendix Table D.1: Co-Benefits Associated with SREP Impacts and Outcomes

SREP Transformative Impact		
Results	**Co-benefits**	**Description**
Support low-carbon development pathways by increasing energy security.	Avoided GHG emissions	▪ All of the technologies in Bangladesh's SREP IP could result in reduction of GHG emissions in line with global and national efforts to fight climate change, including the Bangladesh Climate Change Strategy and Action Plan (2009).
	Employment opportunities	▪ All of the technologies in Bangladesh's SREP IP have the potential for temporary and long-term job creation. ▪ Job opportunities for marginalized groups in rural areas and empowerment of women via training opportunities in relation to the deployment of off-grid solar PV. ▪ With the deployment of waste-to-energy, job opportunities in the supply chain (e.g., waste delivery and management).
SREP Programme Outcomes		
Results	**Co-benefits**	**Description**
Increased supply of renewable energy (RE) New and additional resources for renewable energy projects/programmes	Increased reliability	▪ All of the technologies in Bangladesh's SREP IP would improve the reliability of energy supply. ▪ Grid-connected technologies result in improved access to and reliability of the electricity grid, benefitting rural areas and hospitals with uninterruptible power supply. ▪ Waste-to-energy can also provide heat energy to local areas (businesses and domestic) if so designed.
	Reduced costs of RE	▪ Grid-connected solar PV (whether utility-scale or rooftop) and wind are nearly cost competitive with the current cost of emergency diesel generation in Bangladesh and with the likely future cost of generation from imported coal or LNG. ▪ Off-grid solar PV can provide electricityfor household use or irrigation at lower cost than diesel generation. ▪ SREP contributions will be used to launch first

	projects in grid-connected RE which show cost competitiveness with thermal generation. ▪ SREP grants will be used to provide temporary grant funding or concessional loans to off-grid RE technologies, making them more affordable. ▪

Appendix E: Comments from Independent Technical Reviewer

[To be added after review of this draft.]