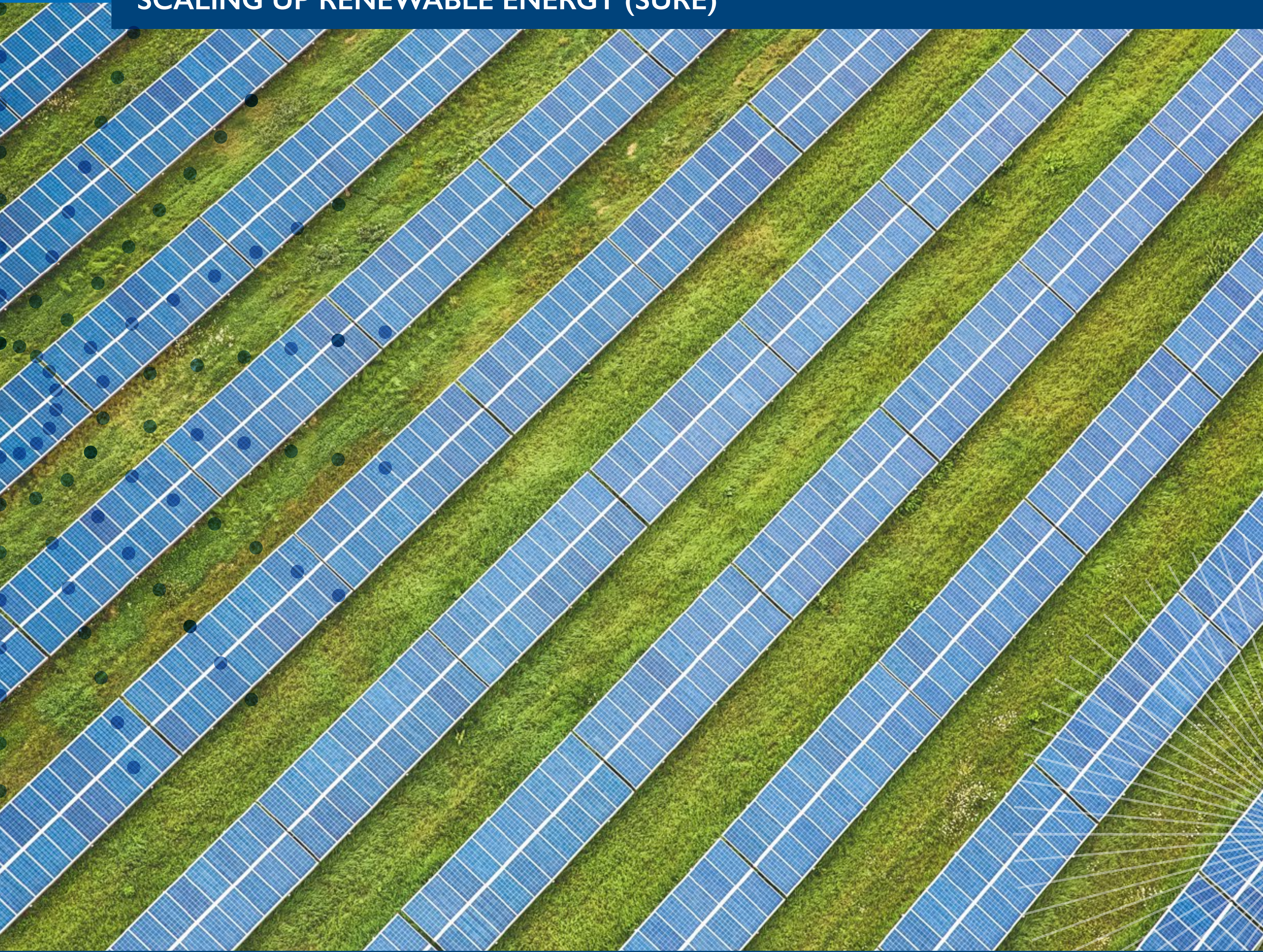
USAID
FROM THE AMERICAN PEOPLE

RECOMMENDATION FOR A RENEWABLE ENERGY IMPLEMENTATION ACTION PLAN FOR BANGLADESH

SCALING UP RENEWABLE ENERGY (SURE)



MARCH 2021

USAID FROM THE AMERICAN PEOPLE

RECOMMENDATION FOR A RENEWABLE ENERGY IMPLEMENTATION ACTION PLAN FOR BANGLADESH

SCALING UP RENEWABLE ENERGY (SURE)

MARCH 2021

This white paper is a deliverable under the United States Agency for International Development (USAID)'s Scaling Up Renewable Energy (SURE) project. The SURE project contributes to increasing grid-connected renewable energy capacity by helping to create an enabling environment for scaling up renewable energy. SURE's high-level outcomes include an increase in clean energy capacity, improved grid integration of clean energy, ensuring that renewable energy capacity can be competitive in the market, strengthened incentives for clean energy, and strategic transmission planning for renewable energy. The SURE Bangladesh activity focuses on integrated resource planning, renewable energy integration and procurement in Bangladesh. Tetra Tech is the implementing partner for SURE.

Prepared for:
Office of Energy and Infrastructure
United States Agency for International Development
1300 Pennsylvania Ave NW
Washington, D.C. 20004

Prepared by:
Tetra Tech ES, Inc.
1320 North Courthouse Road, Suite 600
Arlington, VA 22201
www.tetratech.com

USAID TASK ORDER AID-OAA-I-13-000 19AID-OAA-TO-17-00011

Acknowledgements

This white paper was prepared by Tetra Tech ES, Inc. Contributors included Ritesh Kumar Singh, Dr. Alam Hossain Mondal, Md. Abu Bakar Siddiq and Yusuf Coovadia from Tetra Tech. This paper is one of the outcomes of USAID's Scaling Up Renewable Energy (SURE) project in Bangladesh. We sincerely thank USAID/Bangladesh, which put forth the idea of this white paper, with special thanks to Shayan Shafi, Senior Energy Advisor, USAID/Bangladesh. His help and contributions are highly appreciated.

The publication of this white paper would not have been possible without input from many individuals who generously provided their time and knowledge during the consultation process. We want to thank; Bithi Islam, Director (Technological Development), Power Cell; Sharhan Sadique, Deputy Director (Sustainable Energy), Power Cell; Jarifa Khatun, Deputy Director, System Planning (BPDB); Engr. Monowar Hasan Khan, Deputy Secretary, Power Division; Serajul Islam Khan, Deputy Director, Power Cell 3, BPDB; Kazi Absar Uddin Ahmed, Chief Engineer (Generation), BPDB; Engr. Farhana Alam, Deputy Director (Renewable Energy), BPDB; Engr. S. M. Zahid Hasan, Deputy Director, Design and Inspection-II (BPDB); Firoz Zaman, Deputy Director (BERC); Mr. Kamruzzaman, Deputy Director (BERC); Engr. Mahaimenul Islam, Superintendent Engineer and Project Director, North-West Power Generation Company Limited (NWPGCL); Engr. Tanvir Hasan Bhuiyan, Executive Engineer, System Project (BPDB); Engr. Morshed Alam, Executive Engineer, PGCB; Engr. Shakhawat Hossain, Executive Engineer, Bangladesh-India Power Transmission Station (PGCB); Engr. Jubaer Alvi, Sub-Divisional Engineer, National Load Dispatch Center, PGCB; Engr. Ashaduzzaman Rashed, Executive Engineer (DPDC); Engr. Abdullah Bin Hossain, Project Engineer, Rangunia Solar Ltd.; Abdur Razzak, Professor, Independent University, Bangladesh; Dr. Aminul Islam, Jashore University of Science and Technology; Engr. Mukit Alam Khan, Manager (Project & Planning), US-DK Green Energy (BD) Ltd.; and Prof. Dr. Saiful Haque, Director, Energy Institute, Dhaka University.

We would like to thank the reviewers who provided valuable feedback on this white paper.

Contents

Figures

Tables

List of acronyms

BAU	Business As Usual
BPDB	Bangladesh Power Development Board
GHG	Greenhouse Gas
GIS	Geographic Information System
GOB	Government of Bangladesh
HFO	Heavy Fuel Oil
HSD	High Speed Diesel
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
LNG	Liquefied Natural Gas
MOEF	Ministry of Environment and Forests
MPEMR	Ministry of Power, Energy and Mineral Resources
NDC	Nationally Determined Contribution
NREL	National Renewable Energy Laboratory
PGCB	Power Grid Company of Bangladesh
PSMP	Power System Master Plan
PSPGP	Private Sector Power Generation Policy
PV	Solar Photovoltaic
RE	Renewable Energy
RFP	Request for Proposal
SREDA	Sustainable and Renewable Energy Development Authority
SURE	Scaling Up Renewable Energy
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
VAT	Value-Added Tax
VRE	Variable Renewable Energy

List of unit measurements

BDT	Bangladesh Taka
ckt	Circuit Kilometer
GW	Gigawatt
GWh	Gigawatt-Hour
km^2	Square Kilometer
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt-Hour
MW	Megawatt
mmcfd	Million Cubic Feet per Day
MVA	Megavolt-Ampere
MWh	Megawatt-Hour
TCF	Trillion Cubic Feet
TWh	Terawatt-Hour
USD	United States Dollar

Executive summary

This white paper analyzes Bangladesh's future power generation capacity plans, examines the targets set in various polices that promote utility-scale renewable energy, and proposes an alternative development path for grid-connected renewable energy (RE) that can serve as a new unified RE development plan. This plan will allow Bangladesh to meet its international greenhouse gas (GHG) reduction commitments and to make progress on reducing its high dependence on imported primary fuels.

Bangladesh's *Power Sector Master Plan (PSMP) 2016* estimates that the country will need to bring 60,000 MW of new capacity online by 2041. In order to accommodate a larger share of utility-scale RE, the government has promulgated various policies that set targets intended to drive up installed generation capacity from clean energy. Not much progress has been made; by 2020, RE generation met only 1.32 percent of total electricity supply.

Some studies estimate Bangladesh's solar power potential capacity to be as high as 240 GW and wind power (including offshore wind) as high as 150 GW. Current procurement plans provide little detail on how much RE capacity will be procured, and by when.

This report analyzed Bangladesh's main policy documents to compare the different policies driving RE development in the country.

The updated PSMP (published as *Revisiting PSMP 2016*), which is considered to be the main development roadmap for the power sector, will not allow Bangladesh to fulfill its objectives under the other policy objectives, such as the Renewable Energy Policy 2008 (which calls for 10 percent of supply to come from RE) or Bangladesh's international commitments to reduce GHGs (nationally determined contributions, or NDCs). These unrelated targets make it difficult for decision makers to plan a path forward, which creates uncertainty in the market about government intentions and investment opportunities. This in turn affects the downstream value chain, such as investment in local manufacturing and local industrialization potential. The current PSMP does not address Bangladesh's diverse needs or commitments and is based on projections that were developed when RE was considered to be less competitive. Bangladesh needs a new development path that will allow the country to meet its GHG reduction commitments at the lowest cost, maximize the use of local RE resources, attract private financing and ensure a future less dependent on imported gas and coal.

Studies that explore high RE development paths for Bangladesh find that augmenting RE using least cost planning and removing technology constraints will result in much higher levels of RE penetration. Most of the studies that explore higher levels of RE penetration show that it is possible to meet the targets set out in all government policies. The Renewable Energy Policy 2008, which calls for RE to make up 10 percent of supply by 2020 (extrapolated to 2041 for this paper), has the highest target, with 14,660 MW of renewables required by 2030 and 31,320 MW by 2041.

This white paper considers that target to be achievable, with an estimated 31.32 GW of installed capacity coming from solar photovoltaic (PV) and wind power by 2041. The proposed plan shows that Bangladesh could target 10 percent of total electricity demand to be met by RE after 2021 and maintain this share until 2041 with a realistic rate of increase. This plan will also meet Bangladesh's NDC target of 5 percent GHG emissions reduction from the power sector by 2030.

Studies have shown that Bangladesh has less wind potential than solar potential. Therefore, solar PV installation capacity is proposed to account for between 70 and 80 percent of total RE capacity and wind between 20 and 30 percent of the total to be installed.

TABLE 0-1: Projected Capacity (MW) Required to Meet Targets in Bangladesh's RE Policy Goals

Policy	Target	2021	2030	2041
PSMP 2016	Stated RE target in plan	2,470	-	3,864
Revisiting PSMP 2016	10% share by capacity	2,630	5,307	7,950
Revisiting PSMP 2016	Stated local and imported RE	-	-	9,000
Renewable Energy Policy 2008*	10% share of generation demand[1]	-	14,660	31,320
Bangladesh NDC	Stated RE commitments	-	1,400	-
Bangladesh NDC	5% GHG reduction	-	7,330	-
National Solar Energy Action Plan (Utility-Scale Solar)	Business-as-usual case	-	1,125	5,000
	Medium case	-	3,625	15,200
	High case	-	6,985	25,000

*The target of 10 percent of supply was originally for 2020, but this study has analyzed the target as 10 percent of supply from RE consistently until 2041.

TABLE 0-2: Proposed RE Installation Capacity Targets up to 2041

Target	2025	2030	2035	2041
Electricity generation demand (TWh)[2]	144.32	205.57	322.84	446.02
Target of 10% of demand met from renewable energy generation (TWh)	14.43	20.55	32.28	44.6
Target of total installed capacity from renewable energy (GW)[3]	10.29	14.66	23.03	31.32

Bangladesh will need private sector investment to implement this RE development plan in order to reduce the investment gap from a shortfall in public sector financing capabilities.

This white paper also presents a step-by-step guideline to meet the proposed RE development targets. The Government of Bangladesh (GOB) needs to put a development plan into action, particularly for large-scale RE. The plan will need to include short-term (two to three years), medium-term (2024-2030) and long-term actions. In the short term, the plan will need yearly targets for capacity and activities such as a resource assessment, zone identification, a project feasibility analysis, policy and regulation updates, development of a suitable RE competitive procurement system, pilot projects, and interventions to address infrastructure challenges such as land acquisition and land development, grid extension, connecting roads, *etc*.

In the medium term, the main constraints and challenges will have been addressed. This phase will allow Bangladesh to increase large-scale RE project development and the mid-term development plan should fix yearly development targets. To create long-term sustainability, the GOB needs to create opportunities for local manufacturing; it can achieve this by slowly escalating local content requirements set out during bidding, as well as ensuring enough annual procurement to sustain local manufacturing capacity.

This white paper follows two other papers published under USAID SURE: *Challenges in the Development of Variable Renewable Energy in Bangladesh* identified the most critical challenges hindering the development of grid-connected variable renewable energy (VRE), and *System-Friendly Competitive Renewable Energy Procurement in Bangladesh* presented opportunities and innovative design solutions for Bangladesh to address the system challenges of increasing VRE capacity early and facilitate the continued integration of VRE into its power system.

1 Calculated based on a 16 percent capacity factor for solar PV and wind power in Bangladesh.
2 MPEMR, *Revisiting PSMP 2016*.
3 Based on a 16 percent of capacity factor for solar PV and wind power in Bangladesh.

TABLE 0-3: Guidelines for the Proposed RE Development Plan

Item	Description	Years		
		Short-term (2021-2023)	Mid-term (2024-2030)	Long-term (2031-2041)
Development goal	Establish a renewable energy development plan with yearly targets from wind and solar PV (MW).	✓		
Implementation plan	Develop an implementation plan (short-term, medium-term and long-term) to achieve the renewable energy development goals.	✓	✓	✓
Site/area-specific RE resource mapping and technical potential assessment	Assess potential of renewable energy resources at area- or site-specific level.	✓	✓	
Identify possible project location or renewable energy zones	Land scarcity is the major constraint for developing RE projects in Bangladesh. Identify renewable energy zones that provide suitable sites and grid extension opportunities and develop other necessary infrastructure to aid developers.	✓	✓	
Renewable Energy Policy	The Renewable Energy Policy has not yet produced tangible benefits for RE project development. A new policy needs to address creating a market for RE, development goals and risks that affect project bankability.	✓		
Capacity development and training	Build capacity of key institutions such as the Sustainable and Renewable Energy Development Authority (SREDA). Utility-scale RE is relatively new to Bangladesh and SREDA is not currently oriented to help project developers with utility-scale RE-based power generation.	✓	✓	✓
	Build capacity of other energy stakeholders and individuals with energy backgrounds who work on energy issues. Engage with GOB agencies involved with developing new RE projects and raise awareness of government guidelines and the challenges the private sector faces. SREDA should organize awareness-raising workshops, seminars, and other ways to disseminate information to all stakeholders.	✓	✓	
	RE capacity development training of trainers.	✓		
Standard RFP documents and procurement plans	The bidding template and evaluation system for RE is the same as is used for conventional power plants. There are significant differences in procuring power supply from variable renewable energy (VRE) plants, and these warrant a more suitable procurement framework.	✓		
	Lessons learned from current procurement rounds should inform future procurement processes.	✓	✓	

Item	Description	Years		
		Short-term (2021-2023)	Mid-term (2024-2030)	Long-term (2031-2041)
Enabling business environment	Set public and private targets for RE projects. As Bangladesh's utility-scale RE market is not yet mature, the country would benefit from greater public sector involvement in the short term, which will create long-term market confidence for private sector participants.	✓		
	Remove private sector constraints to developing projects and provide incentives to create a market for RE and a conducive business environment.	✓		
	Due to a lack of experience, local companies are unlikely to be able to participate in bidding for large-scale RE projects alone. GOB could create a program for small-scale projects (5 MW-10 MW) in areas with available distribution substation capacity.	✓	✓	
Smooth integration of renewable energy	Expand the transmission network once renewable energy zones have been identified.		✓	✓
	Increase the flexibility of the power system through upgrades.	✓	✓	✓
	Due to the intermittency associated with VRE energy, adequate storage options will help to maintain system stability.		✓	✓
	Improve system operators' forecasting and scheduling.	✓	✓	
Cost-reflective tariffs and phasing out of subsidies	Implement cost-reflective tariffs and gradually phase out government subsidies that make fossil fuels more attractive than RE and distort market conditions.	✓	✓	
Private sector engagement	Encourage the private sector to invest in RE projects by creating a market for utility-scale RE and ensuring key constraints are identified and addressed.	✓	✓	✓
	Government support to commercial financiers and developers to de-risk and make projects bankable.	✓	✓	

CHAPTER 1.

INTRODUCTION

Between 2010 and 2019, Bangladesh's average gross domestic product grew by more than 6 percent annually.[4] Based on this rate, Bangladesh will need to plan for an 8 percent growth in electricity demand each year. Total electricity supply (including captive power) increased from 29,247 GWh in 2010 to 71,419 GWh in 2020, and according to PSMP 2016, the country will need to bring 60,000 MW of new capacity online by 2041 to meet demand.[5] Under the current PSMP, Bangladesh will achieve this mostly through conventional generation technologies such as natural gas, imported liquefied natural gas (LNG), local and imported coal, nuclear power and cross-border electricity imports.[6]

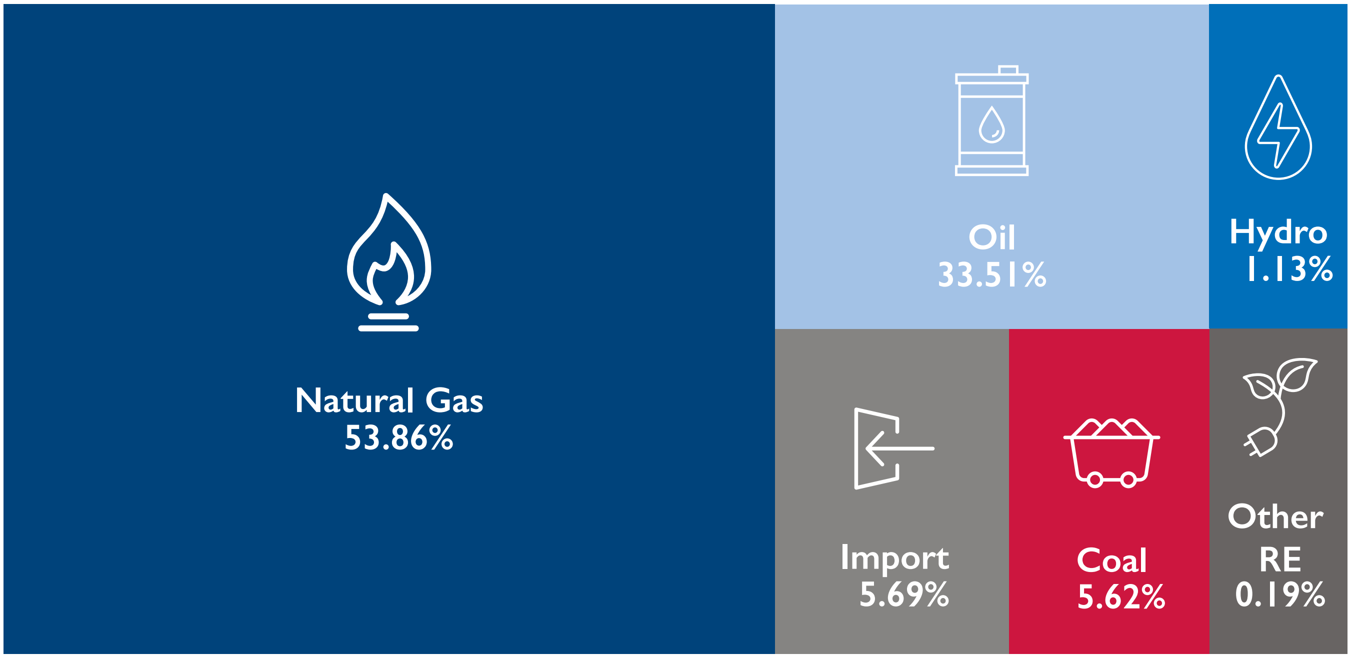
Bangladesh's current generation capacity is predominantly made up of fossil fuel-based power plants. The 25-year transition envisaged in the PSMP sees the replacement of natural gas generation capacity with new coal-fired plants because of dwindling local gas reserves, fundamentally shifting the system to a more diversified fossil fuel mix. In 2020, natural gas contributed about 72 percent of total electricity supply in Bangladesh.[7] Although the country has made large strides in minimizing the supply-demand gap over the last decade, rising electricity demand and a shortage of natural gas dedicated to electricity generation mean that rolling blackouts have persisted. This is compounded by the fact that Bangladesh has 20,383 MW of installed capacity but only 12,893 MW available to meet peak demand. To reduce the impact of blackouts, the country signed short-term agreements for fossil-based rental power and signed on independent power producers (IPPs). Installed capacity of oil-based rental power increased from about 9 percent in 2010 to more than 33 percent of total capacity by 2020.[8] The GOB has also increased the use of furnace oil peaking power plants to meet peak demand. However, although power generation from oil-based capacity is a quick solution for rapidly increasing supply, it is expensive and raises concerns about the long-term sustainability of the power sector.

Energy security depends on using indigenous energy resources and reducing import dependence to meet future energy demand. If Bangladesh is to meet the future generation projections in the PSMP, coal is expected to replace a significant portion of the current gas and oil-based generation, increasing from its current 5.6 percent capacity share to 35 percent by 2041.[9] This high-coal trajectory will see coal imports increase to 60 million tons annually by 2041, in addition to the 10 million tons Bangladesh will mine locally to supply the coal fleet. Cross-border power imports currently make up 5.7 percent of supplied power and are projected to grow to a maximum capacity share of 15 percent by 2041, although that includes RE, leaving some flexibility for the final mix.[10]

---

4 Ministry of Finance, *Bangladesh Economic Review*.
5 BPDB, *Annual Report 2010 and Annual Report 2020*.
6 MPEMR, *PSMP 2016*.
7 BPDB, *Annual Report 2019-2020*.
8 BPDB, *Annual Report 2009-2010* and "Key Statistics," BPDB website.
9 BPDB and MPEMR, *PSMP 2016* Scenario 3.
10 MPEMR, *PSMP 2016*.

FIGURE 1-1: Energy Mix of Installed Power Generation Capacity[12]



Nevertheless, the GOB has started rethinking coal-fired power plants and may cancel proposed and delayed projects due to their high environmental impact, the reluctance of donors and financial institutions to fund coal-fired plants and the increasing cost of coal in the international market.[11] The government might convert planned coal-fired projects into LNG-based plants or might not replace them at all, given the generation overcapacity in the system.

As of 2020, RE resources make up only 1.32 percent of total generation capacity, which includes one large hydropower plant (1.13 percent) and other RE capacity combining to provide a further 0.19 percent (see Figure 1-1).

To increase the amount of utility-scale RE in Bangladesh, the GOB has instituted several policies that set targets to drive up installed capacity from clean energy:

- 10 percent share of RE-based power generation capacity by 2021 (PSMP 2016)
- 10 percent of electricity demand met by 2020 (Renewable Energy Policy 2008)
- Bangladesh's NDC to reduce GHG emissions by 5 percent (voluntary) and by 15 percent (with international support) by 2030[13]

There is no real link between the PSMP targets for RE and Bangladesh's other policy commitments, and it remains to be seen what RE strategy and target the GOB will ultimately pursue. The Renewable Energy Policy 2008's target of 10 percent of electricity coming from RE by 2020 has not been met; RE composed only 1.32 percent of supply in 2020. Bangladesh's position is in stark contrast to the energy transitions happening in many other countries: global investment in RE has increased considerably in recent years, with countries aiming to increase the share of electricity generation from clean energy and reduce their carbon emissions. However, RE development in Bangladesh has been relatively slow, partly due to a lack of planning or support for developers, who face unique challenges. There is also a risk that future bilateral agreements and trade will be influenced by other countries' GHG reduction commitments, with capital inflows and investment becoming contingent on Bangladesh meeting emissions targets. With 15,294 MW of fossil fuel power plants under construction, any additional

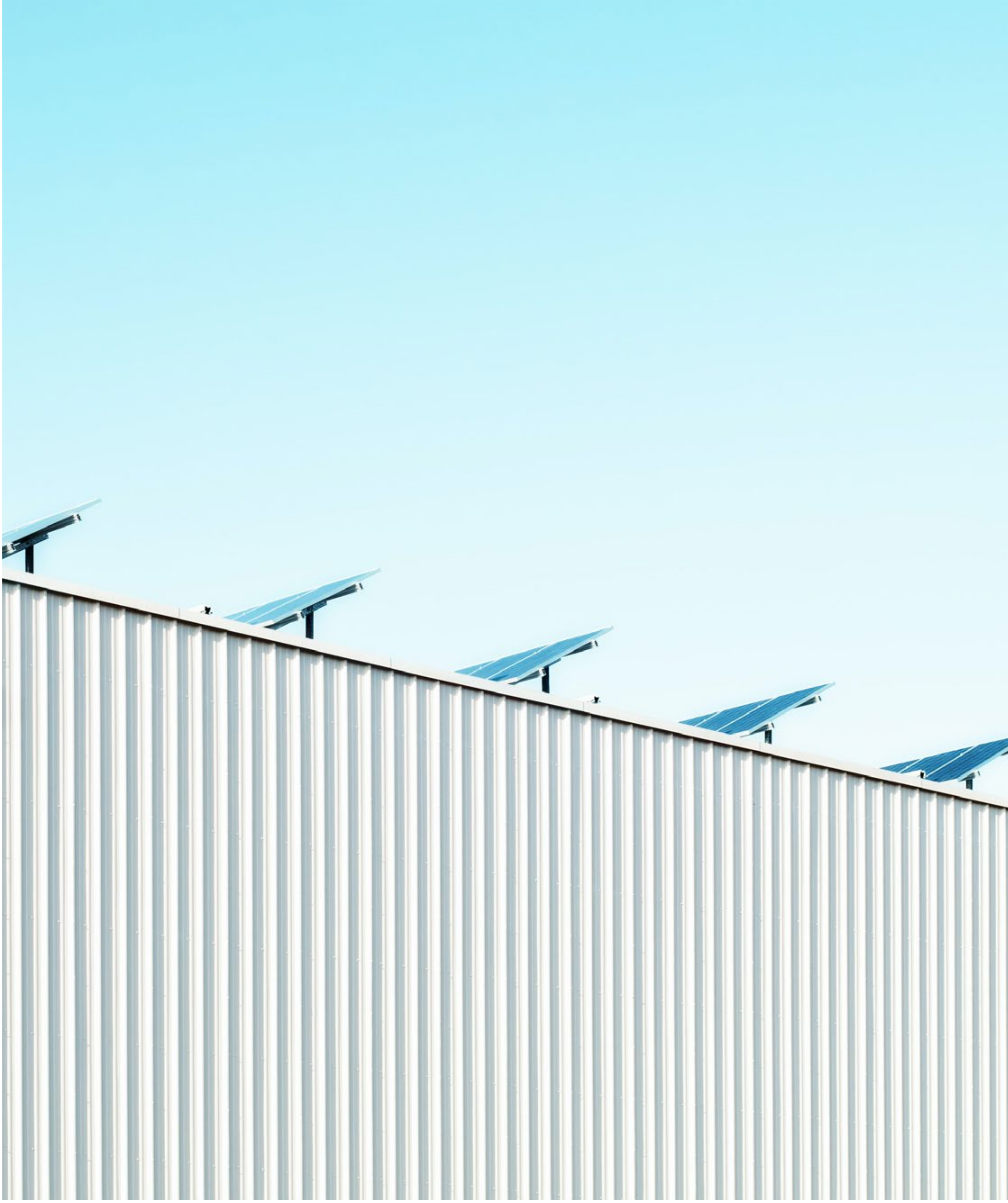
11 Jahangir, "Govt to drop nine coal-fired plants."
12 BPDB, *Annual Report 2020.*
13 MOEF, *Intended Nationally Determined Contributions.*

fossil fuel capacity will lock Bangladesh into a carbon-intensive future, leaving it unable to meet its clean energy targets and international commitments.

This white paper presents an overview of projected power demand, generation plans and policies to achieve future generation growth and lays out the GOB's likely development paths to meet future demand. Based on the country's RE potential, the paper explores alternative studies that assess future generation scenarios with higher levels of RE penetration and proposes an alternative capacity development roadmap to achieve more RE generation. This alternative roadmap is critical for several reasons:

- If Bangladesh pursues one of the PSMP scenarios, it will lock the country into a carbon-intensive future for the long term.
- The PSMP scenarios might not be least-cost; the investment cost of RE technologies—specifically solar PV and wind—has decreased significantly since the original scenarios were produced.
- The PSMP generation scenarios will not allow Bangladesh to meet its international GHG reduction commitments.
- Other policies, such as the Renewable Energy Policy 2008, have fallen well short of their proposed targets and have now expired.
- The PSMP scenarios will not minimize the risk to Bangladesh's security of supply, merely transfer it from gas to coal and imported power.
- There are financial risks and questions about the long-term sustainability of the power sector with a large coal-fired generation fleet.

The white paper proposes an alternative development path with increased RE from solar PV and wind power and recommends strategies to implement alternative energy capacity plans up to 2041. These will help improve energy security and minimize import dependence to meet future electricity demand. The proposed plan recommends steps for the GOB to take in the short, medium and long term to accelerate the uptake of utility-scale RE. This new trajectory offers increased benefits for Bangladesh, not least the ability to meet its RE goals and international commitments to reduce GHG emissions.



CHAPTER 2.

FUTURE ENERGY DEMAND IN BANGLADESH

2.1 Primary energy

Bangladesh's primary energy sources for electricity generation are natural gas, liquid fuels, coal, and RE such as solar, wind and hydropower. The demand for primary energy is increasing along with the increasing demand for electricity; to meet this demand, additional primary energy supply must come either from domestic sources or from fuel imports such as gas or coal.

In 2020, natural gas made up about 71 percent of total energy use, with 43.28 percent of it going to power generation and the rest to other sectors. Natural gas consumption in Bangladesh has increased dramatically, from 0.282 trillion cubic feet (TCF) per year in 1997/1998 to 0.961 TCF and an additional 0.116 TCF from imports in 2018/2019.[14] The overall share of gas in the power sector has declined as the generation mix has diversified, although it is still the dominant generation technology by a large margin. In 2010, roughly 88 percent of total generation capacity came from gas; by 2019, the share had fallen to 68 percent, although it increased slightly to 72 percent in 2020.

In June 2018, the Bangladesh market began using imported LNG to supplement declining local production for the first time. Currently, imported gas only makes up a small amount of total gas consumption (0.116 TCF, compared to 0.961 TCF of local production in 2019) but it increased from June to December 2019: local gas production totaled 0.462 TCF, with an additional 0.102 TCF, or 15 percent of total gas used, being imported. Bangladesh's gas fields have been generous; as of December 2018, they had produced as much as 17.37 TCF, leaving 10.63 TCF of recoverable gas left in natural reserves. Daily gas production is about 3,200 million cubic feet per day (mmcfd), with local gas reserves only expected to last a few more years.

Even though total demand for gas in Bangladesh will increase by 2041, gas demand for power generation is expected to decrease as the energy mix changes. Various projects are underway to meet rising demand, including augmenting local gas production, improving transmission and distribution capacities and importing more LNG. Two floating storage re-gasification units with capacity of 500 mmcfd each were installed at Moheshkhali and began supplying gas to the national gas grid in 2018 and 2019 respectively. A 1,000 mmcfd land-based LNG import station is expected to be commissioned by 2023/2024. Plans to install more land-based LNG terminals are in the pipeline, considering the expected increase in demand for gas imports as local reserves decline.

Coal, less used than gas, comes from one active coal mine in the Barapukuria district that supplies a nearby 524 MW power plant. The mine produced just under 0.8 million metric tons of coal in 2019. Five other coal deposits in the northwestern part of the country have a total estimated reserve of almost 8 billion metric tons.[15] Coal imports are

14 Petrobangla, *Annual Report 2020*.
15 Petrobangla, *Annual Report 2019*.

likely to meet the bulk of future demand, as the cost of local production exceeds import costs. Under PSMP Scenario 3, which projects 35 percent of future generation to be supplied by coal-fired plants, the demand for coal would be approximately 70 million tons per year by 2041. By that time, the GOB plans to increase local production from 1 million to 10 million metric tons per year and to import about 60 million metric tons per year.

2.2 Power sector achievements and future development

Reducing the gap between power supply and demand and increasing access to electricity has been a challenge for Bangladesh, but one that the country has largely been successful in addressing. Between 2010 and 2020, Bangladesh increased its installed capacity almost four-fold, from 5,823 MW to 20,383 MW. During this period, the electrification rate increased from 55 to 97 percent and the electricity supply shortage fell from 1,829 GWh to only 58 GWh.[16] Figure 2-1 and Figure 2-2 compare installed capacity and electricity generation by fuel type between 2010 and 2020.

According to the PSMP, installed capacity must increase to 40,000 MW by 2030 and to 60,000 MW by 2041.[17] Table 2-1 shows the expected capacity development requirements and other key metrics that are expected to change during the next two decades. Power generated in plants all over the country is transmitted to the national grid through 400 kV, 230 kV and 132 kV transmission lines. Between 2009 and 2020, the Power Grid Company of Bangladesh (PGCB) developed transmission lines and substation capacity as part of a comprehensive plan to meet demand up to 2028 (Figure 2-3). A full overview of the transmission and distribution systems is presented in Appendix A.

To meet the installed capacity target of 40,000 MW, the Bangladesh Power Development Board (BPDB) has prepared a generation plan that includes installing 37,500 MW of new capacity by 2030 (Figure 2-4) after taking into account the decommissioning of older plants. The BPDB has already made progress on this plan, with 17,950 MW of new capacity under construction. Award notifications and letters of intent have been issued for a further 3,100 MW, another 3,200 MW are under procurement, and 13,000 MW more are in the planning process.

The procurement plan is largely in line with the PSMP, although surprisingly, it does not include RE; solar PV and wind energy plants fall under a parallel procurement process. There is 566.8 MW of new RE capacity under construction, with an additional 1,327 MW in the planning phase. A comprehensive list of these projects is provided in Appendix B.

If the current trajectory of generation capacity development continues, Bangladesh risks locking itself into a carbon-intensive future. Given the country's RE resource potential and the significant drop in RE capital costs over the last ten years, the GOB should consider alternatives focused on developing utility-scale RE plants. Bangladesh has an opportunity to review its current plans and shift course to clean power generation, as many of its Asian peers have done.

2.3 Renewable energy potential and current development

Bangladesh has very good solar and wind energy resources due to its geographic location. Several international research institutions have studied its potential for solar and wind power generation; their conclusions vary greatly but provide insight into what can be achieved.

A study by the National Renewable Energy Laboratory (NREL) estimates Bangladesh's solar power generation potential to be 380 TWh per year (240 GW) using 1.5 percent of total available land.[18] It calculates solar energy potential as a function of land area per solar class (kWh/m²/day): for Bangladesh, between 4.5 and 5.5 kWh/m²/day. A NREL wind assessment in 2018 demonstrated that an area of more than 20,000 km² exhibits wind speeds between 5.75 and 7.75 meters per second, with gross wind potential of over 30 GW. However, this estimate may be reduced given that agricultural land is not currently available for wind power projects.

16 BPDB, *Annual Report 2020*.
17 Assuming demand of 33,000 MW and 52,000 MW in 2030 and 2041, respectively.
18 NREL, "Solar Resources by Class and Country."

FIGURE 2-1: Installed Capacity by Fuel Type, 2010 and 2020[19]

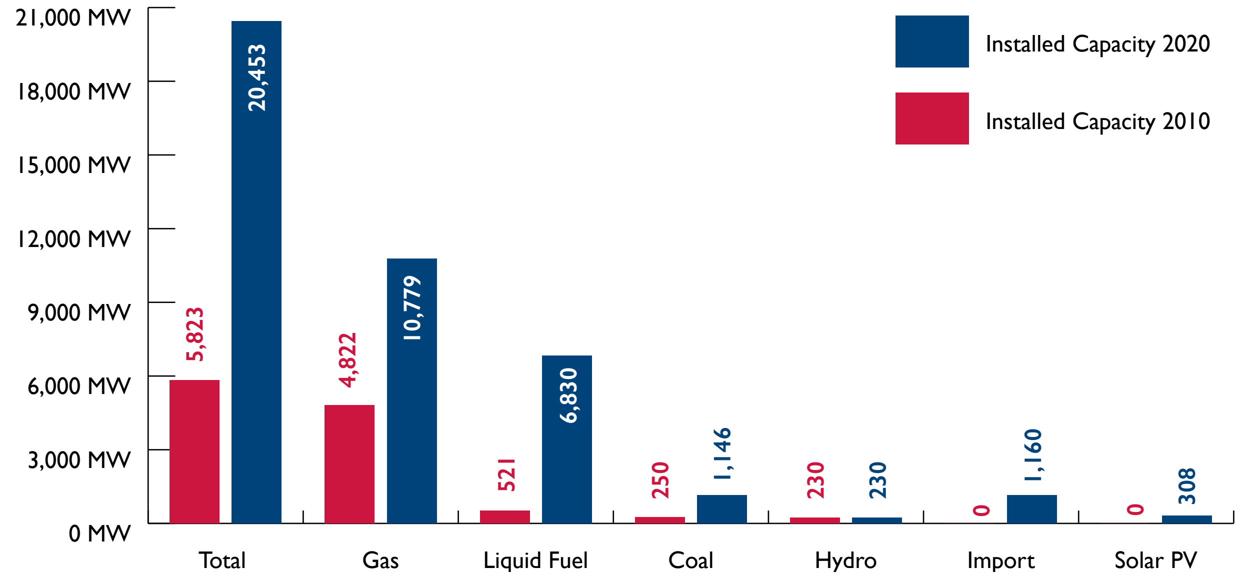


FIGURE 2-2: Electricity Generation by Fuel Type, 2010 and 2020

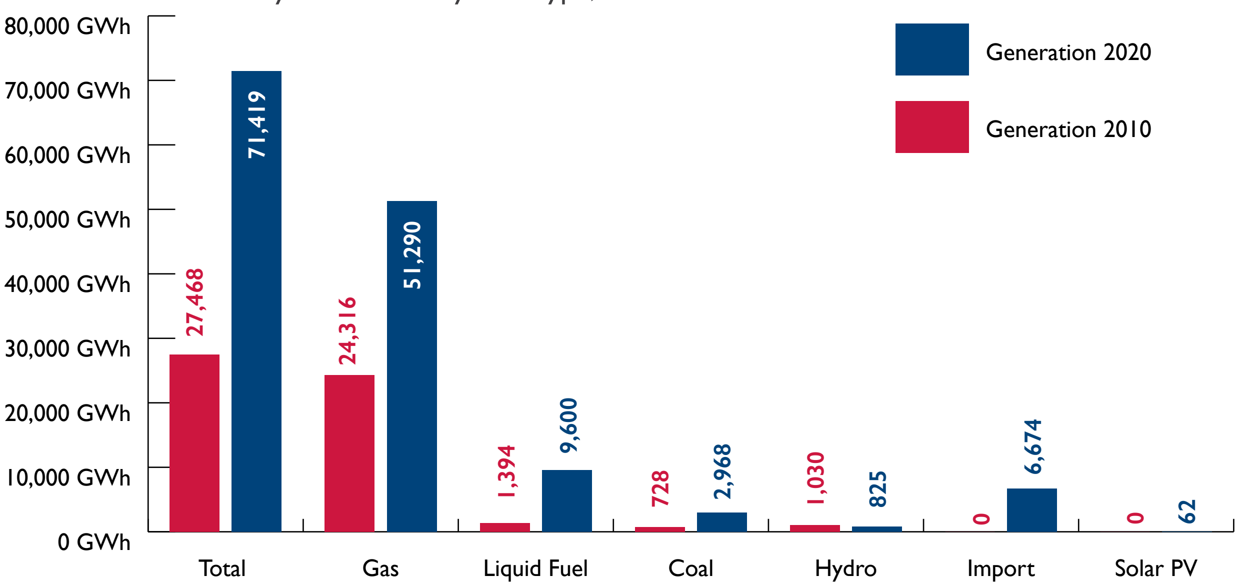


TABLE 2-1: Power Sector Development Plan by 2041[20]

Items	2009	2020	2021	2030	2041
Installed capacity (MW)	5,823	20,383	24,000	40,000	60,000
Maximum demand (MW)	6,454	12,100	19,000	33,000	52,000
Transmission lines (km)	8,251	12,283	18,126	27,300	34,850
Substation capacity (MVA)	13,474	45,478	90,382	120,000	261,000
Distribution lines (km)	260,000	532,000	497,000	660,200	783,200
Electricity access (%)	47	97	100	100	100
Per capita generation (kWh)	183	426	700	810	1,475

19 BPDB, *Annual Report 2010* and *Annual Report 2020*.
20 BPDB, *Annual Report 2020*; PGCB, *Annual Report 2019*; and MPEMR, *PSMP 2016*.

FIGURE 2-3: Existing, Under Construction and Planned Grid Network up to 2028

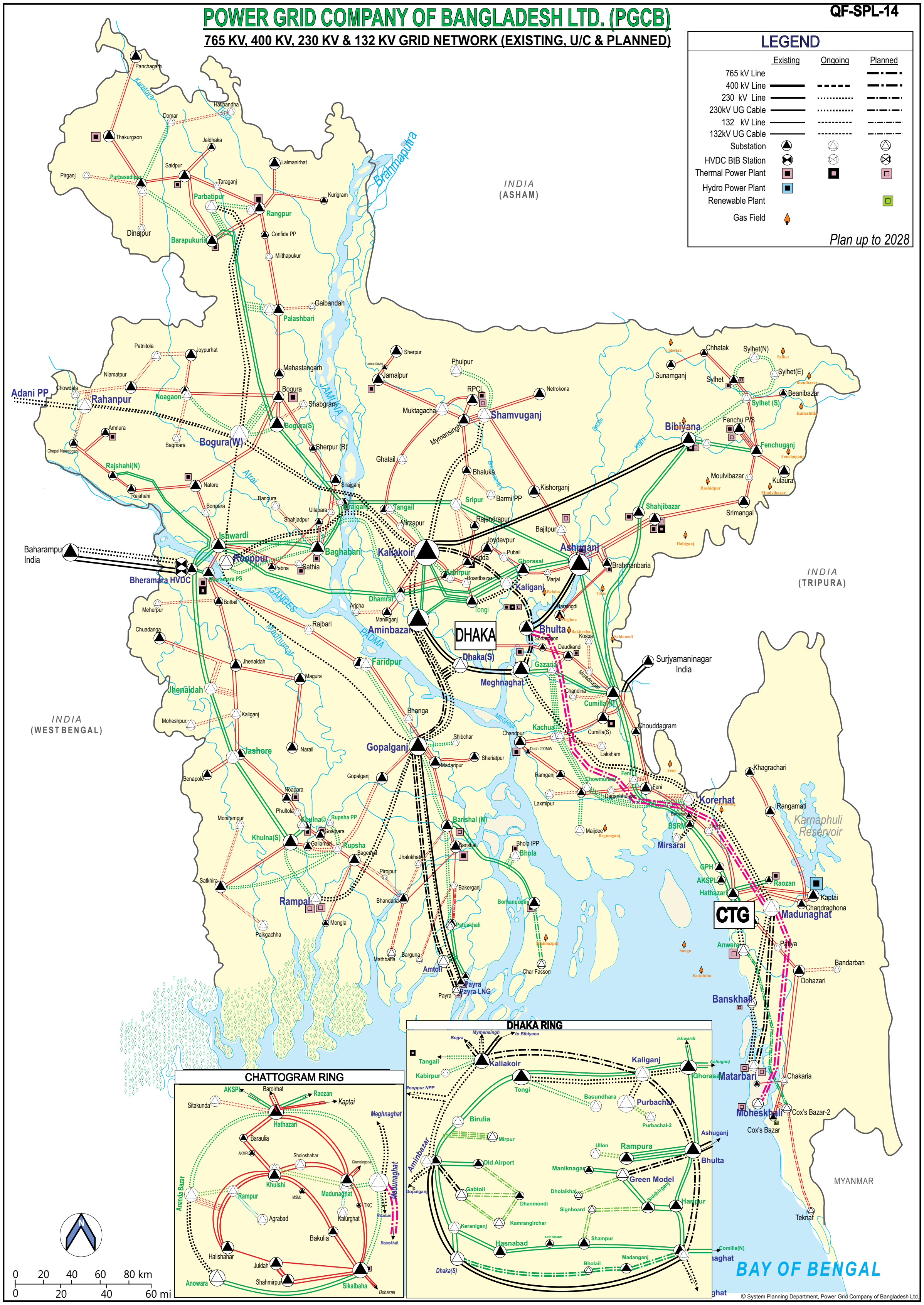


FIGURE 2-4: BPDB New Generation Plan up to 2030

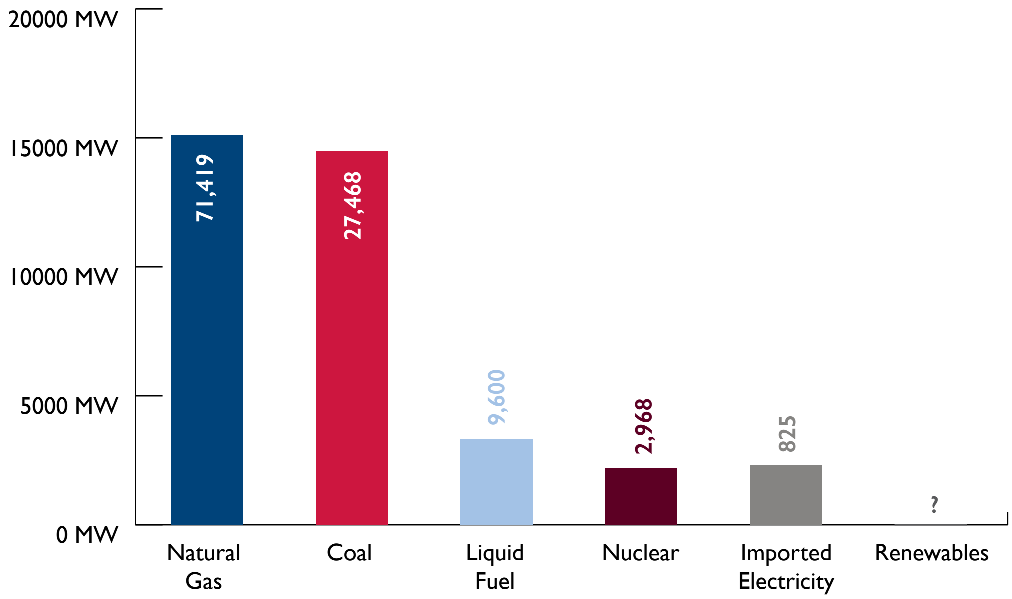


TABLE 2-2: Renewable Energy Installed Capacity, December 2020[21]

Technology	On-grid (MW)	Off-grid (MW)
Solar	138.91	328
Wind	0.9	2
Hydro	230	0
Biogas to power	0	0.63
Biomass to power	0	0.4
Total	369.81	331.03

The Strengthening People's Action on Climate Risk Reduction and Energy Efficiency (SPACE) project study *100% Renewable Energy for Bangladesh* estimated in 2019 that Bangladesh could install up to 16 GW of onshore wind capacity, 134 GW of offshore wind capacity, 35 GW of rooftop solar PV capacity, and 156 GW of utility-scale solar PV capacity, of which 31 GW would be floating solar PV capacity. The study considers only perennial cropland and open bushland when analyzing the potential of solar PV for power generation.

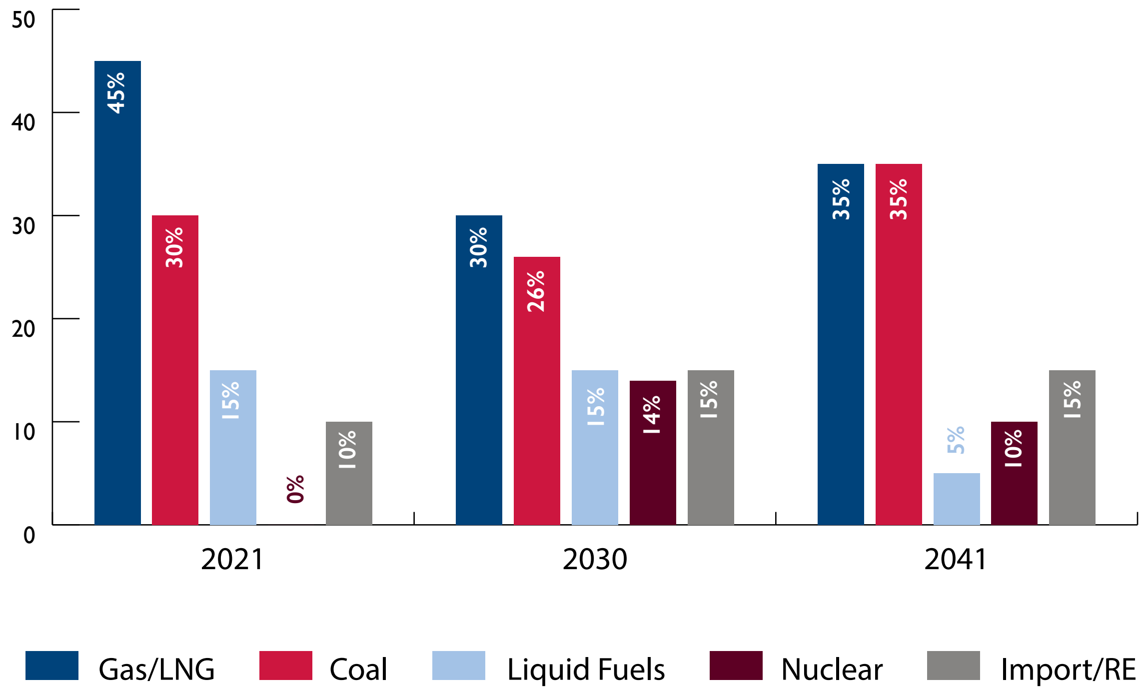
PSMP targets are significantly lower than the estimated potential of solar PV and wind power in Bangladesh: there is room to multiply the RE installation capacity targets (specifically solar PV and wind) severalfold.

RE growth in Bangladesh is primarily in off-grid solar PV systems (328 MW), with grid-connected RE accounting for 139.81 MW (excluding hydro capacity). Table 2-2 shows the current RE generation mix. A large proportion of capacity comes from one 230 MW hydropower plant and 139 MW of grid-connected solar PV.

Currently, there are only four solar and two wind power projects that are connected to the grid. An additional ten solar projects and two wind projects have been approved

21 SREDA, National Database of Renewable Energy.

FIGURE 2-5: Bangladesh Energy Transformation Plan for Power Generation[22]



and are under development; these will add 616.8 MW of solar and 2 MW of wind capacity. A full list of completed RE projects, projects under construction and planned projects can be found in Appendix B.

2.4 Bangladesh and the global energy transition

The global transition to cleaner power generation technologies has seen the international market procuring ever greater amounts of solar PV and wind power generation, which have proved to be the cheapest options in many countries. Select Asian countries' plans for energy transformation and scaling up RE are presented in Appendix C.

Within the next decade, most renewable power sources are expected to be fully competitive with fossil fuel-based generation.[23] Because of this price advantage, new renewable-based power generation is growing faster than other conventional technologies, with the growth rate of fossil fuel-based electricity generation declining since 2019.

The case of Bangladesh has been different; the power sector development plan only aims to transform from a single dominant fossil fuel technology to two fossil fuel technologies with the addition of coal. Although the significant increase in generation capacity over the past decade has led to soaring electrification and a smaller power supply-demand gap, it was achieved with the use of natural gas, coal and liquid fuel generation. The GOB has prepared a time-scaled plan with short-, medium- and long-term capacity expansion objectives. Figure 2-5 shows Bangladesh's expected primary energy transformation for power generation, with the generation fleet transitioning by 2041.

The increasing need for imported LNG and coal is expected to lead to a higher unit cost of electricity generation. On the other hand, both capital investment and generation costs for RE fell by more than 50 percent from 2010 to 2015 and are already the cheapest new generation options in many markets.[24]

In Bangladesh, electricity generation costs from fossil fuels (specifically liquid fuels) are very high. Average unit generation costs vary between 12.83 Bangladesh taka (BDT)/

22 Based on *PSMP 2016* Scenario 3.
23 IRENA, *Global Renewable Outlook: Energy Transformation 2050.*
24 IRENA, *The Power to Change: Solar and Wind Cost Reduction Potential to 2050.*

TABLE 2-3: Average Unit Cost of Utility-Scale Power Generation in Bangladesh[25]

Generation Category	Unit cost (BDT/kWh)
Gas (public, average)	3.27
Coal (public)	8.25
HFO (IPP)	12.83
HFO (rental)	14.84
HFO (public)	14.85
HSD (IPP)	42.83
HSD (rental)	22.16
HSD (public)	20.71
Imported electricity	5.87
Solar PV (BPDB, 2020 – 7.4 MW public project)	11.24
Wind (50 MW IPP in Bangladesh)	11.03

TABLE 2-4: Lowest Total Installed Costs of Solar PV[26]

Country	Cost (USD/kW)
India	618
China	794
Italy	830
Germany	899
Turkey	921
France	979
Saudi Arabia	996
United Kingdom	1,018
Indonesia	1,158
United States	1,221

kWh and 14.84 BDT/kWh for heavy fuel oil (HFO) and between 22.16 BDT/kWh and 42.83 BDT/kWh for high-speed diesel (HSD) (see Table 2-3). The unit cost data provides a basis for assessing RE's competitiveness in Bangladesh. Tariffs for new renewable capacity have not reached some of the low values seen on the international market, which is linked to the risks and difficulties of developing RE capacity in Bangladesh and the fact that the market has not yet matured. Current issues such as the nascent market, land acquisition difficulties, and the risks and costs of transmission systems for RE projects have kept the tariffs for such projects higher than international averages.

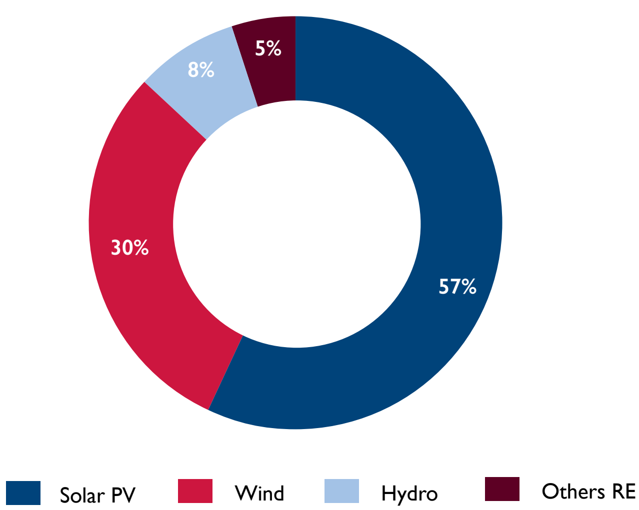
Bangladesh's RE market has not reached a stage of maturity where it can expect very cheap prices; there are no completed utility-scale wind projects to date, although the GOB approved a 55 MW wind power project in December 2020.[27] Tariffs based on completed utility-scale solar PV projects are much higher than the global weighted average tariff, primarily due to higher land acquisition costs and the construction of long transmission lines to plants far from load

25 BPDB, *Annual Report 2019*.
26 Ibid.
27 "Cabinet approves 55 MW wind power project."

TABLE 2-5: Top Ten Countries—Solar and Wind Capacity Addition and Cumulative Capacity, 2019

Solar PV			Wind		
Country	**2019 Capacity Additions (MW)**	**Total (MW)**	**Country**	**2019 Capacity Additions (MW)**	**Total (MW)**
China	30,100	204,000	China	26,800	236,300
United States	13,100	76,000	United States	9,100	105,600
Japan	7,000	63,000	Germany	2,100	61,400
Germany	3,800	49,000	India	2,400	37,500
India	9,900	42,800	Spain	2,300	25,800
Italy	700	20,800	United Kingdom	2,400	23,500
Australia	3,700	14,700	France	1,300	16,600
United Kingdom	300	13,400	Brazil	700	15,500
Republic of Korea	3,100	11,200	Canada	600	13,400
Spain	4,800	9,900	Italy	500	10,500

FIGURE 2-6: Global RE Capacity Addition Share by Type, 2019



centers. Because these costs are included in overall project costs, the resulting tariffs are not comparable to international benchmarks, which typically do not account for the cost of long transmission lines.

The global average installation cost of utility-scale solar PV sharply decreased from $4,621/kW in 2010 to $995/kW in 2019—a staggering 78 percent decline.[28] However, installation costs vary significantly from country to country. India has the lowest installed cost of solar PV at $618/kW.

In Bangladesh, a 7.4 MW utility-scale solar PV farm completed in 2019 cost $8.5 million, representing an investment cost of about $1,150/kW. BPDB provided its own land for the project, keeping the total cost low by removing the land acquisition cost.

Globally, installed RE capacity increased from 1,223 GW in 2010 to 2,588 GW in 2019. In the last five years, capacity expansion grew by about 8 percent annually. More than 200 GW of RE capacity was installed in 2019, 115 GW of which came from solar PV.[29]

Figure 2-6 shows 2019 global RE capacity addition by type of renewable source. About 57 percent of capacity came from solar PV, followed by wind at about 60 GW (30 percent of the total) and hydropower at about 16 GW (8 percent). The remaining 5 percent comprised bio-based, geothermal and concentrated solar power.

China remains the global leader with 789 GW of RE capacity in 2019, followed by the United States with 282 GW, Brazil with 144 GW, India with 137 GW and Germany with 124 GW. At least 17 countries had installed over 10 GW of renewable capacity (excluding hydro) in 2019, up from only five in 2009.

28 IRENA, "Solar costs."

29 REN21, *Renewables 2020: Global Status Report 2020.*

TABLE 2-6: Worldwide Storage Capacity by Technology, 2018[30]

Storage Technology	Capacity (MW)
Sodium sulfur	189
Lithium-ion	1,629
Lead acid	75
Sodium metal halide	19
Flow battery	72
Pumped storage hydropower	169,557
Compressed air energy storage	407
Fly wheels	931
Electrochemical capacitor	49
Total	172,928 MW

Table 2-5 shows the top ten countries by solar and wind capacity addition in 2019 and their cumulative capacity.

The trend toward developing RE capacity is significant in Asia, which represents about 44 percent of total global renewable capacity (as of 2019, 1,119 GW).[31] Key technology options in Asia are solar PV, onshore wind and hydropower; the growth rate of solar PV and onshore wind is rising sharply.

Investment costs are directly reflected in the levelized cost of energy for utility-scale solar PV systems. The global average levelized cost of energy for utility-scale solar PV stood at $0.068/kWh in 2019, down from $0.37/kWh in 2010.[32] That value is expected to drop to $0.04/kWh by 2030.[33] However, tenders and auctions saw solar PV electricity prices reach a new low in 2019. In some procurements, bid prices were below the bulk electricity sale price in those countries. The average bid price of solar PV electricity reached $30/MWh, although bid prices of less than $20/MWh were not uncommon that year.[34] Dubai auctioned 900 MW of solar PV capacity for $0.0169/kWh, while Portugal awarded 1,290 MW of solar PV at an auction price of $0.0162/kWh, the lowest price to date.

The global weighted average cost of electricity generation from onshore wind power projects fell from $0.086 in 2010 to $0.053/kWh in 2019, a drop of 39 percent.[35] Wind turbine prices have declined by about 60 percent since 2010.

As both wind and solar are intermittent, other associated system costs must be considered, especially at higher levels of RE penetration. Balancing electricity supply and demand becomes more complex with higher levels of intermittent power. Mechanisms such as energy storage technologies combined with flexible generation options and system and load management can help ensure system stability. Energy storage is fast becoming a global favorite for smoothing out fluctuations in demand and supply, as well as providing other auxiliary functions to the grid. It will probably be an important feature in most future power systems. According to the U.S. Department of Energy, nearly 173 GW of energy storage has already been installed globally; Table 2-6 shows global energy storage capacity as of 2018. Currently, indirect mechanical energy storage technology (pumped storage hydropower) is the most popular, with installed capacity of around 170 GW (98 percent of total capacity). This is largely because until recently, it was the only economically feasible option. Lithium-ion storage has started to achieve economic price parity in many countries and has the largest deployed capacity of all the electrochemical technologies at just over 1.6 GW.

30 U.S. Department of Energy, *Energy Storage Technology and Cost Characterization Report.*
31 IRENA, *Renewable Capacity Statistics 2020.*
32 IRENA, "Renewable Power Generation Costs in 2019: Latest Trends and Drivers."
33 IRENA, *Global Renewable Outlook: Energy Transformation 2050.*
34 REN21, *Renewables 2020: Global Status Report.*
35 Ibid.

It is now clear that it is technically possible and potentially cheaper for Bangladesh to implement a higher share of RE in its energy mix.

Electromechanical storage is expected to overtake mechanical technology options significantly, mostly based on technological advances and the resulting price decreases, quicker installation times and quicker electrical response characteristics.

2.5 Insights on energy transformation trends

Owing to Bangladesh's significant economic growth, primary energy requirements are expected to rise correspondingly in the coming decades. So far, the country has mostly met its primary energy requirements from natural gas and liquid fuels; due to diminishing local gas reserves, Bangladesh intends to diversify, mostly by importing coal and LNG. About 40 percent of all natural gas is used for power generation. Bangladesh expects to increase the installed capacity of coal-fired plants to 35 percent of the generation mix by 2041. Other indigenous primary energy resources such as solar and wind have thus far been mostly ignored: only 0.9 MW of grid-connected wind power and 138.91 MW of solar PV operate in the power system.

With the country expecting to need 40,000 MW of installed capacity by 2030 and a large portion of the existing generation fleet nearing retirement, the BPDB plans to build 37,500 MW of new generation capacity. Of this, 17,950 MW is already under construction. The plan does not call for any RE capacity construction, instead aiming to procure it through a parallel process. The GOB should consider opportunities to replace some of the allocation to natural gas and coal with indigenous primary energy resources such as wind and solar. Numerous studies have explored their likely potential in Bangladesh, with some estimating solar power potential as high as 240 GW and wind power (including offshore wind) as high as 150 GW. From this, we can infer that Bangladesh has enough RE potential to replace some of the planned coal-fired and gas-fired generation with solar PV and wind power plants.

Energy transitions in other countries have mostly centered around the deployment of ever-increasing amounts of solar PV and wind power, these technologies now being the cheapest options in many markets. In Bangladesh, the energy transition seeks mostly to replace natural gas with coal. Based on unit generation costs in Bangladesh, both solar PV and wind are well positioned to compete with other technologies, even though local prices for both wind and solar are higher than international benchmark prices. Higher unit generation costs come from higher development costs and project risks, land acquisition costs and the inclusion of transmission system costs in overall project costs.

Unit generation costs do not present the full price of increasing RE use. As both wind and solar are intermittent, associated system costs will have to be considered, especially at higher levels of RE penetration. Recent advances in battery technology have increased the use of electromechanical storage, which will provide the perfect technology option to complement higher levels of RE while also providing other useful system stability functions.

It is now clear that it is technically possible and potentially cheaper for Bangladesh to implement a higher share of RE in its energy mix.

CHAPTER 3.

RENEWABLE ENERGY DEVELOPMENT PLANS

So far, decision makers in Bangladesh have used the PSMP as the main implementation tool to guide the procurement of new generation capacity. The GOB last updated it in 2018, publishing Revisiting PSMP 2016 to update demand projections and future generation capacity requirements. These numbers were used to develop the BPDB generation plan. However, the PSMP is not aligned with other policy commitments that seek to increase utility-scale RE, nor is it aligned with the country's NDC targets on reducing GHG emissions.

This chapter explores some of the GOB's other policy commitments and presents several studies that assess alternative generation mixes to meet future demand and fulfill those commitments.

3.1 The PSMP's renewable energy development plan

Bangladesh aspires to become a high-income country by 2041. PSMP 2016 was based on this timeline, aiming to provide decision makers with a comprehensive development roadmap and planning tool to meet anticipated electricity demand. The plan's other objectives are to meet the electricity demand at the least cost, improve energy security and achieve the Sustainable Development Goals linked to energy.

Other key objectives of the PSMP:

1. Enhance infrastructure to facilitate higher levels of imported power and its flexible operation
2. Efficiently develop and use domestic natural resources
3. Construct a robust, high-quality power network
4. Promote green energy and maximize its use
5. Improve skills, capability and mechanisms related to the stable supply of electricity

PSMP 2016 modeled five scenarios for the likely mix of power generation capacity by 2041. Figure 3-1 shows the current power generation mix and the five scenarios, which vary based on differing options for coal and gas-based generation.

The PSMP does provide targets for RE generation, requiring 2,470 MW by 2021 and 3,864 MW by 2041. Confusingly, the same document also sets an RE target of 10 percent of installed capacity. By December 2020, only 369.81 MW (including one 230 MW hydropower plant) of grid-connected renewable-based capacity was installed, while a further 724.8 MW of renewable capacity is currently under construction. An additional 1,377 MW is in the planning phase, but it is not clear when the planned projects will reach financial close and proceed to construction due to issues with land acquisition, permit approvals and power evacuation.

However, although maximizing RE development is listed as a key objective, the targets are underwhelming relative to Bangladesh's RE potential. There is also a disconnect in the targets; in addition to the conflicting figures, which make the GOB's intentions unclear, only 1,394 MW of new RE capacity is required in the 20 years between 2021 and 2041.

FIGURE 3-1: Installed Generation Capacity (2020) and Five PSMP Future Scenarios (2041)[36]

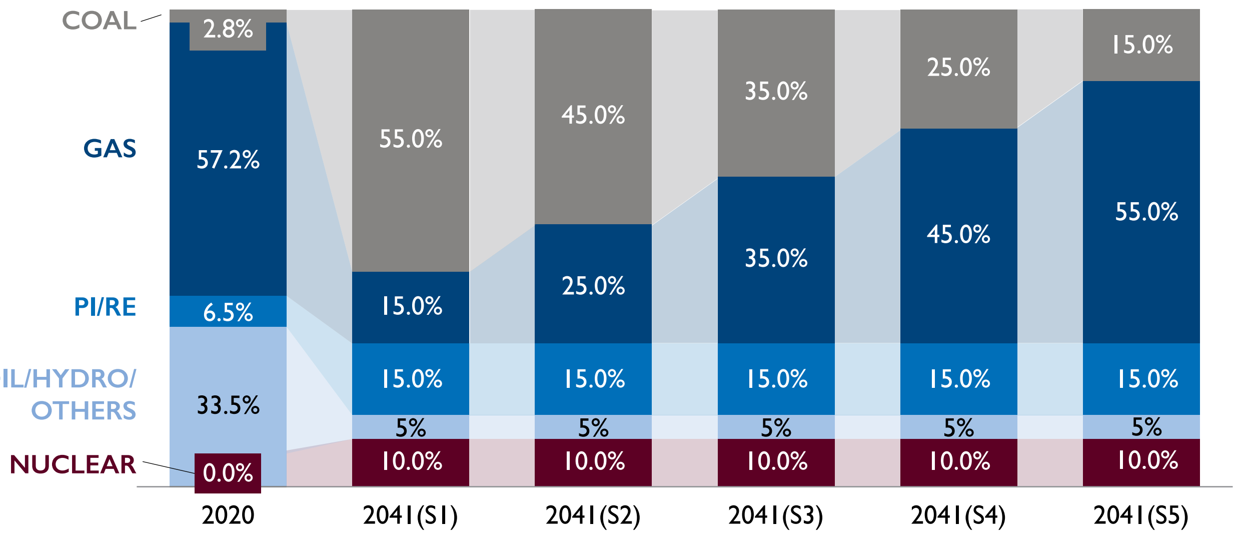


TABLE 3-1: Revisiting PSMP 2016 Generation Development Plan to 2041—Low Case

	2021	2025	2030	2035	2040	2041
Expected total generation capacity (MW)	26,304	39,993	53,077	65,042	77,488	79,507
RE capacity (MW): 10% of total capacity	2,630	3,999	5,307	6,504	7,748	7,950
PSMP development plan to reach target by 2041	4,000 MW from local RE resources and 5,000 MW imported (large hydropower, mainly from Bhutan, Nepal and India)					

3.2 Revisiting PSMP 2016 – the new development plan

According to PSMP 2016, peak demand was forecasted to be 67,710 MW (high case), 61,681 MW (medium case) or 57,946 MW (low case) in 2041. Revisiting PSMP 2016 revised these figures to 82,292 MW, 77,540 MW and 72,379 MW respectively based on data collected from distribution utilities.

Revisiting PSMP 2016 intends to maintain a 10 percent share of total capacity from RE during its planning period. In the high case, about 94,000 MW of total installed capacity will be required to meet peak demand of 82,292 MW in 2041. Revisiting PSMP 2016 expects that 79,500 MW of generation capacity will be required to meet a peak demand of 72,379 MW, consistent with the low case. If PSMP 2016's stated target of 3,864 MW of RE by 2041 is ignored, it can be inferred that a 10 percent share of capacity will mean 7,950 MW by 2041 in the low case. Table 3-1 shows the expected overall capacity additions envisaged in Revisiting PSMP 2016, as well as the share of RE that must come online to meet the target of 10 percent of installed capacity.

According to PSMP 2016, RE potential is very low and it would be challenging to meet this target with domestic RE resources. Therefore, the GOB aimed for 4,000 MW of domestic RE capacity and 5,000 MW from cross-border hydropower by 2041. A yearly utility-scale plan for RE generation using data from generation utilities in Revisiting PSMP 2016 shows about 2,833 MW between 2018 and 2041, with only 950 MW from the private sector. As of December 2020, total grid-connected solar PV capacity is 138.91 MW and wind power capacity is 0.9 MW.

Revisiting PSMP 2016 considers imports from clean energy sources to be part of its RE target; in fact, the target for RE

36 BPDB, Annual Report 2020; SREDA, National Database of Renewable Energy; and MPEMR, *PSMP 2016.*

includes imports in the different PSMP scenarios, leaving the final composition somewhat flexible as to how it will be achieved. The only requirement is that 15 percent of total power generation capacity needed by 2041 come from the two combined sources.

One other area of disconnect in the PSMP is that future generation capacity scenarios do not support the key PSMP objective of improved energy security. The plan envisages a more diversified energy supply mix by reducing gas-based generation, replacing it with coal-based generation and shifting the import dependence to coal, LNG, and imported power from India, Nepal and Bhutan.

3.3 Development plan based on the Renewable Energy Policy

The GOB moved to promote the uptake of utility-scale RE in 2008, when it introduced its first national RE policy. The central objective of the 2008 policy was to scale up the contributions of RE to electricity production. It set targets to meet 5 percent of total electricity demand with RE by 2015 and 10 percent by 2020. The policy introduced mechanisms to facilitate public and private sector investment in utility-scale RE projects.

However, the 2008 policy and others have not been effective in achieving the 10 percent target. Some key interventions such as tax and VAT incentives have been useful, but the majority of interventions and guidelines hold no tangible benefits for RE developers.

Although the policy provided two clear targets, by 2020, only 1.32 percent of Bangladesh's electricity supply came from RE. Although the 2020 target has not been met and the policy does not provide a target beyond that, there are indications that the GOB intends to increase RE-based power to 10 percent of installed capacity beyond 2020 and then maintain that share to 2041, increasing the installed capacity of RE as its total generation capacity increases over the next two decades.[37] It is therefore valuable to understand what such a scenario might look like in terms of RE capacity up to 2041.

Actual electricity demand increased dramatically from 27.46 TWh in 2010 to 71.41 TWh in 2020; based on PSMP 2016 projections, it is expected to double between 2020 and 2025. In 2010, RE contributed 2.65 percent of electricity supplied, mostly because Bangladesh has one large hydropower dam and total installed capacity was much smaller. By 2020, that share had dropped to 1.13 percent, as more conventional power plants came online.

3.4 Renewable energy development plan based on NDCs

At the 21st session of the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties (COP21) in Paris, member nations agreed to take action to limit the increase in global average temperatures to less than 2° C (and ideally 1.5° C) above pre-industrial levels by the end of this century. By the end of 2019, governments pledged their nationally determined contributions (NDCs)[38] to reduce GHG emissions. However, these commitments are not always matched by the capacity to fulfill them.

To meet the targets of the Paris Agreement, many national governments committed to additional GHG emission reduction measures at the United Nations Climate Action Summit in 2019. Seventy countries committed to increase the targets in their action plans by 2020 and 65 countries also committed to achieve net-zero emissions by 2050. Most of the UNFCCC parties have recognized the importance of integrating RE technologies into electricity generation in order to mitigate GHG emissions.

Bangladesh submitted its NDCs to the UNFCCC in September 2015, committing to reduce GHG emissions in the power, industrial and transportation sectors by 5 percent from business-as-usual (BAU) levels by 2030 without any conditions, or by 15 percent conditional on receiving sufficient and appropriate international support. The targets are based on a 20-year period starting in 2011.

Under the BAU scenario, GHG emissions from the power, transportation and industry (energy) sectors is expected to increase from 64 million tons of CO_2 equivalent ($mtCO_2$) in 2011 to 234 $mtCO_2$ by 2030, about a 3.6-fold increase. Emissions and mitigation targets are presented by sector in Table 3-2. Bangladesh's projected NDC was based on analysis carried out in 2015 using data available at the time.

37 This is considered to be a possible GOB target for 2041 and is based on consultations with government stakeholders.
38 MOEF, *Intended Nationally Determined Contributions.*

TABLE 3-2: Bangladesh NDC Projected Emissions and Targets

Sector	Emissions 2011 ($mtCO_2$)	Emissions in BAU scenario 2030 ($mtCO_2$)	Emissions in unconditional mitigation scenario 2030 ($mtCO_2$)	GHG reduction compared to BAU (%)	Emissions in conditional mitigation scenario 2030 ($mtCO_2$)	GHG reduction compared to BAU (%)
Power	21	91	86	-5%	75	-18%
Transport	17	37	33	-9%	28	-24%
Industry (energy)	26	106	102	-4%	95	-10%
Total	64	234	222	-5%	198	-15%

Based on mitigating strategies, Bangladesh aims to use several initiatives to meet its GHG target in the power sector.

Existing initiatives:

- Solar home system program to provide off-grid electricity access
- A target to deliver 5 percent of energy supply from renewable sources by 2015 and 10 percent by 2020
- Rooftop solar PV program

Planned initiatives:

- 100 percent of coal-fired power plants to use supercritical boiler technology by 2030
- 400 MW of wind power by 2030
- 1,000 MW from utility-scale solar power plants by 2030

For the unconditional NDC target of reducing GHG emissions by 5 percent compared to the BAU case, at least 5 percent of total electricity generation must come from RE sources and will require an installed capacity of 7,330 MW from RE (specifically, solar PV and wind power).[39]

However, Bangladesh's NDC also provides targets for new renewable generation capacity, calling for 400 MW from wind and 1,000 MW from solar PV by 2030. This is significantly lower than the 7,330 MW of RE that will be required to meet the 5 percent GHG reduction target.

3.5 Solar PV development under the National Solar Energy Action Plan

The National Solar Energy Action Plan (draft final report completed in October 2020) aims to provide a solar PV power generation plan for Bangladesh from 2021 to 2041.[40] The action plan proposes the country's future solar power generation scenario and identifies potential financing sources and markets, policy requirements, technological supports and barriers in the RE sector.

As in PSMP 2016, the National Solar Energy Action Plan considers three scenarios (BAU, medium case and high case) for solar PV development. According to Revisiting PSMP 2016, 7,950 MW of RE generation capacity will be needed by 2041 to meet the 10 percent target in the base case.

Table 3-3 shows the plan's solar PV development targets by 2041 for the three scenarios, using the PSMP's target of 10 percent of capacity. It considers a variety of solar PV technologies, including solar rooftop, solar home systems and solar irrigation. In the medium and high cases, aggressive solar PV development assumes support from the GOB and international funding. Under these scenarios, a combination of solar PV technologies will meet targets of nearly 31 percent (25,000 MW) and 50 percent (40,000 MW) of installed power capacity respectively.

39 Based on a 16 percent of capacity factor for solar PV and wind power in Bangladesh.
40 SREDA, *National Solar Energy Action Plan, 2021 – 2041 (Draft Final Report)*.

TABLE 3-3: Solar PV Targets for 2041 (BAU, Medium and High Cases)[41]

Solar PV Technologies	BAU	Medium Case (MW)	High Case (MW)
Solar power hub (utility and IPP)	1,500	10,000	16,000
Solar PV power capacity addition by utilities	1,500	2,200	4,000
Solar PV power capacity addition by solar IPPs	2,000	3,000	5,000
Rooftop solar PV systems	2,000	7,500	12,000
Solar irrigation pumps	605	1,870	2,500
Solar mini-/micro-/nano-grids	16	16	16
Solar home systems	280	283	285
Solar-powered telecom towers	30	33	39
Solar streetlights	30	36	44
Solar charging station	31	51	101
Other solar-powered systems	8	11	15
Total	8,000	25,000	40,000

TABLE 3-4: Renewable Energy Capacity Projections for High Wind and Solar PV (MW)

Scenario	Technology	2025	2030	2035	2040	2045
High RE	Solar PV	1,270	5,000	7,500	10,000	10,000
High RE	Wind	1,400	4,600	4,600	4,600	4,600

3.6 Renewable energy development plan from selected studies

This section reviews studies that have been carried out to develop alternative future generation paths to the PSMP. Only the parts of the studies that are relevant to higher levels of RE penetration in Bangladesh are detailed below. The studies focus on two technologies, utility-scale solar PV and wind power.

A 2018 USAID-supported study titled *Bangladesh Power Supply Scenarios on Renewable and Electricity Import* examined four power supply scenarios: the base case of PSMP Scenario 3 and three alternative scenarios.[42]

1. High electricity imports scenario
2. High RE penetration scenario
3. Combination scenario of high electricity imports and high RE penetration

The high imports scenario increases the share of imported electricity share from 16 percent in the PSMP 2016 case to a 30 percent share by 2041. The high RE scenario assumes accelerated deployment of RE technologies for power generation, setting upper bounds of 10,000 MW for solar PV and 4,600 MW for wind. The combined scenario maintains the 30 percent share for imports and the same RE upper bounds as in the high RE case. The base case constraint to maintain a minimum 35 percent share of installed gas capacity was removed for the other three scenarios.

The study used a TIMES energy system optimization model to examine these alternative power supply scenarios. The modeling objectives were to follow a least cost path as well as to optimize use of local energy resources. The model calculates the capacity required to meet the expected demand. Table 3-4 shows the results of the high RE scenario for solar and wind.

In the high RE scenario, the upper capacity boundaries are easily met, highlighting Bangladesh's large RE potential and the cost benefit when no gas capacity minimum must be met. In

41 Ibid.

42 The study was carried out under the USAID South Asia Regional Initiative for Energy Integration (SARI/EI) program.

TABLE 3-5: Projected Renewable Energy Generation Capacity (GW) by Scenario

Technology	Scenario	2020	2030	2040	2050
Wind	Reference	0.003	.005	.007	0.01
	Renewable 2° C	0.01	2.87	12.31	31.20
	Renewable 1.5° C	0.01	3.42	18.14	45.91
Solar PV	Reference	0.11	0.16	0.23	0.34
	Renewable 2° C	0.43	23.08	73.60	96.47
	Renewable 1.5° C	0.43	23.08	104.20	126.69

this scenario, the annual average growth of installed capacity from RE is about 9 percent between 2025 and 2045.

The SPACE study *100% Renewable Energy for Bangladesh: Access to Renewable Energy for All Within One Generation* looked at what would be required to achieve 100 percent RE installed capacity in Bangladesh by 2030, 2040 or 2050. Three scenarios were modeled: a base case, renewable 2° C and renewable 1.5° C. The base case scenario is based on Bangladesh's PSMP 2016 and reflects a continuation of the status quo. The renewable 2° C scenario assumes Bangladesh will meet its energy-related targets to achieve 100 percent RE as soon as possible (focusing on 100 percent RE power generation, while the transportation and industrial sectors remain dependent on fossil fuels). The renewable 1.5° C scenario assumes an ambitious approach to transforming Bangladesh's entire energy system to use 100 percent RE. This scenario focuses on a fully decarbonized power sector by 2030 and a complete RE-based supply system for transportation and industry by 2050. The projected RE outlooks by scenario are presented in Table 3-5.

The study shows that if Bangladesh were to push for 100 percent RE capacity by 2030 for its power generation sector alone (2° C scenario), it would need to acquire 2,870 MW of wind capacity and 23,080 MW of solar PV capacity. If Bangladesh aims to decarbonize all sectors by 2050, it will need 45,910 MW of wind power and 126,000 MW of solar PV. The renewable 1.5° C scenario results show that the growth of total installed capacity from RE can be significant, about 22 percent annually between 2020 and 2050. RE integration analysis showed that it is possible to generate more than 10 percent of total electricity supply from RE, which is the target set in the Renewable Energy Policy 2008.

A study titled *Deployment of Renewable Energy Technologies in Bangladesh: Long-Term Policy Implications in the Power Sector* assessed future energy supply strategies for the power sector up to 2035.[43] The study applied an optimization model called MARKAL, which minimized long-term system costs and used demand projections developed by other studies.

The study developed four generation scenarios, including a BAU reference case and alternative policy options:

1. 10 percent CO_2 emission reduction scenario
2. Renewable energy target production
3. Null coal import scenario

The first scenario assesses the effects of a 10 percent reduction in CO_2 emissions from 2015 onward compared to the BAU reference scenario. The RE target production scenario assumes specific policy interventions that accelerate the development of RE for power generation, applying the GOB targets of 5 percent generation from RE by 2015 and 10 percent by 2020. The null coal import scenario assumes no imported coal will be used for power generation in Bangladesh, aiming to maximize the use of indigenous energy resources and minimize import dependence. The study applied an upper bound for wind and solar PV potential of 4.61 GW and 50.17 GW, respectively. The RE development path for each of the scenarios is presented in Table 3-6.

43 Mondal, "Development of Renewable Energy Technologies in Bangladesh."

TABLE 3-6: Least-Cost Opportunities to Invest in RE Technologies in Bangladesh (GW)

Scenario	Technology	2025	2030	2035
Reference	Wind	1.02	3.8	4.61
	Solar PV	0	0	0
CO_2 emission reduction	Wind	1.02	3.8	4.61
	Solar PV	0.49	1.83	6.8
RE target production	Wind	1.02	3.8	4.61
	Solar PV	5.54	7.65	14.16
Null coal import	Wind	1.02	3.8	4.61
	Solar PV	7.44	27.63	40.84

TABLE 3-7: Bangladesh's Key Renewable Energy Policy Goals and Required Targets (MW)

Policy	Target	2021	2030	2041
PSMP 2016	Stated RE target in plan	2470	-	3,864
Revisiting PSMP 2016	10 percent share by capacity	2630	5307	7,950
Revisiting PSMP 2016	Stated local and imported RE	-	-	9,000
Renewable Energy Policy 2008*	10 percent share of generation demand[44]	-	14,660	31,320
Bangladesh NDC	Stated RE commitments	-	1,400	-
Bangladesh NDC	5% GHG reduction	-	7,330	-
National Solar Energy Action Plan (Utility-Scale Solar)	BAU case	-	1,125	5,000
	Medium case	-	3,625	15,200
	High case	-	6,985	25,000

*The target of 10 percent of supply was originally for 2020, but this study has analyzed the prospect of meeting 10 percent of supply with renewables consistently to 2041.

RE technologies' contribution to power generation is higher in the null coal import scenario than in the others. The annual growth of RE capacity installation reaches 24 percent between 2015 and 2035.

3.7 Overall assessment of renewable energy development paths for Bangladesh

This paper analyzed Bangladesh's five main policy documents relating to RE in order to understand how the different policy objectives could be met. Targets were converted into required capacity to allow a comparison between the different policies driving RE development in Bangladesh. Table 3-7 compares the policies and their targets. Most policies contain multiple targets, each of which was analyzed separately.

The current PSMP will not allow Bangladesh to fulfill its objectives under the Renewable Energy Policy 2008 or the NDC of 5 percent GHG emissions reduction from the BAU case. The Renewable Energy Policy 2008 target, which sees 10 percent of supply coming from RE, is the most ambitious target among the policies and will allow Bangladesh to meet its NDC targets comfortably. In all cases, these targets are well below Bangladesh's full RE potential.

These varying targets make it difficult for decision makers to plan a path forward and create market uncertainty about GOB intentions and investment opportunities, which affects the downstream value chain such as investment in local manufacturing and local industrialization potential. It is clear that the current PSMP does not address Bangladesh's diverse needs and commitments and is based on projections that

44 Based on a 16 percent of capacity factor for solar PV and wind power in Bangladesh.

Most of the studies that explore higher levels of RE penetration find that it can meet the targets in all GOB policies.

were developed when RE was considered less competitive. Bangladesh needs a new path that will allow it to meet its GHG reduction commitments at the lowest cost, maximize the use of local RE resources, attract private financing and ensure a future less dependent on imported gas and coal.

Studies exploring high RE development paths for Bangladesh show that using least cost planning, removing technology constraints such as minimum gas capacity requirements and ending the use of imported coal result in much higher levels of RE penetration.

Most of the studies that explore higher levels of RE penetration find that it can meet the targets in all GOB policies. The Renewable Energy Policy 2008 has the highest target, calling for 10 percent of supply (14,660 MW) to be met with RE by 2030. The scenarios in the SPACE study can meet this target, as can the scenario in the Mondal study that allows no coal imports. However, it is unlikely that Bangladesh would be able to achieve such large renewable capacity by 2030; a more appropriate development path is to pursue 10 percent of supply to be met with RE by 2041.

CHAPTER 4.

PROPOSED RENEWABLE ENERGY DEVELOPMENT PLAN AND IMPLEMENTATION GUIDELINES

4.1 Proposed renewable energy development plan

One of the main objectives of the Renewable Energy Policy 2008 is to scale up RE contributions to electricity production. The policy set a target of 10 percent of total electricity demand served with RE by 2020. The PSMP adopted the same RE percentage but as a share of installed capacity by 2021.[45] According to the PSMP 2016, RE potential is very low and it would be challenging to meet this target from domestic RE resources. Therefore, the GOB plans to meet the 10 percent share of capacity with a combination of 4,000 MW from domestic RE sources and 5,000 MW from cross-border hydropower by 2041. The recently published draft National Solar Energy Action Plan 2021-2041 targets cumulative utility-scale solar PV installation capacity of 5,000 MW, 15,200 MW and 25,000 MW in the 2041 BAU, medium and high cases, respectively.[46]

It is unclear from the policy documents and commitments assessed in Chapter 3 what RE generation development plan the GOB intends to follow. Having multiple targets and commitments makes it difficult to plan a path forward and creates uncertainty for decision makers. It also does not send useful signals to developers and investors, who have to make decisions about the value of investing time and resources in the local market. If the GOB pursues the Revisiting PSMP 2016 targets, this will not address Bangladesh's need to diversify the energy mix, reduce import dependence or open up other least cost opportunities, nor will it allow the country to meet its GHG emission reduction commitments. This path will result in a large amount of thermal power in the energy mix, which will lock Bangladesh into a carbon-intensive future for at least a few decades.

This paper proposes an outlook that seeks to converge the different generation paths into a new generation plan that will enable Bangladesh to meet all its requirements and commitments while following a least cost path. The plan provides an accelerated growth path for solar PV and wind power so they will contribute a significant share of electricity generation in the country by 2041.

The most recent policy document, Revisiting PSMP 2016, projects energy demand of 416.338 TWh, 446.025 TWh and 473.36 TWh in low, base and high economic growth scenarios by 2041.[47] This proposal considers the target of meeting 10 percent of electricity demand with RE in the base case, which

45 MPEMR, *PSMP 2016.*

46 SREDA, *National Solar Energy Action Plan, 2021 – 2041 (Draft Final Report).*

47 MPEMR, *Revisiting PSMP 2016.*

TABLE 4-1: Proposed Renewable Energy Installation Capacity Targets to 2041

	2025	2030	2035	2041
Electricity generation demand (TWh)	144.32	205.57	322.84	446.02
Target of 10 percent generation demand from renewable energy (TWh)	14.43	20.55	32.28	44.6
Target of total installed capacity from RE (GW)[48]	10.29	14.66	23.03	31.32

TABLE 4-2: Investment Required by 2041 in Alternative RE Development Scenarios

	Scenario 1 (solar : wind ratio 70 : 30)	Scenario 2 (solar : wind ratio 75 : 25)	Scenario 3 (solar : wind ratio 80 : 20)
Solar PV installed capacity (GW)	21.92	23.49	25.06
Wind installed capacity (GW)	9.40	7.83	6.26
Solar PV installed cost (billions of USD)	19.73	21.14	22.55
Wind installed cost (billions of USD)	12.21	10.18	8.14
Total installed cost (billions of USD)	31.95	31.32	30.69

is equivalent to 44.6 TWh by 2041. Meeting this target will require an estimated 31.32 GW of installed capacity from solar PV and wind power based on a 16 percent capacity factor. Table 4-1 shows a combination of the proposed solar PV and wind installed capacity targets that could replace the Revisiting PSMP 2016 trajectory for renewable-based generation. The proposed plan shows that the GOB could target 10 percent of total electricity demand to be met by RE beyond 2020 and maintain this share by 2041 comfortably. This plan also meets the Bangladesh NDC target of 5 percent GHG mitigation from the power sector by 2030.

The roadmap considers the technical potential of solar PV and wind in Bangladesh, the country's energy security, GHG reduction commitments, diversification of the energy mix for power generation, global RE capacity development trends, and declining capital cost for RE generation.

According to the International Renewable Energy Agency (IRENA), the 2019 global weighted average installed cost of solar power was $0.995 million/MW and the cost of wind was $1.47 million/MW, both of which continue to decline.[49] The total investment required to fund the proposed RE plan is about $31 billion between 2021 and 2041. This clean energy investment will help meet about 10 percent of Bangladesh's total electricity demand with RE beyond 2020 and by 2041.

Different studies show that wind potential is lower than solar potential in Bangladesh. Therefore, this paper proposes that solar PV compose between 70 and 80 percent of total installed capacity and wind between 20 and 30 percent for investment calculations. Table 4-2 shows three alternative investment plans for the proposed RE development targets.

Private sector investment will be needed to reduce the investment gap from a shortfall of public sector financing capabilities. The private sector has been active in Bangladesh for many years and has been instrumental in the development of its conventional power plants.

New technology advancements such as larger wind turbines and the increasing efficiency gains in solar PV panels mean that over time, the land requirements for RE projects will decrease. Currently, 1 MW of solar PV requires about 3.5 acres of land. With this rate of land usage, implementing this plan will require about 480 km2 of land for solar PV and wind power plants by 2041, representing about 0.32 percent of the total land area in Bangladesh. Unused government-owned land and floating solar systems should be sufficient to meet the land requirement. Agricultural land can now be used for agricultural activities and solar PV generation simultaneously, as demonstrated in other countries around the world. However, laws will need to be updated to allow it. The allocation of zones for RE projects would also represent a more appropriate solution for

48 Based on a 16 percent of capacity factor for solar PV and wind power in Bangladesh.
49 IRENA, *Renewable Power Generation Costs in 2019*.

Bangladesh. In addition, hybrid solar PV and wind development sites can reduce land use and could be appropriate in the southern part of Bangladesh, where wind potential is high.

However, the GOB will need to develop infrastructure in order to create areas where developers can build projects with reduced infrastructure and land risks, thereby reducing expected tariffs from future projects. In addition, a comprehensive study is required to assess grid stability and reliability for VRE integration.[50] However, step-by-step implementation guidelines will be a more appropriate tool to assist the GOB to carry out the proposed RE development plan.

4.2 Implementation guidelines for renewable energy development

4.2.1 Establish a renewable energy development goal

A broader energy development goal is crucial for the promotion of RE. Detailed guidelines need to include determining the broader energy development goals, identifying the likely technology options, and detailing the types of activities that are necessary to bring the new generation capacity to realization, including identifying and engaging with the likely stakeholders involved.

The GOB needs to establish a transparent and publicly available RE development plan that provides clear direction for both public and private energy stakeholders. Bangladesh must take key steps to accelerate RE, including: set up a development plan; conduct a RE resource mapping to confirm technical potential; identify suitable project locations or create RE development zones, transmission and infrastructure facilities for project locations; and standardize RE procurement. Table 4-3 presents these and other key steps that are required to achieve the proposed RE development target.

4.2.2 Develop an implementation plan: short-term, medium-term and long-term

Meeting these RE capacity targets will require a development plan that details specific actions to enable the development of RE projects. The plan will need to include short-term (two to three years), medium-term (2024-2030) and long-term actions. The short-term development plan should have yearly targets and include a resource assessment, zone identification, a project feasibility analysis, policy and regulation updates, development of a suitable RE competitive procurement system, pilot projects, and interventions to address infrastructure challenges such as land acquisition and land development, grid extension, connecting roads, *etc*.

The GOB needs to establish a transparent and publicly available RE development plan that provides clear direction for both public and private energy stakeholders.

In the medium term, the main constraints and challenges will have been addressed. This phase will allow Bangladesh to expand large-scale RE project development and the mid-term development plan should fix yearly development targets. To create long-term sustainability, the GOB needs to create opportunities for local manufacturing; it can achieve this by slowly escalating local content requirements set out during bidding, as well as ensuring enough annual procurement to sustain local manufacturing capacity.

50 One such study is already in progress under the GOB's Power Cell unit.

TABLE 4-3 : Guidelines for the Proposed RE Development Plan

Items	Descriptions	Years		
		Short-term (2021-2023)	Mid-term (2024-2030)	Long-term (2031-2041)
Development goal	Establish a renewable energy development plan with yearly targets from wind and solar PV (MW).	✓		
Implementation plan	Develop an implementation plan (short-term, medium-term and long-term) to achieve the renewable energy development goals.	✓	✓	✓
Site/area-specific RE resource mapping and technical potential assessment	Assess potential of renewable energy resources at area- or site-specific level.	✓	✓	
Identify possible project location or renewable energy zones	Land scarcity is the major constraint for developing RE projects in Bangladesh. Identify renewable energy zones that provide suitable sites and grid extension opportunities and develop other necessary infrastructure to aid developers.	✓	✓	
Renewable Energy Policy	The Renewable Energy Policy has not yet produced tangible benefits for RE project development. A new policy needs to address creating a market for RE, development goals and risks that affect project bankability.	✓		
Capacity development and training	Build capacity of key institutions such as the Sustainable and Renewable Energy Development Authority (SREDA). Utility-scale RE is relatively new to Bangladesh and SREDA is not currently oriented to help project developers with utility-scale RE-based power generation.	✓	✓	✓
	Build capacity of other energy stakeholders and individuals with energy backgrounds who work on energy issues. Engage with GOB agencies involved with developing new RE projects and raise awareness of government guidelines and the challenges the private sector faces. SREDA should organize awareness-raising workshops, seminars, and other ways to disseminate information to all stakeholders.	✓	✓	
	RE capacity development training of trainers.	✓		
Standard RFP documents and procurement plans	The bidding template and evaluation system for RE is the same as is used for conventional power plants. There are significant differences in procuring power supply from variable renewable energy (VRE) plants, and these warrant a more suitable procurement framework.	✓		
	Lessons learned from current procurement rounds should inform future procurement processes.	✓	✓	

Items	Descriptions	Years		
		Short-term (2021-2023)	Mid-term (2024-2030)	Long-term (2031-2041)
Enabling business environment	Set public and private targets for RE projects. As Bangladesh's utility-scale RE market is not yet mature, the country would benefit from greater public sector involvement in the short term, which will create long-term market confidence for private sector participants.	✓		
	Remove private sector constraints to developing projects and provide incentives to create a market for RE and a conducive business environment.	✓		
	Due to a lack of experience, local companies are unlikely to be able to participate in bidding for large-scale RE projects alone. GOB could create a program for small-scale projects (5 MW-10 MW) in areas with available distribution substation capacity.	✓	✓	
Smooth integration of renewable energy	Expand the transmission network once renewable energy zones have been identified.		✓	✓
	Increase the flexibility of the power system through upgrades.	✓	✓	✓
	Due to the intermittency associated with VRE energy, adequate storage options will help to maintain system stability.		✓	✓
	Improve system operators' forecasting and scheduling.	✓	✓	
Cost-reflective tariffs and phasing out of subsidies	Implement cost-reflective tariffs and gradually phase out government subsidies that make fossil fuels more attractive than RE and distort market conditions.	✓	✓	
Private sector engagement	Encourage the private sector to invest in RE projects by creating a market for utility-scale RE and ensuring key constraints are identified and addressed.	✓	✓	✓
	Government support to commercial financiers and developers to de-risk and make projects bankable.	✓	✓	

4.2.3 Conduct renewable energy resource mapping and technical potential assessment

Understanding the location and potential of RE resources is a crucial prerequisite to scaling up RE for electricity generation: without RE resource mapping, it is difficult to establish a development goal and development plan. Lack of reliable and publicly available data on RE resource potential in Bangladesh limits new project development. Resource mapping at site-specific or area levels, zoning guidance, transmission network planning and price regulations or incentives all need to be considered. This helps potential developers quickly identify suitable sites and reduces some of the early-stage risk that developers have in Bangladesh.

Country-level RE resource maps are useful and provide a good starting point to identify potential areas that can be considered for development. They focus only on theoretical potential. Some places have abundant potential, but due to geographical limitations, land use constraints, system performance or other infrastructure limitations, that potential is not exploitable or financially viable. Useful information such as topographic limitations, land use restrictions, and other aspects linked to the site and infrastructure would prove useful to developers.

4.2.4 Identify possible project locations or renewable energy zones

Land scarcity is the major constraint for developing RE projects in Bangladesh. Many projects have not proceeded past the feasibility stage or are delayed due to issues around suitable land or the acquisition of land. Most available land is along rivers, far from existing grid infrastructure and with high associated land development costs. Considering these challenges, it would be better for the GOB to identify land or open up land it already has access to, such as land in export processing zones, economic zones, or specially identified RE zones, which could free up suitable land in the short term.

In Bangladesh, government organizations like the Sustainable and Renewable Energy Development Authority (SREDA) or BPDB can be made responsible for identifying land to site RE projects. Where applicable and required, project developers can use their own land for selected projects. Although the land requirement for the proposed RE development plan is not much (0.32 percent of total land in Bangladesh), considering the size of the country, SREDA or BPDB can also work on identifying alternative options such as floating solar, offshore wind, hybrid solar PV and wind sites, or identifying areas where agricultural land can be used in combination with RE projects.

To minimize land costs and ensure a faster acquisition process, the GOB may prioritize the use of government-owned land or land categorized as having no ownership, reducing the need to acquire private land. If the land cannot be made available in a single location, then the GOB should consider using land in multiple locations near each other to optimize use of transmission and infrastructure facilities. The GOB should consider providing a minimum amount of infrastructure in areas considered for development, such as roads for access, water supply and even transmission lines for power evacuation. If the project location is close to rivers, the GOB should consider taking responsibility for river protection infrastructure. Current transmission network projects based on the PSMP transmission plan are a result of planning for power evacuation only from conventional power plants, which are mostly situated close to load centers. Although national grid coverage is present almost everywhere (95 percent of people are connected to the national grid), transmission lines will need to extend to remote areas where RE projects are expected to be developed. By having the GOB take responsibility for these early-stage activities, project risks and costs will decrease for developers, which will result in stronger competition between bidders and reduced tariffs in the bids. A third party can undertake these activities on behalf of the GOB.

4.2.5 Capacity development and training

SREDA is a government agency set up under the Power Division of the Ministry of Power, Energy and Mineral Resources, and is mandated to act as a coordination body for RE development. To date, only four utility-scale solar projects have been completed. The projects were completed under the BPDB, a public sector stakeholder. SREDA has focused mainly on off-grid solar systems, a small amount of rooftop solar PV and solar irrigation. SREDA does not have the requisite experience to be able assist stakeholders with utility-scale RE projects. Project developers are required to collect more than 40 approvals or clearances from local and national agencies and would greatly benefit from a central agency coordinating between other relevant government agencies and institutions. The GOB should consider developing a one-stop shop where project developers can benefit from a central coordinator and receive general assistance with project development activities.

Besides capacity development in government agencies, relevant private sector stakeholders, non-governmental organizations, and academic and research institutions, individual energy experts and other entities will also need to be educated. Skills in project financing, public-private partnerships (PPPs), transaction advisory, environmental, and legal and commercial aspects will also be required to run a suitable procurement process and assist in project financing and construction.

SREDA can organize workshops, seminars, and training programs for capacity development for all energy stakeholders. Due to its own institutional capacity limitations, capacity-building programs for utility-scale RE would be challenging for SREDA to implement. Training for the trainers for the RE development plan is essential. Conventional energy technology is widely taught in universities, whereas RE courses are not commonly available. SREDA could implement capacity-building programs through collaboration with research institutes and private organizations in the RE sector and prepare educational curricula for institutes. SREDA could also develop RE certifications covering technical topics and competencies specific to utility-scale RE.

4.2.6 Prepare standard RFP documents and procurement plans

The bidding and evaluation systems for RE projects in Bangladesh are the same as those used for conventional power plants. There are significant differences between electricity generation from renewable and conventional power plants, including how they generate electricity, capital costs, capacity factor, *etc*. The terms and conditions in the bidding documents should be prepared specifically for RE procurement, with consideration for the prevailing realities in Bangladesh, including covering specific risks and providing requisite guarantees.

The current procurement has been mostly dominated by a large number of unsolicited offers, where many developers with limited experience submit competitive bids without having fully considered the complexities of building projects in Bangladesh or fully assessing the risks. Once these projects are awarded, costs increase, and project development stops or the projects are canceled. A combination of good procurement documents that take into account developers' expected project risks and a transparent competitive bidding process will go a long way to attracting international bidders, who have more experience and understanding of project risks and project costs, and who can offer realistic bid prices that will result in projects reaching financial close and moving to commercial operation. From a government perspective, transparent and competitive bidding create a market for high quality RE projects to be built by competent private sector companies.

4.2.7 Set new renewable energy development targets

According to the GOB's vision and the Renewable Energy Policy 2008, Bangladesh aimed to meet 5 percent of electricity demand with RE technologies by 2015 and 10 percent by 2020. Although this target was not met by 2020, the installation targets for conventional power plants have been achieved. This indicates that there is political will and institutional capability to carry out new procurement, but that the current barriers to entry are too great. Bangladesh needs a RE policy that understands these risks and gives due consideration to actual generation procurement plans, grid transmission extension in areas that will benefit future RE plants, incentives for area or site infrastructure development, and support and security to potential commercial lenders. The GOB must look back at and update policy guidelines for RE-based power generation for the long term. RE generation targets and plans should also reflect the optimal energy supply mix for total power generation in Bangladesh.

4.2.8 Smooth integration of variable renewable energy

The scale-up of RE can be held back if there is a lack of confidence in the grid's ability to function with higher VRE penetration. Smooth integration and operation of RE-based power plants have been a big challenge in Bangladesh, mostly

due to poor dispatching practices and aging infrastructure. The GOB will need to develop a plan to support the integration of more intermittent power into the network, taking the following actions:

1. Establish a plan that considers future RE areas and assesses what requirements will need to be met by transmission networks, substations, and transformers so that developers can evacuate power to the national grid.
2. Model higher amounts of RE in future load studies' scenarios and include scenarios with added storage.

As RE becomes more prevalent in Bangladesh, various actions can be put into place to maintain system stability.

- **Increase the flexibility of conventional power plants**: The intermittent nature of RE resources affects power system stability. The supply flexibility of conventional power plants is very important for minimizing the gaps created by VRE generation in the power system. Although Bangladesh has a large amount of gas and liquid fuel capacity, many of the plants are aging, with relatively old technology that might not be capable of ramping up and down quickly to respond to fluctuations in VRE generation. Therefore, it is important to consider introducing other flexibility options into the power system, such as storage, that can complement the existing fleet of conventional power plants in meeting demand fluctuations. Automated demand-side management will significantly help manage stability issues. Therefore, energy storage and automated demand-side management need to be considered for increased VRE integration as well as the stability of the overall power system.
- **Optimize forecasting and scheduling:** Solar and wind energy output depend on variable weather conditions and will create increasing and larger fluctuations in the power system. Forecasting likely VRE generation and scheduling are two mechanisms that can be used to provide more certainty in likely power generation output and can be used to ensure higher grid stability.

4.2.9 Minimize subsidies and capacity payments

The GOB pays large subsidies in the form of capacity payments due to significantly lower capacity utilization from conventional power IPPs. The country's current reserve margin of power generation is 50 percent. If Bangladesh proceeds with its planned generation, there is a strong possibility that the country will have to pay a higher share of capacity payments. The economic impact of COVID-19 will also reduce electricity demand growth and worsen the overcapacity situation.

The capacity utilization of new expected (and expensive) imported coal and LNG power plants will be much lower if they come online as planned. Overall power capacity utilization was only 43 percent in 2018/2019.

Excess power generation capacity in Bangladesh has meant large capacity payments for plants that are lying idle. Government capacity payments for idle power plants have increased from about 40 billion BDT in 2016/2017 to 90 billion BDT in 2019/2020.

Overall, planned capacity addition by expensive imported coal and LNG will increase capacity payments for idle plants in the long run and will have an impact on the economy and on consumer tariffs.

4.2.10 Private sector engagement

It is not always possible for governments to fund their infrastructure requirements by themselves, or to have the required technical capability and skills to develop projects. In most instances, governments require the private sector to play a role in infrastructure development. Providing the right incentives and signals to encourage private sector participation in the power sector is one of the most important levers that governments have to ensure that necessary infrastructure is built in time. There is always a trade-off with private sector participation, as private companies are driven by market incentives and a return on their efforts. Policymakers and governments must decide the role that the private sector is best suited to play for any infrastructure development program. In the case of Bangladesh, the GOB already has vast experience with signing on conventional fossil fuel IPPs, but does not have much experience with utility-scale RE IPPs.

To encourage private sector participation in electricity generation, the GOB adopted a Private Sector Power Generation Policy (PSPGP) in 1996 and revised it in 2004. This policy was mainly used to encourage IPPs in the power sector, create opportunities for PPPs, introduce competition into the sector and allow private companies to rehabilitate old and inefficient power plants.

Bangladesh also adopted the Policy Guideline for Enhancement of Private Participation in the Power Sector in 2008, introducing new policies and incentives. Since 2008, this policy guideline has been a huge catalyst for IPPs to develop power projects. Currently, there are a total of 81 IPPs in Bangladesh with capacity of 8,868 MW, mostly built within the last few years. Public sector generation capacity stands at 9,567 MW with 56 power plants, some as much as 50 years old. Since 2014, private developers in Bangladesh have organized themselves under an industry association called Bangladesh Independent Power Producers' Association. The association's main aim is to protect, represent and promote the activities of IPPs engaged in commercial power production in Bangladesh. The association currently has 62 members.

Another 34 conventional IPP plants with a total capacity of 6,406 MW are under construction, and 15 projects with a total capacity of 4,159 MW are now in the signing process. In the last decade, private sector participation in the power sector has been remarkable due to strong policy guidelines and GOB commitment.

For RE, the GOB adopted the Renewable Energy Policy in 2008 and published Guidelines for the Implementation of the Solar Power Development Program in 2013. The government support and incentives mentioned in the PSPGP and the Policy Guideline for Enhancement of Private Participation in the Power Sector also apply to RE projects. However, there is little to show in the way of capacity from utility-scale RE projects. This is mainly due to the lack of appropriate and targeted RE development guidelines to meet RE targets.

The private sector will have to play a role in project development as well as financing; about $31 billion is required between 2021 and 2041 to meet the proposed RE development plan. A total of $135 billion will be needed for the new additional capacity (mainly from conventional plants) required between 2021 and 2041 to meet the total demand projected by Revisiting PSMP 2016.[51]

With the COVID-19 pandemic, power project development has slowed in Bangladesh and demand growth has decreased, with availability of power exceeding demand.

4.2.11 Lessons from current market trends

On average, per unit electricity generation costs in Bangladesh are 13-4 BDT/kWh from furnace oil plants and 25-30 BDT/kWh from diesel power plants. Currently, BPDB purchases electricity from three solar IPP projects for 11-16 BDT/kWh. As solar PV and wind generation costs decline, prices have dropped. In September 2019, a new solar power plant was signed up with a tariff of 6.5 BDT/kWh.

In China and India, solar and wind power generation costs are currently lower than domestic coal-fired power generation costs. (China and India are in the top three countries worldwide for coal-fired power generation.) Many countries, both developed and developing, have been struggling to finance coal-based power plants due to lenders shifting away from providing debt for coal-fired power. With the COVID-19 pandemic, power project development has slowed in Bangladesh and demand growth has decreased, with availability of power exceeding demand.

There is an opportunity for Bangladesh to revise its power sector development policy and pivot toward high levels of RE, along with grid extension and power system modernization. The PSMP 2016 development path is not suitable for long-term capacity development and needs to be revised to include higher RE penetration and discourage a trajectory toward imported coal, oil and LNG-based power plants. To reduce dependence on short-term rental power plants, the GOB can provide incentives to promote energy storage systems.

51 NREL, "Advanced Energy Systems: Grid Integration of Variable Renewable Energy and Flexibility Solutions" webinar, 2020.

Conclusion

Bangladesh has had significant year-on-year economic growth over the past decade, and its power system will need to keep pace with the expected increase in demand in the coming decades. As natural gas reserves in Bangladesh decline, future generation capacity will have to come from other primary resources. Moving to replace local gas with imported LNG and imported coal for power generation will likely translate into higher tariffs and put pressure on affordable access to electricity, as well as on the reliability and quality of the power system. This could have far-reaching consequences for the long-term sustainability of the power sector, including the inability to raise funding for future fossil fuel projects due to changes in sentiment from international lenders.

The current power sector planners and decision makers need to consider the gains made in utility-scale RE over the last decade and the benefits of shifting some of the primary energy requirements to indigenous and renewable resources, reducing reliance on fossil fuels.

This paper has made a great effort to highlight the disconnect between various government policies aimed at scaling up the deployment of grid-connected RE.

The next iteration of the PSMP needs to address this discrepancy, and this white paper provides a blueprint for ambitious, but entirely achievable RE capacity goals to 2041. These high-level targets are meant to serve as a guide for conducting more robust long-term modeling on electricity demand and future development scenarios.

Considering the current business case for deploying large-scale RE when solar and wind are many countries' cheapest options by far, Bangladesh should be well positioned to increase RE's contribution in its energy mix, like many of its South Asian peers. The country has good solar and wind resources and the potential to deploy both in large numbers, based on the studies listed in this paper.

Under the few RE projects developed in Bangladesh so far, tariffs have not been as low as in other South Asian countries, although this is to be expected. Investors and developers will need to see evidence of government commitment, and a formal RE procurement program will go a long way toward instilling investor confidence, which should help make tariffs more competitive. It is now clear that it is technically possible and potentially cheaper for Bangladesh to implement a higher share of RE in its energy mix.

The PSMP will not allow Bangladesh to fulfill its objectives under the Renewable Energy Policy 2008 or the NDC targets, which is why this paper proposes continuing the 2008 policy target of meeting 10 percent of electricity demand with RE past 2020 and extending it to 2041. It is the most ambitious target in the policies and will allow Bangladesh to meet its NDC commitments comfortably. In all cases, these targets are well below Bangladesh's RE potential.

This translates into an estimated 31.32 GW of installed solar PV and wind capacity required by 2041. The short-term recommendations in this paper provide a platform for immediate steps that Bangladesh can take to start down the road to effective RE deployment.

In the short term, it is absolutely imperative that the GOB develop a yearly procurement target for RE, as this will send a strong message to stakeholders both inside and outside the country. A RE development plan needs to sit within a large integrated resource plan but needs enough detail to be able to provide a signal to the market. In part, this means defining when and how procurement will be conducted and moving away from accepting unsolicited project offers.

As Bangladesh has very little experience with large-scale RE, the GOB must be cognizant of the barriers and challenges faced by developers and investors and address them with interventions that, in combination, can reduce risk and result in much more favorable tariffs in bids. Such interventions can include conducting more site-specific resource assessments for both solar and wind and dealing with land acquisition risks specific to Bangladesh by providing land for project development, possibly through RE zones.

Based on the high failure rate of projects in the early stages of development in Bangladesh, sector stakeholders need to determine the unique challenges project developers and commercial lenders face in the country. This will allow the GOB to deal with the risks it is best positioned to address, *i.e.*, risks and challenges that would otherwise create an environment that prevents project bankability. These were identified in detail in the USAID white paper *Challenges in the Development of Variable Renewable Energy in Bangladesh.*

Many stakeholders in Bangladesh come together to ensure power projects can be developed. This includes a large number of government institutions and agencies, many of which have broad-ranging functions, of which the power sector is just one. Other include civil society, local manufacturers and service providers, developers, commercial and financial institutions, and institutions of learning and education. Having a central agency that can engage with various stakeholders and increase coordination, training and capacity-building makes sense in these early stages, as many of the stakeholders have limited exposure to utility-scale RE.

Many countries have moved away from utilities being the source of funding for new power generation capacity, with both local and foreign capital markets as the source of project funds. Bangladesh has a long and successful history with conventional IPPs and its commercial lenders are familiar with project financing requirements; however, RE plants (particularly wind and solar) are not dispatchable and financing structures for such technologies are somewhat different from those used with conventional plants. The GOB will need to familiarize the local capital markets with the differences and help them to understand the unique risks in using intermittent energy sources such as solar PV and wind.

Bangladesh has good RE potential, and recent trends in technology and fast declining costs create an opportunity to quickly increase RE's share in the electricity supply mix. If the GOB follows these guidelines for an alternative RE development plan, then the country will be able to improve its energy security, meet its GHG reduction commitments at the lowest cost, maximize the use of local RE resources, attract private financing, and ensure a future less dependent on imported gas and coal.

References

Asian Development Bank. Eastern Economic Corridor Independent Power Project *Thailand - Sector Overview*. Manila, Philippines: ADB, 2019.

Bangladesh Power Development Board (BPDB). *Annual Report 2019-2020*. Dhaka, Bangladesh: BPDB, 2020.

Bangladesh Power Development Board (BPDB). *Annual Report 2009-2010*. Dhaka, Bangladesh: BPDB, 2010.

Das, A., A. Halder, R. Mazumder, and V. Saini. "Bangladesh Power Supply Scenarios on Renewable and Electricity Import." *Energy* 155 (2018).

"Cabinet approves 55 MW wind power project." The Daily Star, December 9, 2020.

Central Statistics Office. Energy Statistics 2019. New Delhi, India: Ministry of Statistics and Programme Implementation, Government of India, 2019.

China Energy Portal website, https://chinaenergyportal.org/en/.

China National Petroleum Corporation (CNPC) Economics & Technology Research Institute. *China Energy Outlook 2050*. Beijing, China: CNPC, 2018.

Department of Energy. *2019 Power Situation Report*. Taguig City, Philippines: Department of Energy, 2019.

Department of Energy. *Power Development Plan 2016-2040*. Taguig City, Philippines: Department of Energy, 2016.

Electricity Generating Authority of Thailand. *Annual Report 2019*. Bangkok, Thailand: EGAT, 2019.

International Renewable Energy Agency (IRENA). Electricity Storage and Renewables: Cost and Market 2030. Abu Dhabi, U.A.E: IRENA, 2017.

IRENA. *Global Renewable Outlook: Energy Transformation 2050*. Abu Dhabi, U.A.E: IRENA, 2020.

IRENA. *The Power to Change: Solar and Wind Cost Reduction Potential to 2050*. Abu Dhabi, U.A.E: IRENA, 2016.

IRENA. *Renewable Capacity Statistics 2020*. Abu Dhabi, U.A.E: IRENA, 2020.

IRENA, *REmap Renewable Energy Prospects for India*. Abu Dhabi, U.A.E: IRENA, 2017.

IRENA. *Renewable Power Generation Costs in 2019*. Abu Dhabi, U.A.E: IRENA, 2020.

IRENA. "Renewable Power Generation Costs in 2019: Latest Trends and Drivers," *Insights Webinar Series*. Abu Dhabi, U.A.E: IRENA, 2020.

Jacobson, M. et al. *Assessing the Wind Energy Potential in Bangladesh: Enabling Wind Energy Development with Data Products*. Washington, D.C., United States: NREL, 2018.

Jahangir, Shamim. "Govt to drop nine coal-fired plants." Daily Sun, February 24, 2021. https://www.daily-sun.com/printversion/details/537552/Govt-to-drop-nine-coalfired-plants

"Key Statistics," BPDB, last modified March 19, 2021, https://www.bpdb.gov.bd/bpdb_new/index.php/site/page/13e9-2cc0-ce41-9c09-088d-94d5-f546-04a6-b4fa-1d18.

Ministry of Energy. *Thailand Power Development Plan (2018–2037)*. Bangkok, Thailand: MOE, 2019.

Ministry of Environment and Forests. *Intended Nationally Determined Contributions (INDC)*. Dhaka, Bangladesh: MOEF, 2015.

Ministry of Finance. *Bangladesh Economic Review*. Dhaka, Bangladesh: Finance Division, Ministry of Finance, 2019.

Ministry of Power, Energy and Mineral Resources (MPEMR). *Renewable Energy Policy of Bangladesh*. Dhaka, Bangladesh: MPEMR, 2008

MPEMR. *Power System Master Plan 2016*. Dhaka, Bangladesh: Power Division, MPEMR, 2016.

MPEMR. *Revisiting PSMP 2016*. Dhaka, Bangladesh: Power Division, MPEMR, 2018.

Mondal, M. A. "Development of Renewable Energy Technologies in Bangladesh: Long-term policy Implications in Power Sector." *Energy Strategy Reviews; 2* (2017), 307-312.

National Renewable Energy Laboratory (NREL). "Advanced Energy Systems: Grid Integration of Variable Renewable Energy and Flexibility Solutions," *Bangladesh Renewable Energy Development Webinar Series 2*. Washington, D.C., United States: USAID, 2020.

NREL. "Dataset: Solar Resources by Class and Country." Washington, D.C., United States: NREL OpenEI, 2014.

Petrobangla. *Annual Report 2019*. Dhaka, Bangladesh: Petrobangla, 2019.

Petrobangla. *Annual Report 2020*. Dhaka, Bangladesh: Petrobangla, 2020.

Power Grid Company Bangladesh (PGCB). *Annual Report 2019*. Dhaka, Bangladesh: PGCB, 2019.

"National Database of Renewable Energy," Sustainable and Renewable Energy Development Authority (SREDA), last modified March 11, 2021, http://www.renewableenergy.gov.bd/.

REN21. *Renewables 2020: Global Status Report.* Paris, France: REN21 Secretariat, 2020.

"Solar costs," IRENA, https://www.irena.org/Statistics/View-Data-by-Topic/Costs/Solar-Costs.

SREDA. *National Solar Energy Action Plan, 2021 – 2041 (Draft Final Report)*. Dhaka, Bangladesh: SREDA, 2020.

U.S. Department of Energy (DOE). *Energy Storage Technology and Cost Characterization Report*. Washington, D.C., United States: U.S. DOE, 2019.

List of key informants and subject matter experts interviewed

- Bithi Islam, Director (Technological Development), Power Cell
- Q. A. Sharhan Sadique, Deputy Director (Sustainable Energy), Power Cell
- Jarifa Khatun, Deputy Director, System Planning, BPDB
- Engr. Monowar Hasan Khan, Deputy Secretary, Power Division
- Engr. Serajul Islam Khan, Deputy Director, Power Cell 3, BPDB
- Kazi Absar Uddin Ahmed, Chief Engineer (Generation), BPDB
- Engr. Farhana Alam, Deputy Director (Renewable Energy), BPDB
- Engr. S M Zahid Hasan, Deputy Director, Director of Design and Inspection-II, BPDB
- Firoz Zaman, Deputy Director, Bangladesh Energy Regulatory Commission (BERC)
- Mr. Kamruzzaman, Deputy Director, BERC
- Engr. Mahaimenul Islam, Superintendent Engineer and Project Director, North-West Power Generation Company Limited (NWPGCL)
- Engr. Tanvir Hasan Bhuiyan, Executive Engineer, System Project, BPDB
- Engr. Morshed Alam, Executive Engineer, PGCB
- Engr. Shakhawat Hossain, Executive Engineer, Bangladesh-India Power Transmission Station, PGCB
- Engr. Jubaer Alvi, Sub -Divisional Engineer, National Load Dispatch Center, PGCB
- Engr. Ashaduzzaman Rashed, Executive Engineer, Dhaka Power Distribution Company
- Engr. Abdullah Bin Hossain, Project Engineer, Rangunia Solar Ltd
- Prof. Abdur Razzak, Professor, Independent University, Bangladesh (IUB)
- Dr. Aminul Islam, Jashore University of Science and Technology (JSTU)
- Engr. Mukit Alam Khan, Manager (Project & Planning) US-DK Green Energy (BD) Ltd
- Prof. Dr. Saiful Haque, Director, Energy Institute, Dhaka University

Appendices

Appendix A – power transmission and distribution

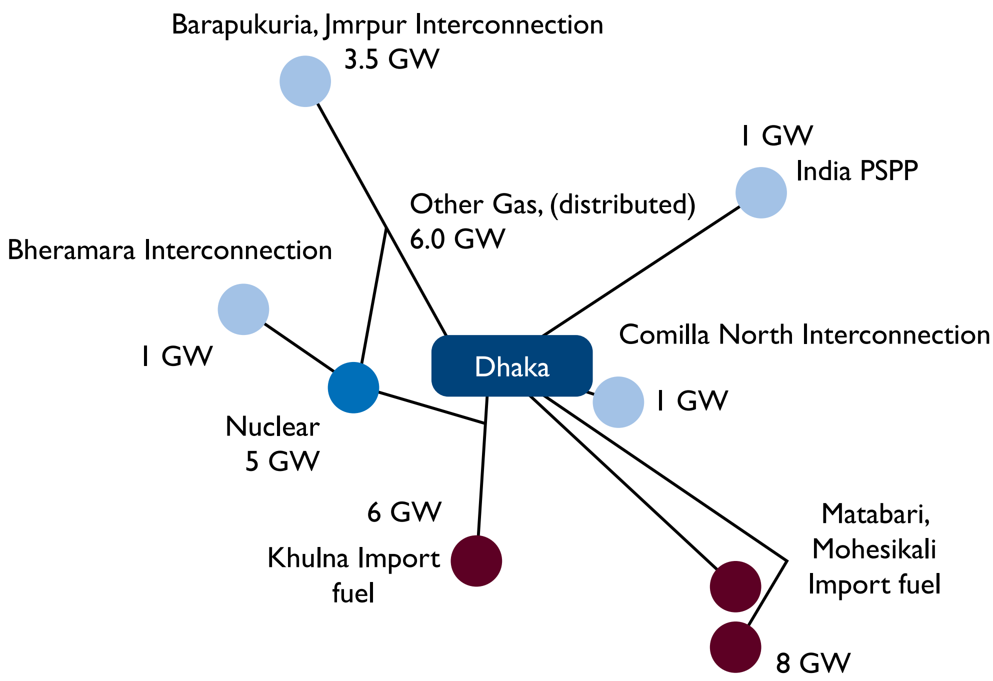
Power Transmission: Presently, the Power Grid Company of Bangladesh (PGCB) is fully responsible for the operation, maintenance, and development of power transmission in Bangladesh. Power generated in different power plants all over the country is transmitted to the national grid through 400 kV, 230 kV and 132 kV transmission lines. PGCB started its journey in 1996 with 838 circuit kilometers (ckt) of 230 kV and 4,755 ckt of 132 kV transmission lines. As of June 2019, PGCB added 698 ckt of 400 kV transmission line and increased its 230 kV and 132 kV transmission lines to 3,407 ckt and 7,545 ckt respectively. In the same time, transmission substation capacity has also increased: 400 kV high-voltage direct current is 1,111 megavolt-amperes (MVA), 400/230 kV is 3,770 MVA, 400/132 kV is 650 MVA, 230/132 kV is 13,135 MVA and 132/33 kV is 23,640 MVA. Transmission losses have also improved and are now only 2.75 percent.

PGCB has created a comprehensive plan to develop transmission lines and improve substation capacity to meet the future demand of 18,126 ckt km and 90,382 MVA by 2021, and 34,850 ckt km and 261,000 MVA by 2041 based on PSMP 2016 (which mostly focuses on electricity from imported coal and gas/LNG plants). Future development projects by PGCB include:

- Construction of 400 kV transmission line from Rahanpur to Monakasha border in Chapai Nawabganj District to import power from Jharkhand, India
- Transmission infrastructure development project for the southern area of Chattogram Division and Bangabandhu Hi-Tech City at Kaliakair
- Renovation and capacity enhancement of existing grid substations and transmission lines
- Expansion and strengthening of power system network in the Dhaka Power Distribution Company (DPDC) area
- Banshkhali–Madunaghat 400 kV transmission line project
- Madunaghat–Moheshkhali 765 kV transmission line project
- Madunaghat–Bhulta 765 kV transmission line project
- Construction of Payra–Gopalganj–Aminbazar 400 kV transmission system
- Energy efficiency in grid base power supply 2 (the main objective of this project is to increase the reliability and efficiency of Bangladesh's electrical power supply by expanding and improving the power transmission system)
- Integration capacity development project in the overall power transmission system

Power Distribution: Six distribution utilities distribute power to the entire country: the BPDB, Dhaka Power Distribution Company (DPDC), Dhaka Electric Supply Company Limited (DESCO), Western Zone Power Distribution Company Limited (WZPDCL), Bangladesh Rural Electrification Board (BREB), and Northern Electricity Supply Company Limited (NESCO). In alignment with the GOB's vision of electricity for all by 2020 and improved consumer service, all distribution companies implemented many projects and increased distribution line capacity from 260,000 km in 2009 to 532,000 km in 2019, with a target of 530,000 km in 2041. In the same period, customer numbers rose from 10.8 million to 38.3 million, distribution companies increased grid connection from 47 percent of the population to 95 percent, and distribution losses fell from 13.57 percent to 9.12 percent. All these companies are focusing on distribution system modernization and capacity enhancement in their ongoing and upcoming projects, such as introduction of smart grids and smart pre-paid meters, implementation of a GIS-based distribution network, migration to an underground distribution system, system supervisory control and data acquisition (SCADA) and demand-side management.

FIGURE A-1: Conceptual Map of Locations of Large-Scale Power Stations Planned Until 2035



Appendix B – renewable energy projects in various stages of development

TABLE B-1: Completed Solar and Wind Projects

Sl.	Project Name	Capacity	Location	RE Technology	Agency	Finance	Completion Date	Present Status
1	Kaptai 7.4 MWp Grid-connected Solar PV Power Plant	7.4 MW	Kaptai Upazila, Rangamati	Solar Park	BPDB	ADB	5/28/19	Completed & Running
2	8 MW Solar Park by Parasol Energy Ltd.	8 MW	Panchagarh Sadar, Panchagarh	Solar Park	Private	IPP (Unsolicited)	5/13/19	Completed & Running
3	20MW (AC) Solar Park by Joules Power Limited (JPL)	20 MW	Teknaf Upazila, Cox's Bazar	Solar Park	BPDB	IPP (Unsolicited)	9/15/18	Completed & Running
4	3 MW Grid-connected PV Power Plant at Sharishabari, Jamalpur	3 MW	Sarishabari Upazila, Jamalpur	Solar Park	BPDB	IPP	7/14/17	Completed & Running
5	50 MW (AC) Solar Park by HETAT-DITROLIC-IFDC Solar Consortium	50 MW	Gauripur, Mymensingh	Solar Park	BPDB	IPP (Unsolicited)	11/4/20	Completed & Running

Sl.	Project Name	Capacity	Location	RE Technology	Agency	Finance	Completion Date	Present Status
6	Feni Wind Power Plant	900 kW	Sonagazi, Feni	Wind (On-Grid)	BPDB	Self	9/27/06	Completed & Running
Total		89.3MW						

TABLE B-2: Solar and Wind Projects Under Construction

SL.	Project Name	Capacity	Location	RE Technology	Agency	Finance	Completion Date	Present Status
1	Sonagazi 50 MW Solar Power Plant Construction Project	50 MW	Sonagazi, Feni	Solar Park	EGCB	WB	6/30/21	Implementation Ongoing
2	Sirajganj 7.6 MWp Grid Connected Solar Photovoltaic Power Plant	7.8 MW	Sirajganj Sadar Upazila, Sirajgonj	Solar Park	NWPGCL	Self	10/4/20	Implementation Ongoing
3	5 MW (AC) Solar Park by PV Power Patgram Ltd.	5 MW	Patgram, Lalmonirhat	Solar Park	BPDB	IPP (Unsolicited)	7/13/20	Implementation Ongoing
4	35 MW (AC) Solar Park by Consortium of Spectra Engineers Limited & Shun-feng Investment Limited	35 MW	Shibalaya Upazila, Manikganj	Solar Park	BPDB	IPP (Unsolicited)	11/4/19	Implementation Ongoing
5	50 MW (AC) Solar Park by HETAT-DITROL-IC-IFDC Solar Consortium	50 MW	Gauripur, Mymensingh	Solar Park	BPDB	IPP (Unsolicited)	10/31/19	Implementation Ongoing
6	32 MW (AC) Solar Park by Haor Bangla-Korea Green Energy Ltd.	32 MW	Dharampasha, Sunamganj	Solar Park	BPDB	IPP (Unsolicited)	8/14/19	Implementation Ongoing
7	5 MW (AC) Solar Park by Sun Solar Power Plant Ltd.	5 MW	Gowainghat, Sylhet	Solar Park	BPDB	IPP (Unsolicited)	8/2/19	Implementation Ongoing
8	200 MW (AC) Solar Park by Beximco Power Co. Ltd.	200 MW	Sundarganj, Gaibandha	Solar Park	BPDB	IPP (Unsolicited)	4/26/19	Implementation Ongoing
9	30MW (AC) Solar Park by Intraco CNG Ltd & Juli New Energy Co. Ltd.	30 MW	Gangachara, Rangpur	Solar Park	BPDB	IPP (Unsolicited)	9/27/18	Implementation Ongoing

SL.	Project Name	Capacity	Location	RE Technology	Agency	Finance	Completion Date	Present Status
10	200 MW (AC) Solar Park by SunEdison Energy Holding (Singapore) Pvt Ltd	200 MW	Teknaf Upazila, Cox's Bazar	Solar Park	BPDB	IPP (Unsolicited)	7/9/18	Implementation Ongoing
11	Design, Supply, Installation, Testing and Commissioning of 2 MW Capacity Wind Power Plant on turnkey basis at the bank of the River Jamuna adjacent to the existing Sirajganj 150 MW Power Plant , Sirajganj, Bangladesh	2 MW	Sirajganj Sadar Upazila, Sirajgonj	Wind (On-Grid)	BPDB	Self	1/14/19	Implementation Ongoing
Total		616.8 MW						

TABLE B-3: Solar and Wind Projects Under Planning

SL.	Project Name	Capacity	Location	RE Technology	Agency	Finance	Completion Date	Present Status
1	Sonagazi 100 MW Solar Power Plant Project-2	100 MW	Sonagazi, Feni	Solar Park	EGCB	N/A	12/31/23	Under Planning
2	Sonagazi 100 MW Solar Power Plant Project-1	100 MW	Sonagazi, Feni	Solar Park	EGCB	N/A	12/31/22	Under Planning
3	Madargonj 100MW Solar PV Power Project	100 MW	Madarganj Upazila, Jamalpur	Solar Park	RPCL	IPP (Unsolicited)	6/30/22	Under Planning
4	30 MW Solar Park	30 MW	Boda, Panchagarh	Solar Park	RPCL	IPP (Unsolicited)	6/30/21	Under Planning
5	Madarganj 100 MW Grid Tied Solar Power Plant Project	100 MW	Madarganj Upazila, Jamalpur	Solar Park	B-R PowerGen	IPP (Unsolicited)	6/30/21	Under Planning
6	20 MW (AC) Grid-tied Solar PV Power Plant at Debganj, Panchagarh, Bangladesh	20 MW	Debiganj, Panchagarh	Solar Park	BPDB	IPP (Unsolicited)	2/15/21	Under Planning

SL.	Project Name	Capacity	Location	RE Technology	Agency	Finance	Completion Date	Present Status
7	47 MW (AC) Grid-tied Solar PV Power Plant at Debiganj, Panchagarh, Bangladesh	47 MW	Debiganj, Panchagarh	Solar Park	BPDB	IPP (Unsolicited)	2/15/21	Under Planning
8	10 MW (AC) Grid-tied Solar PV Power Plant at Moulvibazar Sadar, Moulvibazar, Bangladesh	10 MW	Moulvibazar Sadar, Moulvibazar	Solar Park	BPDB	IPP (Unsolicited)	2/15/21	Under Planning
9	Ashuganj 100 MW Grid Tied Solar Park	100 MW	Katiadi Upazila, Kishoreganj	Solar Park	APSCL	GoB	12/31/20	Under Planning
10	50 MW Solar Park by 8minutenergy Singapore Holdings 2 Pte. Ltd. Singapore	50 MW	Whole Bangladesh, Panchagarh	Solar Park	BPDB	IPP (Unsolicited)	12/31/19	Under Planning
11	50 MW Solar Park by Scatec Solar ASA	50 MW	Whole Bangladesh, Nilphamari	Solar Park	BPDB	IPP (Unsolicited)	9/6/19	Under Planning
12	Installation of a 100 MWp Solar Photovoltaic (PV) based Grid-connected Power Generation Plant, Sonagazi, Feni	100 MW	Sonagazi, Feni	Solar Park	BPDB	GoB	6/30/19	Under Planning
13	100 MW (AC) Solar Park by Zhejiang Dun An New Energy Co., Ltd, China National Machinery Import & Export Corporation, Solar Tech Power Limited, & Amity Solar Limited	100 MW	Aditmari, Lalmonirhat	Solar Park	BPDB	IPP (Unsolicited)	6/30/18	Under Planning
14	Rangunia 60 MWp Solar Park Project Rangunia, Chittagong	60 MW	Rangunia Upazila, Chittagong	Solar Park	BPDB	GoB	6/30/18	Under Planning
15	Gangachara 55 MWp Solar Park	55 MW	Gangachara, Rangpur	Solar Park	BPDB	GoB	6/30/18	Under Planning

SL.	Project Name	Capacity	Location	RE Technology	Agency	Finance	Completion Date	Present Status
16	100 MW Solar Park by Shapoorji Pallonji Infrastructure Capital Company Private Ltd.	100 MW	Pabna Sadar Upazila, Pabna	Solar Park	BPDB	IPP (Unsolicited)	3/6/18	Under Planning
17	30 MW (AC) Solar Park by Beximco Power Company Ltd & Jiangsu Zhongtian Technology Co Ltd., China	30 MW	Tetulia, Panchagarh	Solar Park	BPDB	IPP (Unsolicited)	12/31/17	Under Planning
18	10 MWp Grid-Tied Solar Power Project by Eiki Shoji Co Ltd, Japan & Sun Solar Power Plant Ltd	5 MW	Gowainghat, Sylhet	Solar Park	BPDB	IPP (Unsolicited)	9/22/16	Under Planning
19	100 MW (AC) Solar Park by Energon Technologies FZE & China Sunergy Co.Ltd (ESUN)	100 MW	Mongla Upazila, Bagerhat	Solar Park	BPDB	IPP (Unsolicited)	9/22/16	Under Planning
20	10 MW Wind Power Plant	10 MW	Kalapara Upazila, Patuakhali	Wind (On-Grid)	RPCL	GoB	12/31/22	Under Planning
21	"60 MW Wind Power Project" at Cox's Bazar by US-DK Green Energy (BD) Ltd	60 MW	Chakaria Upazila, Cox's Bazar	Wind (On-Grid)	BPDB	IPP (Unsolicited)	11/30/17	Under Planning
Total		1,327 MW						

Appendix C – renewable energy transformation plans in Asia (India, China, Thailand, Philippines)

India: India has huge potential to generate electricity from RE sources like wind, solar, biomass, small hydro and cogeneration bagasse. The total potential for RE power generation capacity in India is estimated at about 1,096 GW. Out of this, about 68 percent is expected from solar power and 28 percent from wind power at a turbine hub height of 100 m. The remaining share comes from small hydro, biomass, bagasse-based cogeneration and waste-to-energy.

India has also huge conventional energy potential, such as from coal, lignite, crude oil and natural gas. In 2018, total estimated reserves of coal were 319.04 billion tons, lignite 45.66 billion tons, crude oil 594.49 million tons and natural gas 1,339.57 billion cubic meters.[52] The Government of India has developed the power sector in the last decade and increased power utilities' installed capacity from 147.96 GW in 2009 to 356.77 GW by 2019. It is targeting 619 GW of total installed capacity

52 Central Statistics Office, *Energy Statistics 2019*.

TABLE C-1: India's Current Installed Capacity and Transformation Plan by 2027

Fuel Type	2019[51]		FY 2021-2022[52]		FY 2026-2027	
	Installed capacity (GW)	%	Installed capacity (GW)	%	Installed capacity (GW)	%
Thermal	226.28	63.40	243.03	50.80	263.88	42.70
Nuclear	6.78	1.93	10.08	2.10	16.88	2.70
Hydro	45.34	12.72	51.3	10.70	63.3	10.20
Renewables	78.31	21.95	175	36.50	275	44.40
Total	356.71	100	479.41	100	619.06	100

TABLE C-2: China's Current Electricity Generation and Transformation Plan by 2050[53]

Fuel Type/ Year	2019		2035		2050	
	Generation (TWh)	% share	Generation (TWh)	% share	Generation (TWh)	% share
Thermal	5,054.25	69	5,819.5	56.5	5,265	45
Nuclear	366.25	5	772.5	7.5	1,404	12
Hydro	1,318.5	18	1,442	14	1,755	15
Renewable	586	8	2,266	22	3,276	28
Total	**7,325**	**100**	**10,300**	**100**	**11,700**	**100**

by 2027 and 670 GW by 2030. An estimated 48.288 GW of installed power plant capacity will be retired between 2017 and 2027. To meet growing demand, replace retirement capacity, mitigate GHG emissions and ensure energy security, the Government of India aims to develop RE-based generation from about 78 GW in early 2019 to 275 GW in 2027 and to 455 GW by 2050.[56] The government's plan clearly shows that RE's share of installed capacity is expected to increase from about 22 percent in 2019 to 36 percent and 44 percent by 2022 and 2027, respectively. Thermal plant capacity's share is expected to decrease from 63 percent in 2019 to about 42 percent in 2027. The government target helps accelerate development of RE technologies for power generation in India.

China: Coal-based power plants dominate China's power sector. Total installed capacity was 874 GW in 2009 and thermal capacity made up 681 GW (about 78 percent of total capacity, of which 90 to 95 percent came from coal), with RE accounting for about 8 percent (70 GW). Between 2009 and 2019, China's power sector development was significant and installed capacity increased from 874 GW to 2,010 GW. It also produced a remarkable energy transformation, reducing thermal generation capacity from 78 percent to 69 percent and increasing RE generation capacity to 414 GW (not including hydro). Similarly, electricity generation increased from 3,681 TWh in 2009 to 7,325 TWh in 2019.[57]

Annual per capita electricity consumption has also risen substantially. However, there is still a big difference in

53 Ministry of New and Renewable Energy of India, *Annual Report 2018-2019.*
54 IRENA, *REmap Renewable Energy Prospects for India.*
55 China Energy Portal website.
56 IRENA, *Electricity Storage and Renewables: Cost and Market 2030.*
57 China Energy Portal website.

TABLE C-3: Electricity Production by Fuel Source in 2019 and 2037

Fuel Type	Production capacity percentage, 2019[56]	Production capacity percentage, 2037[57]
Natural gas	57%	53%
Coal (including lignite)	18%	13%
Hydro	4%	10%
Import	11%	0%
Renewable energy	10%	18%
Energy efficiency	0%	6%

per capita consumption between China and developed countries such as the United States, the UK, Japan, and Germany. Therefore, China has set a target to increase per capita consumption to 9,000 kWh by 2050; meeting this target would require around 12,000 TWh generated. The contribution of non-fossil-fuel-based generation reached 31 percent of total generation in 2019 and the government aims to increase that figure to 43.5 percent by 2035 and 55 percent by 2050.[60] China's energy transformation plan shows an increase in non-hydro RE-based generation from 8 percent in 2019 to 22 percent by 2035 and 28 percent by 2050.

Thailand: There are many similarities between Thailand's and Bangladesh's power sectors. The Electricity Generating Authority of Thailand, a state-owned utility, owns and operates most of the country's power generation capacity and works as a single buyer. The Government of Thailand encourages private investment in electricity generation through an IPP program set up in 1994. Thailand's installed generation capacity reached 42,835 MW in 2019, of which 14,566 MW (34 percent) is produced by the Electricity Generating Authority, 14,949 MW (35 percent) by IPPs, 9,443 MW (22 percent) by small producers, and 3,878 MW (9 percent) by imported power. According to Thailand's Ministry of Energy, total generation increased from 135,182 GWh in 2009 to 184,577 GWh in 2018. Thailand's power sector relies heavily on natural gas, which had a total share of 57 percent in 2019; the government aims to reduce this share to 53 percent in 2037. According to Thailand's Power Development Plan 2018-2037 (PDP2018), total installed capacity in 2037 is expected to be 77,211 MW to meet projected demand of 367,458 GWh and peak power demand of 53,997 MW. Considering the upcoming retirement of 25,310 MW of capacity, 56,431 MW more capacity will need to be installed by 2037.[61] The Government of Thailand plans to diversify the fuel supply mix through PDP2018 targets to reduce the use of fossil fuels and increase RE use. The PDP2018 aims to increase RE generation from 10 percent in 2019 (excluding hydro) to 18 percent in 2037. The current imported power share (11 percent in 2019) is expected to fall to zero by 2037 and coal-based generation's share is expected to decrease from 18 percent in 2019 to 13 percent by 2037. The PDP2018 clearly aims to improve the country's energy security with targets to minimize dependence on fossil-based generation, reduce imported power and rely on sustainable energy (renewable and energy efficiency).

Including hydropower, renewables are expected to make up 34 percent of electricity generation by 2037. The PDP2018 also highlights strategies to improve energy efficiency in conventional technologies, which will contribute about 6 percent of the total for energy technologies.

Philippines: In the Philippines, RE contributes about 29 percent (526 MW including off-grid) of total generation capacity. Peak demand is expected to increase from 15,422 MW in 2016 to about 49,287 MW in 2040, requiring an additional 43,765 MW. The Philippines' power sector roadmap targets 15.3 GW of renewable-based generation capacity by 2030 and 20 GW by 2040.[62] As of 2019, the country's installed geothermal capacity was 1,928 MW and it aims to become the top geothermal energy producer in the world by increasing geothermal capacity to 75 percent of total capacity before 2030.[63]

58 Electricity Generating Authority of Thailand, *Annual Report 2019.*
59 Ministry of Energy, *Thailand Power Development Plan (2018–2037).*
60 CNPC, *China Energy Outlook 2050.*
61 Asian Development Bank, *Eastern Economic Corridor Independent Power Project Thailand - Sector Overview.*
62 Philippines Department of Energy, *2019 Power Situation Report.*
63 Philippines Department of Energy, *Power Development Plan 2016-2040.*

SCALING UP RENEWABLE ENERGY (SURE)

USAID FROM THE AMERICAN PEOPLE

FOR MORE INFORMATION

Shayan Shafi
Senior Energy Advisor
USAID Bangladesh, Dhaka
SShafi@usaid.gov

Ritesh Kumar Singh
SURE/Bangladesh Activity Lead
Tetra Tech (SURE Implementing Partner)
RiteshKumar.Singh@tetratech.com