

Energy crisis in Bangladesh: Challenges, progress, and prospects for alternative energy resources

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ABSTRACT

Providing uninterrupted and reliable electricity to all at an affordable price is a major undertaking for the governments of increasingly energy-hungry countries. This study assesses the energy supply-demand gap, progress, and prospects of alternative energy sources in Bangladesh. Several methods, including descriptive, trend, and comparative analyses, were carried out using time-series energy data to determine the current and historical energy status. Results show that between 1990 and 2018, the country experienced an approximate 3.05-fold increase in energy consumption from 12,743 to 38,807 ktoe, and a 3.11-fold increase in energy production from 10,760 to 33,504 ktoe. The shortfall between supply and consumption is approximately 26%, but this can be resolved by addressing energy diversification barriers related to policy, governance through regulatory actions, investment, transmission and distribution, resources optimisation, energy efficiency, conservation, research and education, and regional cooperation.

1. Introduction

Whilst Bangladesh currently has a population of 170 million people, the goal of becoming a middle-income country providing electricity to all is anticipated to be achieved by 2021 (Sadeque et al., 2014). To become a developed country by 2041 (GoB, 2012), Bangladesh must rise above low-income country status and implement consistent free market-type economic policies (Neusiedl, 2016; ADB, 2016). In 2014, the World Bank recognised Bangladesh as a lower middle-income country based on its per capita income, electricity consumption, literacy rate, unemployment and poverty rates, and healthcare indicators (World Bank, 2016; Badiuzzaman et al., 2018). For Bangladesh to become a middle-income country¹ within the next five years, per capita income should reach US\$4,645, electricity consumption should be in the range of 600–1000 kWh, and the poverty rate should be below 14% (World Bank, 2016). Development experiences in other countries demonstrate that energy consumption tends to rise quickly when per

capita income reaches between US\$1000 and US\$10,000, a range that Bangladesh is currently entering (Mujeri et al., 2014). Thus, the energy supply must increase rapidly to meet the country's speedy and sustainable economic growth (Saint Akadiri et al., 2019).

Energy supply and its sources are limited in Bangladesh, where only natural gas and coal exist in large amounts. Indigenous natural gas is the principal fuel, but its reserves will be exhausted within the next 10–15 years if new gas reservoirs are not found (MoPEMR, 2016). The country regularly imports oil and coal to meet baseload electricity. Gas, oil, and coal meet approximately 57.37%, 32.39%, and 2.76%, respectively, of the total electricity generation (BBS, 2016; BPDB, 2018–2019). There are no oil reserves, but 65 million barrels of oil are located as condensates in 26 gas fields (MoPEMR, 2016). Although the country possesses approximately 3.2 billion tonnes of coal reserves in 5 discovered mines, only a limited amount of coal is being extracted from Barapukuria coal mines, which is enough to power the two coal-based plants with 125 MW capacity each (BPDB, 2016). The power generated from local coal is

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¹ The basic indicators for recognition as a lower middle-income country are per capita income US\$1,300, electricity consumption 321 kWh, 70% literacy rate, 24% poverty reducing rate, low infant mortality rate, low maternal mortality rate, low malnutrition rate, women empowerment, etc. World Bank data indicators, 2016, USA.

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limited due to poor policy, geopolitics, technology selection, and environmental concerns (Muhammad, 2016).

Presently, about 76% of the total population has access to electricity. The situation is dire in rural areas where 70% of the population lives, and only 42% are connected to the grid (GoB, 2015). Current per capita electricity consumption in Bangladesh stands at approximately 348 kWh, which is well below the global average of 3,065 kWh (IEA, 2016), and this, per capita, is even much lower than India (800 kWh) and Pakistan (500 kWh) (Sufi, 2017). The total installed generation capacity of electricity in the 2018–2019 fiscal year was 18,961 MW, with the maximum peak generation being 12,893 MW. The actual average generation hardly exceeded 10,000 MW due to various constraints such as limited fuel supply, poor grid availability, system loss, lack of finance for maintenance of the aging power plants and skilled workforce, and bureaucratic bottlenecks and inefficiencies (BPDB, 2018-2019).

However, average electricity demand in Bangladesh is growing at over 10% per year, owing to rapid economic growth, industrialisation, expansion in grid connection, and the adoption of new electrical devices and appliances. Demand is projected to be about 23,800 MW by 2021, when more than 40% of electricity is expected to be consumed in the industrial sector (Hasanuzzaman et al., 2015). Furthermore, electricity will be consumed in the growing industrial sector if a reliable electricity supply can be guaranteed. Bangladesh is one of the fastest-growing Readymade garments exporters globally, with garment manufacturing buildings consuming vast amounts of electricity (Habib et al., 2016). The GDP growth rate solely depends on the per capita electricity consumption of the total population (Ahmad and Islam, 2011). To maintain the GDP growth rate at 7% or higher in successive years, and to ensure electricity for all by 2021, 23,800 MW of electricity needs to be supplied cost-effectively and sustainably (Islam, 2017).

Bangladesh is currently experiencing significant energy inefficiency in all forms of production, transmission, and how much is being distributed (Islam and Khan, 2017). Since independence, Bangladesh has had energy crises because the energy supply is not meeting the country's energy demands. A recent report by the United Nations Conference on Trade and Development (UNCTAD, 2017) noted that more than 50% of enterprises in Bangladesh identify the lack of consistent access to energy as a significant barrier to higher production. The industrial sector needs sufficient energy to be meaningful to the economy of Bangladesh, as this sector is responsible for 21% of the total energy demand. However, due to increasing consumption, Bangladesh cannot ensure 100% accessibility of power supply in the near future. The current literature indicates that the average per capita electricity consumption for developed countries is above 8000 kWh, whereas, for developing countries, it is just over 1200 kWh. For any high-income country, the average per capita electricity consumption is over 9,789 kWh (Ahmed et al., 2013). In every single index, Bangladesh is far behind every aspect of electricity generation and consumption. The government has subsequently committed to providing electricity for all by 2021 since taking power in 2009 (GoB, 2012). The country had set a target of an electricity generation mix of 23,800 MW by 2021, 38,600 MW by 2030, and 50,000 MW by 2041 to meet the demand for electricity for accelerating economic growth (PSMP, 2010).

A balanced energy mix consisting of a diversified policy was introduced in the PSMP2010² to meet the government's vision. The policy seeks to reduce indigenous gas dependence by increasing liquefied natural gas (LNG) imports. PSMP2010 had set targets to increase electricity generation from 2% to 50% of the total electricity generation by 2021 using local and imported coal. This achievement would not have been possible without experience gathered from the currently operating Barapukuria coal power plant and the unexpected progress of a reasonable number of coal power plants under construction (BPDB,

2016). PSMP2010 had planned to generate 10% of electricity from renewable energy sources by 2020. In reality, by 2015, only 1.5% of this was achieved. It will be almost impossible to generate 10% of the total electricity from renewable energy by 2020. Considering the present reserves of gas, oil, coal, and the development progress of renewable energy sources, the role of nuclear power is strongly favoured in the national energy policy. The PSMP2010 projected 2,000 MW electricity from nuclear sources by 2021. To realise this, the government set up an agreement with the Russian Federation on November 2, 2011, to construct two nuclear power plants (NPPs) with 1200 MW capacity each at the Rooppur site by 2021 (Islam, 2015). The new PSMP2016 has been revised for power sources up to 2041 and diminishes dependence on coal from 50% to 30%. Emphasis is given on more nuclear and renewable energy sources, power trading, and energy efficiency and conservation programmes (PSMP, 2016).

Although these various efforts are expanding the energy supply, they are still insufficient for resolving the energy crisis. It is imperative to identify the factors responsible for the energy crisis and ascertain the possible pathways for energy sustainability. No study has yet been published on the underlying reasons for the energy crisis using time series data and any gaps evident in the policy, master plans, regulatory frameworks, governance, education, and research. This study aims to determine the strategies for reducing the energy shortage so that decision-makers and practitioners can devise appropriate policies and an infrastructure development roadmap. Consequently, this study explores alternative energy sources,³ their progress and prospects to meet future energy demands and sustainable economic development targets.

The research study is divided into four sections. Background of the problem, literature reviews, and research motivation are given in the introduction section. Section 2 describes the methodology, results, and discussions. Section 3 mainly focuses on existing energy sources and reserves, energy and power supply-demand scenarios, energy performance concerning economic indicators, policy, governance, factors for energy crisis, and mitigations and suggestions. Finally, section 4 draws the conclusions.

2. Methodology

This study attempts to determine the energy situation of Bangladesh by using time series energy data. Table 1 presents different types of secondary data sources that include the International Energy Agency (IEA), World Bank (WB), Bangladesh Power Development Board (BPDB), Power System Master Plan (PSMP), Perspective Plan of Bangladesh, and others. This study employs several indicators, namely energy demand, energy sources, gross domestic product (GDP) and population, electricity generation by different sources, total and per capita energy use, as well as the energy mix, to explore the progress and challenges of the energy sector in Bangladesh. The time-series data of some indicators from 1991 to 2018 have been collected from the world development indicators of the WB and IEA to derive trends concerning energy supply, electricity generation, total and per capita energy consumption, and GDP. The study calculates the annual growth (%) of energy consumption of Bangladesh based on equation (1) which is compared with the GDP growth of the country:

$$\text{Annual growth} = \frac{\text{Current year growth} - \text{Previous year growth}}{\text{Previous year growth}} \times 100 \quad (1)$$

The performance of the Bangladesh energy sector is also compared with other Asian countries in terms of the subsidies given to the energy sector. This study determines the current trends of energy indicators and highlights policies and challenges relevant to the sustainability of

² PSMP refers to the power system master plan that is revised every 5 years by the government.

³ Apart from conventional fossil fuels, alternative energy sources can refer to nuclear, solar, wind, biomass, energy efficiency and conservation, resources optimisation, management integration, regional energy, and power trading.

Table 1
Secondary data type and their sources.

Data type	Data source	Reference
Primary energy supply by sources from 1990 to 2018	International Energy Agency (IEA)	IEA, 2020
GDP and population, electricity generation by different sources from 1990 to 2018, total and per capita energy use	World Development Indicator	World Bank, 2019; IEA, 2020
Electric generation	Bangladesh Power Development Board	BPDB, 2018-2019; IEA, 2020
Energy mix	Power System Master Plan	PSMP, 2016
Development target	Perspective Plan of Bangladesh 2010–2021	GoB, 2012
Energy sources and reserve	Ministry of Power, Energy and Mineral Resources; Petrobangla	MoPEMR, 2016; PetroBangla, 2016

Source: Authors' compilation

Table 2
Predicted energy sources and reserves in Bangladesh.

Energy sources	Recoverable reserve	Availability
Natural gas	400 × 10 ⁹ m ³ in 26 gas fields	15-20 Yrs
Coal	3.2 billion tons in five coalfields	5000–6,000 MW@ 20 Yrs
Oil	65 million barrels as condensate in 26 gas fields	Mainly import-dependent
Hydropower	230 MW	Limited
Solar	Infinite	Infinite (4–6.5 kWh/m ²)
Wind	Coastal belt, 725 km long	Limited, Average speed < 5.7 m/s
Nuclear	Nil	Import

Sources: GoB, 2012; Petrobangla, 2016; MoPEMR, 2016.

energy sources of Bangladesh.

3. Results and discussion

3.1. Major energy sources and their reserves

The available energy sources, probable reserves, and their use are summarised in Table 2. Natural gas is one of the major available energy sources in Bangladesh. There is as much as 397 × 10⁹ m³ of gas being produced leaving only 399.55 × 10⁹ m³ of recoverable gas (MoPEMR, 2016). Industrial and residential sectors and power generation mainly rely on domestic natural gas. Recoverable reserves will last for at least 10–15 years, assuming a yearly gas demand of 32.29 × 10⁹ m³ considering the 2015–2016 production rate. In 2015–2016, there was a shortfall of about 4.78 × 10⁹ m³ of gas production against the previous year. Five years earlier (FY:2011–2012), the shortfall was 3.57 × 10⁹ m³ of gas (MoPEMR, 2016).

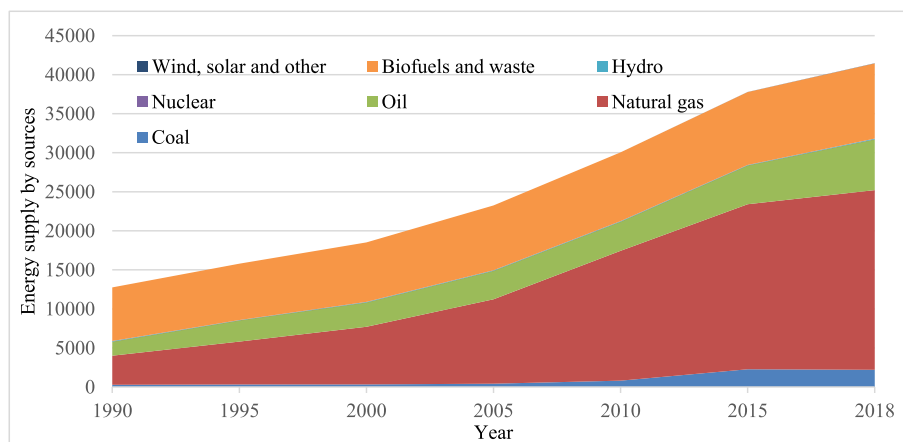


Fig. 1. Total primary energy supply by sources (ktoe), Source: IEA, 2020.

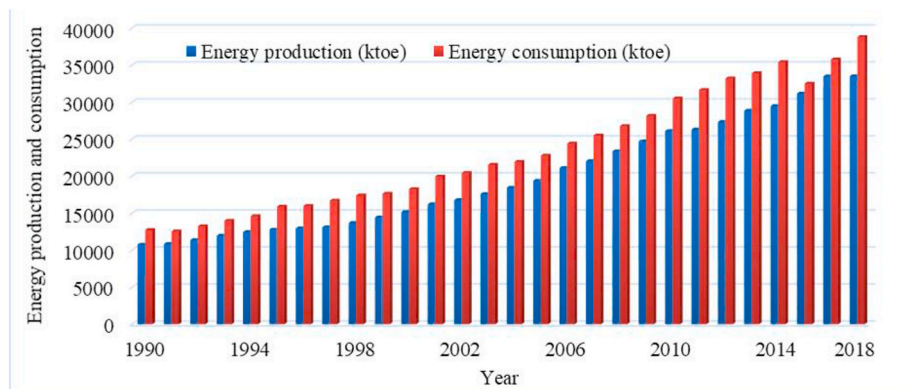


Fig. 2. Energy production and consumption in Bangladesh from 1990 to 2018.

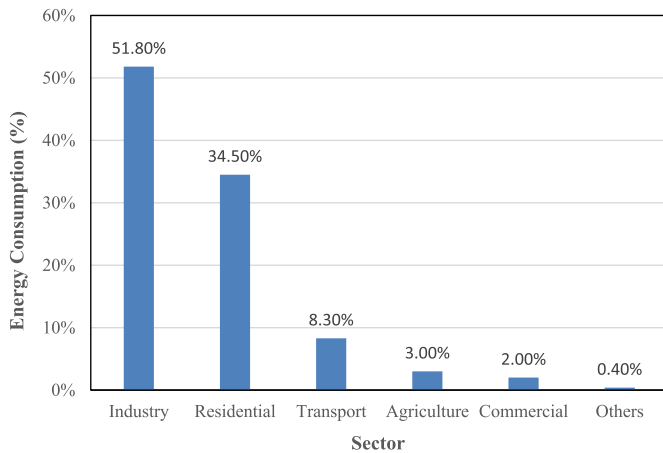


Fig. 3. Sector-wise energy consumption in 2018. Source (IEA, 2020).

The daily shortfall is increasing yet failing to meet current demands. The second-largest energy resource is coal, with a predicted 3.2 billion tonnes mainly deposited deep underground as of 2016 (Worldometer, 2016). It is predicted by the geologists that 5000–6,000 MW capacity of coal-based power plants can be operated using the presently reserved coal if it is extracted via open-pit coal mining (Badrul, 2013). Doubling that capacity can be achieved if coal is extracted via underground coal

mining. There is no oil depository, except for 65 million barrels of condensate in 26 gas fields. No potential reserves of heavy minerals (uranium and thorium) are reported currently.

Apart from fossil energy sources, Bangladesh has suitable renewable energy sources. Examples include solar irradiance on a daily average of 4–6.5 kWh/m², a limited potential of wind energy along the 725 km coastal belt, and hydropower in the hills (Ahmed et al., 2013; Hossain et al., 2011).

According to studies by the Bangladesh University of Engineering and Technology, Bangladesh Centre for Advanced Studies (BCAS), local engineering and meteorological departments, winds are exploitable in Bangladesh during the monsoon and sometimes a couple of months before or after it (MoPEMR, 2016; Ahmed et al., 2013; Hossain et al., 2011). The BCAS initiated one-year data, which found that 50-m tall turbines in the coastal regions have a wind force that varies between 4.1 and 5.8 m/s, whereas energy density is about 100–250 W/m² (MOEF, 2008). At a higher altitude of wind turbine technology, there would be enormous potential for wind energy.

The Bangladesh economy is mainly based on agriculture, where biomass makes a significant contribution to the total primary energy consumption in the form of cooking fuel. More than 85% of rural people depend on traditional biomass for cooking, crop drying, and winter heating. Up to 40% of electrical conversion efficiencies are achievable in the form of about 30 MW in a short period (MoPEMR, 2016; Saidur, 2010). Various feedstocks such as domestic organic waste, manufacturing waste, fertiliser, sludge, and others have been

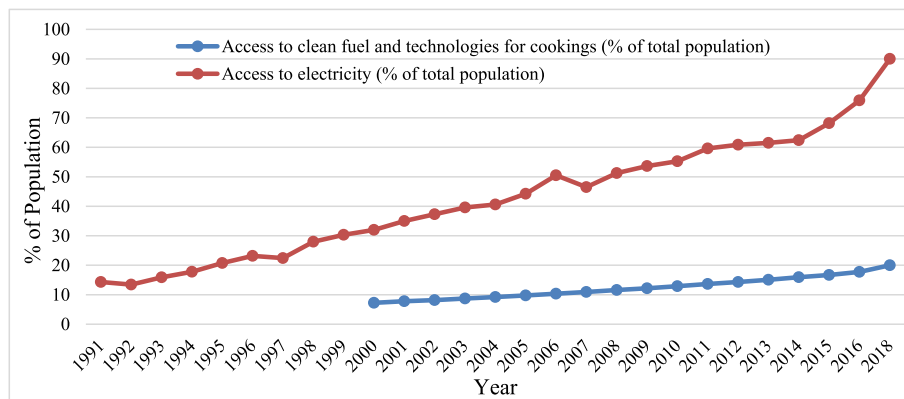


Fig. 4. Access to clean fuel and electricity in Bangladesh.

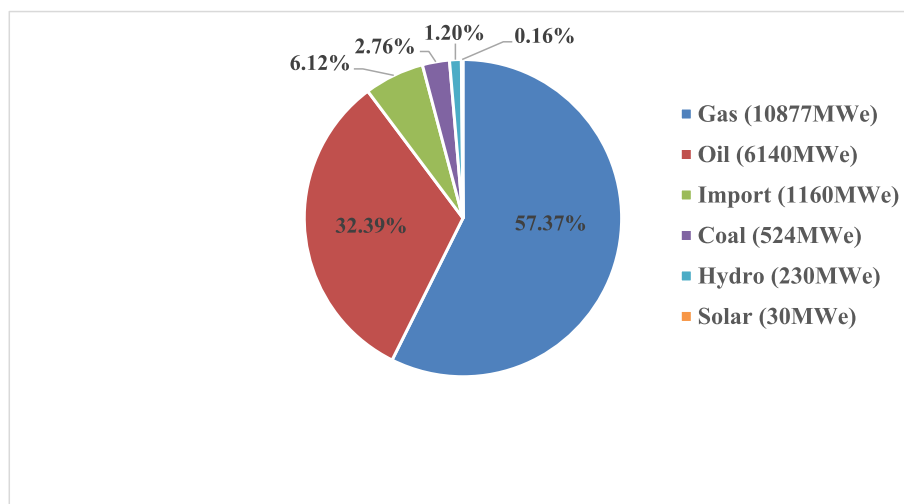


Fig. 5. Total electricity generation capacity (18,961 MW) and fuel mix in 2018–2019. Sources: (BPDB, 2018–2019)

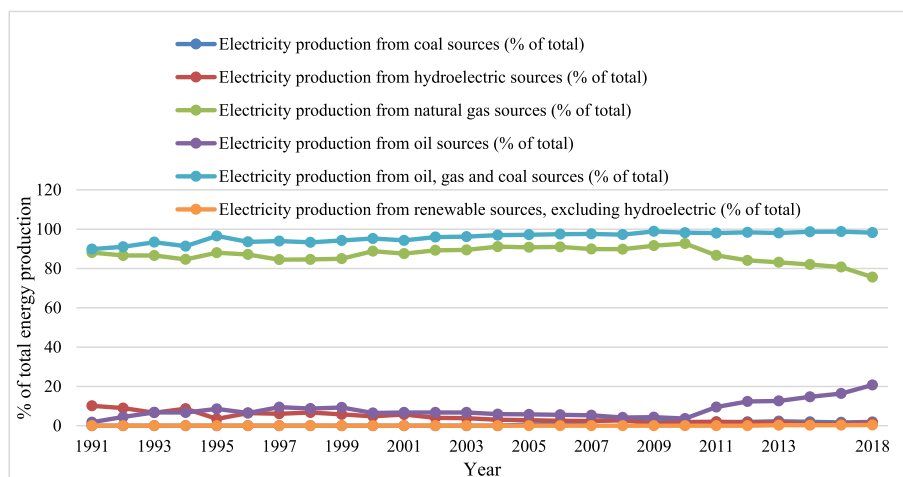


Fig. 6. Electricity generation by different sources of energy from 1991 to 2018.

Table 3
Fuel mix and electricity generation suggested in PSMP2016

Fuel type	2021(23800 MW)	2030 (38600 MW)	2041(50000 MW)
% of total fuel			
Gas	42	25	35
Coal	29	50	35
Oil	13	5	5
Hydro	2	2.5	–
Nuclear	10	10	10
Import/regional grid	4	7.5	–
Renewable excluding hydro	–	–	15

Sources: PSMP, 2016.

demonstrated and developed commercially by the anaerobic digestion of biomass. Bangladesh is a country whose primary agricultural production is rice, and the average production is about 35,000,000 MT per year. If 20% of the produced rice (i.e. 7,000,000 MT) could be turned into biomass, this will improve the biomass power generation from rice husk (MoPEMR, 2016; Petrobangla, 2016; GoB, 2012).

3.2. Energy supply and demand scenarios

The energy supply in Bangladesh mainly depends on indigenous gas reserves. This gas energy is primarily used for electricity generation, household cooking, and industrial process heating. Most of the total primary energy supply comes from natural gas, as shown in Fig. 1. The total amount of primary energy supply was 12752 ktoe in 1990, which rose by 41464 ktoe in 2018 (IEA, 2020). Data reveals that 55.50% of the total primary energy supply comes from natural gas, followed by 23.22% from biofuel and waste, 15.69% from imported oil, 5.31% from domestic and imported coal (IEA, 2020). It is evident from Fig. 1 that Bangladesh is increasingly dependent on domestic natural gas supply.

As a growing economy, Bangladesh is also facing a rising energy consumption trend over time. Fig. 2 shows that the total energy use in the country was 12743 ktoe in 1990, which increased to 38807 ktoe in 2018. Energy production is increasing over time, from 10760 ktoe in 1990–33504 ktoe in 2018 (IEA, 2020). It is evident that energy consumption was higher than energy production over the year. The gap between the two was about 5300 ktoe in 2018. The shortage of primary energy supply is usually filled by importing oil and coal. Over the past few years, the gap between primary energy supply and consumption has gradually increased (Onneshan, 2014).

Fig. 3 shows the final energy consumption in the industrial,

residential, transportation, agricultural, commercial, and other sectors. The industrial sector was the highest consumer with a share of 51.80%, followed by the residential and transportation sectors at 34.50% and 8.30%, respectively. Agriculture consumed 3%, where commercial and other sectors consumed 2% and 0.4%, respectively (IEA, 2020). However, the industry and residential sectors consume 56% and 29.3%, respectively, of gas. The transportation sector consumes the largest share with 59.8% of petroleum oil, followed by agriculture with 25.8%, and the residential sector with 9% in the form of kerosene oil (EE&CMP, 2016).

3.3. Electricity supply and demand scenarios

Bangladesh is facing insufficient electricity generation and distribution, as one-quarter of the people are still deprived of access to electricity. On the other hand, most people are not getting access to clean fuel and technologies for cooking. Fig. 4 shows that about 90% of the population are now dependent on the electricity supply while only 20% of the population has access to clean fuel and technologies. Although the number of people having electricity has increased over time, clean fuel coverage is still insufficient. Nonetheless, the Ministry of Power, Energy and Mineral Resources (MoPEMR) prepared the PSMP to ensure clean fuel and electricity for all. It was estimated that grid-connected power generation capacity, excluding captive power, was approximately

Table 4
Electricity generation enhancement program.

Fuel type	Under construction (MW) as of December 2020	Under tendering & agreement processes (MW) as of Dec 2020	Under planning up to 2030 (MW) as of December 2020
Natural gas	1289	400 + 50	–
Natural gas/ LNG	1598	0 + 1040	8075
Oil	709	–	–
Combined cycle	2358	–	–
Coal	7619	+1240	5740
Renewable (Solar)	444	150 + 496.583	961.50
Renewable (Wind)	62	100 + 85	162
Nuclear	2400	0	2400
Wastes	–	+48.5	80
Import/regional grid	–	–	1996
Total	16,479	650 + 2961	19,415

Source: BPDB, 2019–2020

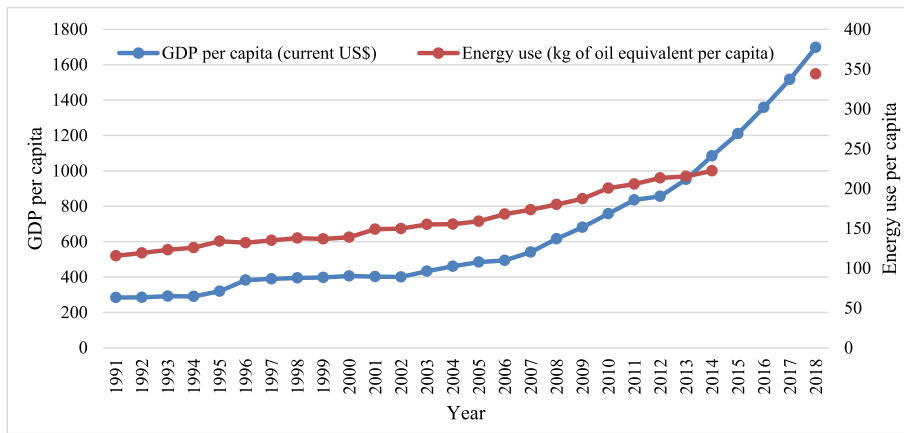


Fig. 7. Per capita GDP and energy consumption in Bangladesh from 1991 to 2018.

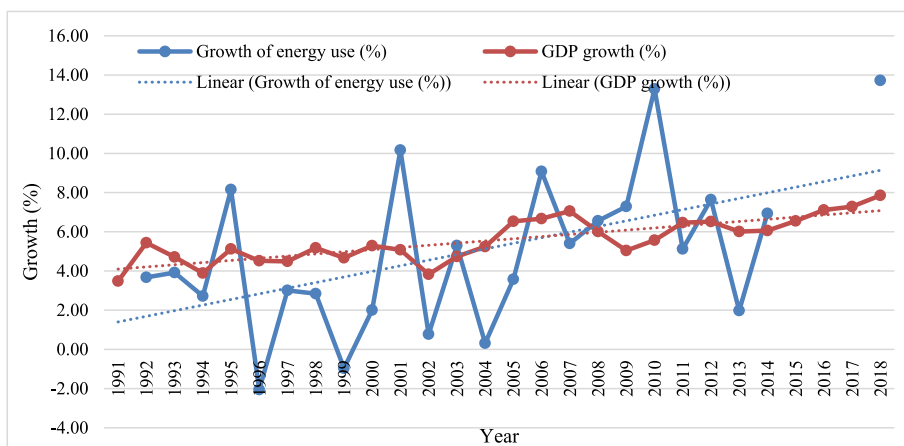


Fig. 8. Comparison between GDP growth and energy consumption growth from 1991 to 2018.

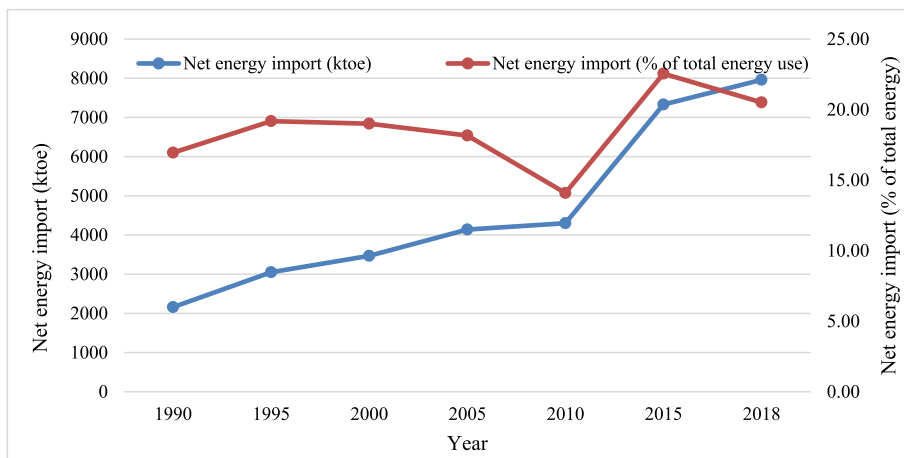


Fig. 9. Net energy imports into Bangladesh from 1990 to 2018.

18,961 MW in 2018 (BPDB, 2018–2019). Due to various system losses, fuel supply constraints, and low plant capacity factors, it was hardly possible to supply on an average 10,000 MW of electricity. The deficit was approximately 3,000 MW against the demand during summer in 2018. Fig. 5 presents total power generation by sources and fuel mix in 2018, which indicates that more than half (57.37%) of the total electricity generation was obtained from natural gas in 2018. Oil served as the second major primary energy source, which contributed a share of

32.39%. Importing power from India through cross-border contributes to 6.12% of the total electricity supply. The contribution of power generation from coal and renewable energies (hydro and solar) was not significant.

The gap between the electricity generation target and actual generation is falling gradually from previous years due to pragmatic power generation enhancement programs. The share of electricity generation between the public and private sector was 52% and 43%, respectively

Table 5

Rate of average subsidisation in Bangladesh compared to other some countries, 2013

Country	Average subsidisation (%)	Subsidy per capita (USD/person)	Total subsidy as % of GDP
Bangladesh	33.6	29	3.2
China	2.6	16	0.2
India	19.9	38	2.5
Malaysia	15.6	178	1.7
Sri Lanka	6.1	15	0.5
Thailand	6.7	54	0.9

Source: CPD, 2016.

(BPDB, 2018–2019).

The lion's share of electricity consumption in 2018 is associated with the residential, industrial, and commercial sectors. The residential sector consumed the most electricity (about 50%), followed by the industrial (29%) and commercial (10%) sectors, respectively (IEA, 2020). However, Bangladesh is largely dominated by electricity production using domestic gas, as shown in Fig. 6. According to the WB (2018), 81% of the total electricity was produced by domestic gas in 2015, followed by 16% from oil sources with coal and hydro generating 2% and 1%, respectively. There is a lack of diversity in generating electricity in Bangladesh, making it very challenging for the power sector to be sustainable.

There is no major change in the electricity generation target between the PSMP2010 and PSMP2016 rather than fuel diversification. In the PSMP2010, electricity generation using gas by 2021 and 2030 shifted from 62% to 25%, respectively, due to a shortage of adequate gas supply. The generation of electricity using coal will be increased from 2% to 50% by 2030, which would be difficult to achieve due to the uncertainty of the coal supply, constraints of infrastructure development, vibrant energy policy, and bureaucratic bottlenecks. However, the fuel mix has been modified in PSMP2016 as shown in Table 3, where gas and coal equally contribute 70% of the total power generation, and renewable sources, including hydro, would produce 15% (PSMP, 2016). The current contribution of renewable energy with hydro is only 2%, although it was expected to be 5% by 2015 in the PSMP2010 (PSMP, 2016). It was suggested that 10% of the total electricity generation from nuclear power would be connected to the national grid by 2021 (MoPEMR, 2016), but doing so would be difficult to achieve in the current circumstances. It might be possible to get 2,400 MW electricity generation (6%) from nuclear power by 2025 if construction is on schedule. The PSMP2016 has also projected that approximately 7.5% of electricity over the total electricity generation would be achieved by 2030 by importing electricity from neighbouring countries (Sufi, 2016; PSMP, 2016).

Table 4 shows the electricity generation enhancement program in both public and private sector under construction, tendering and agreement processes, and planning stages as of December 2020 (BPDB, 2019–2020). Approximately 16,479 MW installed capacity from gas, LNG, coal, oil, nuclear, renewables (solar, wind), and biomass (wastes) is presently under construction. A total of 3,611 MW in the tendering and agreement processes is to be produced mainly from gas, LNG, coal, solar, and wind. Furthermore, addition of 19,415 MW mainly from LNG, coal, solar, nuclear, and importing electricity through cross-border, is at the planning stage (BPDB, 2018–2019). It is evident from Table 4 that apart from coal and LNG, the electricity generation enhancement program is heavily emphasised on energy diversification policy with clean sources like solar, wind, nuclear, biomass, and regional energy and power trading.

3.4. Comparative performance of energy with economic indicators

Bangladesh has made some remarkable achievements related to development in recent times by upgrading itself into the World Bank's

“lower middle income” country category in 2015 (Badiuzzaman et al., 2018). Moreover, for the first time (2018), the country has fulfilled the conditions for becoming a developing country from the Least Developed Country (WB, 2018). The country's development requires a sufficient energy supply as energy is considered one of the key factors of production in addition to capital, labour, and materials (Sarkar et al., 2015). Energy plays a central role in a country's economic growth, social development, and living standards (Sarkar et al., 2015). Thus, over time, Bangladesh has experienced simultaneous gains in per capita energy use and per capita GDP.

Fig. 7 shows that per capita GDP has increased from US\$285 in 1991 to US\$1698 in 2018, indicating a 5.96 times increase over 27 years. Per capita energy consumption in Bangladesh increased about three times from 115 kgoe in 1991 to 344 kgoe in 2018 (MoPEMR, 2008). Fig. 7 provides trends of both the GDP growth and growth of energy consumption of Bangladesh, where the average annual GDP growth and growth of energy consumption is measured by 5.50% and 4.64% for the period of 1991–2017 and 1991–2014, respectively. However, for 2010–2014, the average growth of energy consumption (6.99%) reaches GDP growth (6.13%) will become a matter of great concern. Thus, the estimated linear trend line of energy use has surpassed the linear trend line of GDP growth (Fig. 8). Therefore, growth in Bangladesh illustrates the energy-economy nexus.

3.5. Import and economic cost of energy

Bangladesh has experienced a shortage of energy supply relative to demand for many years. The most critical concern regarding the energy shortage is that the country could not fill the gap between supply and demand. Fig. 9 reveals that Bangladesh imported energy ranging from 12% to 22% of its total energy use between 1990 and 2018 (IEA, 2018). The share of energy imported to total energy consumption was 14.09% in 2010, which increased at the highest level (22.55%) in 2015 (IEA, 2020). The country imported about 17% and 20.5% of its total energy use in 1990 and 2018, respectively, indicating that energy dependence has increased in recent years. Thus, Bangladesh is still far behind in achieving energy self-sufficiency and energy security, and perhaps never will so.

The government's allocation for the power and energy sector has risen during the last decade, but the country still struggles to meet the growing energy demands. The government has allocated Tk24,921 cores, which is 5.36% of the total 2018–2019 budget, to expand the power and energy sector. The proposed allocation is 2.72% higher than the revised budgetary allocation of Tk24,260 cores for the previous year. The allocation for the power sector was only Tk4,310 cores in 2009–2010, which was increased approximately 8-fold in 2018–2019. In the last ten years, the number of power plants quadrupled to 130, power installation capacity tripled to 18,353 MW, and even the maximum power generation tripled to a record of 10,958 MW (Rahman, 2018). Bangladesh provides the largest subsidy (33.6%) to the energy sector compared to other Asian countries (Table 5). The total subsidy provided to the energy sector in 2013 was estimated at 3.2% of the GDP compared to China which only provided a 0.2% subsidy. However, Fig. 10 shows that Bangladesh has gradually reduced its energy subsidy over time. The contingent liability of the power sector of Bangladesh has increased over the years from Tk7,795 cores in 2013 to Tk14,466 cores in 2015 (Table 6). Not surprisingly, the economic burden continues to rise due to the ongoing energy crisis.

3.6. Policy, plan, regulatory frameworks, and governance of energy and power sector

The Ministry of Power, Energy and Mineral Resources (MoPEMR) is responsible for dealing with energy, power, and mineral resources policies, plans, laws, rules, regulations, codes, standards, and guidelines. Table 7 lists existing policies and plans for ensuring energy and power in

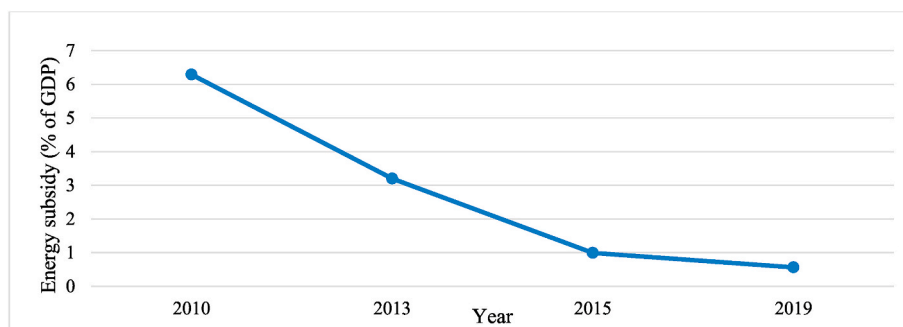


Fig. 10. Energy subsidy in Bangladesh from 2010 to 2019.

Table 6

Contingent liability of the power sector of Bangladesh (*Tk core).

Period	Power	Energy
As of 30 June 2013	7795	34,160
As of 30 June 2014	10,963	35,148
As of 30 June 2015	14,466	23,860

Note: *1 US\$ = 84.21 Tk (Bangladeshi Taka), Source: CPD, 2016.

the country. Bangladesh has a national energy policy (NEP) that encompasses all energy resources, energy policies, power policies, and regulatory policy (NEP, 2010). There also are separate coal, renewable energy, and nuclear energy policies, a power system roadmap, and energy efficiency and conservation master plans. In the NEP, priority is given to the diversification of indigenous commercial energy resources, with coal assumed to be a potential source for providing the country's future energy needs. Due attention is also given to the construction of NPPs as baseload plants for fuel diversity.

New policies are adopted to strengthen the utilization and expansion of renewable energy sources to reduce dependence on fossil fuels. Table 8 lists existing legislative and regulatory frameworks for energy and power management. It is seen in Table 8 that there are several statutes, ordinances, rules, and regulations concerning energy and power sector management. Table 9 lists the two energy regulators responsible for licensing, adjustments to tariffs, monitoring, and ensuring energy efficiency and conservation roadmaps. However, there are too many energy and power-related organisations responsible for energy and power generations and distributions - both public and private - in a small country like Bangladesh. There is a single transmission company, one think-tank technical support organisation, and a few research and development (R&D) organisations but their activities are limited.

3.7. Reasons for the energy crisis

Although Bangladesh has made significant progress in power generation and distribution, there are still many factors contributing to an energy crisis. These factors include a lack of policy, regulation, and governance, primary fuel supply, infrastructure, investment, supply, and demand-side management, research, and education. Although the economy is growing more than 5% annually, the power supply is not increasing at the same pace to support sustainable economic growth. The factors mentioned for the energy crisis are addressed in the following sections.

3.7.1. Policy, regulatory framework, and governance

As reported in Tables 7–9, numerous policies, master plans, regulatory frameworks, and energy, and power operating organisations exist but are not working effectively due to bureaucratic management. Most importantly, energy and power policies and regulatory frameworks are not up-to-date, given the need to consider accessibility, affordability,

Table 7

Policies and plans for energy and power vision.

Energy-related policies and plans
1. The National Energy Policy (NEP)-1996 updated in 2005
2. Draft Coal Policy-2006
3. Draft Renewable Energy Policy-2008
4. Draft Nuclear Energy Policy-1996
5. Energy Efficiency and Conservation Master Plan up to 2030–2015
6. Action Plan for Energy Efficiency and Conservation-2013
Power-related policies and plans
1. Private Sector Power Generation Policy-1996 updated in 2004
2. Power System Master Plan updated in 2016
3. Bangladesh Nuclear Power Action Plan-2000
4. Policy Guidelines for the Enhancement of Private Participation in the Power Sector-2008
5. Policy Guideline for Small Power Plant in Private Sector-2008
6. Policy Guidelines for Power Purchase from Captive Power Plant-2007
7. Guideline for Remote Area Power Supply System-2007
8. Power Pricing Framework-2004
9. Net Metering Guidelines-2018

and sustainability with clean energy sources. Most of the in charge of the public sector power generating organisations are led by bureaucrats. There is no distribution policy and regulatory frameworks for both urban and rural areas. There is also no policy or regulation for excess electricity use during the winter season and off-peak hours. The government has to pay a surcharge to private owners when private power plants sit idle during off-peak periods. The conventional production and distribution of the power system incur a 12% system loss. Any diversity in power generation is not being realised as natural gas dominance has existed for a long time. Different companies have received licenses from the government, but they are implementing conventional energy systems. The government and companies have made no effective and fruitful efforts to explore alternative energy sources or integrate them into an energy-power system master plan. There is also an absence of collaboration and guidance between the public and private sectors towards achieving energy sustainability. Due to bureaucratic management practices, weak monitoring, and corruption, power plants under construction take too long to complete, raising costs and hindering the expansion of the energy and power sector.

3.7.2. Primary fuels

The present power generation mainly relies on indigenous gas, diesel, and furnace oil. About 57.37% of generated power originates from indigenous gas, 32.39% from diesel and furnace oil, 2.76% from coal, 1.2% from hydro, and 6.12% from imports (BPDB, 2018–2019). The present production rate of gas is increasing, but the growth rate in production is decreasing. Currently, 26 discovered gas fields are under-productive due to policy barriers, lack of finance, expertise, technology, and infrastructure problems. Approximately 30% of the gas-based power plants are sitting idle mainly due to a lack of gas supply (The Daily Prothom Alo, 2019). So the government must rely on

Table 8
Legislative and regulatory frameworks for energy and power management.

Energy-related legislative and regulatory frameworks
<ol style="list-style-type: none"> 1. Bangladesh Energy Regulatory Commission (BERC) Act-2003 amended in 2020 2. Sustainable and Renewable Energy Development Authority (SREDA) Act-2012 3. The Gas Act-2010 4. The Bangladesh Petroleum Act-1974 amended in 2016 5. The Bangladesh Petroleum Corporation Ordinance –1976 6. The Bangladesh Atomic Energy Commission Order-1973 amended as Act in 2017 7. Bangladesh Atomic Energy Regulatory Act-2012 8. The Petroleum Rules-1937 9. Energy Efficiency & Conservation Rules-2016 10. Energy Audit Regulation-2018 11. BERC Licensing Regulations-2006 12. BERC Disputes Settlement(Amendment) Regulations-2016 13. BERC Gas Transmission Tariff Regulation-2008 14. BERC Natural Gas Transmission Tariff Regulation-2010
Power-related legislative and regulatory frameworks
<ol style="list-style-type: none"> 1. The Electricity Act-1910 amended in 2012 2. Rural Electrification Board Ordinance-1977 3. Bangladesh Energy Regulatory Commission (BERC) Electricity Grid Code- 2012 4. Nuclear Power Plant Act-2015 5. Electricity Rules-1937
Energy and Power-related legislative and regulatory frameworks
<ol style="list-style-type: none"> 1. Emergency Energy & Power Supply Special Act-2010 2. Bangladesh Energy and Power Resource Council Act-2015

imported LNG and oil due to the inadequate supply of gas from local gas fields.

The government pays a large subsidy for importing oil which adversely affects economic growth and expansion of power plants to meet the increasing energy demand. Another important source of power generation is coal. However, political barriers, lack of appropriate expertise, and environmental concerns mean that these four coal fields are still not in production and do not support several coal power plants presently under construction. Moreover, the country's coal policy is not finalised, although PSMP2016 projects aim for about 50% of power generation based on imported coal by 2030. Running coal power plants by feeding imported coal may create uncertainty due to the inefficient transportation of a large amount of coal. There is no potential nuclear fuel reserve. Prospects of solar, wind, and biomass are currently unattractive due to policy issues and a lack of research. Thus, in the PSMP2016 future power generation is dependent on imported LNG, oil, and coal, which may create uncertainty in supplying primary fuels.

3.7.3. Infrastructure and investment

Presently, the installation capacity of electricity is about 18,961 MW. However, about 70–80% of electricity generation over installed capacity is not efficiently and reliably delivered to all consumers. This situation is due to both the unreliable and inefficient grid, lack of transmission and distribution lines and substations. One-quarter of the generation plants are more than 20 years old, causing regular plant outages, higher maintenance costs, idle capacity, and higher capacity charges from the government. Capacity building of the state-owned gas and oil exploration and production company is not working independently due to bureaucratic problems. Appropriate sites for constructing coal, nuclear, and solar power plants are inadequate in a highly densely populated country. Additionally, the present investment rate is insufficient to meet the required expansion rate of power plant transmission and distribution. Poor infrastructure and investment are significant impediments to the expansion of the energy and power sector.

3.7.4. Energy efficiency and conservation

The government has prepared EE&CMP up to 2030, EE & C rules-2016, and energy audit regulation-2018 to ensure energy efficiency & conservation for both supply and demand. However, little work, such as introducing energy-saving lighting, has been done. Tamim (2017) has

Table 9
Energy and power governance in Bangladesh.

Apex body
<ul style="list-style-type: none"> • Ministry of Power, Energy and Mineral Resources (MoPEMR) Two divisions of MoPEMR: <ol style="list-style-type: none"> 1. Power Division 2. Energy and Mineral Resources Division
Regulatory Organisation
<ol style="list-style-type: none"> 1. Bangladesh Energy Regulatory Commission (BERC) 2. Sustainable and Renewable Energy Development Authority (SREDA) Technical Supportive Organisation for Energy and Power Sector
Energy Operating Organisation (Public)
<ol style="list-style-type: none"> 1. Bangladesh Oil, Gas, and Mineral Corporation (Petrobangla) 2. Bangladesh Petroleum Exploration and Production Company Limited (BAPEX) 3. Bureau of Mineral Development (BMD) 4. Bangladesh Petroleum Institute (BPI) 5. Bangladesh Petroleum Corporation (BPC)
Power Generating Organisation (Public)
<ol style="list-style-type: none"> 1. Bangladesh Power Development Board (BPDB) 2. Electricity Generation Company Bangladesh (EGCB) 3. North-West Power Generation Company Ltd. (NWPGL) 4. Rural Power Company Ltd. (RPCL) 5. Ashuganj Power Station Company Ltd. (APSCL) 6. Coal Power Generation Company Bangladesh Ltd. (CPGCL) 7. B-R Powergen Ltd. (BRPL) 8. Nuclear Power Company of Bangladesh Ltd. (NPCBL)
Joint Venture Power Generating Organisation (Public-Private Partnership)
<ol style="list-style-type: none"> 1. Bangladesh-China Power Company Ltd. (BCPCL) 2. Bangladesh-India Friendship Power Company Ltd. (BIFPCL) 3. RPCL NORINCO Intl. Power Ltd. (RNPL)
Power Generating Organisation (Private)
<ol style="list-style-type: none"> 1. Independent Power Producer (IPP) 2. Small Independent Power Producer (SIPP) 3. Quick Rental 4. Rental 5. Captive
Power Distribution Company (Public)
<ol style="list-style-type: none"> 1. Bangladesh Power Development Board (BPDB) 2. Rural Electrification Board (REB) 3. Dhaka Power Distribution Company (DPDC) 4. Dhaka Electric Supply Company (DESCO) 5. West Zone Power Distribution Company (WZPDC) 6. Northern Electricity Supply Company (NESCO)
Power Transmission Company (Public)
<ul style="list-style-type: none"> • Power Grid Company of Bangladesh Ltd.(PGCBL) R&D Organisation in Energy and Power Sector
<ol style="list-style-type: none"> 1. Hydro Carbon Unit (HCU) 2. Bangladesh Energy and Power Research Council (BEPRC) 3. Bangladesh Power Management Institute 4. Bangladesh Engineering Research Council (Yet to function)

Source: Authors' compilation

estimated that 5% of grid improvement would save 5,000 MW electricity by 2030 using the same amount of fuel, while 20% demand-side efficiency improvement would save 7,000 MW electricity. Thus, integrated resources planning and optimisation of resources are not working reciprocally. Bangladesh is still lagging far behind by not using energy-efficient technology, saving an average of 10% of energy annually in the industrial, residential, commercial, and agricultural sectors (EE&CMP, 2016). Alternatively, energy conservation has great potential to save energy by changing people's behaviours and actions. Much energy is being lost due to taking unrealistic conservation measures. There is no cutting-edge policy and regulatory framework in place to stop waste in energy supply and demand. The absence of an energy culture among individuals and organisations results in inefficient energy use in residential, commercial, and industrial scenarios. Recent studies show that beliefs, attitudes, and behaviours are among the factors that perpetuate energy waste (Fornara et al., 2016; Andrews and Johnson,

2016; Rotzek et al., 2018).

3.7.5. Research and education

There is a lack of research, education, and training activities in Bangladesh's energy and power sector to address the challenges that the 2041 roadmap must address. Azzuni and Breyer (2018) identified that expenditures on R&D and education are key to addressing the energy expansion challenge. A similar study by Huang and Chen (2020) stated that more R&D activities with effective knowledge management are essential to minimise energy uncertainty. Khanna et al. (2020) found that R&D and education can help level future electricity costs and meet the energy crisis through sustainable energy and power expansion plans. A sustainable and long-term visioned national energy policy and power expansion plan are thus essential to accelerate the growth of energy expansion in line with future energy demands, as noted by Chachuli et al. (2020).

A sustainable energy and power expansion plan depends on research, education, training, and knowledge management activities which are largely missing in the case of Bangladesh. There are few in-country experts in energy system planning, exploration and production, energy economics, energy management, energy diplomacy, energy conversion, and conservation. Only one academic institution amongst 156 focuses on energy science and engineering education. Recently, the Energy and Power Research Council and Bangladesh Power Management Institute, under the Ministry of Power, only operate with limited resources. Energy engineering education, R&D policy, and implementation practices are still inadequate.

3.7.6. Regional cooperation

Bangladesh is slow in diversifying resources and domestic reforms in expanding regional energy cooperation, energy investment, and cross-border energy trade for at least the last two decades with its neighbouring countries, especially India, Nepal, and Bhutan. Though multi-lateral energy sector collaboration in the Southeast Asian region has recently expanded, broader (e.g. regional) cooperation and investment actions are still lagging due to national policy barriers. Healthier cooperation and improved cross-border energy trade among the South Asian Association for Regional Cooperation (SAARC) countries can carry economies of scale investments in the power sector, strengthen financing capacity and capability, and cost-effective energy diffusion, which are still inadequate. Debatably, the magnitude and current state of energy cooperation and cross-border energy trade in SAARC, particularly between India and Bangladesh, are not their best (Timilsina and Toman, 2016). Although much potential exists to import electricity from India, Nepal, Bhutan, and Myanmar, this is yet to materialise.

3.8. Ways to mitigate the energy crisis using alternative energy sources

Bangladesh needs to take extensive measures to achieve energy self-sufficiency and, in this way, address the energy crisis and growing energy demand. These measures require multi-dimensional actions and initiatives, as described in more detail below.

Firstly, Bangladesh needs to seek and promote alternative energy sources as fossil fuels (gas, coal, and oil) are limited. Indigenous gas will be exhausted within the next 10–15 years if no new reservoir is found. The existing pipeline gas distribution network needs to be stopped from wasting gas in the industrial, commercial, and residential sectors, strengthening gas and oil exploration both onshore and offshore, grid expansion, introducing net metering and smart grid development in transmission and distribution lines. As Bangladesh has set approximately 35% of total electricity generation by 2041 to be generated from coal (PSMP, 2016), an extensive coal policy must be finalised by overcoming policy barriers and environmental issues. An effective communication channel for importing coal from potential countries, such as India, Indonesia, China, and Australia must also be established.

Secondly, another alternative source is renewable energy, and this

should be the long-term vision for Bangladesh. Recent evidence suggests that renewable energy could soon provide the majority share of electricity (Hosenuzzaman et al., 2015; Saidur, 2010). Although renewable energy is still considered expensive, extensive work is required to make it a viable alternative option. Having the prospects of renewable energy options, the Bangladesh government has already set targets to generate 15% of total electricity from renewable sources by 2041. However, the current penetration rate of renewable energy in Bangladesh is still negligible and unable to meet the power sector vision for 2041. Biomass/biogas is also considered to be a very acceptable technology that requires further refinement. Wind can be added as a significant contributor from renewable energies to resolve the energy crisis if appropriate policies, programs, and technology innovation are put in place (Islam et al., 2008; Biswas et al., 2011; Khan and Khan, 2011). Recently the national renewable energy laboratory of the Department of Energy of the United States has estimated the potential to generate electricity of 30,000 MW from wind at 120-m altitude in the country's coastal regions (Mark et al., 2018). Thus, the government needs to attract investment in renewable energy from indigenous and foreign investors by offering various incentives.

Thirdly, apart from the renewable and conventional energy options, the issue of nuclear power is unavoidable for an energy-hungry country like Bangladesh. Nuclear power is attractive in the long-term from an economic viewpoint (Rubbia, 2005). The challenges of introducing nuclear power in developing countries include investment, safety, security, proliferation, waste management, and knowledgeable expertise. The first NPPs under construction at the Rooppur site will generate electricity of 1,200 MW by 2023 and an additional 1,200 MW by 2024, and will contribute 10% of the total electricity generation throughout the country. However, based on the present demand, much more electricity needs to be generated by nuclear technology. Construction of more units at the Rooppur NPP site will be economically attractive. Other potential sites in the Southern part of the country (Khulna, Patuakhali) need to be selected to generate more electricity from nuclear energy (Karim et al., 2018).

Fourthly, there should be a robust regulatory framework for energy efficiency and conservation program (EE&CP). It is estimated that potential energy-saving opportunities from industrial, commercial, and residential sectors could be approximately 21%, 10%, and 28.8%, respectively (EE&CMP, 2016). Achieving this energy-saving target could be realised by introducing an efficient energy management program. The government of Bangladesh has prepared the EE&CMP up to 2030, intending to save a substantial amount of energy and improve energy intensity per GDP by 15% by 2020 and 20% by 2030 (EE&CMP, 2016; ADB, 2014). However, the question arises about the effectiveness of the existing framework and activities to meet the 2030 target. Thus, EE&CP needs to be incorporated in master plans, energy policies, and regulatory frameworks for the sector. The regulatory framework should address energy-efficient equipment, energy audits, cogeneration, periodic monitoring, assessing the effectiveness of the EE&CMP, and raising awareness through education, information, and communication campaigns.

Fifthly, as a part of the energy efficiency and conservation program, energy auditing should be implemented regularly to measure the accounting system for energy supply, consumption, and evaluation of energy conservation programs (Krarti, 2016; Khare et al., 2012; Zhu, 2006; Anderson and R.G., 2004). Based on energy data, energy auditors should ascertain the rational use of energy in all systems, processes, electrical appliances, etc., to evaluate energy conservation options (Fischer, 2008). The auditor should assess the organisation's current energy usage and provide recommendations on how to improve energy efficiency through an effective management program that will curtail energy waste. Large amounts of energy are lost due to traditional mechanical processes, less efficient electric motors, and lack of awareness (Saidur, 2010). Furthermore, industries can save energy by using cogeneration systems and promoting energy audits (Khan, 2014; Dobes,

2013; Abdelaziz et al., 2011; Benelmir and Feidt, 1998). Regular energy audits in industries and commercial buildings could identify shortfalls in technology use and intensify energy conservation programs. Online monitoring systems of machines or equipment in industries with or without wire can result in ample energy-saving opportunities.

Sixthly, as a part of the energy efficiency and conservation program, an energy culture could be developed by changing people’s beliefs and attitudes (Hards, 2013; Gadenne et al., 2011; Oikonomou et al., 2009; Poortinga et al., 2003). An energy culture model based on theory, analysis, and data is of paramount importance to saving energy (Sweeney et al., 2013). Fostering energy culture in people’s beliefs and attitudes can save a substantial amount of energy from waste in industry and households (Lawson and Williams, 2012; Stephenson et al., 2015; Ke et al., 2012; Lee and Harrison, 2000). Practising energy cultural norms in organisations and by people should be linked with energy efficiency and conservation program.

Lastly, regional cooperation is another option to ensure energy security. Bangladesh, along with other South Asian countries, is a member of SAARC. Regional, and regional cooperation, namely Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC), Bangladesh, China, India, and Myanmar (BCIM), Bangladesh, China, India, and Myanmar-Economic Corridor (BCIM-EC), Bangladesh, Bhutan, India, and Nepal (BBIN), Bangladesh, Myanmar, India (BMI), were introduced, focusing on the South Asia energy market for rapid economic growth (Shahi, 2015; Hossain, 2012, 2015). Bangladesh should focus on cross-border energy investment, trade, technology transfer, and expertise under subregional and bilateral agreements. Cross-border energy cooperation will generate more foreign direct investment, which will support efficient use of resources, regional market access, multilateral energy infrastructure, and additional investment opportunities. Bangladesh has already added 1160 MW of electricity through cross-border connectivity with India. These networks

have opened up enormous opportunities to develop the electricity market in South Asia. Cross-border electricity trading from South Asian countries under bilateral/regional or international agreements is a viable option for meeting future energy demand (Rodrigo, 2015; Hossain, 2012; CIA, 2011).

This study outlines a framework/roadmap to achieve fuel mix and electricity generation target by 2041 to overcome the energy crisis of Bangladesh, which is presented in Fig. 11. It stresses four broad areas: policy and planning, capacity building, financing, and implementation strategies for accelerating energy self-sufficiency. Thus, the government of Bangladesh should give special priority to the energy and power sector by allocating a higher share of public expenditure and managing external finances offered by donor organisations.

This study offers the following specific recommendations to address the energy crisis and the challenges of the energy and power sector in Bangladesh:

- (i) Due to prevailing draft energy and power policies and lack of regulatory actions, good governance, and local energy experts, future energy and power forecast may not accurately predict energy demand. To avoid this, energy experts and practitioners should work on pre-emptive policies and decision-making processes.
- (ii) Strengthen policies and collaboration for energy exploration and production and resolve challenges related to developing alternative energy and clean energy resources and technologies.
- (iii) Implement and develop different policies, legislation, rules, and guidelines relating to energy conservation and efficiency must focus on changing people’s habits and ensure that energy-efficient electrical appliances, engines, buildings, etc., are promoted.

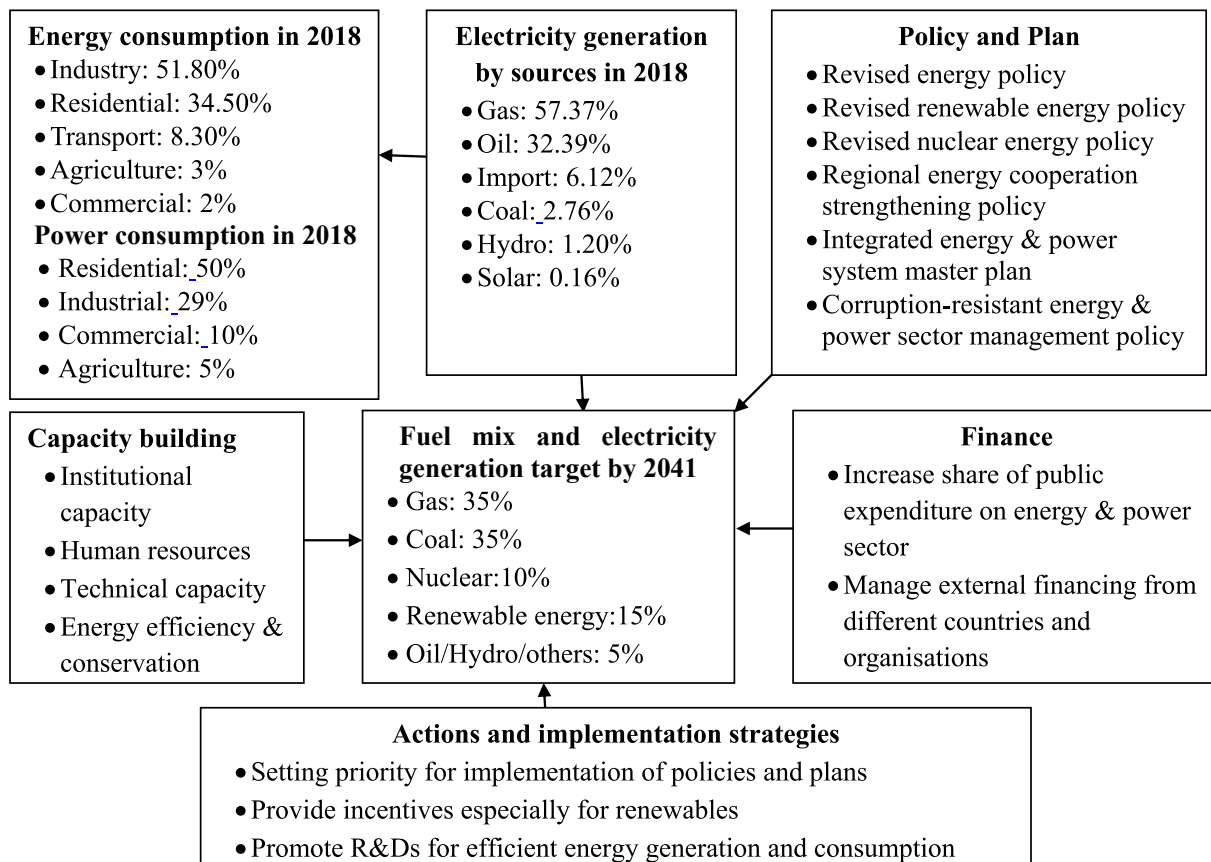


Fig. 11. Energy generation, consumption, and utilization roadmap.

- (iv) Run energy and power-related R&D organisations to their fullest capacities in terms of infrastructure, budget, and utilising the best human resources to create energy innovation.
- (v) Introduce new energy engineering courses that are well funded in the public and private sector universities in order to acquire in-depth knowledge about energy policy, energy system planning, energy diplomacy, energy financing, energy exploration, energy trading, energy management, energy efficiency and conservation, etc.
- (vi) Create good governance by employing and deploying technical experts rather than bureaucrats in the top energy and power sector positions. They will have the expertise to oversee and monitor energy and power-related projects, minimise corruption and get the most out of the resources through an integrated management approach.
- (vii) Implement and strengthen regional and sub-regional cooperation agreements in South Asia for exploiting maximum energy resources for countries' mutual interests.

4. Conclusion

Bangladesh is a small island nation covering 147,570 km², and it has 170 million people. Ensuring affordable, uninterrupted, and quality energy for all with limited resources and infrastructure is a great challenge to the government. A decade ago, there was an approximate gap of 50% between energy supply and demand. This gap has recently been reduced to 26% due to priority given to the energy sector in powering the economy. The current progress is significant due to the adaptation of fuel diversification in the energy and power sectors' roadmap and investments. Ensuring energy security for a sustainable economy (SDG-7) includes setting the right policies for energy exploration and production, equal energy distribution in urban and rural areas, removing political and bureaucratic bottlenecks, controlling and eliminating corruption, timely completion of power projects, and putting the right people in the right place. This study addresses the reasons for the energy crisis in Bangladesh and suggests how to resolve it using alternative energy sources. Some examples include strengthening renewable energy sources (solar, wind), developing more NPPs, grid expansion, investing in energy-efficient technologies, developing an energy culture through social change so that energy is used more efficiently, and effective channelising regional, sub-regional, and bilateral energy cooperation with South Asian countries.

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The authors declare there is no conflict of interest.

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Glossary

- ADB:** Asian Development Bank
BPDB: Bangladesh Power Development Board
BCAS: Bangladesh Centre for Advanced Studies
EE&CP: Energy Efficiency and Conservation Program
FY: Fiscal Year
GDP: Gross Domestic Product
IEA: International Energy Agency
KTOE: Kilotonne of Oil Equivalent
kWh: Kilowatt-hour
KGOE: Kilogram Oil Equivalent
LNG: Liquefied Natural Gas
MoPEMR: Ministry of Power, Energy, and Mineral Resources
MT: Metric Ton
MW: Megawatt
NEP: National Energy Policy
NPP: Nuclear Power Plant
PSMP: Power System Master Plan
R&D: Research and Development
SAARC: South Asian Association for Regional Cooperation
SREDA: Sustainable and Renewable Energy Development Authority
US\$: United States Dollar
WB: World Bank