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Charting an Electricity Sector Transition Pathway for Bangladesh

Subsidy Burdens and Rising Costs Call for Enhancing Renewable Energy Ambition

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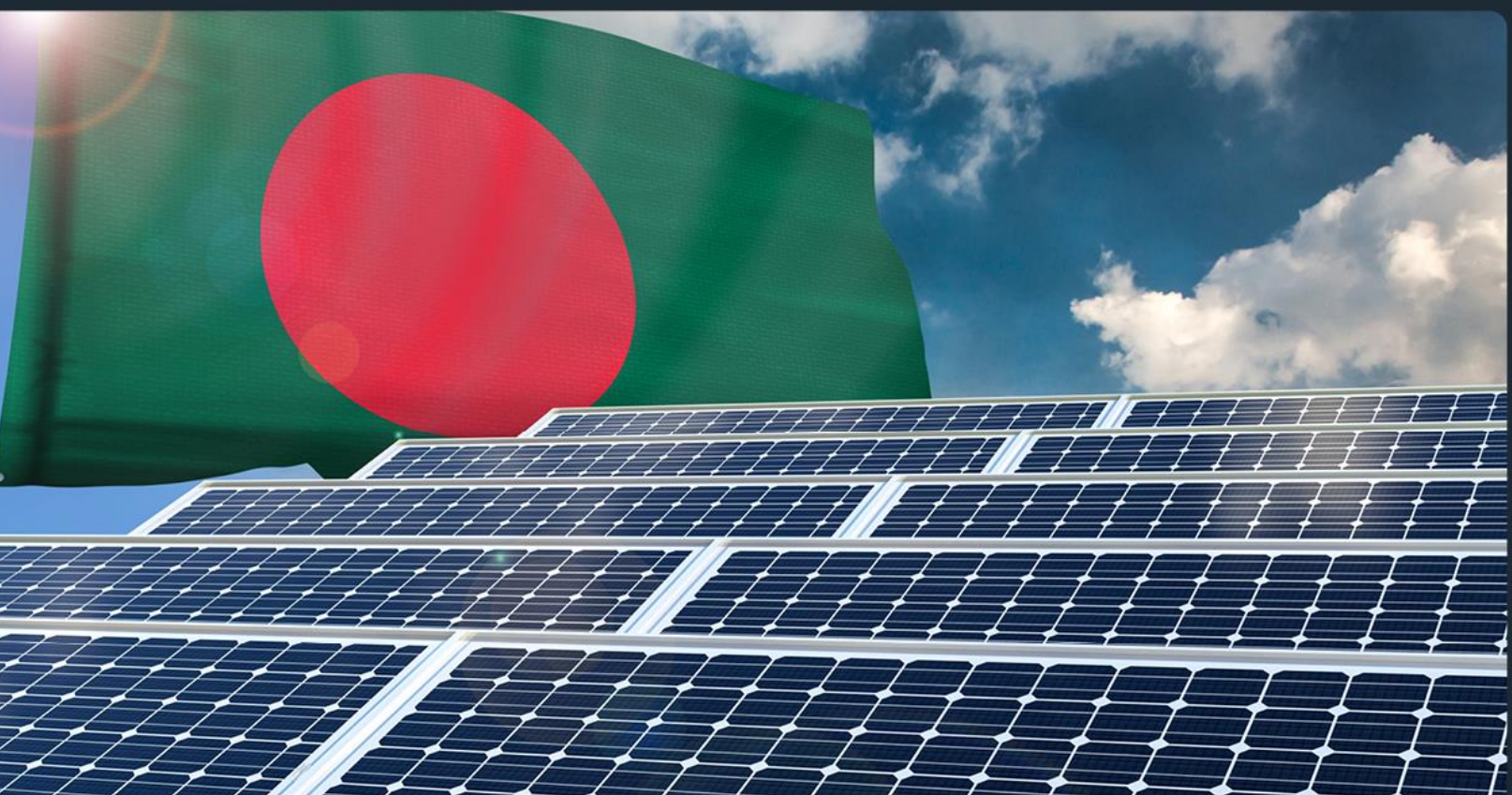

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Key Findings

Bangladesh's existing power system can incorporate 1,700 megawatts (MW) to 3,400MW of solar power during the day and, subject to technical and economic feasibility, 2,500MW to 4,000MW of wind power at night to reduce the use of costly oil-based electricity.

The subsidy burden of Bangladesh's power sector could surpass the US$2.82 billion recorded in FY2021-22.

Average electricity generation cost will likely cross double-digits in Bangladeshi Taka (Tk) terms in FY2022-23.

Enhancing renewable energy capacity to 40% of Bangladesh's power generation capacity by 2041 requires an annual investment of between US$1.53 billion and US$1.71 billion from 2024 onwards.

Executive Summary

Renewable energy capacity addition is the most favourable option for Bangladesh's power system, which suffers from a hefty subsidy burden and overdependence on imported fossil fuels. The Bangladesh government should enhance renewable energy ambition to achieve a higher target like 40% renewable energy capacity by 2041 and reflect the same in the upcoming Integrated Energy and Power Master Plan (IEPMP). It should also set a year-wise action plan backed by a monitoring mechanism to track progress. By our estimates, Bangladesh needs between US$1.53 billion and US$1.71 billion of annual investment from 2024 through 2041, not including the cost of grid modernisation and storage facilities, to meet such a target. This figure is less than the subsidy burden of the power sector in the fiscal year 2021-22. Not only does the country need a plan to mobilise such level of investments from various channels, but the government also needs to take several policy measures to send the right signals to the market about Bangladesh's electricity transition goals.

Bangladesh's grid-based electricity generation capacity increased rapidly from 5,493 megawatts (MW) to 23,482MW over the last 14 years (from 2009 to January 2023). The need for quickly ramping up generation capacity to fill the demand-supply gap and minimise load-shedding prompted the government to resort to imported fossil fuels-based generation, since 2009, amid dwindling local gas supply. The flip side is that the growing reliance on imported fossil fuels will limit the space for renewable energy development.

The power sector of Bangladesh is also grappling with colossal subsidy burdens. For instance, high prices of fossil fuels and increased power generation costs led to a subsidy burden of Bangladeshi Taka (Tk) 297 billion (US$2.82 billion) during the fiscal year (FY) 2021-22, a steep rise of 152% from FY2020-21 and a whopping leap of 301% from FY2019-20.

The burgeoning pressure of fossil fuel imports eventually compels the government to pass the rising cost on to consumers. This results in a spectre of price hikes for electricity and different fuels in quick succession. Despite these price hikes, the subsidy burden of the power sector in FY2022-23 could still surpass the Tk297 billion (US$2.82 billion) recorded in FY2021-22.

The strained power sector indicates that Bangladesh's electricity generation model appears unsustainable. Increasingly competitive renewable energy capacity addition is more favourable for Bangladesh. However, without a clear transition pathway, the fossil fuels-driven electricity generation system will likely stay for the foreseeable future.

There have been some policy lapses in the past. For example, the renewable energy policy of 2008 could not stimulate the uptake of clean energy at the desired level. Further, the Power System

Master Plans (PSMP) of 2010 and 2016 primarily focused on imported fossil fuels, such as coal and liquefied natural gas (LNG).

Now, there are some encouraging signs that utility-scale solar and wind projects are gaining traction. Besides, ballpark estimates show that the levelised cost of electricity (LCOE) from rooftop and utility-scale solar is around Tk5.25/kilowatt-hour (kWh) (US$0.05/kWh) and Tk7.6/kWh (US$0.072/kWh), respectively. This is at a time when the average electricity generation cost of the Bangladesh Power Development Board (BPDB) was Tk8.84/kWh (US$0.084/kWh) during FY2021-22. Notably, the average electricity generation cost will likely cross double-digits in Tk during FY2022-23.

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The electricity sector transition to renewable energy would free up financial resources, which otherwise end up as subsidy payments, and enhance the country's energy security.

The encouraging sign is that the existing power system capacity can incorporate 1,700MW to 3,400MW of solar during the day, representing 7-15% of renewable energy on top of the currently operational grid-scale clean energy capacity. Similarly, Bangladesh could use wind energy capacity ranging from 2,500MW to 4,000MW at night, subject to the feasibility of location and availability of sufficient wind speed. Our analyses of energy curves from March 2022 to February 2023 show that this solar and wind capacity could significantly reduce the use of costly furnace oil-based power generation.

Alongside additional wind and solar capacity, Bangladesh should develop an ecosystem for introducing energy storage systems to address the variability of renewable energy and utilise clean energy around the clock. Despite the current high cost, the decreasing cost trajectory indicates energy storage systems will be competitive in the future.

The exigencies and opportunities of the power sector mean that the policymakers should raise renewable energy ambition and reflect the same in the upcoming Integrated Energy and Power Master Plan (IEPMP). As the Bangladesh government is preparing the renewable energy policy, this would be the best opportunity to set a clear goal like 40% renewable energy promotion by 2041. Then, the government can translate the policy target into a year-wise action plan backed by a monitoring mechanism to track progress.

It is important to note that renewable energy projects are capital hungry. On a rough estimate, achieving a 40% renewable energy capacity target could cost Bangladesh between US$1.53 billion and US$1.71 billion annually from 2024 through 2041, not including the cost of grid modernisation and storage facilities. The yearly investment needed in renewable energy technologies is less than the BPDB's revenue shortfall in FY2021-22. At the same time, Bangladesh needs to modernise its grid to meet the growing need for quality electricity supply.

Stimulating the investment consistently until 2041 requires Bangladesh to have a map of funding channels, including local resources and international sources like multilateral agencies, climate funds and global pension, private equity and infrastructure funds.

> **Drawing lessons from Indonesia and Vietnam's Just Energy Transition Partnership, Bangladesh could explore the possibility of striking deals with developed countries to arrange finance for transforming its electricity sector.**

Drawing lessons from Indonesia and Vietnam's Just Energy Transition Partnership, Bangladesh could explore the possibility of striking deals with developed countries to arrange finance for transforming its electricity sector. Additionally, rapid implementation of renewable energy projects would posit the need for designing conducive instruments.

Experience from India substantiates that risk mitigation measures, such as risk guarantee funds, will shield the project developers. Furthermore, competitive renewable energy procurement through auctions will help reduce renewable energy tariffs and help Bangladesh contain the rising electricity generation cost.

An assessment of Vietnam's renewable energy revolution demonstrates that the current tariff for industries in Bangladesh, after three rounds of upward adjustments, is much better than what the Southeast Asian nation offers to industries for solar energy. Therefore, from a financial perspective, Bangladesh's industries should find the prevailing situation highly feasible to use rooftop solar.

The government should lift the current cap on rooftop solar installation capacity of up to 70% of the sanctioned load of industrial and commercial buildings to enhance the country's renewable energy capacity. The government should also waive applicable duties on fibre-reinforced polymer (FRP) walkways, imported inverters, mounting structures and direct current (DC) cable, ranging from 15.25% to 58.6%, for rooftop solar projects. This will send the right market signals about the government's vision for the electricity sector's transition.

As the difficulty in identifying suitable land hinders the uptake of large-scale renewable energy projects, earmarking land for such projects will accelerate the electricity sector transition in Bangladesh.

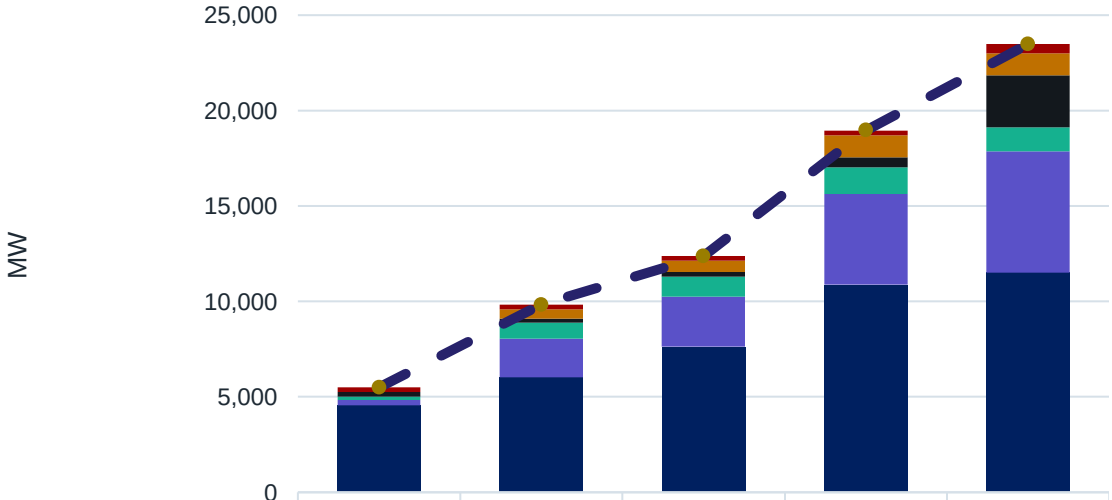
While such a transition will require sustained efforts and investment over a long period, making little or no attempt at renewable energy expansion will be an even bigger risk for Bangladesh.

The Electricity Sector Shifts to Reliance on Imported Fossil Fuels

Bangladesh's electricity sector changed rapidly between 2009 and 2023, driven mainly by a quick-fix strategy and the ambition to ensure electricity security.

In 2009, the installed electricity generation capacity was only 5,493 megawatts (MW). With 82.7% contribution, local natural gas dominated the energy mix of the electricity grid, followed by oil (8.6%), coal (4.6%) and hydropower (4.2%).[1]

Figure 1: Changes in Installed Power Generation Capacity and Energy Mix, 2009 – 2023 (January)



	2009	2013	2016	2019	2023 (Jan)
Renewable Energy including Hydro	230	230	230	260	489
Import	0	500	600	1,160	1,160
Coal	250	200	250	524	2,692
Diesel	191	825	1,028	1,370	1,290
Furnace oil	280	2,050	2,629	4,770	6,329
Gas	4,542	6,016	7,628	10,877	11,522
Total	5,493	9,821	12,365	18,961	23,482

Source: Bangladesh Power Development Board (BPDB)

The gap between the maximum demand for and supply of electricity in 2009 was as high as 20.9%. Moreover, only 47% of the population had access to electricity.[2] These factors, and the goal of keeping the economy afloat, prompted the government to ramp up generation capacity quickly.

[1] Bangladesh Power Development Board (BPDB). Annual Report 2008-09. 1 August 2008.
[2] World Bank. In the Dark: How Much Do Power Sector Distortions Cost South Asia?. 2019.

As of 8 January 2023, government measures have increased installed electricity generation capacity by around five-fold to 23,482MW, excluding off-grid and captive units.[3]

Of the total installed capacity (23,482MW), 49% comes from gas, more than 32% from oil, 11% from coal-fired plants and 5% from cross-border imports. On-grid renewable energy has a small share of 2.5% (489MW), of which 259MW is solar and 230MW is hydropower (see Figure 1).

Oil-based plants rely on imported fuels. Likewise, coal-fired plants run on imported fuel, except the 525MW Barapukuria power station, which uses local coal.

The government also started to import liquefied natural gas (LNG) in 2018 to meet the increasing demand for gas in power generation, industries, households and other sectors.[4]

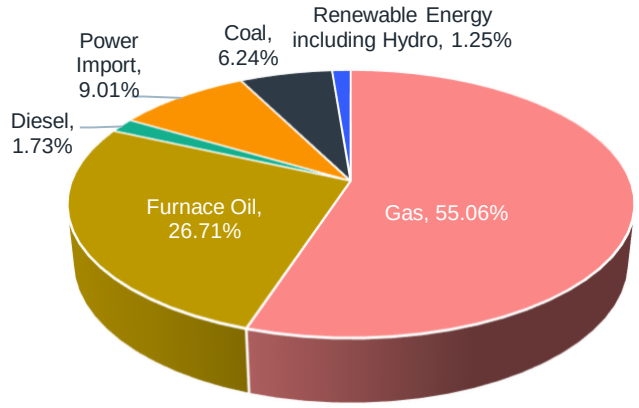
The electricity sector eventually experienced a shift towards an increasing reliance on imported fossil fuels in the energy mix. The initiative for enhancing local gas exploration could not keep pace with the rising demand for gas. At the same time, the country has had limited success in exploiting renewable energy at scale.

Energy Mix in Power Generation

The trend in the energy mix of Bangladesh's power generation is similar to that of the installed capacity. In FY2021-22, gas-fired plants generated 55% of the total power in the country, followed by oil (more than 28%), coal (around 6%) and renewable energy (1.25%). Bangladesh imported its remaining power requirement from India (see Figure 2).

[3] BPDB. Key Statistics. 9 February 2023.
[4] The Daily Star. Country Enters LNG Era. 24 April 2018.

Figure 2: Energy Mix in Power Generation 2021-22

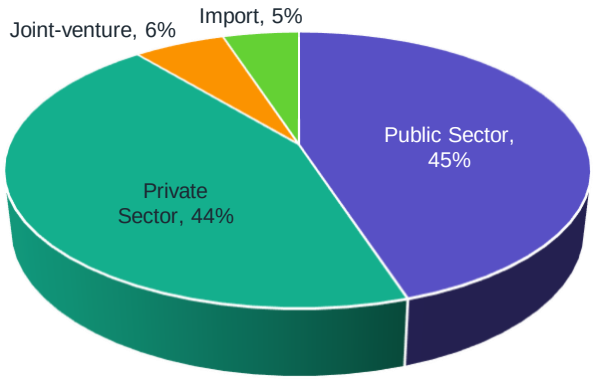


Source: BPDB Revised Annual Report 2021-22

Ownership of Different Power Plants

The public sector currently owns almost half of the power plants (45%). The Bangladesh Power Development Board (BPDB) has a major share, and government-owned companies own the remaining power plants. Private sector plants, including Independent Power Producers (IPPs) and rental plants, have a combined share of 44%. The rest of the capacity comes from joint-venture units implemented by Bangladesh and other countries and cross-border imports (see Figure 3). However, the BPDB, apart from its generation, is the sole buyer of all electricity generated in the power plants.

Figure 3: Power Plant Ownership Category (February 2023)



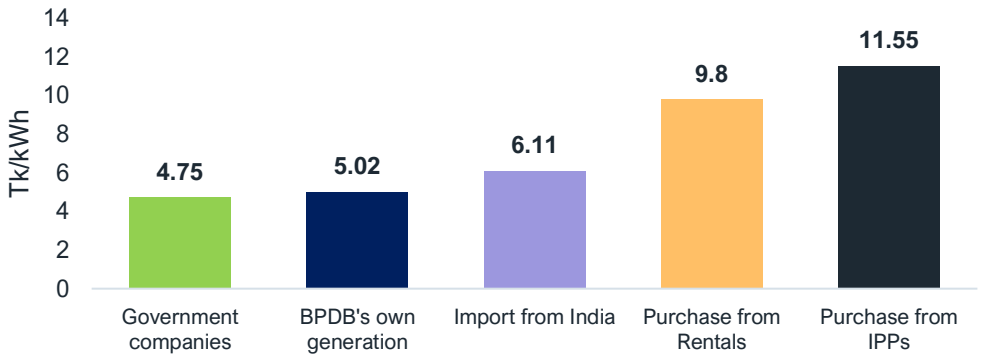
Source: BPDB Key Statistics

Cost of Power Generation by Plant Ownership

Notably, in FY2021-22, power plants of the government-owned companies and BPDB generated the least cost electricity in the country, with the average cost ranging from Bangladeshi Taka (Tk) 4.75/kilowatt-hour (kWh) (US$0.045/kWh) to Tk5.02/kWh (US$0.048/kWh). Cross-border import was also competitive at Tk6.11/kWh (US$0.058/kWh).

However, power from rental plants and IPPs was very costly at Tk9.8/kWh (US$0.093/kWh) and Tk11.55/kWh (US$0.11/kWh), respectively (see Figure 4).[5] Therefore, Bangladesh can reduce its average power generation cost by replacing rental plants and IPPs, which run on costly fossil fuels.

Figure 4: Average Power Generation Cost by Plant Ownership, 2021-22



Source: BPDB

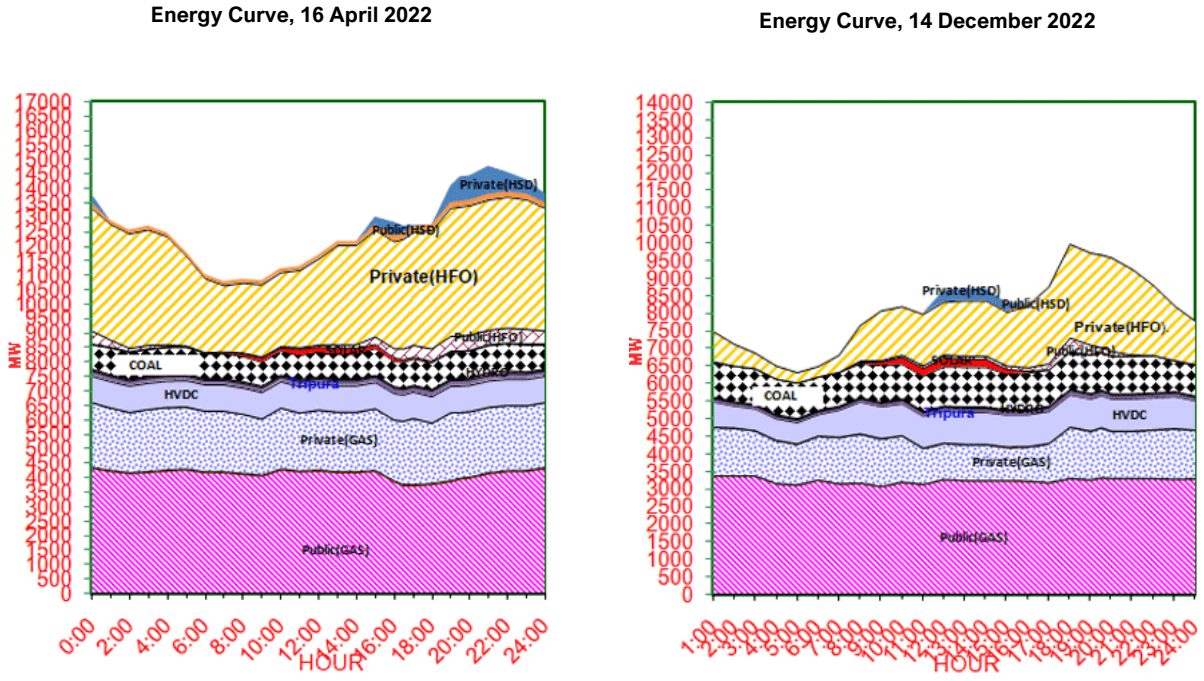
High Dependence on Costly Oil-Fired Power Plants

A closer inspection of Bangladesh's energy curves during the summer and winter of 2022-23 shows that the country used private furnace oil-fired plants significantly to meet energy demands (see Figure 5).[6] Based on the BPDB annual report, electricity generation data from different plants substantiate that furnace oil-based electricity is exorbitantly expensive. Costly diesel-run plants also helped meet the peak energy demands.

The heavy use of expensive furnace oil in power generation beyond the demand, met by gas, coal, renewable energy and imports, makes a convincing case to harness variable solar energy during the daytime to reduce furnace oil-based generation. Solar energy thus has the potential to rein in the country's rising cost of power generation. Similarly, utilising wind energy at night to cut down on expensive oil-fired plants can be an option.

[5] BPDB. Annual Report 2021-22. 27 November 2022.
[6] BPDB. Daily Generation Archive. 28 February 2023.

Figure 5: Sample Energy Curves for Bangladesh



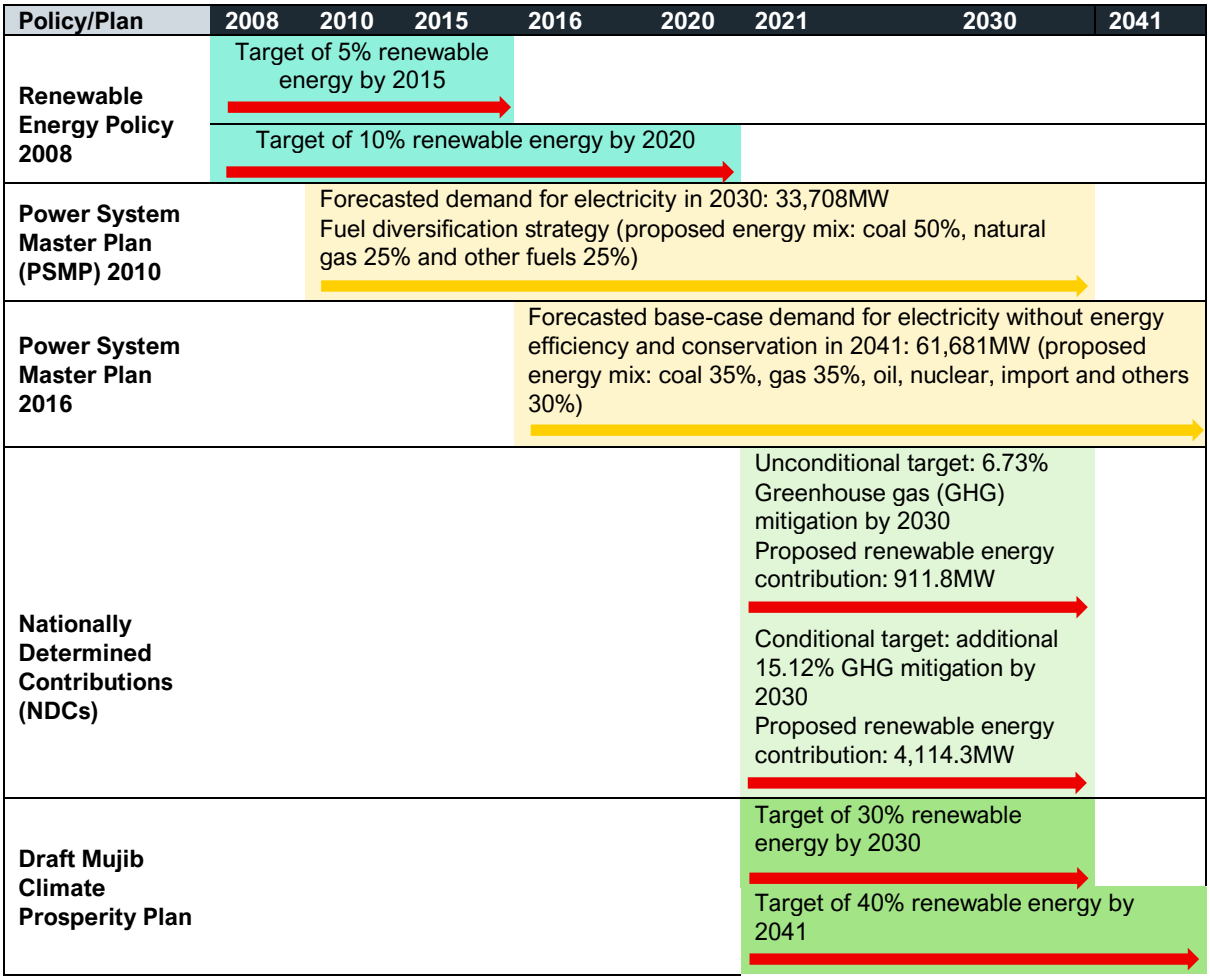
Source: BPDB Daily Generation Archive

Existing Policy Framework for the Electricity Sector Transition

The Bangladesh government crafted the country's renewable energy policy in 2008, stipulating the target of generating 5% and 10% of electricity from renewable energy sources by 2015 and 2020, respectively.[7] However, against the backdrop of the electricity crisis in 2009, the government started to increase oil-based quick-rental and rental power plants to fill the demand-supply gap.[8]

[7] Ministry of Power, Energy and Mineral Resources. Renewable Energy Policy of Bangladesh. 18 December 2008.
[8] The National Bureau of Asian Research. Toward a Sustainable Energy Pathway for Bangladesh. 4 August 2022.

Figure 6: Relevant Policies for the Electricity Sector Transition in Bangladesh



Source: Renewable Energy Policy 2008; Power System Master Plans 2010 & 2016; Nationally Determined Contributions (NDCs) 2021 Bangladesh and Mujib Climate Prosperity Plan

In 2011, the Bangladesh government formulated the Power System Master Plan (PSMP) 2010, a long-term power sector development plan until 2030. It developed the plan with a strategy to diversify fuels in the country's power generation system in the face of an imminent local gas crisis.[9] The PSMP in 2010 recommended an energy mix comprising 50% coal and 25% gas-based generation for the forecasted demand of 33,708MW in 2030. Further, the plan recommended using a combination of energy sources, like oil, nuclear, renewable energy and cross-border imports, to fulfil the remaining 25% of demand.

[9] Ministry of Power, Energy and Mineral Resources. Power System Master Plan 2010. February 2011.

While the share of oil started to increase in the energy mix of the power sector swiftly in the years following the release of the PSMP in 2010, Bangladesh began to sign deals for coal-fired power plants.[10]

The government later revised the PSMP and released a follow-up version in 2016.[11] It projected an electricity demand of 61,000MW in 2041 under the base scenario, excluding energy efficiency and conservation measures. The PSMP of 2016 identified that the best fuel mix for Bangladesh's power system would be to generate 70% of electricity from coal and gas (35% each). The other 30% of capacity would come from oil, nuclear, renewable sources and cross-border imports.

Eventually, the PSMP of 2016 provided the impetus to increase coal-fired generation capacity and cross-border electricity imports. In addition, in the face of the local gas shortage, the government started to import LNG, as the PSMP of 2016 prescribed.

Although Bangladesh has enhanced its ambition in the revised Nationally Determined Contributions (NDCs) to reduce greenhouse gas (GHG) emissions, it assumes renewable energy's contribution at only 911.8MW to meet the unconditional target.[12]

Meanwhile, the draft Mujib Climate Prosperity Plan has laid ambitious renewable energy targets of 30% and 40% by 2030 and 2041, respectively.[13]

Notably, a lack of success in utility-scale renewable energy deployment over a decade from 2008 to June 2018, following the formulation of the renewable energy policy in 2008, raised concerns about the real possibility of implementing renewable energy at scale in the country.

For example, the first utility-scale renewable energy project of 28MW capacity came online only in July 2018.[14] On the other hand, hydroelectric power plants with an aggregate capacity of 230MW came online during 1962-88, and even the solar home programme comprising 216.75MW of off-grid systems came online before the utility-scale project.[15,16]

Apart from the high cost of renewable energy technologies, various challenges, such as limited planning, land constraints, doubts over renewable energy potential, lack of suitable finance, absence of standard renewable energy procurement process, and insufficient institutional capacity, can explain the lack of successful utility-scale renewable energy project development in the past.[17]

[10] The Economic Times. Bangladesh and India Sign Agreement for Joint Coal Fired Power Plant. 12 July 2016.
[11] Ministry of Power, Energy and Mineral Resources. Power System Master Plan 2016. September 2016.
[12] Ministry of Environment, Forest and Climate Change. Nationally Determined Contributions (NDCs) 2021 Bangladesh (Updated). 26 August 2021.
[13] Government of Bangladesh. Mujib Climate Prosperity Plan Decade 2030. September 2021.
[14] PV Magazine. Proinso Collaborates with Joules Power on the First Utility Scale Solar Project in Bangladesh. 5 July 2018.
[15] Global Energy Observatory. Karnafuli Hydroelectric Power Plant Bangladesh. 14 September 2016.
[16] The Financial Express. Trend in Renewable Energy Use in Bangladesh. 28 August 2017.
[17] Tetra Tech ES, Inc. Challenges in the Development of Variable Renewable Energy in Bangladesh. June 2020.

For instance, despite interest in deploying renewable energy, the government had limited planning on the pathway to ramp up utility-scale renewable energy.

The land constraint is a significant challenge in realising utility-scale renewable energy projects. While renewable energy projects cannot come up on agricultural land, there are no studies to earmark land for renewable energy projects, avoiding disruptions in agricultural production.

Local banks lack experience in financing large-scale renewable energy projects and have limited interest in financing projects for a tenure of more than five years.

The procurement process of renewable energy involves the acceptance of unsolicited proposals. Bidding has a minimal time frame. Moreover, reportedly, project developers need to collect more than 40 clearances from different government departments to get approval for utility-scale renewable energy projects.[18]

Additionally, given that solar has the highest potential in the country, the variable nature of solar energy raised concerns about how to utilise this energy at a large scale.

Hence, the country's power system hinged on coal, oil and LNG-based development amid local gas scarcity.

Rationale of Designing an Electricity Sector Transition Pathway

The mainstream power sector development pathway, which centres on fossil-fuel-based capacity addition, is rapidly worsening the sector in multiple ways.

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The power sector is increasingly caught in the grip of the global energy market, raising serious energy security and cost concerns. Meanwhile, consumers suffer from the burden of expensive electricity. Despite tariff hikes, subsidy burdens on the government continue to mount every year.

Overall, the existing development pathway of the power sector has impacted the country indelibly and now provides a wake-up call to design a transition pathway for increasing the integration of affordable renewable energy.

[18] Tetra Tech ES, Inc. Challenges in the Development of Variable Renewable Energy in Bangladesh. June 2020.

Energy Security Remains the Prime Concern

Many problems in Bangladesh's power sector today emanate from the increasing reliance on imported fossil fuels. For instance, the country generated 28.44% of its electricity in FY2021-22 from power plants that run on imported furnace oil and diesel (see Figure 2).

The Payra power plant needs four million tonnes of imported coal annually.[19] As the Rampal power plant has a similar rated capacity to the Payra plant, it will need another four million tonnes of imported coal to operate at full capacity. Moreover, Bangladesh imports LNG to meet 20% of its gas demand.[20]

Overdependence on imported fossil fuels has left Bangladesh scathed as it encounters increasing difficulty in ensuring fuels for its power plants amid dwindling foreign currency reserves and declining local currency value.[21]

For example, Bangladesh needs US$4.45 billion for the cost of fuels for uninterrupted power supply from February to June 2023.[22]

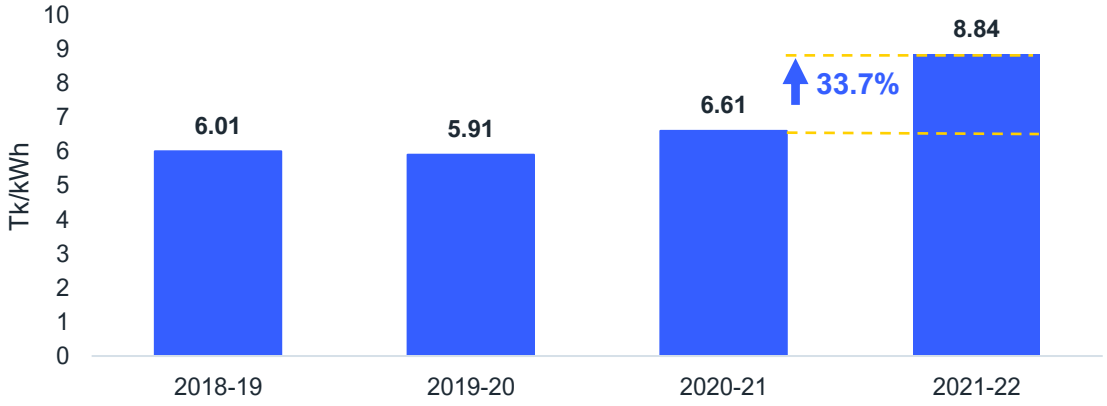
All of the above call for an urgent overhaul of power sector development with greater integration of renewable energy to enhance the country's energy security.

The Rising Cost of Electricity Generation

The average cost of BPDB's electricity generation and purchase from other power plants in FY2021-22 stood at Tk8.84/kWh (US$0.084) against Tk6.61/kWh (US$0.063/kWh) in FY2020-21.[23] Within a year, the BPDB saw a massive 33.7% increase in power generation cost (see Figure 7). The international market's expensive and unaffordable fossil fuels compelled the government to hike gas prices.

[19] IEEFA. Ramping up Clean Energy Will Help Bangladesh Reduce Its Reliance on Imported Fossil Fuels. 16 February 2023.
[20] IEEFA. Global LNG Outlook 2023-27. 15 February 2023.
[21] IEEFA. Renewable Energy May Provide South Asia Relief from Energy Price Shocks. 14 February 2023.
[22] The Daily Star. Power Supply During Summer: At Least $4.45b Needed to Cover Fuel Costs. 16 February 2023.
[23] BPDB. Annual Report 2020-21. 14 October 2021.

Figure 7: Trend of Rising Average Power Generation Cost



Source: Bangladesh Power Development Board Annual Reports 2018-19 to 2021-22

Analysis shows that the hike in gas price has increased the BPDB's gas-based electricity generation cost by Tk2/kWh (US$0.02).[24] Electricity generated by fossil fuel based-IPPs is already expensive. In FY2021-22, the BPDB purchased electricity mostly from fossil fuel-based IPPs at an average cost of Tk11.55/kWh (US$0.11/kWh) (see Figure 4).

Electricity from coal-fired plants is not cheap either. As such, the average cost of electricity for FY2022-23 is likely to cross double digits compared to Tk8.84/kWh (US$0.084) in the previous FY.

With no immediate respite from the rising power generation cost, the government has adopted a strategy to pass the cost on to the consumers. As part of that, the government raised the tariffs for electricity twice by 5% in January 2023, effective 1 February 2023.[25] The government has further increased electricity prices by 5%, effective 1 March 2023.[26]

On the other hand, ballpark estimates show that the levelised costs of electricity (LCOE) from rooftop and utility-scale solar are around Tk5.25/kWh (US$0.05/kWh) and Tk7.6/kWh (US$0.072/kWh), respectively.

Contrary to a decade ago, grid-tied solar projects are now gaining momentum. Some utility-scale solar projects are nearing completion. For example, the BPDB recently signed a Memorandum of Understanding (MoU) with a Saudi Arabian company for implementing a 1,000MW solar project.[27]

[24] IEEFA. Ramping up Clean Energy Will Help Bangladesh Reduce Its Reliance on Imported Fossil Fuels. 16 February 2023.
[25] The Business Standard. Consumers cornered as electricity price hiked again – twice in 20 days. 31 January 2023.
[26] The Daily Star. Electricity Price Hiked Again by 5pc. 1 March 2023.
[27] The Daily Star. Saudi Firm Signs Deal with BPDB to Set up 1000 MW Solar Power Plant. 29 November 2022.

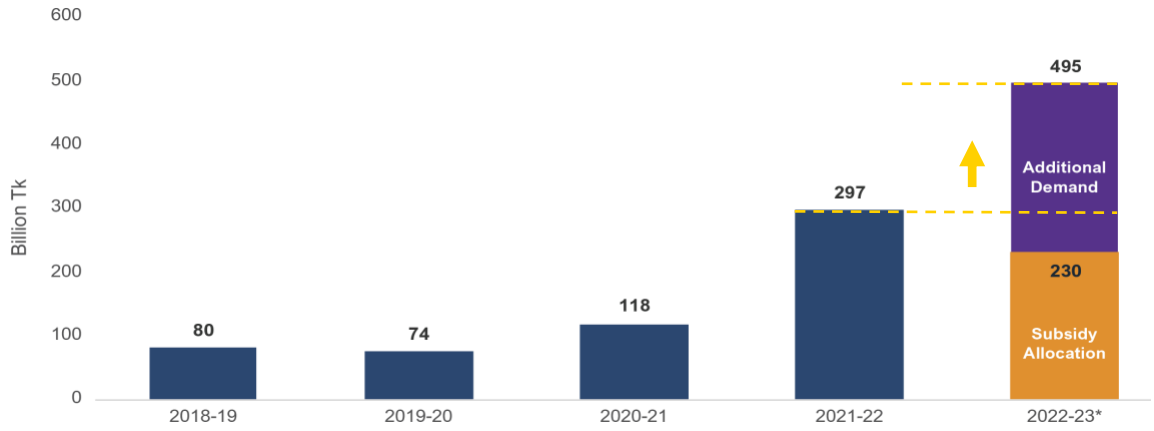
Bangladesh's largest grid-scale renewable energy project of 230MW should be online soon. In this project, the developer raised funds from Green Sukuk, similar to green bonds.[28] Additionally, a couple of wind power projects are in different stages of construction.

While the elevated power generation cost is a reminder to make significant strides towards deflationary renewable energy promotion in Bangladesh, the situation also seems favourable as the country can now build on its experience of grid-scale renewable energy projects.

Growing Subsidy Burden for the Government

As Figure 8 depicts, the power sector of Bangladesh continues to depend on increasing subsidies, with an exception in FY2019-20 compared to FY2018-19.[29] During FY2021-22, the BPDB registered a hefty operating loss, and as such, the subsidy burden rose to Tk297 billion (US$2.82 billion), an increase of 152% from FY2020-21.[30] Compared to FY2019-20, the subsidy amount for FY2021-22 was 301% higher.[31]

Figure 8: Trend of Subsidy Burden



*Source: BPDB Annual Reports 2018-19 to 2021-22; * The Business Standard*

Despite three electricity price hikes of 5% each in the first two months of 2023, the government would still have huge revenue shortfalls in the power sector in FY2022-23.

The total subsidy burden could exceed the amount provided by the government in FY2021-22. While the Power Division asked for an allocation of Tk325 billion (US$3.1 billion) on top of the initial budget allocation for the power sector subsidy of Tk170 billion (US$1.62 billion), the government has recently approved an additional budget of Tk60 billion (US$0.57 billion) instead.[32] The subsidy

[28] PV Magazine. Green Bond in Bangladesh Attracts Investors in Trading Debut. 14 January 2022.
[29] BPDB. Annual Report 2018-19. 9 October 2019; BPDB. Annual Report 2019-20. 15 October 2020.
[30] BPDB. Annual Report 2021-22. 27 November 2022; BPDB. Annual Report 2020-21. 14 October 2021.
[31] BPDB. Annual Report 2019-20. 15 October 2020; BPDB. Annual Report 2021-22. 27 November 2022.
[32] The Business Standard. Subsidy Burden Balloons on War. 22 March 2023.

burden, which now stands at Tk230 billion (US$2.19 billion), will likely surpass the previous FY's subsidy despite the recent tariff adjustment.

> **Without rapid integration of cheaper renewable energy in the power system, Bangladesh will suffer a double whammy of a hefty subsidy burden and soaring power generation costs.**

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Renewable Energy can Help Reduce Oil-Based Power Generation

Where does variable renewable energy fit within the existing power system that runs mostly on gas and oil, followed by coal, cross-border imports and a meagre quantity of clean energy?

To address this, we analyse the energy curves of three days per month over one year, from March 2022 to February 2023. We divide the period into summer and winter to understand power demand patterns clearly. Further, we conduct the analysis at three different times of the day and night.

For instance, we point out the energy demands at 9:30am and 4pm of a day and the maximum energy demand between 9:30am and 4pm served by the BPDB.

We compare these numbers with energy demands fulfilled by gas, coal, cross-border imports and renewable energy at 9:30am, 4pm, and when the BPDB serves the maximum demand to roughly estimate the amount of oil-based power consumption during a day.

We conduct a similar exercise from 6pm to 12am for both winter and summer. These provide a clear impression of the potential of variable renewable energy to replace expensive oil-based power generation.

Energy Curve Analysis from March to October 2022

Bangladesh used gas, coal-based power plants, renewable energy and cross-border imports to generate power of around 6,267MW to 8,133MW at 9:30am in the summer season (see Figure 9).

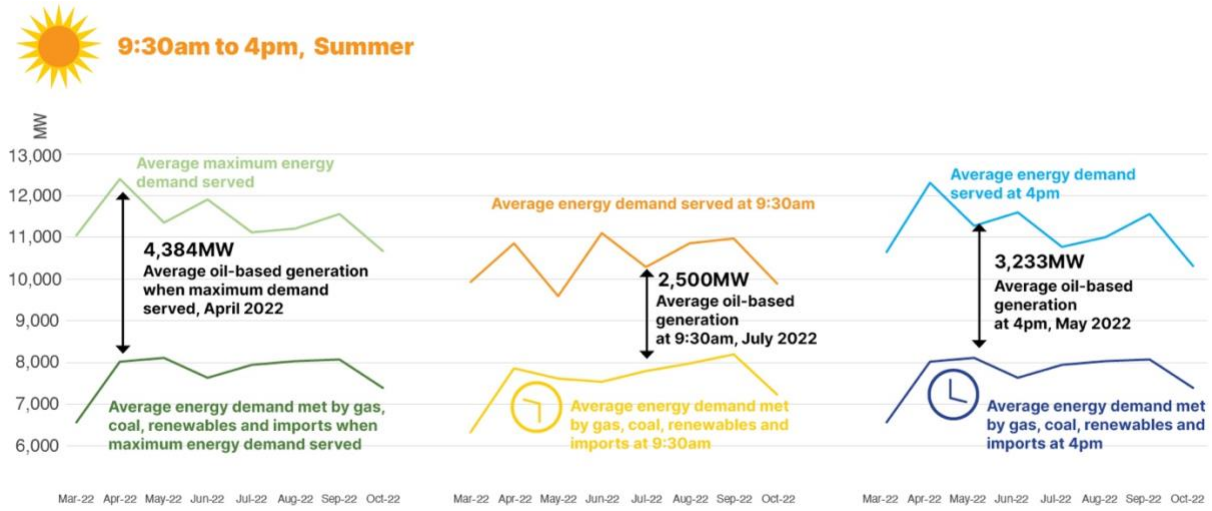
Meanwhile, the average energy demand served by the BPDB at the same time ranged from roughly 9,533MW to 11,050MW. Electricity generated by furnace oil-based plants met this gap between the energy demand served by the BPDB and the demand met by gas, coal, renewable energy and imports. In the case of high electricity demand, even diesel-fired plants filled in the gap alongside furnace oil-based plants.

Similarly, the average energy demand served by the BPDB at 4pm was hovering from 10,267MW to 12,267MW, of which gas, coal, clean energy and imports met 6,550MW to 8,033MW. The remaining energy demands came from furnace oil and diesel-run power plants.

From 9:30am to 4pm during the summer season, Bangladesh's maximum average energy demand ranged from 10,633MW to 12,367MW, where gas, coal, clean energy and imports supplied 6,517MW to 8,067MW.

A detailed data assessment substantiates that from 9:30am to 4pm in the summertime, average oil-based power generation was roughly 3,400MW, depending on the month (see Table 1 in Annex). As oil-fired power plants generate costly electricity and sunlight remains available from morning until 4pm, Bangladesh could comfortably reduce the oil-based generation from 9:30am to 4pm by utilising 3,400MW of variable solar energy.

Figure 9: Variations in Energy Demands Served vs Energy Demands Met by Gas, Coal, Renewables and Imports from 9:30am to 4pm (Summer, March 2022 to October 2022)



Source: BPDB Daily Generation Archive and IEEFA Analysis

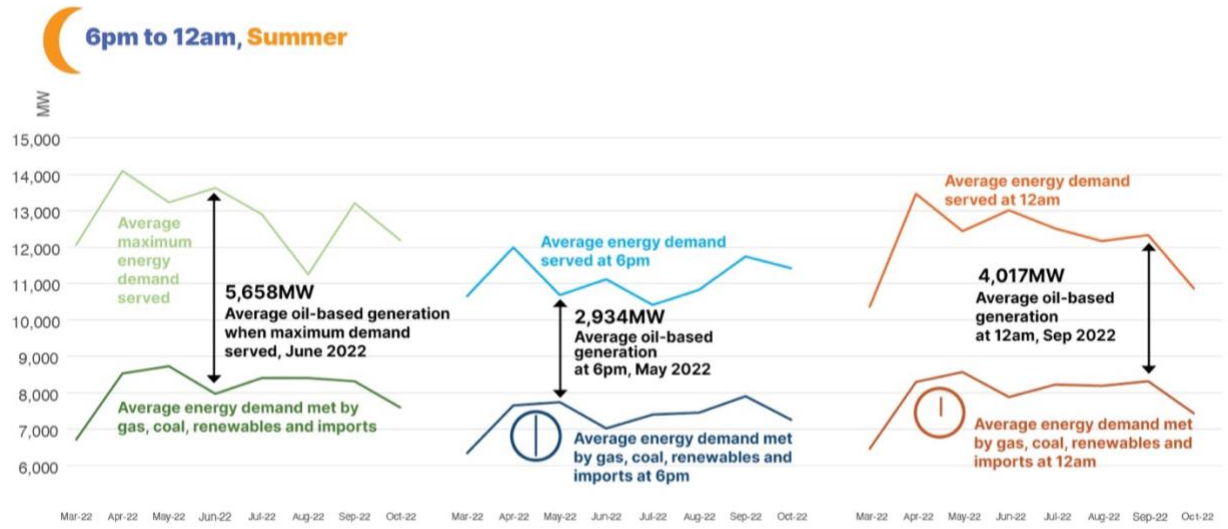
Bangladesh's energy demand peaks between 6pm and 12am in the summer (see Figure 10). Data for six hours from 6pm to 12am of the summer season shows that the average monthly energy demand ranged roughly from 10,400MW to 11,983MW and 10,433MW to 13,550MW at 6pm and 12am, respectively. The maximum energy demand served was 14,782MW on 16 April 2022.

The average energy demand fulfilled by gas, coal, and hydroelectric plants and imports hovered from 6,317MW to 7,883MW and 6,533MW to 8,650MW at 6pm and 12am, respectively, depicting that a large amount of energy came from oil-based power plants.

Overall, the average contribution of oil-fired plants from 6pm to 12am during the summer was over 4,000MW (see Table 2 in Annex). This high level of oil-based power generation at night represents

the opportunity to harness wind energy to replace part of the oil-based power. Utilising wind energy depends on the feasibility of location and other parameters.

Figure 10: Variations in Energy Demands Served vs Energy Demands Met by Gas, Coal, Renewables and Imports from 6pm to 12am (Summer, March 2022 to October 2022)

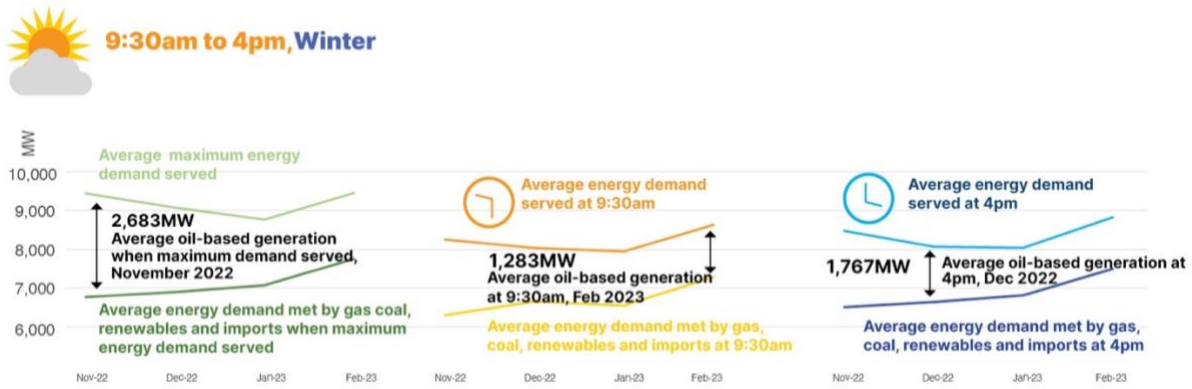


Source: BPDB Daily Generation Archive and IEEFA Analysis

Energy Curve Analysis from November 2022 to February 2023

The average energy demand from 9:30am to 4pm from November 2022 to February 2023 (winter season) was approximately between 8,000MW and 9,350MW (see Figure 11). Gas, coal, renewable energy and energy imports helped Bangladesh meet average energy demand between 6,300MW and 7,650MW. The average energy demand met by oil-based power plants was over 1,700MW, representing the opportunity to utilise solar energy to cut down the use of oil in power generation (see Table 3 in Annex).

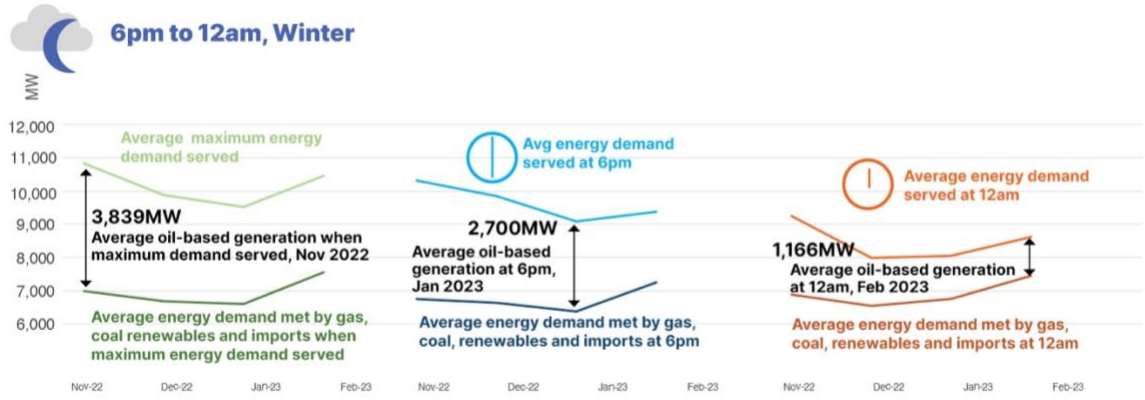
Figure 11: Variations in Energy Demands Served vs Energy Demands Met by Gas, Coal, Renewables and Imports from 9:30am to 4pm (Winter, November 2022 to February 2023)



Source: BPDB Daily Generation Archive and IEEFA Analysis

Finally, the assessment of energy curves from 6pm to 12am during the winter substantiates that the average contribution of oil-fired plants was more than 2,500MW (see Figure 12 and Table 4 in Annex). Dependence on oil-based power can reduce if wind power is found feasible.

Figure 12: Variations in Energy Demands Served vs Energy Demands Met by Gas, Coal, Renewables and Imports from 6pm to 12am (Winter, November 2022 to February 2023)



Source: BPDB Daily Generation Archive and IEEFA Analysis

Within the existing installed power generation capacity of 23,482MW, there is a realistic possibility of utilising 3,400MW of solar capacity for daytime application during the eight months of summer to reduce expensive oil-based power generation. In the winter, solar could replace more than 1,700MW of oil power generation. Thus, Bangladesh could add renewable energy capacity of 7-15% to the existing power system beyond the current clean energy capacity of less than 3%.

The energy curves of different months also demonstrate that all gas-fired plants were not in use as baseload plants. Solar energy could reduce the application of gas-fired plants not operated as

baseload plants. Therefore, the solar potential within the current power system can be more than 3,400MW during the summer. Bangladesh could thus reduce oil and gas-based power generation, free up resources for alternative use and minimise subsidy burdens.

On the other hand, the existing power system allows the reduction of roughly 2,500MW to 4,000MW of oil-based generation at night, contingent upon the technical viability of wind power systems.

While the energy curve analyses specify the scope to incorporate variable solar energy for daytime use and wind energy during the night, subject to feasibility, energy storage facilities could address the variability of renewable energy to ensure the round-the-clock availability of electricity.

While battery energy storage systems are still expensive, the downward cost trajectory is likely to make the technology financially viable in the foreseeable future. Bangladesh could immediately work on creating an enabling environment for grid-scale energy storage applications keeping an eye on the future price trend of storage systems.

Meeting Climate Pledges

In the wake of the ratcheting up of different countries' ambitions for climate change mitigation in 2021, Bangladesh increased its greenhouse gas (GHG) mitigation targets. As part of the revised NDC, Bangladesh must unconditionally reduce 26.31 million tonnes of GHG emissions from the energy sector alone by 2030.[33]

In this vein, a rooftop solar capacity of 2,000MW operating four hours per day for 350 days a year can roughly reduce 15 million tonnes of CO_2 from 2023 to 2030. Alongside this, another 2,000MW of utility-scale solar, without battery storage systems, can reduce a similar quantity of CO_2 emissions and help achieve the unconditional GHG mitigation goal of the energy sector under the NDC by 2030.

The combination of renewable energy sources can include rooftop solar and utility-scale solar for daytime applications, along with wind energy for evening-time applications, subject to feasibility. In the future, storage systems will help Bangladesh attain more emission reductions.

Lessons from Other Countries

The global fossil fuel crisis caused by the Ukraine-Russia conflict has reignited the argument of strengthening Bangladesh's energy security and reducing its dependence on imported fossil fuels.

It is increasingly evident that renewable energy is paramount in addressing energy security challenges. For instance, India is considerably reducing costly fossil fuel consumption by riding on

[33] IEEFA. Time to Make Rooftop Solar Shine in Bangladesh. 6 December 2022.

solar energy. This shows that more investment in renewable energy would reduce Bangladesh's exposure to the international fossil fuel market and improve the health of its power sector.

India's Clean Energy Investment Pays Off

India's aggregate installed renewable energy capacity was 168.96 gigawatts (GW), including large hydroelectric power plants, as of February 2023. Of the installed capacity, 64.38GW is solar energy, and 42.01GW is wind energy.[34]

Owing to solar energy, during the first half of 2022, India saved fuel bills worth US$4.2 billion, which helped the country avoid the need for 19.2 million tonnes of coal and relieve pressure on the already strained supply of local coal.[35]

A closer inspection of India's success in renewable energy shows that strong policies are helping renewable energy thrive. For instance, in 2015, India set an ambitious target of attaining 175GW of renewable energy by 2022. Reportedly, in May 2017, India's installed renewable energy capacity reached 57GW, more than double that of 2013.[36] India's current goal is to increase renewable energy capacity to 500GW by 2030.[37] This is a testament to India's sustained policy measures for promoting renewable energy.

The present state of achievement in renewable energy is a combination of different instruments and enabling factors. Among other things, the Indian Renewable Energy Development Agency (IREDA) supported renewable energy development through the Credit Enhancement Scheme, the Credit Guarantee Scheme, Payment Security Mechanism, risk mitigation instruments and bridge loans etc.[38]

Indian states must also fulfil the renewable energy purchase obligation (RPO), which currently stands at 25% of their energy needs. The RPO target will increase to 43% by 2030.[39]

Furthermore, India introduced auctions as early as 2010 to reduce the cost of renewable energy-based electricity and attract private capital. While the cost of electricity from solar energy was US$0.17/kWh in 2010, it fell to US$0.0315/kWh by 2020.[40]

It is also evident that the private sector provided a significant impetus in the growth of India's renewable energy sector. The price volatility of coal in 2021 and energy security concerns motivated private sector business entities to focus on cleaner, affordable and reliable renewable energy.[41]

[34] Ministry of Power, Government of India. Power Sector at a Glance All India. 28 March 2023.
[35] The Economic Times. India Saved over USD 4 Bn in Fuel Costs through Solar Power from Jan to June: Report. 10 November 2022.
[36] World Resources Institute (WRI). Achieving India's Ambitious Renewable Energy Goals - A Progress Report. 12 May 2017.
[37] IEEFA. Renewable Energy May Provide South Asia Relief from Energy Price Shocks. 14 February 2023.
[38] Natural Resources Defense Council (NRDC) and Council on Energy, Environment and Water (CEEW). Investing in a Green Future – India's Initiatives in Clean Energy Finance. December 2020.
[39] Business Standard. States to Meet 25% of Their Energy Needs from Renewable Energy Sources. 24 July 2022.
[40] Bridge to India. India Country Report - International Experiences in Designing and Implementing Renewable Energy Auctions for Sub-Saharan Africa. October 2020.
[41] IEEFA. Private Sector Driving Renewable Energy Wave in India. 14 April 2022.

As the Indian experience substantiates, policy-level ambition and suitable instruments have contributed to the country's remarkable success in renewable energy development. For example, the Infrastructure Development Company Limited (IDCOL) can help accelerate renewable energy promotion like its counterpart in India, Indian Renewable Energy Development Agency (IREDA).

IDCOL has already successfully implemented a solar home systems programme for off-grid people and provides loans to various renewable energy projects. It could gradually consider applying instruments, such as a risk guarantee scheme, to minimise renewable energy project risks.

The government could encourage Bangladesh Infrastructure Finance Fund Limited (BIFFL), which operates similarly to IDCOL and supports financing energy efficiency projects, to catalyse finance for renewable energy development.

Utility-scale renewable energy is still costly in Bangladesh. As reported based on the power purchase agreement (PPA), a 68MW utility-scale solar project will deliver energy for 20 years at US$0.102/kWh.[42] Bangladesh should, therefore, gradually move towards a competitive procurement process instead of the current practice of accepting unsolicited proposals. The auction mechanism has a good record in India and other countries in bringing down costs. Bangladesh would be better off creating the framework for introducing auctions going forward.

On the other hand, RPO may not be a viable option for Bangladesh at this stage, given that the country has a significant surplus power generation capacity and BPDB as a single buyer of electricity, has faced revenue shortfalls.

Solar Revolution in Vietnam

Vietnam installed a jaw-dropping amount of solar capacity in 2020, including 1.549GW of utility-scale solar and more than 9GW of rooftop solar systems. The guaranteed feed-in tariff of US$0.0838/kWh for 20 years provided the necessary market signal for investment in solar energy.[43] Apart from the favourable tariff, the government's commitment to enhancing energy security and the public demand for improved air quality helped spur solar energy in Vietnam.[44]

Bangladesh formulated net metering guidelines in 2018 and revised them in 2019 to allow industries and commercial entities with three-phase connections to install rooftop solar systems and reduce grid electricity consumption.[45]

Using rooftop solar energy, industries and commercial buildings in Bangladesh could reduce their energy bills against their corresponding rates of tariffs. After the electricity price hikes during

[42] The Business Standard. BPDB to Buy Power from Sirajganj 68MW Solar Park at $0.102 per kWh. 9 January 2023.
[43] PV Magazine. Scaling up Rooftop Solar in Vietnam – More Than 9GW Installed in 2020. 19 January 2021.
[44] ISEAS Perspective. Vietnam's Solar Power Boom: Policy Implications for Other ASEAN Member States. 11 March 2021.
[45] Sustainable and Renewable Energy Development Authority (SREDA). Net Metering Guidelines-2018. Revised on 14 November 2019.

January and February 2023, large industries would now pay Tk9.78/kWh (US$ 0.093/kWh) for purchasing electricity at a flat rate.[46] The cost would be Tk10.44/kWh (US$ 0.1/kWh) for commercial buildings considering the three rounds of hikes.[47] Therefore, industries and commercial buildings in Bangladesh will receive more financial benefits from rooftop solar systems than the US$0.0838/kWh tariff that helped massive rooftop solar expansion in Vietnam in 2020. The prevailing financial return should provide enough rationale to make the rooftops of industrial and commercial buildings shine with solar.

Indonesia and Vietnam to Switch to Clean Energy from Coal as Developed Countries Agreed to Provide Funds

On the sidelines of the G20 Summit in November 2022, Indonesia signed a deal for a Just Energy Transition Partnership (JETP) of US$20 billion to shift away from coal. Of the total amount, a coalition led by the United States of America (the U.S.) and Japan, along with Canada, Denmark, the European Union, Germany, France, Norway, Italy, and the United Kingdom, would provide US$10 billion. The remaining funds will come from private-sector financial institutions.[48]

Likewise, Vietnam agreed to a JETP of US$15.5 billion to reduce emissions from its electricity sector, minimise the number of coal-fired plants and enhance renewable energy capacity. The parties (the U.S., Japan, Canada, Denmark, the European Union, Germany, France, Norway, Italy, and the United Kingdom) will provide half of the funding at attractive terms.[49]

These may set new standards for coal and/or other fossil fuel-dependent countries to consider a similar approach in the foreseeable future.

There are often discussions in Bangladesh on the availability of finance to support the electricity sector transition. Notably, Bangladesh's tax to Gross Domestic Product (GDP) ratio is very low. Therefore, allocating finance for the clean energy transition could be challenging. As such, drawing lessons from Indonesia's pursuit of a coal phase-out and Vietnam's energy transition plan, Bangladesh may work on drafting a plan to access international finance.

[46] IEEFA. Ramping up Clean Energy Will Help Bangladesh Reduce Its Reliance on Imported Fossil Fuels. 16 February 2023.
[47] Bangladesh Energy Regulatory Commission. Order on Retail Tariffs for Bangladesh Power Development Board. 27 February 2020.
[48] RMI. Architecting Indonesia's Record-Setting Climate Deal. 17 November 2022.
[49] Vietnam Briefing. Unpacked: Vietnam's US$15.5 Billion JETP Agreement. 19 December 2022.

Considerations for the Transition

As the previous renewable energy policy could not provide the required impetus, Bangladesh must consider several steps, including a proper action plan, the compatibility of the renewable energy policy with the power sector policy, and the level of investment needed for the electricity sector transition. Additionally, the government should support renewable energy expansion with conducive measures.

Targets Backed by Action Plan and Tracking Mechanism

While targets of 5% and 10% of the installed electricity generation capacity from renewable energy by 2015 and 2020, respectively, outlined in the renewable energy policy 2008, fell short, some utility-scale solar projects have already come online.

Several utility-scale solar projects, including the 230MW project under Green Sukuk, should be online in 2023. A couple of wind energy projects are at different stages of construction. Rooftop solar systems, under net metering guidelines, are also gaining momentum. For all practical purposes, the present situation surrounding renewable energy differs from several years ago.

As the government is preparing a new renewable energy policy, it should provide a long-term vision for the electricity sector transition, considering the respective advantages of renewable energy compared to imported fossil fuel-based electricity generation, future technological advancement and related challenges.

For instance, the Mujib Climate Prosperity Plan has already stipulated an ambitious target of 40% renewable energy expansion by 2041. There have also been discussions on similar renewable energy targets in different forums.[50,51] Therefore, the time is ripe to stipulate a 40% renewable energy capacity target in the policy document, which the government should follow with an action plan to detail annual targets with contributions of different renewable energy technologies.

> **The time is ripe to stipulate a 40% renewable energy capacity target.**

Moreover, a monitoring framework should be in place to assess progress towards the annual renewable energy target. The monitoring framework would help review renewable energy deployment trends, identify the need for adjustments and support in achieving the overall policy goal of 2041.

[50] PV Magazine. Bangladesh Outlines Plan for up to 40 GW of Renewables in 2041. 20 October 2020.
[51] Dhaka Tribune. State Minister Nasrul: 40% of Power Will Come from Renewable Sources in 2041. 25 June 2021.

Reflection of Renewable Energy Policy Goal in the Integrated Energy and Power Master Plan

The Integrated Energy and Power Master Plan (IEPMP) of Bangladesh, expected to be finalised in 2023, will forecast the country's long-term power and energy demand and outline the most suitable energy mix that the country should follow in the foreseeable future.

As such, aligning the upcoming renewable energy policy with IEPMP would be essential. The IEPMP should reflect the renewable energy policy targets to avoid divergence between the policy and the energy master plan. Previous experience shows that the power sector development trend was somewhat compatible with the energy mix proposed in the PSMP of 2010 and 2016. However, Bangladesh missed the renewable energy targets by big margins, both in 2015 and 2020.

Waive Duties and Remove Cap on Rooftop Solar Installation Capacity

While utility-scale solar projects receive a waiver on import duties on different accessories, rooftop solar projects suffer as the building owners need to pay duties on fibre-reinforced polymer (FRP) walkways, inverters, mounting structures and direct current (DC) cables.

The import duties on FRP walkways, inverters, mounting structures and DC cable for rooftop solar systems are 15.25%, 37%, 58.6% and 58.6%, respectively.[52,53] The government could provide a directive in its new renewable energy policy to waive these import duties for rooftop solar projects. The waiver of duties on the mentioned renewable energy accessories will underscore the government's commitment to renewable energy and incentivise rooftop solar projects.

> **Since Bangladesh struggles to shore up clean energy capacity, the new renewable energy policy may lift this cap on rooftop solar capacity.**

The existing net metering guidelines allow industrial and commercial buildings to install rooftop systems of up to 70% of their sanctioned load. Since Bangladesh struggles to shore up clean energy capacity, the new renewable energy policy may lift this cap on rooftop solar capacity.

[52] Business Post. Promises Never Kept - Renewable Energy Plans in Limbo. 30 June 2022.
[53] Bangladesh Customs. Duty Calculator. 20 March 2023.

Mapping Sources to Mobilise Finance

Renewable energy technologies are capital-intensive. There is a global race for capital to seize renewable energy opportunities as countries try to fix their energy models amid the price volatility of fossil fuels and to meet climate goals.

Likewise, building a 40% renewable energy capacity of the base case electricity demand of 61,866MW in 2041, as forecasted in the PSMP of 2016, would necessitate Bangladesh to mobilise finance for roughly 25,000MW of renewable energy capacity. We have developed three scenarios to estimate the investment requirement in renewable energy technologies to attain the 40% target. As solar energy has proven potential in the country, the scenarios include the higher contribution of solar systems.

In Scenario 1, installing 25,000MW of renewable energy would cost Bangladesh US$27.5 billion from 2024 to 2041, considering utility-scale solar, rooftop solar and wind capacity of 15,000MW, 6,000MW and 4,000MW, respectively (see Figure 13).[54]

In Scenario 2, the investment need reaches US$29.75 billion until 2041 as utility-scale solar, rooftop solar and wind capacity change to 14,000MW, 5,000MW and 6,000MW, respectively.

In the last scenario, utility-scale solar capacity further reduces to 13,000MW, rooftop solar capacity is the same as Scenario 2, and wind capacity increases to 7,000MW. The combined investment in this scenario is US$30.75 billion from 2024 to 2041.

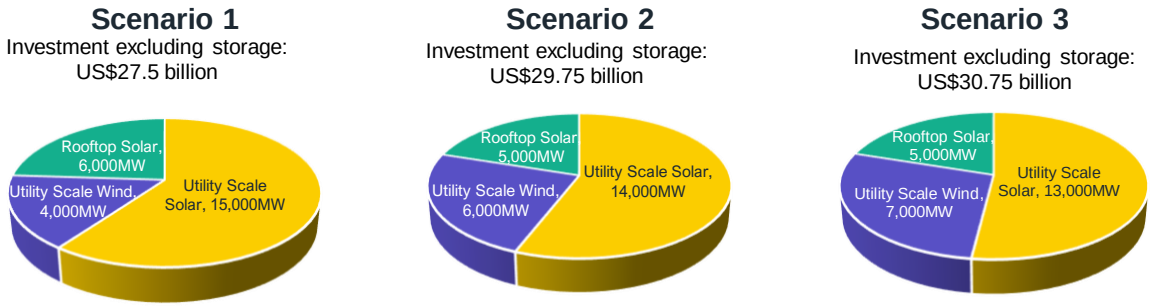
On average, Bangladesh would need to consistently invest US$1.53 billion to US$1.71 billion annually until 2041 in renewable energy technologies, based on the different combinations of solar and wind technologies, not including the cost of grid modernisation and storage facilities.

Bangladesh needs to modernise its old grid to improve the quality of its electricity supply. Still, the annual investment required in renewable energy technologies is less than the BPDB's revenue shortfall of FY2021-22.

It is important to note that the cost to achieve the 40% renewable energy target will differ if we further change the combination of utility-scale solar, rooftop solar and wind capacity and include agri-photovoltaics and floating solar in the technology mix.

[54] Cost of Technologies – Utility-scale Solar: US$1 million/MW; Rooftop Solar: US$0.75 million/MW; Wind Energy: US$2 million/MW

Figure 13: Investment Requirement to Reach 40% Renewable Energy Target



Source: IEEFA Calculation

Since Bangladesh's power sector already suffers from the burden of hefty subsidies, a scarcity of new capital could inhibit renewable energy investments. Hence, mapping channels to mobilise sufficient finance to spearhead the electricity sector transition would be crucial for the government. The exercise would enable the government to visualise the finance that it could channel from local sources, like the green refinance scheme of the Bangladesh Bank, green bond/sukuk, sovereign bonds etc. Different climate finance facilities, funding channels of multilateral development agencies, and global pension, private equity and infrastructure funds could also help mobilise quite a good amount. For the remainder of the funding need, the government may explore the possibility of reaching deals with developed countries like the one signed by Indonesia.

Way Forward

Owing to increased electricity generation capacity, until July 2022, load-shedding was a phenomenon of the past in Bangladesh, at least in cities. It eventually returned aggressively as the Ukraine-Russia crisis reshaped the global energy order with high and volatile prices of fossil fuels.

It would, however, be unjust to blame only the Ukraine-Russia crisis. The import-dependence and relentless persuasion for electricity security are taking a heavy toll on the already distressed power sector of the country.

While the winter was a great relief as demand falls in Bangladesh during the cold weather, from March 2023, power demand will increase significantly. As a result, Bangladesh may face another period of load shedding unless the government solves the dollar crunch.

The time is ripe to make a passage for increasing renewable energy-based generation capacity to reduce costly fossil-fuel imports and drive down subsidy burdens on the power sector. While the

government cannot address the challenges within a few months or even a year, it should chart a long-term transition pathway for the electricity sector.

The upcoming IEPMP and renewable energy policy will provide the government with opportunities for designing the transition pathway to clean energy.

The positive is that the existing power generation system can accommodate 1,700MW to 3,400MW of solar energy during the daytime, representing 7 to 15% renewable energy capacity beyond the current grid-scale renewable capacity. This allows the government to immediately ramp up grid-scale solar capacity to minimise expensive oil-based power generation during the day. Similarly, Bangladesh should explore the feasibility of using wind power to reduce oil-fired plants' operating hours at night.

Although energy storage remains costly, the decreasing trend of cost signals that storage systems will be competitive to support round-the-clock electricity supply from renewable energy in the coming years. Hence, Bangladesh should work on creating an ecosystem to promote energy storage once it becomes financially viable for the country.

Enhancing renewable energy capacity to 40% from the current on-grid contribution of less than 3% will require all-out efforts. Bangladesh should, therefore, assess the benefits and viability of technology options, such as agrivoltaics, floating solar etc. Moreover, steps for earmarking suitable lands for renewable energy projects should start now.

> **Enhancing renewable energy capacity to 40% from the current on-grid contribution of less than 3% will require all-out efforts.**

As the BPDB still procures electricity from grid-scale renewable energy, for example, solar, at a double-digit tariff in Tk, competitive procurement through auctions will help reduce the tariff. Competitive energy procurement will allow the BPDB to steer the electricity sector towards reducing generation costs instead of the current increasing trajectory.

While the costly electricity generation and subsidy burden are tempting factors for Bangladesh to rapidly shore up renewable energy capacity, applying risk-guarantee funds, green bonds, etc., will help provide traction for renewable energy in the country.

This study identifies that Bangladesh would consistently need US$1.53 billion to US$1.71 billion annually until 2041, excluding the cost of grid modernisation and storage facilities, to have 40% of installed capacity from renewable energy. Since the electricity sector transition is capital intensive, Bangladesh must look into all avenues to manage the cost.

Bangladesh should look at local options like financial institutions' funds, the central bank's refinance scheme, green bonds/sukuks and sovereign bonds. In addition, it should also explore other channels like multilateral development agencies, different climate funds and global pension, private equity and

infrastructure funds. For the rest of the financing, Bangladesh may work with developed countries to secure finance for the electricity sector transition, following Indonesia and Vietnam's Just Energy Transition Partnership.

The private sector will have an important role in the transition of Bangladesh's electricity sector. For instance, technology providers should be able to supply technologies and execute projects quickly and with quality. Similarly, financial institutions will need to disburse loans to the projects promptly. Last but not least, successful private sector partnerships with international renewable energy companies will help expedite renewable energy promotion.

The government should lift the restriction on maximum rooftop solar installation of up to 70% of the sanctioned load of industrial and commercial buildings to accelerate deployment in the country.

Furthermore, to encourage investment in rooftop solar projects, Bangladesh should waive the existing duties on imported inverters, DC cables, FRP walkways and mounting structures.

The electricity sector transition to renewable energy is the most feasible solution Bangladesh could pursue to avoid the disastrous subsidy burden and reliance on the unpredictable international fossil fuel market. While such a transition will require sustained efforts and investment, making little or no attempt at renewable energy expansion will expose Bangladesh to more risks. Notably, our calculated annual investment amount targeted to attain a 40% renewable energy goal by 2041 is even less than the subsidy burden of FY2021-22. Additionally, Bangladesh must modernise its old grid to ensure a quality electricity supply.

Annexure 1: Details of Energy Curve Analysis

Table 1: Potential to Use Solar Energy Instead of Oil-Fired Plants from 9:30am to 4pm During Summer

Summer - Day (9:30am to 4pm)*											
Month	Average energy demand met by gas, coal, imports and renewables at 9:30am (MW)	Average energy demand served at 9:30am (MW)	Average oil-based generation at 9:30am (MW)	Average energy demand met by gas, coal, imports and renewables at 4pm (MW)	Average energy demand Served at 4pm (MW)	Average oil-based generation at 4pm (MW)	Average energy demand met by gas, coal, imports and renewables when maximum energy demand served (MW)	Average maximum energy demand served (MW)	Average oil-based generation when maximum energy demand served (MW)	Average oil-based power generation (MW)	Average solar capacity to replace oil-fired generation (MW)
Mar-22	6,267	9,867	3,600	6,550	10,600	4,050	6,517	11,000	4,483	4,044	3,402
Apr-22	7,800	10,800	3,000	7,800	12,267	4,467	7,983	12,367	4,384	3,950	
May-22	7,550	9,533	1,983	8,000	11,233	3,233	8,067	11,317	3,250	2,822	
Jun-22	7,483	11,050	3,567	7,250	11,567	4,317	7,600	11,867	4,267	4,050	
Jul-22	7,733	10,233	2,500	7,250	10,733	3,483	7,900	11,083	3,183	3,055	
Aug-22	7,917	10,800	2,883	7,767	10,967	3,200	8,000	11,167	3,167	3,083	
Sep-22	8,133	10,917	2,784	8,033	11,517	3,484	8,033	11,517	3,484	3,250	
Oct-22	7,167	9,833	2,666	7,333	10,267	2,934	7,350	10,633	3,283	2,961	
Range	6,267–8,133	9,533–11,050	1,983–3,600	6,550–8,033	10,267–12,267	2,934–4,467	6,517-8,067	10,633-12,367	3,167-4,483	2,822-4,050	

* Methodology applied:

Step 1: We select three days for each month and download the energy curves of the respective days from the BPDB daily generation archive. For March 2022, we analyse data from the 1st, 15th and 30th days of the month.

Step 2: We take data on energy demand served by BPDB at 9:30am for each of the selected days of March 2022 and calculate the average energy demand served at 9:30am in March 2022. We calculate the average demand at 9:30am in March 2022 as 9,867MW.

Step 3: We identify energy demand data met by gas, coal, energy imports and renewables at 9:30am on the selected days and take the average of the three data. We found the average energy demand met by gas, coal, imports and renewables to be 6,267MW.

Step 4: The difference between the average energy demand served by BPDB at 9:30am and the average energy demand met by gas, coal, imports and renewables provides the average oil-based capacity utilisation of 3,600MW.

Step 5: We employ a similar approach to determine the oil-based capacity utilisation at 4pm and when BPDB served the maximum energy demand in March 2022.

Step 6: We then take an average of oil-based capacity utilisation at 9:30am, 4pm and when the BPDB served the maximum energy demand in March 2022. We found that the average oil-based capacity use was 4,044MW in March 2022.

Step 7: We apply the same calculation process for the other seven months of summer 2022. Taking the average of the eight values, we calculate the solar energy potential of around 3,400MW to replace oil-fired plants during the eight summer months.

Note: We follow the preceding seven steps in calculating solar potential during winter and wind potential during both summer and winter.

Table 2: Potential to Use Wind Energy Instead of Oil-Fired Plants from 6pm to 12am During Summer

Summer - Night (6pm to 12am)											
Month	Average energy demand met by gas, coal and hydro at 6pm (MW)	Average energy demand served at 6pm (MW)	Average oil-based generation at 6pm (MW)	Average energy demand met by gas, coal and hydro at 12am (MW)	Average energy demand Served at 12am (MW)	Average oil-based generation at 12am (MW)	Average energy demand met by gas, coal and hydro when maximum energy demand served (MW)	Average maximum energy demand served (MW)	Average oil-based generation when maximum energy demand served (MW)	Average oil-based power generation (MW)	Average wind capacity to replace oil-fired generation (MW)
Mar-22	6,317	10,633	4,316	6,533	10,433	3,900	6,633	11,981	5,348	4,521	4,241*
Apr-22	7,633	11,983	4,350	8,383	13,550	5,167	8,450	14,011	5,561	5,026	
May-22	7,733	10,667	2,934	8,650	12,517	3,867	8,650	13,153	4,503	3,768	
Jun-22	7,000	11,100	4,100	7,967	13,100	5,133	7,883	13,541	5,658	4,964	
Jul-22	7,383	10,400	3,017	8,300	12,583	4,283	8,317	12,816	4,499	3,933	
Aug-22	7,440	10,817	3,377	8,267	12,250	3,983	8,317	11,167	2,850	3,403	
Sep-22	7,883	11,733	3,850	8,400	12,417	4,017	8,225	13,135	4,910	4,259	
Oct-22	7,250	11,400	4,150	7,517	10,933	3,416	7,517	12,104	4,587	4,051	
Range	6,317-7,883	10,400-11,983	2,934-4,350	6,533-8,650	10,433-13,550	3,416-5,167	6,633-8,650	11,167-14,011	2,850-5,658	3,403-5,026	

** Subject to the feasibility of location, wind speed and other parameters.*

Table 3: Potential to Use Solar Energy Instead of Oil-Fired Plants from 9:30am to 4pm During Winter

Winter - Day (9:30am to 4pm)											
Month	Average energy demand met by gas, coal and renewables at 9:30am (MW)	Average energy demand served at 9:30am (MW)	Average oil-based generation at 9:30am (MW)	Average energy demand met by gas, coal and renewables at 4pm (MW)	Average energy demand served at 4pm (MW)	Average oil-based generation at 4pm (MW)	Average energy demand met by gas, coal and renewables when maximum energy demand served (MW)	Average maximum energy demand served (MW)	Average oil-based generation when maximum energy demand served (MW)	Average oil-based power generation (MW)	Average Solar capacity to replace oil-fired generation (MW)
Nov-22	6,417	8,317	1,900	6,367	8,633	2,266	6,650	9,333	2,683	2,283	1,787
Dec-22	6,767	8,100	1,333	6,450	8,217	1,767	6,783	8,967	2,184	1,761	
Jan-23	6,667	8,017	1,350	6,517	8,183	1,666	6,967	8,650	1,683	1,566	
Feb-23	7,417	8,700	1,283	7,350	8,983	1,633	7,650	9,346	1,696	1,537	
Range	6,417-7,417	8,017-8,700	1,283-1,900	6,367-7,350	8,183-8,983	1,633-2,266	6,650-7,650	8,650-9,346	1,683-2,683	1,537-2,283	

Table 4: Potential to Use Wind Energy Instead of Oil-Fired Plants from 6pm to 12am During Winter

Winter - Day (6pm to 12am)											
Month	Average energy demand met by gas, coal and hydro at 6pm (MW)	Average energy demand served at 6pm (MW)	Average oil-based generation at 6pm (MW)	Average energy demand met by gas, coal and hydro at 12am (MW)	Average energy demand served at 12am (MW)	Average oil-based generation at 12am (MW)	Average energy demand met by gas, coal and hydro when maximum energy demand served (MW)	Average maximum energy demand served (MW)	Average oil-based generation when maximum energy demand served (MW)	Average oil-based power generation (MW)	Average wind capacity to replace oil-fired generation (MW)
Nov-22	6,767	10,337	3,570	6,900	9,267	2,367	7,033	10,872	3,839	3,259	2,564*
Dec-22	6,650	9,862	3,212	6,550	8,000	1,450	6,717	9,907	3,190	2,617	
Jan-23	6,400	9,100	2,700	6,767	8,067	1,300	6,633	9,564	2,931	2,310	
Feb-23	7,267	9,400	2,133	7,467	8,633	1,166	7,600	10,505	2,905	2,068	
Range	6,400-7,267	9,100-10,337	2,133-3,570	6,550-7,467	8,000-9,267	1,166-2,367	6,633-7,600	9,564-10,872	2,905-3,839	2,068-3,259	

** Subject to the feasibility of location, wind speed and other parameters.*

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