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THE RENEWABLE RISE: SHAPING BANGLADESH'S ENERGY FUTURE

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The Renewable Rise: Shaping Bangladesh's Energy Future

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Executive Summary

Bangladesh's energy sector stands at a decisive moment. The country is growing rapidly, urbanising quickly, and facing rising demand for reliable and affordable energy. Yet the current energy system remains heavily dependent on conventional sources, especially natural gas, while modern renewables still occupy only a marginal place in the energy mix. This creates a difficult policy challenge. Bangladesh must expand energy supply to support economic growth, but it must also improve energy security, reduce emissions, and build resilience against climate shocks that are already affecting infrastructure, supply systems, and demand patterns.

Bangladesh's energy transition is no longer a choice, the paper argues. Natural gas production remained the top contributor to domestic energy production at over 69% of total production, and biofuels and waste accounted for about 28%, mostly from traditional biomass in households and small industries. In comparison, solar and wind combined only account for 0.4%, with hydropower only contributing another 0.2%. This arrangement exposes the country to a triplet of threats: reliance on gas-fired energy supply systems, ongoing environmental and health impacts from conventional biomass, and slow development of modern renewable technologies. If reshaping the global energy system toward more renewables and efficiency does not happen, Bangladesh's struggle to make higher energy demand consistent with its climate commitments is well underway.

Climate change is already challenging the energy system. Higher temperatures drive demand, particularly cooling demand for electricity, and extreme weather-related events such as cyclones, floods, storm surges, and heat waves damage power generation, transmission, and distribution infrastructure. Coastal power plants are subject to even more risks from sea level rise, salinity intrusion, and storm surges. Needless to say, recent disasters underscore the size of the problem. Thousands of poles and hundreds of kilometres of distribution lines were damaged by Cyclone Amphan, while electricity for millions was disrupted, along with loss or damage to transformers, meters, distribution poles, and transmission equipment due to Cyclone Remal. These events demonstrate that energy resilience is not only a technical issue, but also core to disaster response and economic recovery in our everyday lives.

The emissions profile of Bangladesh makes the energy challenge even clearer. Electricity and heat producers are the largest contributors to CO_2 emissions, with emissions rising sharply since 2010 because of greater reliance on fossil fuels. In 2023, electricity and heat producers emitted 59 Mt CO_2, followed by industry at 17.59 Mt CO_2, transport at 14.90 Mt CO_2, and residential energy use at 9.75 Mt CO_2. Natural gas remains the largest source of fuel-related CO_2 emissions, but oil and coal emissions have also increased. The trend confirms that Bangladesh's growth path has become increasingly energy-intensive and fossil-fuel dependent.

Bangladesh's NDC 3.0 gives the energy sector a central place in the national mitigation agenda. In the 2022 base year, the energy sector emitted 123.01 $MtCO_2eq$, accounting for 48.81% of total national emissions. Within the sector, power generation was the largest source, followed by energy use in manufacturing, transport, households, brick kilns, agriculture, and fugitive emissions. Under the business-as-usual scenario, energy-sector emissions are projected to rise to 264.00 $MtCO_2eq$ by 2035. NDC 3.0, therefore, sets a target to reduce energy-sector emissions by 69.84 $MtCO_2eq$ by 2035 through renewable energy expansion, lower transmission and distribution losses, cleaner power generation, electric transport, industrial energy efficiency, rooftop solar, clean cooking, solar irrigation, and gas leakage reduction.

The paper shows that NDC 3.0 is more specific and measurable than earlier climate commitments. Compared with NDC 2.0, it gives clearer targets for renewable electricity, grid efficiency, cleaner peaking plants, electric vehicles, railway electrification, rooftop solar, industrial efficiency, solar irrigation, clean cooking, non-fired bricks, and gas leakage reduction. It also distinguishes more clearly between unconditional actions that Bangladesh can pursue through domestic capacity and conditional actions that require international finance and technology support. This matters because the energy transition will require not only ambition, but also implementation capacity and financing.

Bangladesh's policy landscape already contains several important instruments for a cleaner energy future. These are the Energy Efficiency and Conservation Master Plan, Integrated energy and power master plan 2023, Perspective Plan 2041, Bangladesh Delta Plan 2100, 8th Five-Year Plan, Bangladesh Climate Prosperity Plan (BCPP), National Adaptation plan of Bangladesh (NAP), and Renewable Energy Policy-2025. The frameworks work in tandem to harness renewable energy, energy efficiency, grid modernization, and private investment, as well as solar irrigation, rooftop solar, floating solar, power trading across borders, cleaner technologies, and resilience built. For instance, the Energy Efficiency and Conservation Master Plan identifies key savings potential in industry, households, commercial buildings, and agriculture.

At the same time, the paper identifies a major weakness: policy coherence remains limited. Different policy documents set different renewable energy targets. As an example, the Power System Master Plan 2016 targets 20% renewable energy by 2041, whereas both the Bangladesh Climate Prosperity Plan and the Integrated Energy and Power Master Plan indicate a target of at least 40% renewables consumption in generating electricity. That uncertainty is bad for investors and hampers implementation. The policy ambition is high, but the route is sometimes less clear. A smooth transition will also need an aligned target, improved inter-agency coordination, refined implementation plans, and stronger regulatory support with credible financing mechanisms.

To assess the wider economic implications of the energy transition, the paper applies a recursive-dynamic Computable General Equilibrium model developed by IFPRI. The model is calibrated with a 2022 Social Accounting Matrix for Bangladesh and captures linkages across sectors, households, factor markets, product markets, government, investment, and trade. This allows the paper to examine how energy-sector reforms affect not only emissions, but also GDP, employment, household income, poverty, and energy security. The model focuses on energy-sector interventions that can be translated into NDC 3.0-based scenarios, particularly solar expansion, efficiency improvements, and demand-side energy savings.

The energy-sector simulations include four individual scenarios and one combined scenario. The renewable energy expansion scenario assumes that 25% of total electricity supply will come from solar by 2035, compared with about 2% in 2023. The transmission and distribution loss scenario assumes total system losses fall to 8%. The industrial energy efficiency scenario assumes a 10% improvement in energy efficiency and a shift from fired bricks to concrete blocks for 40% of brick demand, reducing coal use. The household energy savings scenario assumes that households save 10% of their electricity use by adopting energy-efficient appliances. The combined scenario brings all these interventions together.

The results are striking. Under the combined energy package, GDP growth rises from 6.10% under the baseline to 6.94%. GDP in 2035 becomes 8.19% higher than the baseline level, equivalent to an additional USD 66 billion in constant 2023 prices. The energy transition, therefore, emerges not only as a climate response but also as a growth strategy. Renewable energy expansion delivers the strongest individual gain, raising GDP by 6.95% above the baseline in 2035. Industrial energy efficiency also contributes positively, while reduced transmission and distribution losses produce more modest gains. Household energy savings help demand management and energy self-sufficiency, although their direct GDP impact is limited.

The employment gains are also substantial. Under the baseline, total employment is projected to rise from 71 million people in 2023 to 101 million in 2035. Against this baseline, the combined energy package creates 6.5 million additional jobs by 2035. Renewable energy expansion alone creates 5.5 million additional jobs, mainly through solar production, battery supply, installation services, repair activities, and related value chains. Industrial energy efficiency creates 1.2 million additional jobs, while reduced transmission and distribution losses create 0.5 million. This shows that the employment gains from renewable energy are not confined to power generation. They come from the wider ecosystem required to build, operate, and maintain a cleaner energy system.

The distributional impacts are especially important. The combined energy package raises household income by 9.0% for the bottom 30%, 7.1% for the middle 50%, and 4.1% for the richest 20%, compared with the baseline. This means poorer households gain proportionately more than richer households. Renewable energy expansion is again the strongest individual intervention, raising income by 7.5% for the bottom 30%, 5.8% for the middle 50%, and 3.3% for the richest 20%. The poverty results reinforce this inclusive pattern. Under the combined energy package, an additional 1.7 million people are lifted out of poverty by 2035. Renewable energy expansion alone lifts 1.2 million people out of poverty.

Energy security benefits are also significant. The combined energy-sector intervention reduces primary energy imports by 15.08% in 2035 compared with the baseline. This is particularly pertinent to Bangladesh as fossil fuel imports are straining foreign exchange reserves, fiscal balances, and energy affordability. The development of energy efficiency technology has a well-known impact on fossil fuel consumption reduction, while the expansion of renewable energy leads to import dependence reduction through various pathways, including a higher level of domestic high-quality electricity supply. The wider lesson is also simple: energy-sector reform can reduce Bangladesh's vulnerability to erratic global fuel markets while facilitating economic growth and poverty alleviation.

The paper identifies strategic pathways for a low-carbon and resilient energy future. Bangladesh has to harmonize its renewable energy targets across national policy, strengthen measures on energy efficiency, and introduce deeper incentives for investment in renewables in the short term. These would come in the form of numerous incentives like subsidies, tax credits, and low-interest loans for installing renewable energy systems, and incentives geared towards small solar and wind projects. Until then, there is a need for decentralised climate-resilient energy infrastructure across the country in the medium term: layers of rooftop solar (rural and urban); floating solar; battery storage; and off-grid solutions for coastal districts/ disaster-prone areas. Carbon trading frameworks and renewable energy certification systems need to be created in order to tap climate finance, resulting in improved investor confidence.

Longer-term transformation will require deeper institutional and financial reforms. Bangladesh needs a more coherent renewable energy roadmap, stronger grid infrastructure, better land-use planning for renewable projects, domestic capacity for battery and solar-related services, and stronger technical skills. It also needs to mobilise international climate finance through the Green Climate Fund, carbon markets, green bonds, and other mechanisms. Local institutions and project developers must be able to design bankable projects and manage climate finance effectively. Without this capacity, even ambitious policy targets may remain under-implemented.

The paper's central message is that renewable energy must be at the center of Bangladesh's climate-resilient development plan. A carefully and well-designed energy transition has the potential to lessen fossil fuel dependence, end emissions, create jobs, bolster household income, mitigate poverty, and ensure energy security. However, this will not happen by itself. This action will need to be coordinated across renewable generation, industrial energy efficiency, grid modernization, appliance standards, battery systems, financing, and institutional investment. It's particularly critical to this end that solar power undergoes more than moving the needle on generation capacity. It has to create an ecosystem that connects production, technology, skills, finance, and resilience.

The conclusion is clear. Bangladesh's energy sector is under pressure from climate change, fossil fuel dependence, rising demand, and policy fragmentation. Yet the same sector also offers one of the strongest opportunities for transformation. If Bangladesh can expand renewable electricity, improve energy efficiency, reduce system losses, strengthen climate-resilient infrastructure, and mobilise finance at scale, the energy transition can become a major driver of sustainable growth. Done well, it can support industrialisation, protect poor households, reduce import dependence, and build a more resilient economy. For Bangladesh, the renewable rise is not only an environmental necessity. It is a development opportunity.

1. Introduction

Bangladesh is a developing country with rapid population growth and is increasingly vulnerable to energy security, climate resilience, and long-term sustainability challenges. As a result, in recent years, it has clearly appeared that the country must expand its energy mix beyond conventional sources of energy (Al-tabatabaie et al., 2022). Given that Bangladesh is also one of the most climate-concerned nations globally, this need is even more critical. The impact of rising temperatures, changing rainfall patterns, and an increasing number of extreme weather events such as floods and cyclones is already pressure testing the infrastructure, economy, and development potentials of the country (Ahmed et al., 2016; Rakib et al., 2019).

This challenge is right at the centre of the energy sector. On one side, reliable, affordable energy is the backbone that will continue to fuel economic growth, industrialisation, till date urbanisation, and uplift in living standards. It is, on the other hand, one of the largest greenhouse gas-emitting sectors in Bangladesh. As per the Nationally Determined Contributions (NDC) 2021, the top five emitting subsectors were electricity generation, transport, industrial processes and product use, households, and brick kilns in terms of contributing to total emissions. The power subsector is still the main source of emissions in the energy sector under NDC 3.0 of 2025.

The energy mix in Bangladesh as of now is dominantly natural gas, along with the traditional household consumption of biomass and waste. The renewable energy technology continues to be residual, even though these technologies play an increasingly vital role in diversifying supply chains, reducing emissions, and making electricity grids more climate resilient. It is useful to establish this baseline as it conveys both the vulnerabilities within the sector and also where there are opportunities for a renewables-based transition.

Currently, the balance of Bangladesh's domestic energy mix remains overwhelmingly dominated by natural gas, which accounts for approximately 69% of all production. An additional 28% is derived from biofuels and waste, mostly classic biomass utilized in homes and small-scale businesses. Modern renewables, in contrast, have only made some limited gains. Along with hydropower, solar and wind together contribute merely 0.4%, while hydro adds up to a paltry 0.2%. This just highlights the distance this country still has to go in actually transitioning to a decarbonized and diverse energy future.

This structure suggests three key challenges. Initially, the over-dependency on natural gas puts the country at risk of supply limitations in addition to creating a hefty infrastructure burden on it and future energy safety stress contributors. Second, the ongoing use of traditional biomass is a source of environmental and health burdens, particularly for households and small-scale users. Finally, the minuscule amount of modern renewables underscores the need to ramp up solar, wind, and other clean energy technologies. In the absence of such a pivot, Bangladesh faces a real dilemma over how it reconciles increasing energy needs with ever-more demanding climate commitments.

This paper provides an analysis of the effects of climate change on the energy sector in Bangladesh against that backdrop. It examines the contribution of the energy sector to the future profile of the country's greenhouse gas emissions and assesses the vulnerability of energy infrastructure and supply chains to extreme weather events on climate change. It also provides an overview of the current energy and climate policy context, encompassing the NDCs and sectoral strategies relevant to national responses. It explores the economy-wide impacts of various energy transition pathways on the macroeconomy and factor markets using modelling techniques. It then presents potential low-carbon alternatives to the energy sector and evaluates their macroeconomic and macroenvironmental effects.

The analysis incorporates both policy and institutional review and quantitative modelling. The first consists of a critical analysis of national strategies and plans to identify the priority areas, gaps, and challenges within the existing policy framework. Second, in order to investigate economy-wide impacts of energy-sector change, the study simulates using a computable general equilibrium (CGE) model developed by the International Food Policy Research Institute (IFPRI). IFPRI standard recursive-dynamic CGE model (economy-wide simulation tool). Its static and dynamic modules contain flexible behaviour, micro-consistency through Nash-equilibrium solution techniques at both the sectoral level (inter-sectoral) and at the individual household, factor market, product market, government, investment, and trade levels. We calibrate the model with an economy-wide database for Bangladesh, a Social Accounting Matrix (SAM).

The structure of the paper comprises eight sections. After this introduction, Section 2 defines that climate risks affect the energy sector through their supply, demand or infrastructure resilience. Section 3 examines the emissions profile of Bangladesh in terms of sectoral contributions and the extent to which fossil fuels are relevant for both national and international mitigation pledges. Section 4 analyses energy-sector commitments in Bangladesh's Nationally Determined Contributions. Part 5 explores other central policy frameworks and assesses the extent to which they are ambitious and coherent. In Section 6, we present the impact of renewable energy adoption on growth, employment, and distributional outcomes in the economy using results from the CGE modelling exercise. Section 7 outlines strategic pathways for a low-carbon and resilient energy future. Section 8 concludes.

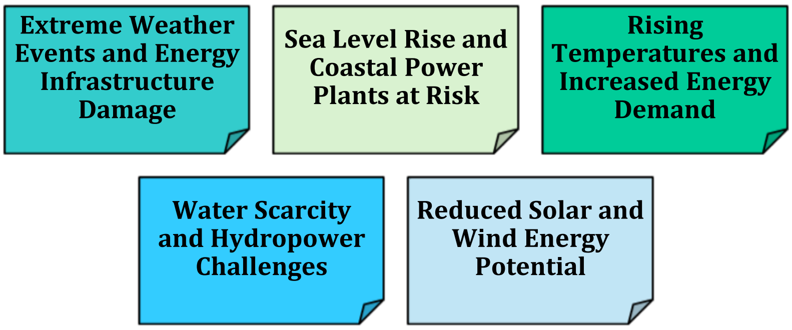
2. Climate Vulnerability and the Energy Sector in Bangladesh

2.1 Impacts of Climate Change on Energy Supply, Demand, and Infrastructure

Bangladesh faces challenges in maintaining energy security with climate resilience. Climate change has a positive impact on water access and electricity consumption, whereas it has a negative impact on GDP growth, agriculture, forests, health, and the coastal economy (Roy and Haider, 2018). The heavy reliance on gas-based power plants, along with depleting natural resources and fluctuating fuel prices, causes instability in the electricity supply in Bangladesh. To mitigate these challenges, Bangladesh is exploring renewable energy options such as solar, wind, hydroelectricity, biomass, and biogas. However, inadequate infrastructure, technological limitations, and high investment costs hinder the implementation of large-scale renewable projects (Hossain et al., 2023). To improve climate resilience, power system planning must integrate climate resilience concepts (Mukhi et al., 2017). Energy system models predict rising electricity consumption and emphasize the need for sustainable growth through a gradual transition to renewable resources (Bala et al., 2014).

Moreover, climate change affects the energy sector by altering supply, demand, and infrastructure stability. Hotter summers increase the demand for cooling, resulting in higher power consumption, while milder winters reduce the need for heating (Bazazzadeh et al., 2021). Increased rainfall may boost hydropower output, but droughts can diminish it (Wasti et al., 2022). Extreme weather events like storms and floods can damage energy infrastructure, causing power outages and escalating maintenance costs (Bianchi and Malki-Epshtein, 2021; Nyangon, 2024). Water scarcity might limit power plant operations, reducing overall energy production. Bangladesh's energy sector is vulnerable to climate hazards like sea level rise, which threatens coastal power plants. If these plants are disrupted, they could have serious effects on electricity generation and economic growth (Rahman et al., 2020). Additionally, rising sea levels and heatwaves weaken energy grids and coastal power plants, impacting energy reliability (Mitra et al., 2023). Notable impacts of climate change on the energy sector are listed in Figure 1.

Figure 1: Impact of climate change on the energy sector



Source: Compiled by the Authors from various sources

2.2 Sector-specific Risks

Table 1 documents the impact of some recent natural disasters on the power supply. Some sector-specific risks are discussed below.

Table 1: Impact of natural disasters on power supply

Event and year	What happened to the power and energy system	Quantified impact
Super Cyclone Amphan (2020)[4]	Cyclone Amphan caused extensive damage to the power distribution system, toppling electric poles and destroying power lines.	• 2,797 electric poles toppled in 48 districts. • 781 electric poles toppled, 1,716 leaning in the West Zone Power Distribution area. • 790 km of distribution lines collapsed. • 114 transformers damaged. • Power outages affected approximately 1.5 crore people.

[4] https://www.tbsnews.net/bangladesh/energy/1-crore-people-remain-without-power-84055

Event and year	What happened to the power and energy system	Quantified impact
Cyclone Sitrang (2022)[5]	Power supply was disconnected in vulnerable areas, including coastal regions, to prevent damage due to Cyclone Sitrang.	• Over 55 lakh people without electricity in 30 REB societies. • 1.25 lakh customers in 5 vulnerable districts were affected. • Electricity demand reduced to 8,500 MW (down from 13,500 MW the previous day).
Cyclone Remal (2024)[6]	Power supply in several coastal areas was suspended to prevent damage.	• 2.66 crore customers without electricity. • 2,392 electricity poles, 1,982 transformers, 21,848 insulators, and 46,318 meters damaged. • 6,2454 spans with snapped wires. • Loss of power equipment estimated at Tk91.02 crore. • 9 lakh people without power in Satkhira, Feni due to snapped power lines and fallen trees.

Source: Compiled by the Authors from different sources

Extreme weather events and energy infrastructure damage: Extreme weather can cause power outages by disrupting energy supplies, which affects important services and causes widespread electrical problems worldwide (Gonçalves et al., 2024). Stronger cyclones are leading to higher storm surges, which can severely damage energy infrastructure (Bianchi and Malki-Epshtein, 2021). Climate-related extreme weather makes existing issues, like old infrastructure and changing rules, worse, leading to big disruptions in energy and making power systems more vulnerable (Nyangon, 2024).

Sea level rise and coastal power plants at risk: Rising sea levels in Bangladesh threaten coastal ecosystems and livelihoods. Coastal power plants are at risk of flooding, saltwater intrusion, and rising water levels, which could disrupt energy production (Islam, 2025). Lower river flow and higher salinity in river water will harm power generation, damage infrastructure, and cause water shortages in power plants, especially in coastal areas (Shahid, 2012). Sea-level rise threatens Bangladesh's coastal power plants. Projections show that flooding could affect up to 2.8 million people and large areas of land by 2150, leading to disruptions in the energy sector (Mitra et al., 2023). Bangladesh's energy sector is vulnerable to climate hazards like sea level rise, which threatens coastal power plants. If these plants are disrupted, they could have serious effects on electricity generation and economic growth (Rahman et al., 2020).

Rising temperatures and increased energy demand: Rising temperatures and changing rainfall patterns in Bangladesh will increase power usage, especially during the hot summers. This will also reduce power plant efficiency and lead to more energy loss during transmission (Shahid, 2012). With temperatures soaring to around 40°C in the summer, electricity demand will rise, causing frequent power cuts (Ahmed et al., 2016). Warmer temperatures drive up the need for heating and cooling, which puts more pressure on electricity and other energy sources, making existing energy problems even worse (Alam et al., 2025). As temperatures climb, electricity demand in Bangladesh rises, worsening the ongoing energy crisis. The country's heavy reliance on costly imported fossil fuels for power generation leads to more power outages, hindering economic growth (Islam et al., 2024).

[5] https://www.tbsnews.net/bangladesh/over-45-lakh-people-without-electricity-cyclone-sitrang-519358
[6] https://www.tbsnews.net/bangladesh/energy/cyclone-remal-leaves-155-crore-people-without-electricity-861406

Water scarcity and hydropower challenges: Water scarcity impacts Bangladesh's energy sector, especially hydropower, as growing irrigation demands compete for limited water resources (Amin and Rahman, 2019). Water scarcity and shortages in energy resources, like natural gas, challenge hydropower generation, with ageing plants and poor transmission further hindering power supply (Hossain et al., 2023). Reliance on water for electricity production worsens water stress, especially as Bangladesh's energy portfolio transitions. Dry season river flow reduction, compounded by climate change, disrupts hydropower generation by affecting water availability and plant efficiency (Shahid, 2012).

Reduced solar and wind energy potential: Limited solar and wind energy potential challenges Bangladesh's energy sector, hindering renewable projects and contributing to electricity instability due to reliance on gas-based plants (Hossain et al., 2023). Bangladesh's limited renewable energy potential, particularly in solar and wind, drives a coal-heavy energy mix, undermining decarbonization and Sustainable Development Goal 7 (Debnath and Mourshed, 2022). Reduced solar and wind energy potential hampers Bangladesh's transition to renewables, affecting energy security and rural electrification (Puri et al., 2024). Reduced solar and wind energy potential poses significant challenges to Bangladesh's energy sector, hindering the transition to renewable sources. Economic barriers, particularly in rural areas, limit the adoption of solar technology (Islam et al., 2024).

2.3 Energy System Resilience Concerns Coastal and Disaster-prone Regions

Bangladesh faces major energy security challenges. This is because the country is highly vulnerable to floods, cyclones, and other hydrometeorological hazards. Also, there is a high dependency on imported fossil fuels. The energy sector is important in disaster management. Daily services and emergency responses depend on reliable energy infrastructure (Rahman et al., 2020). However, energy-related actions are not well included in the early stages of disaster risk planning. Therefore, Bangladesh needs stronger resilience measures (Rahman et al., 2020). Climate change should also be included in power system planning. Planning processes and institutional arrangements need to be improved to address the impacts of climate change on power infrastructure (Mukhi et al., 2017).

The resilience of Bangladesh's energy system is especially concerning in coastal and disaster-prone regions, where climate-induced risks are most pressing. These regions are home to key energy infrastructure, including power plants, oil refineries, and transmission lines. The vulnerability of these areas is exacerbated by the interplay of multiple climate risks, including cyclones, sea-level rise, and saltwater intrusion, which threaten both the supply and delivery of energy.

In coastal regions, where some of the energy infrastructures is located, the risks of storm surges and sea-level rise are particularly a matter of concern (Islam, 2025). The construction of energy infrastructure in these areas has not always accounted for the long-term impacts of climate change, making them susceptible to damage from extreme weather events (Bianchi and Malki-Epshtein, 2021). For instance, the destruction of transmission lines in coastal districts due to cyclonic events leads to prolonged power outages and hampers economic recovery in the aftermath of storms (Rahman and Rahman, 2015). This has highlighted the need for a more climate-resilient energy infrastructure that can withstand extreme weather conditions and continue functioning even under adverse circumstances.

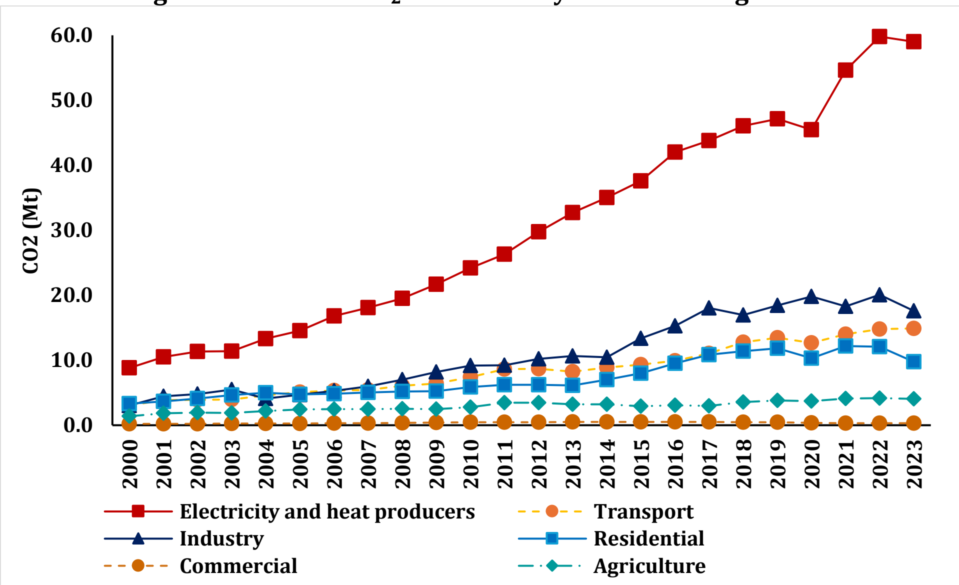
To address these concerns, Bangladesh needs to integrate climate resilience into energy-sector planning and infrastructure investment. Climate risks should be considered in power system planning because extreme weather can affect power plants, transmission systems, and distribution networks. Promotion of renewable energy systems, such as solar home systems and solar microgrids, can improve energy resilience in remote and disaster-prone regions by helping communities maintain access to electricity during disruptions. Given Bangladesh's vulnerability to climate risks, climate resilience should be integrated into energy planning and policymaking so that energy systems can better withstand and adapt to climate change impacts.

3. Emissions Profile and Sectoral Contributions

3.1 Trends in GHG Emissions from Electricity, Transport, Industry, and Households

The sectoral contribution to CO_2 emissions from 2000 to 2023 reveals that electricity and heat producers are the leading contributors, with emissions increasing significantly since 2010 due to a greater reliance on fossil fuels. The industry sector comes next, showing consistent development with minimal changes in recent years. The transportation sector exhibits a steady rise in emissions, reflecting increased fuel usage. Although the residential and commercial sectors have lower emissions, they are gradually growing. Agriculture remains the lowest-emitting sector (Figure 2).

Figure 2: Trend in CO_2 Emissions by Sector in Bangladesh



Source: International Energy Agency (IEA)

In 2023, electricity and heat producers were the primary sources of CO_2 emissions in Bangladesh, accounting for 59 Mt CO_2, the highest percentage among all sectors. The industrial sector followed, with 17.59 Mt CO_2 emissions from manufacturing and production operations. The transportation sector emitted 14.9 Mt CO_2 due to increased vehicle usage and reliance on fossil fuels. Residential emissions totalled 9.75 Mt CO_2, primarily from household energy consumption. Agriculture and forestry contributed 4.08 Mt CO_2, mainly from land-use activities and farming. Commercial and governmental services (0.32 Mt CO_2) and other energy industries (0.15 Mt CO_2) made minor contributions, while non-specified sources contributed only 0.02 Mt CO_2 (Table 2).

Table 2: CO_2 Emissions by sector in Bangladesh in 2023

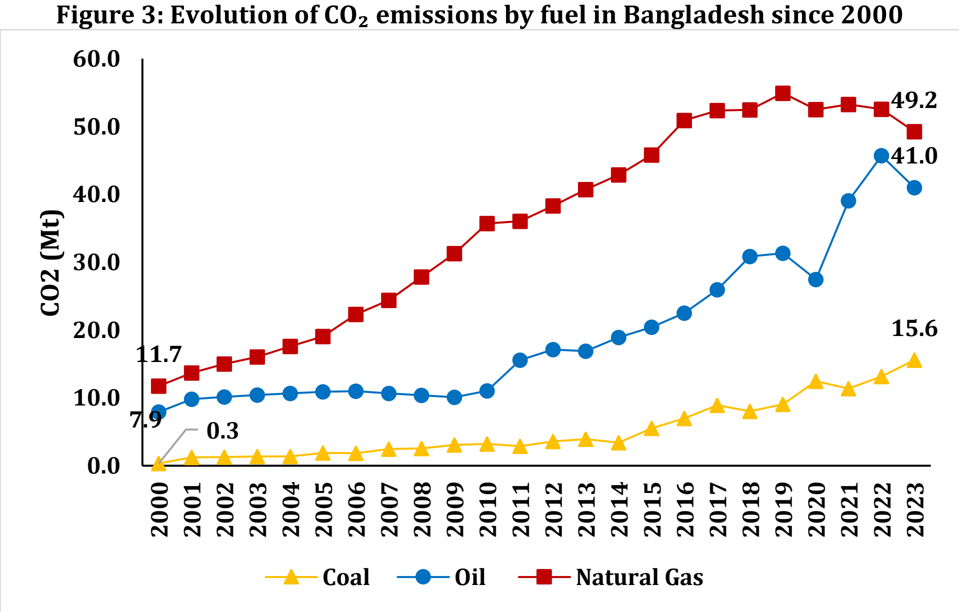
Sectors	Value (Mt CO2)
Electricity and heat producers	**59.00**
Industry Sector	**17.59**
Transport Sector	**14.90**
Residential	9.75
Agriculture/Forestry	4.08
Commercial and Public Services	0.32
Other energy industries	0.15
Fishing	0.00
Non-specified (Other)	0.02

Source: International Energy Agency (IEA)

3.2 Comparative Emissions Data from 2000–2023

Energy is a measure of social and economic advancement as well as an improvement in living standards. Currently, fossil fuels provide a large portion of the world's energy, and this use is unsustainable even if sustainable alternatives are investigated and technology remains unchanged (Al-Obaidi and NguyenHuynh, 2018; Worku et al., 2024). There is a rising trend in carbon dioxide emissions from coal, oil, and natural gas (Figure 3).

Figure 3: Evolution of CO_2 emissions by fuel in Bangladesh since 2000



Source: International Energy Agency (IEA)

Natural gas has been the most significant source of carbon dioxide emissions among these fuels, rising gradually since 2000, with a dramatic increase after 2010 and a slight stabilization following 2018. Oil-related emissions remained generally steady until around 2010, when they began to climb dramatically, with a particularly sharp increase beginning in 2020, most likely due to rising fuel usage in transportation and industry.

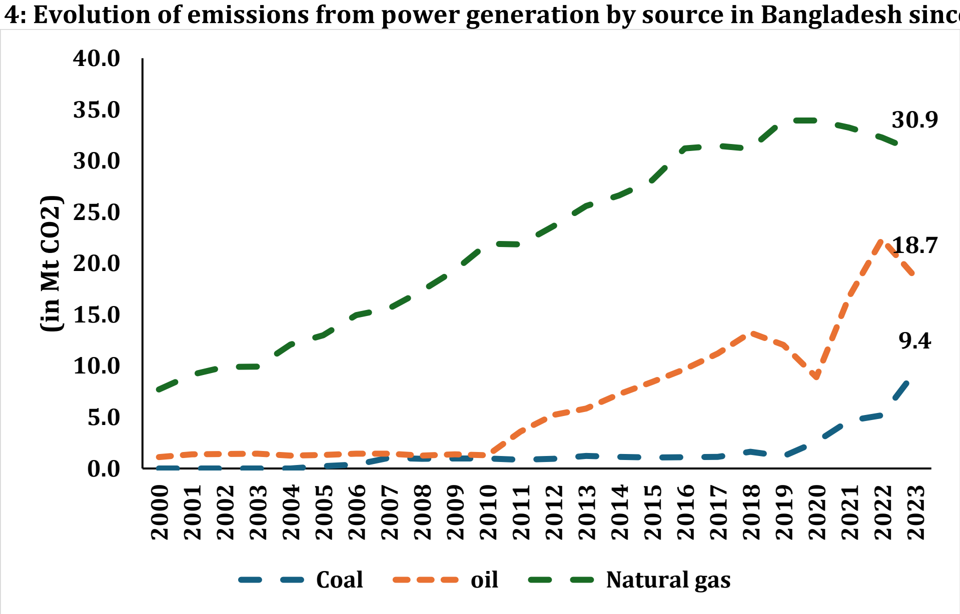
Coal emissions, which were initially minimal, began to rise steadily after 2010, indicating a growing reliance on coal-based energy. The overall trend reflects Bangladesh's persistent reliance on fossil fuels for energy generation, emphasizing the critical need for cleaner energy sources and long-term measures to reduce emissions.

3.3 Role of Fossil Fuels and the Rise in CO_2 Emissions

As the global focus shifts toward addressing climate change, the role of fossil fuels in energy production remains a critical issue, particularly in developing countries like Bangladesh. With a rapidly growing economy and increasing energy demand, Bangladesh's energy sector is heavily reliant on fossil fuels. This dependency not only shapes the country's energy landscape but also contributes significantly to its rising carbon emissions. Understanding the current energy mix and its environmental impact is crucial for shaping future policies aimed at sustainable development and reducing greenhouse gas emissions. The following analysis delves into the sources of electricity generation in Bangladesh and examines the relationship between fossil fuel use and the surge in CO_2 emissions.

Figure 4 tracks the trend of CO_2 emissions from electricity generation in Bangladesh from 2000 to 2023. Emissions from natural gas have risen sharply, increasing from approximately 7.7 Mt CO_2 in 2000 to over 30.9 Mt CO_2 in 2023. Emissions from oil and coal also show an upward trend.

Figure 4: Evolution of emissions from power generation by source in Bangladesh since 2000



Source: International Energy Agency (IEA)

The continued reliance on fossil fuels has hindered efforts to reduce global CO_2 emissions, necessitating a transition to renewable energy sources and the implementation of stricter emission regulations.

The rapid rise in emissions from natural gas is directly linked to its growing share in the energy mix. This underscores the central role that fossil fuels, particularly natural gas, play in driving CO_2 emissions in Bangladesh's power sector. The limited share of renewable energy sources further exacerbates the situation, signaling the need for a more diversified and sustainable energy strategy to mitigate environmental impact.

In conclusion, the data highlights the crucial role of fossil fuels, especially natural gas, in Bangladesh's electricity generation and their significant contribution to rising CO_2 emissions. The country's energy mix remains heavily skewed toward fossil fuels, with renewable energy sources playing a minimal role. This trend underscores the urgency for Bangladesh to transition to a more sustainable energy system that reduces its reliance on fossil fuels and mitigates its growing carbon footprint

3.4 Implications for National and International Mitigation Commitments

The continued increase in global greenhouse gas emissions creates major challenges for achieving the Paris Agreement target of limiting global warming to 1.5°C. Under current policies, global temperature rise could reach around 3.1°C by the end of the century. This indicates that existing mitigation actions are not sufficient (UNEP, 2024).

For Bangladesh, this situation highlights the need to align energy planning with its Nationally Determined Contribution commitments. The country needs to expand renewable energy, improve energy efficiency, reduce dependence on fossil fuels, and modernize the power grid (Ministry of Environment, Forest and Climate Change, 2021)

International support will also be important. Bangladesh will require climate finance, technology transfer, and capacity-building support to pursue a low-carbon energy transition while maintaining energy security and economic growth (Ministry of Environment, Forest and Climate Change, 2022).

4. Nationally Determined Contributions (NDCs) and Energy Sector Commitments

Nationally Determined Contributions have increasingly focused on the energy sector in Bangladesh because this sector is a major source of greenhouse gas emissions. Bangladesh submitted its Intended Nationally Determined Contribution (INDC) in 2015. In that first submission, the country mainly focused on the power, transport, and manufacturing industry sectors. The INDC set targets to reduce emissions by 5% below the Business-as-Usual (BAU) scenario by 2030 through unconditional action, with a further 10% reduction depending on international support.

In the NDC submitted in 2021, Bangladesh expanded the coverage of sectors by following IPCC guidelines. The base year for this update was 2012. In that year, total national emissions were estimated at 169.05 $MtCO_2eq$. The updated NDC included additional sectors, but the energy sector remained one of the main areas of focus.

Furthermore, Bangladesh published its third NDC in September 2025. In NDC 3.0, 2022 was taken as the base year. In that year, the energy sector was the largest source of emissions in the country. It produced 123.01 $MtCO_2eq$ out of the total national emissions of 252.04 $MtCO_2eq$. This means the energy sector alone accounted for 48.81% of total emissions. Within the sector, power generation produced the highest emissions, followed by the manufacturing industry and transport (Table 3).

Table 3: GHG emission reduction scenario of base year 2022

Sector	***Sub Sector***	***Emission ($MtCO_2eq$)***	***% of Grand Total***
Energy	Power	42.53	16.87
	Transport	18.74	7.44
	Energy Usage in Manufacturing Industry	23.83	9.45
	Construction (Brick kilns)	7.51	2.98
	Households	14.10	5.59
	Commercial	1.74	0.69
	Energy Usage in Agriculture	4.56	1.81
	Fugitive	10.00	3.97
Energy Total		**123.01**	**48.81**
Non-Energy Total		129.03	51.19
Grand Total		**252.04**	**100.00**

Source: Compiled by Authors from NDC 3.0 (MoEFCC, 2025).

In terms of the GHG emissions mitigation targets for 2035, under the Business-as-Usual scenario, emissions from the energy sector are projected to increase to 264.00 $MtCO_2eq$. The biggest share within the energy sector is expected to come from the manufacturing industry, followed by power generation and transport. This rise is linked to higher energy demand, industrial growth, urbanization, and population increase (Table 4).

Table 4: GHG emissions mitigation targets for 2035

Sector	**Sub Sector**	**BAU Emission ($MtCO_2eq$)**	**Unconditional Reduction ($MtCO_2eq$)**	**Unconditional (%)**	**Conditional Reduction ($MtCO_2eq$)**	**Conditional (%)**	**Total Reduction ($MtCO_2eq$)**	**Total (%)**
Energy	**Power**	61.66	6.16	9.99	11.48	18.61	17.64	28.60
	Transport	30.00	2.32	7.74	4.21	14.03	6.53	21.77
	Energy Usage in the Manufacturing Industry	108.82	10.03	9.22	17.17	15.78	27.20	25.00
	Construction (Brick kilns)	25.59	2.56	9.99	4.30	16.79	6.85	26.78
	Households	18.87	1.14	6.04	2.21	11.71	3.35	17.76
	Commercial	0.83	0.04	4.48	0.08	9.94	0.12	14.42
	Energy Usage in Agriculture	8.43	0.66	7.81	1.55	18.44	2.21	26.24
	Fugitive	9.80	0.00	0.00	5.94	60.62	5.94	60.62
Energy Total		264.00	22.90	8.67	46.94	17.78	69.84	26.46
Non-Energy Total		154.40	3.84	2.49	11.29	7.31	15.13	9.80
Grand Total		418.40	26.74	6.39	58.23	13.92	84.97	20.31

Source: Compiled by Authors from NDC 3.0 (MoEFCC, 2025).

To reduce these emissions, Bangladesh's NDC 3.0 sets several energy-related commitments. By 2035, the energy sector is expected to reduce 69.84 $MtCO_2eq$. The main actions include increasing renewable energy, reducing transmission and distribution losses, replacing liquid-fuel peaking plants with cleaner alternatives, promoting electric vehicles, expanding MRT and BRT systems, electrifying railways, improving industrial energy efficiency, using rooftop solar, increasing energy-efficient appliances, promoting clean cooking, expanding solar irrigation, and reducing gas leakage.

4.1 Conditional vs. Unconditional Scenarios and Emission Reduction Expectations

The mitigation action of the NDC has highlighted some of the government's feasible but ambitious planned initiatives to alleviate the effects of GHG emissions. The activities are divided into two categories: unconditional contribution and conditional contribution.

The unconditional contribution includes mitigation actions from relevant ministries that would be implemented based on current local-level capacity and funded through internal resources, whereas the conditional contribution includes proposed mitigation actions that would require international assistance (Ministry of Environment, Forest, and Climate Change, 2021).

The mitigation actions for energy under unconditional contribution as per the NDC 2021 are highlighted in Table 6. In the unconditional scenario, GHG emissions would be reduced by 27.56 Mt CO_2e (6.73%) below BAU by 2030 in the respective sectors. The energy sector would account for 26.3 Mt CO_2e (95.4%) of this emission reduction (MoEFCC, 2021). Specific targets were set related to modernizing power generation, increasing energy efficiency, and transitioning towards a cleaner energy mix, supporting Bangladesh's commitment to a low-carbon and sustainable energy future (Table 5).

Table 5: Priorities and mitigation actions for energy sector in unconditional scenario in NDC 2021

Priorities		**Mitigation Action**
Unconditional Contribution	**Power** • Implementation of renewable energy projects • Enhanced efficiency of existing power plants • Use of improved technology for power generation	• Implementation of renewable energy projects of 911.8 MW • Grid-connected Solar-581 MW, Wind-149 MW, Biomass-20 MW, Biogas-5 MW, New Hydro-100 MW, Solar Mini-grid-56.8 MW • Installation of a new Combined Cycle gas-based power plant (3208 MW) • Efficiency improvement of Existing Gas Turbine power plant (570 MW) • Installation of prepaid meter
	Transport • Improvement of fuel efficiency for the transport subsector • Increase the use of less emission-based transport systems and improve the Inland Water Transport System	• Improvement of road traffic congestion (5% improvement in fuel efficiency) • Modal shift from road to rail (10% modal shift of passenger-km) through different Transport projects such as BRT, MRT in major cities, Multi-modal hub creation, Padma Bridge, etc. • Improved and enhanced Inland Water Transport (IWT) system (Improve navigation for regional, sub-regional, and local routes, improve maintenance of water vessels to enhance engine performance, introduce electric water vessels, etc.)
	Industry • Increase energy efficiency in the industry sub-sector	• Achieve 10% Energy efficiency in the industry sub-sector through measures according to the Energy Efficiency and Conservation Master Plan (EECMP)
	Brick Kilns • Enforcement and Improved technology use	• 14% emission reduction through Banning Fixed Chimney kiln (FCK), encouraging advanced technology and non-fired brick use
	Residential and Commercial • Enhanced use of energy-efficient appliances in household and commercial buildings	• Use energy-efficient appliances in household and commercial buildings (achieve 5% and 12% reduction in emissions, respectively)

Source: Compiled by Authors from NDC, 2021 (MoEFCC, 2021)

It is mentioned in the NDC that under the conditional scenario, the energy sector accounts for 59.7Mt CO_2 e (96.46%) of emission reduction. Table 6 highlights the mitigation actions under conditional contribution.

Table 6: Priorities and mitigation actions for energy sector in conditional scenario in NDC 2.0

Priorities		Mitigation Action
Conditional Contribution	**Power** • Implementation of renewable energy projects • Enhanced efficiency of existing power plants • Use of improved technology for power generation	• Implementation of renewable energy projects of 4114.3 MW • Grid-connected Solar-2277 MW, Wind-597 MW, Biomass-50 MW, Biogas-5 MW, New Hydro-1000 MW, Solar Mini-grid-56.8 MW, Waste to Electricity-128.5 MW • Coal power plant with Ultra supercritical technology-12147 MW • Installation of a new Combined Cycle gas-based power plant (5613 MW) • Efficiency improvement of Existing Gas Turbine power plant (570 MW) • Installation of prepaid meter • Bring down total TandD loss to a single digit by 2030
	Industry • Increase energy efficiency in the industry sub-sector	• Achieve 20% Energy efficiency in the industry sub-sector through measures according to the Energy Efficiency and Conservation Master Plan (EECMP) • Promote green Industry • Promote carbon financing
	Transport • Improvement of fuel efficiency for the transport subsector • Increase the use of less emission-based transport systems and improve the Inland Water Transport System	• Improvement of road traffic congestion (15% improvement in fuel efficiency) • Modal shift from road to rail (25% modal shift of passenger-km) through different Transport projects such as BRT, MRT in major cities, Multi-modal hub creation, new bridges etc. • Improved and enhanced Inland Water Transport (IWT) system (Improve navigation for regional, sub-regional, and local routes, improve maintenance of water vessels to enhance engine performance, introduce electric water vessels, etc.)
	Brick Kilns • Enforcement and Improved technology use	• 47% emission reduction through Banning Fixed Chimney kiln (FCK), encouraging advanced technology and non-fired brick use
	Residential and Commercial • Enhanced use of energy-efficient appliances in household and commercial buildings	• Use energy-efficient appliances in household and commercial buildings (achieve 19% and 25% reduction in emissions, respectively)
	Fugitive Emission Gas leakage reduction	• 51% emission reduction from Gas leakage through CDM projects

Source: Compiled by Authors from NDC, 2021 (MoEFCC, 2021).

Bangladesh's NDC 3.0 has set clear targets for the energy sector and related areas by 2035. It focuses on more renewable energy, lower power loss, cleaner power plants, electric vehicles, railway electrification, energy-efficient industry, rooftop solar, clean cooking, solar irrigation, and lower gas leakage. Many of these targets are divided into unconditional and conditional parts, which means some actions can be done by the country itself, while others depend on international support. The key priorities, conditional and unconditional scenarios, are shown in Table 7.

Table 7: Priorities and mitigation actions for energy sector in NDC 3.0

<table>
<tr><th>Priorities</th><th>Unconditional</th><th>Conditional</th></tr>
<tr><td>Energy Industries - Electricity generation
Expansion of renewable energy in the electricity mix (MW)
Reduced electricity transmission and distribution loss
Replace liquid fuel–based peaking capacity powerplant with a cleaner alternative, including battery storage</td><td>Renewable energy will share 25% of the total electricity demand by 2035, and 40% of this target will be unconditional.
Reduced transmission loss to 2.98% and distribution loss to 6.5%.
Replace 95% of liquid fuel–based peaking capacity power plants with cleaner alternatives, including battery energy storage systems. 30% of this target will be unconditional.</td><td>Renewable energy will share 25% of the total electricity demand by 2035. 60% of this target will be conditional.
Reduced transmission loss to 2.95% and distribution loss to 6%.
Replace 95% of liquid fuel–based peaking capacity power plants with cleaner alternatives, including battery energy storage systems. 70% of this target will be conditional.</td></tr>
<tr><td>Transport
Modal shift to MRT/BRT
Electric vehicle penetration in the public vehicle fleet
Improvement of fuel efficiency and electrification</td><td>30% of passenger cars will be EVs
Implementation of solar-equipped railway stations and installation of solar energy plants on at least 30% of railway-owned vacant land. 20% of this target will be unconditional. This target will complement the RE total unconditional target.
Electrification of 348 km railway route, 20% of this target will be unconditional. Purchase of modern rolling stock, introduction of color light signaling system.</td><td>Construction of following MRT lines in Dhaka city: MRT-1, MRT-2, MRT-4, MRT-5N, MRT-5S and construction of BRTs in major cities
25% of buses in the Dhaka city area will be EVs
Implementation solar equipped railway stations and install solar energy plants on at least 30% of railway-owned vacant land. 80% of this target will be conditional. This target will complement the RE total conditional target.
Electrification of a 348 km railway route, 80% of this target will be conditional.</td></tr>
<tr><td>Manufacturing Industries and Construction
improvement of technology use in brick
Energy Efficiency in Industry</td><td>40% of the total demand for bricks will be met by non-fired bricks/concrete blocks replacing burnt clay bricks. 25% of this target will be unconditional.
Achieve 10% Energy efficiency in the industry. 40% of this target will be unconditional.
Promote rooftop solar systems in industrial buildings, 30% will be unconditional. This</td><td>40% of the total demand for bricks will be met by non-fired bricks/concrete blocks replacing burnt clay bricks. 75% of this target will be conditional.
Achieve 10% Energy efficiency in the industry. 60% of this target will be conditional.
Promote rooftop solar systems in industrial buildings, 70% will be conditional. This target will complement the RE total conditional target.</td></tr>
</table>

Priorities	Unconditional	Conditional
	target will complement the RE total unconditional target.	

Other Sectors - Commercial/ Institutional and Residential
• Enhanced use of energy-efficient appliances in household and commercial buildings
	• Use energy-efficient appliances in household, institutional, and commercial buildings to achieve 10% energy savings (energy-efficient lighting, fan, television, oven, washing machine, refrigeration, cooling systems, geyser, water purification). 50% of this target will be unconditional.
	• Installation of rooftop solar systems in 50% of existing government buildings, institutions, schools, and hospitals, and 100% of new government buildings, institutions, schools, and hospitals. 30% of this target will be unconditional. This target will complement the RE total unconditional target.
		• Use energy-efficient appliances in household, institutional, and commercial buildings to achieve 10% energy savings (energy-efficient lighting, fan, television, oven, washing machine, refrigeration, cooling systems, geyser, water purification). 50% of this target will be conditional.
		• Installation of rooftop solar systems in 50% of existing government buildings, institutions, schools, and hospitals, and 100% of new government buildings, institutions, schools, and hospitals. 70% of this target will be conditional. This target will complement the RE total conditional target.
		• Promotion of modern cooking systems
		  • 20% of Cooking Energy Mix will be energy-efficient modern electric cookstoves, and 20% of Cooking Energy Mix will be energy-efficient improved cookstoves (ICS)
		  • 50% of Cooking Energy Mix will be energy-efficient LPG
		• Hospitality and Tourism
		  • At least 10% of electricity consumption should be from renewable energy sources. This target will complement the RE total conditional target.

Other Sectors - agriculture/Forestry/Fish Farms • Enhanced use of solar energy in agriculture	• implementation of 45,000 Nos. Solar irrigation pumps (generating 1000 MWp). 10% of this target will be unconditional. This target will complement the RE total targets.	• Implementation of 45,000 Nos. Solar irrigation pumps (generating 1000 MWp). 90% of this target will be conditional. This target will complement the RE total targets.
Fugitive Emission • Gas leakage reduction		• 70% emission reduction from Gas leakage through international carbon trading, including Article 6 market and non-market mechanisms.

Source: Compiled by Authors from NDC 3.0 (MoEFCC, 2025)

Compared to NDC 2.0, NDC 3.0 gives a clearer and more detailed plan for the energy sector. NDC 2.0 mainly focused on broad actions such as renewable energy, better power generation, lower transmission and distribution loss, fuel efficiency in transport, energy efficiency in industry, cleaner brick kilns, and energy-saving appliances. In contrast, NDC 3.0 sets more specific targets for 2035. It gives more attention to renewable electricity, cleaner power plants, electric transport, railway electrification, rooftop solar, solar irrigation, clean cooking, and lower gas leakage. It also shows more clearly which targets depend on international support. Overall, NDC 3.0 is more specific, more organized, and more focused on measurable results.

4.2 Renewable Energy, Energy Efficiency, and Green Technology Targets

Table 8 outlines Bangladesh's key targets for renewable energy, energy efficiency, and green technology as part of its updated Nationally Determined Contributions (NDC) for 2021. It shows the country's commitment to expanding renewable energy sources, improving energy efficiency in various sectors, and adopting cleaner technologies. Specific actions include increasing renewable energy capacity, enhancing energy efficiency in industries, promoting green technologies in agriculture and brick kilns, and improving fuel efficiency in the transport sector. These measures are expected to contribute significantly to reducing greenhouse gas emissions and help Bangladesh achieve its climate goals by 2030.

Table 8: Key targets for emission reduction through renewable energy, energy efficiency, and green technologies in NDC 2.0

Target Area	Key Actions	Target by 2030	Emissions Reduction Contribution
Renewable Energy	Expansion of grid-connected solar (e.g., 581 MW solar)	Increase renewable energy capacity	Major contribution to emission reduction
	Wind energy development (e.g., 149 MW wind)	Integration of solar mini grids	
	Biomass and biogas projects (e.g., 20 MW biomass, 5 MW biogas)	Solar irrigation systems in rural areas	
Energy Efficiency	Energy efficiency improvements in power plants	10% reduction in energy intensity in industry	Significant sectoral reductions, especially in industry and buildings
	Energy-efficient appliances in residential and commercial buildings	20% reduction in energy intensity (national goal)	
Green Technologies	Adoption of cleaner technologies in industries	Promotion of green technologies like energy-efficient stoves	Supporting sustainable practices across sectors
	Efficient use of F-gases and reduction in industrial emissions	20% improvement in efficiency in industrial processes	
Transport	Fuel efficiency improvements in road transport	15% improvement in fuel efficiency	Major reductions in transport emissions
	Increased use of electric and hybrid vehicles	Development of electric vehicle charging infrastructure	
Agriculture	Adoption of solar irrigation pumps (5,925 pumps)	176.38 MW generated from solar in agriculture	Emissions reduction through clean energy applications in agriculture
Brick Kilns	Energy-efficient technologies in brick manufacturing	14% reduction in emissions from the brick kiln sector	Reduction through clean brick production methods

Source: Compiled by Authors from NDC 2021 (MoEFCC, 2021)

Bangladesh's NDC 3.0 sets several energy-related targets for 2035. It aims to increase renewable energy to 25% of total electricity demand. It also aims to reduce transmission and distribution losses. The plan includes replacing 95% of liquid-fuel-based peaking plants with cleaner alternatives. It promotes electric transport, railway electrification, and better energy efficiency in industry. It also supports rooftop solar, energy-efficient appliances, clean cooking, solar irrigation pumps, non-fired bricks, and lower gas leakage. Together, these measures aim to build a cleaner, more efficient, and more climate-resilient energy system in Bangladesh (Table 9).

Table 9: Key targets for emission reduction through renewable energy, energy efficiency, and green technologies in NDC 3.0

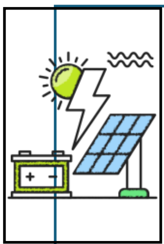
Target Area	Key Actions	Target by 2035	Emissions Contribution
Renewable Energy	Expansion of renewable energy in the electricity mix through rooftop solar, solar parks, floating solar, agrivoltaics, wind, biomass, tidal energy, solar charging systems, solar drinking water systems, and solar irrigation	Renewable energy will meet **25% of total electricity demand by 2035**	Major contribution to emission reduction in the power sector
Energy Efficiency	Reduction of electricity transmission and distribution loss	Transmission loss to be reduced to **2.95%** and distribution loss to **6%**	Significant reduction in power-sector emissions
Green Technologies	Replacement of liquid-fuel-based peaking power plants with cleaner alternatives, including battery energy storage systems	**95%** of liquid-fuel-based peaking plants to be replaced	Major reduction through cleaner power generation
Transport	Construction of MRT lines and BRT systems; electrification of rail; solar-equipped railway stations; EV penetration in public transport	MRT-1, MRT-2, MRT-4, MRT-5N, MRT-5S and BRT in major cities; **25% of buses in Dhaka** to be EVs; **348 km** railway electrification	Major reductions in transport emissions
Industry	Energy efficiency in industry; rooftop solar in industrial buildings	**10% energy efficiency** in industry; rooftop solar promotion in industrial buildings	Significant reduction in industrial emissions
Buildings	Use of energy-efficient appliances in households, institutions, and commercial buildings; rooftop solar in public buildings	**10% energy savings** from efficient appliances; rooftop solar in **50% of existing** and **100% of new** government buildings, institutions, schools, and hospitals	Reduction in building-related energy emissions
Clean Cooking	Promotion of modern electric cookstoves, improved cookstoves, and LPG	**20%** of cooking energy mix from modern electric cookstoves, **20%** from improved cookstoves, and **50%** from LPG	Emission reduction through cleaner household energy use

Target Area	Key Actions	Target by 2035	Emissions Contribution
Agriculture	Solar irrigation pumps	**45,000 solar irrigation pumps** generating **1000 MWp**	Emission reduction through clean energy use in agriculture
Brick Kilns	Shift from burnt clay bricks to non-fired bricks or concrete blocks	**40%** of total brick demand to be met by non-fired bricks/concrete blocks	Reduction through cleaner brick production methods
Fugitive Emissions	Reduction of gas leakage through international carbon trading, including Article 6 mechanisms	**70% emission reduction** from gas leakage	Strong reduction in fugitive emissions

Source: Compiled by Authors from NDC 2021 (MoEFCC, 2021)

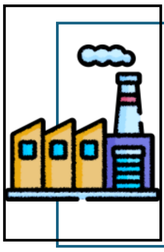
NDC 3.0 proposes several policy measures to reduce emissions in the energy sector. In the power sector, the focus is on expanding renewable energy, improving grid efficiency, increasing system flexibility, managing demand, and strengthening planning and governance. In manufacturing, the plan gives importance to energy efficiency, electrification of industrial processes, cogeneration, waste heat recovery, renewable energy use, and skill development. Overall, these measures aim to make Bangladesh's energy system cleaner, more efficient, and more sustainable (Box 1).

Box 1: Policy measure for energy in NDC 3.0



Policy measures in Power sector

- Renewable Energy Expansion
- Grid Modernization and Efficiency
- System Flexibility
- Demand-side Management
- Public Institutions as Demonstrators
- Governance and planning



Policy Measures in Energy use in Manufacturing Industry

- Energy efficiency & management
- Electrification of processes
- Cogeneration & waste heat recovery
- Renewable integration
- Skills & capacity

Source: Compiled by Authors from NDC 2021 (MoEFCC, 2021)

4.3 Energy-related Provisions in EECMP and other Instruments

The Sustainable and Renewable Energy Development Authority (SREDA) formulated the Energy Efficiency and Conservation Master Plan (EECMP) up to 2030, which aims to make Bangladesh's energy use more efficient and save more energy, especially in the industrial, residential, and commercial sectors. This plan is meant to help with the growing demand for energy caused by rapid industrialization and economic growth. It aims to help with energy shortages, lower energy costs, and help fight global climate change. The plan aims to reduce energy consumption per unit of GDP by 20% by 2030. The Energy Efficiency and Conservation Master Plan (EECMP) outlines several energy-related provisions aimed at promoting energy efficiency and sustainability in Bangladesh. Key provisions mentioned in the document are provided in Table 10:

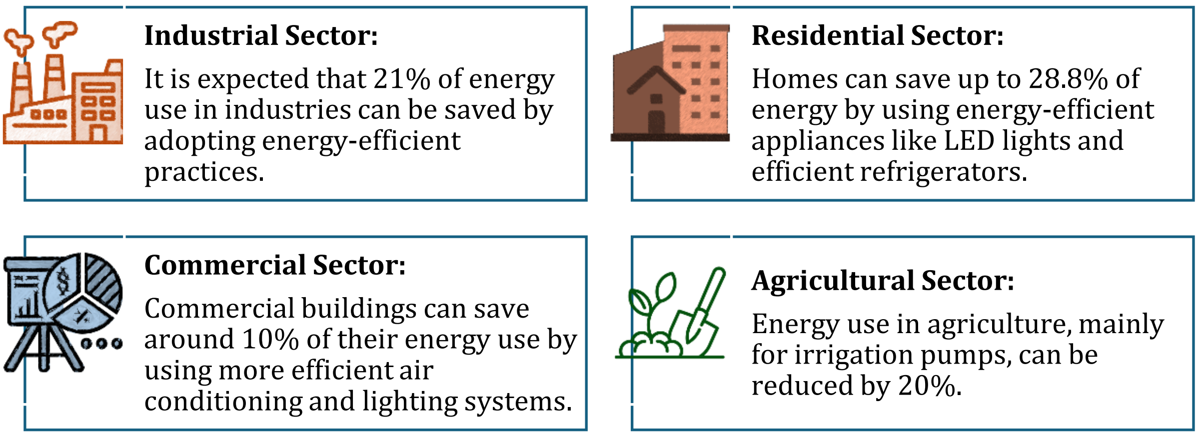
Table 10: Some provisions/programs related to energy in EECMP

Program/Provision	Target Sector	Key Mechanisms and Actions
Energy Management Program (EMP)	Industrial and Large Consumers	Mandates compulsory Energy Audits and the appointment of certified Energy Managers for "Designated Consumers" (DCs).
Energy Efficiency Labeling Program	Residential and Commercial Appliances	Establishes Minimum Energy Performance Standards (MEPS) and a Star Labeling System for devices (e.g., ACs, refrigerators).
Energy Efficiency Buildings Program	Commercial and Residential Buildings	Enforces EE standards via the Bangladesh National Building Code (BNBC). Promotes voluntary Green Building Guidelines.
EEandC Finance Program	Cross-Sectoral	Provides low-interest loans and subsidies to private businesses to fund investments in efficient technology.

Source: Compiled by Authors from Energy Efficiency and Conservation Master Plan (EECMP) up to 2030

The EECMP outlines significant energy savings that can be achieved across various sectors by adopting the energy-efficient practices and technologies described in Figure 5.

Figure 5: Energy efficiency targets and goals in EECMP



Source: Compiled by Authors from Energy Efficiency and Conservation Master Plan (EECMP) up to 2030

The EECMP is the principal policy instrument driving energy demand reduction and conservation efforts. It establishes the institutional framework and action plan necessary to meet the national efficiency targets. Other instruments reinforce the NDC and EECMP objectives, particularly concerning the energy sector:

Bangladesh's climate policy is characterized by an ambitious commitment, defined by quantifiable unconditional targets backed by domestic resources, and a substantial conditional increase contingent upon global partnership. The successful integration of energy efficiency and conservation policies, as codified in the EECMP, is critical for reducing the BAU emission trajectory and enabling the country to meet its global climate obligations while ensuring sustainable economic growth.

5. Energy Policy Landscape and Institutional Architecture

To move toward a clean and sustainable energy sector, Bangladesh has implemented several policies that emphasize energy security, efficiency, and the growth of renewable energy. In addition to promoting private sector investment in renewable energy, the National Adaptation Plan (2023–2050) places a strong emphasis on rooftop solar installations, solar-powered irrigation systems, and biodiversity preservation. Additionally, it encourages research on solar and wind-powered farm mechanization. In the Bangladesh Climate Prosperity Plan (2022–2041), important projects like the Bongoposagor Independence Giga Array, a 4-gigawatt wind power project, are intended to update the energy grid, boost resilience, and raise renewable energy to 30% by 2030 and 40% by 2041. To integrate Bangladesh's energy network, the Strategic Energy Hubs also intend to transform coal and diesel power plants into green hydrogen and biomass energy facilities.

By guaranteeing low-cost power generation, private sector investment, and long-term renewable energy plans, the Perspective Plan 2041 and Bangladesh Delta Plan 2100 emphasized sustainable energy planning. In addition to promoting creative financing methods to assist renewable energy projects, the Bangladesh Delta Plan places a high priority on solar energy integration in flood-prone areas, solar-driven water pumping systems, and floating solar systems. The adoption of sustainable energy, energy efficiency, and regulatory changes away from coal-fired power plants are prioritized in the 8th Five-Year Plan (8FYP) and IEPMP 2023. While maintaining the safety and dependability of nuclear power, the IEPMP promotes innovative energy technologies, including hydrogen power, ammonia co-firing, and carbon capture storage (CCS), and aims for 40% clean energy in power generation. The detailed priorities and action plans are mentioned in Table 12. However, there lies a problem in policy coherence.

5.1 Key Policies and Plans

To move toward a clean and sustainable energy sector, Bangladesh has implemented several policies that emphasize energy security, efficiency, and the growth of renewable energy. Some of the key policies are mentioned in Box 2.

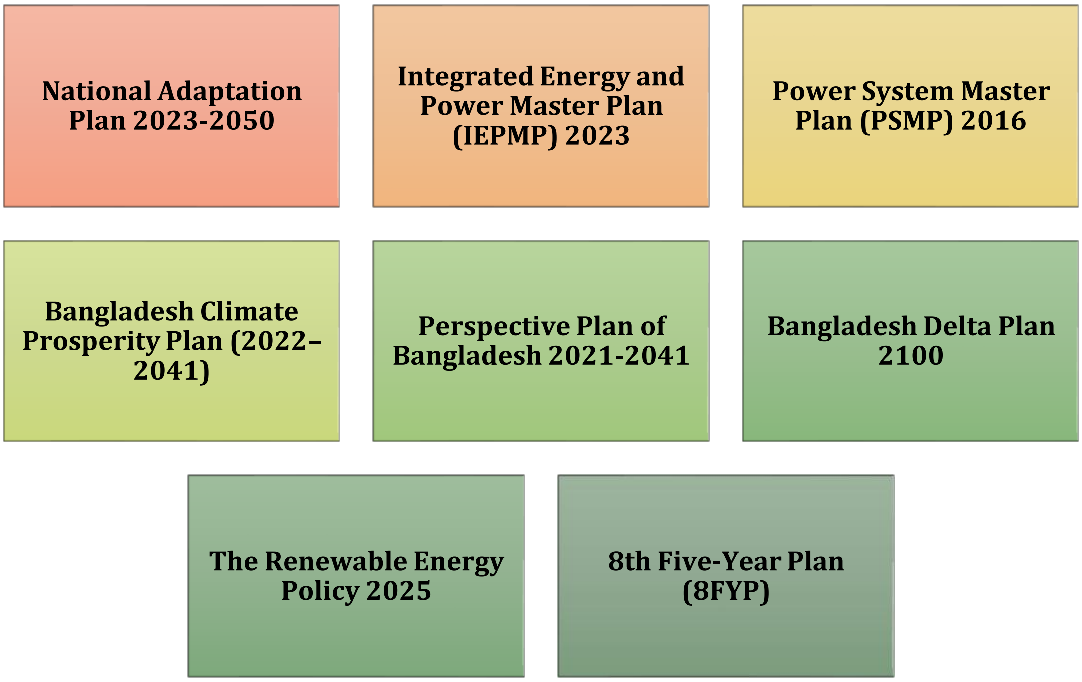
National Adaptation Plan 2023-2050 emphasizes the integration of renewable energy into climate-resilient development strategies. Key initiatives include expanding solar-based irrigation systems to reduce dependence on fossil fuels and promoting rooftop gardening, solar installations, and biodiversity conservation through fiscal incentives. The plan also supports the development of climate-smart solar utilities, the installation of lightning arresters in buildings, and encourages private sector participation in renewable energy-based power supply. Additionally, it advocates for research into farm mechanization powered by renewable sources such as solar and wind energy (Ministry of Environment, Forest, and Climate Change, 2022).

Some key initiatives mentioned in the NAP are given below:

- Renewable energy-based product generation and distribution, such as expanding solar-based irrigation systems
- Expansion of solar irrigation pumps for reducing biofuel energy sources

- Support rooftop gardening or plantations, installation of solar energy, and biodiversity conservation through tax instruments
- Development of climate-smart solar energy-based utilities and installation of lightning arresters in residential and commercial buildings
- Expansion of renewable energy-based power supplies through the private sector
- Research on farm mechanization using renewable energy (solar, wind, etc).
- Utilize solar energy to avoid GHG.
- Expansion of green buildings and green roofs to reduce the urban heat island effect and enhance cooling, carbon sequestration, and energy efficiency.

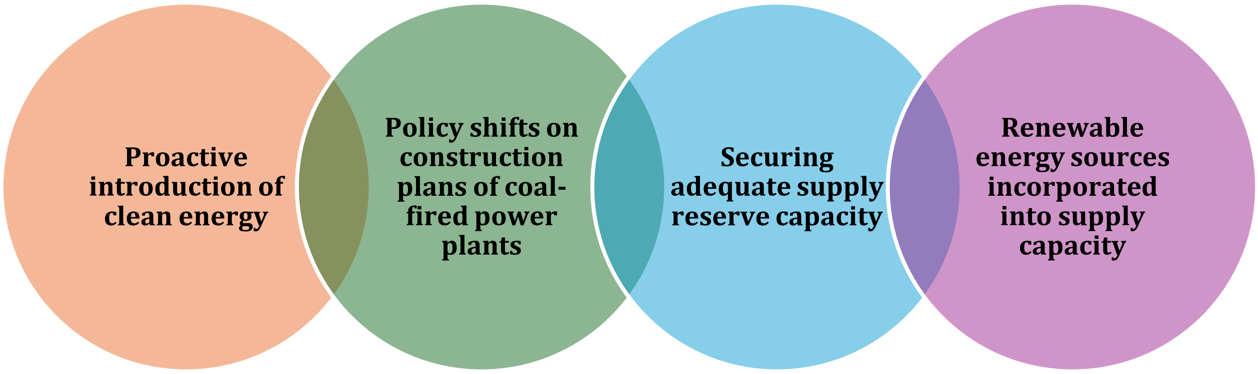
Box 2: Major plans and policies by the government



Source: Compiled by the Authors from different sources

Integrated Energy and Power Master Plan (IEPMP) 2023 focuses on establishing a clean, efficient, and sustainable energy system to support Bangladesh's long-term development goals under Vision 2041. It emphasizes the "S plus 3E" approach, ensuring Safety in energy supply, strengthening Energy Security through local resource utilization and import infrastructure, achieving Economic Efficiency with affordable energy access, and protecting the Environment by minimizing greenhouse gas emissions—all aimed at creating a low-carbon economy by 2050 (Ministry of Power, Energy and Mineral Resources, 2023). Box 3 presents the focus areas of IEPMP 2023.

Box 3: Focus areas of IEPMP 2023



Source: Compiled by Authors from IEPMP, 2023

Some key initiatives mentioned in the IEPMP are mentioned below:

- Up to 40% clean energy in power generation
- Besides the adoption of clean energy, energy efficiency and conservation (EE&C, also EEC) actions should be another pillar of Bangladesh's endeavor toward a clean energy society. Saving energy consumption simply brings economic benefits by reducing expenses for energy
- Policy support to clean energy development, such as the feed-in-tariff (FIT) system
- Establishment of a system to ensure the safe and reliable nuclear power generation and operation
- Adopting novel energy technologies such as hydrogen power generation, co-firing of ammonia at thermal power plants, and carbon capture and storage (CCS).
- Promoting R&D of low-carbon technologies

Power System Master Plan (PSMP) 2016 sets Bangladesh's energy strategy to support Vision 2041, aiming for energy security and sustainable growth. It emphasizes diversifying energy imports, maximizing domestic resources, enhancing power system quality, promoting renewable energy, and strengthening institutional capacity. The plan aligns with key Sustainable Development Goals, including clean energy, infrastructure development, and climate action (Power Division, 2016).

The Power System Master Plan (PSMP) 2016, sponsored by Japan International Cooperation Agency (JICA), aims at assisting Bangladesh in formulating an extensive energy and power development plan up to the year 2041, covering energy balance, power balance, and tariff strategies. Bangladesh has an aspiration to become a high-income country by 2041. The development of energy and power infrastructure, therefore, pursues not only the quantity but also the quality to realize the long-term economic development.

Some key initiatives mentioned in the Power System Master Plan (PSMP) 2016 are mentioned in Figure 6.

Figure 6: Priorities mentioned in the PSMP 2016

Transition to Renewable Energy:	• Increase the share of **solar, wind, and hydropower** in the energy mix to reduce reliance on fossil fuels.
Energy Efficiency Improvements:	Implement the **Energy Efficiency and Conservation Master Plan (EECMP)** to optimize energy consumption across sectors and reduce emissions.
Carbon Capture and Storage (CCS):	• Explore the feasibility of **CCS technologies** for mitigating emissions from fossil fuel-based power generation.
Diversification of Energy Sources:	• Include **gas-based**, **nuclear**, and **clean coal technologies** (with CCS) in the energy mix for low-carbon development.
Regional Power Import:	• Establish **cross-border electricity trade** to import **cleaner energy** and reduce domestic carbon emissions.
Climate Resilient Energy Infrastructure:	• Develop **climate-resilient infrastructure** to withstand the impacts of climate change and maintain a low-carbon energy system.
International Cooperation and Climate Finance:	• Leverage **international collaboration** and **climate finance** to support the transition to renewable energy and implement mitigation technologies.

Source: Compiled by the Authors from Power System Master Plan (PSMP), 2016

Bangladesh Climate Prosperity Plan 2022–2041 emphasizes important projects like the Bongoposagor Independence Giga Array, a 4- gigawatt wind power project, which are intended to update the energy grid, boost resilience, and raise renewable energy to 30% by 2030 and 40% by 2041 with grid resilience and modernization. The major priority areas (Box 4) include ensuring energy systems resilience, maximizing renewable energy wealth, energy efficiency, and energy storage infrastructure, and modernization of the grid and the ancillary market to support resilience (Ministry of Environment, Forest and Climate Change, 2022).

Box 4: Priorities mentioned in the Bangladesh Climate Prosperity Plan

Ensuring energy systems resilience	**Maximized renewable energy wealth, energy efficiency and energy storage infrastructure**	**Modernization of the grid and the ancillary market to support resilience**

Source: Compiled by the Authors from Bangladesh Climate Prosperity Plan 2022-2041

Some key initiatives mentioned in the Bangladesh Climate Prosperity Plan are mentioned below:

- Securing resilience, energy independence, and energy security, and becoming a net green energy exporter to the world.
- 30% renewable energy by 2030 and up to 40% by 2041, with grid resilience and modernization.
- Bongoposagor Independence Giga Array: A 4-gigawatt wind generation array network linked to a mangrove green belt, which is claimed to be the first large-scale hybrid RE-adaptation infrastructure project.
- Strategic Energy Hubs: A strategic program of reconversion of coal, oil, and diesel thermal power plants together with workforce upskilling to act as high-tech green hydrogen production facilities, and waste-to-energy/biomass power plants, interconnected with Bangladesh's growing LNG/natural gas network.

Perspective Plan of Bangladesh 2021-2041 focuses on the development of a sustained power sector, which includes: adopting a least-cost power generation expansion path, promoting the supply of low-cost primary energy, developing the required infrastructure for primary fuel, ensuring investment balance between generation, transmission and distribution, promoting efficient use of installed capacity and private investment in energy and expanding power trade, ensuring proper energy pricing policy and strengthening power and energy institutions (General Economics Division, 2020).
Some key initiatives mentioned in the Perspective Plan of Bangladesh 2021-2041 are mentioned below:

- Adopting a least-cost power generation expansion path
- Promoting supply of low-cost primary energy
- Developing the required infrastructure for primary fuel
- Ensuring investment balance between generation, transmission, and distribution
- Promoting efficient use of installed capacity
- Promoting private investment in energy
- Expanding power trade
- Ensuring proper energy pricing policy
- Strengthening power and energy institutions

Bangladesh Delta Plan 2100 places a high priority on solar energy integration in flood-prone areas, solar-driven water pumping systems, and floating solar systems. Moreover, developing long-term renewable energy policy as well as strategies and formulating a master plan for 50-100 years to harness the potential of renewable energy resources in the country, involving public and private sector investments, are also some key concerns (General Economics Division, 2018). Some key initiatives of the Bangladesh Delta Plan 2100 are mentioned in Table 11.

Table 11: Key initiatives mentioned in the Bangladesh Delta Plan 2100

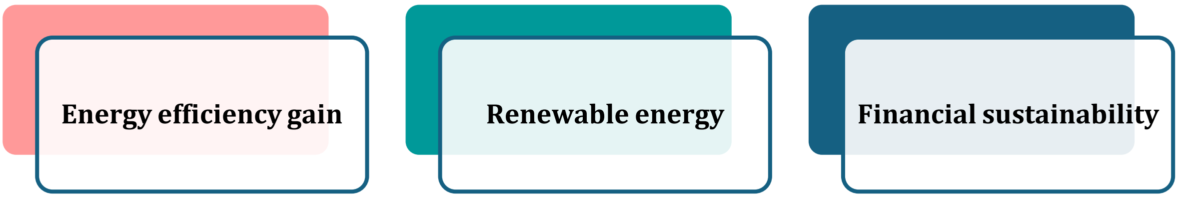
Institutional	Solar Power Energy	Financing
• Developing long-term renewable energy policy as well as strategies and formulating a master plan for 50-100 years to harness the potential of renewable energy resources in the country, involving public and private sector investments.	• Installing solar panels in land strips available in flood embankments, barrages, and other hydraulic structures. • Developing pumping facilities driven by solar power for pumping	• Devising innovative financing packages for grant funding and low-interest financing to address affordability for both grid and off-grid renewable energy projects.

Institutional	Solar Power Energy	Financing
• Promoting research on the development of technology in the field of renewable energy in universities and research institutions, as well as building capacity for its application • Enhancing Green Growth through research and development of renewable technologies, including clean development mechanism (CDM).	water from both surface water and groundwater. • Developing floating solar systems in water bodies of haor and hard-to-reach areas.	• Incorporating a financing mechanism for procuring land to make land available to private investors for implementing renewable energy projects.

Source: Compiled by the Authors from Bangladesh Delta Plan 2100

8th Five-Year Plan (8FYP) prioritizes the adoption of sustainable energy, energy efficiency, and regulatory changes away from coal-fired power plants (Box 5). It emphasizes mobilizing private and joint-venture investments, diversifying primary fuel sources with a strong focus on renewable energy, and maintaining some highly efficient, low-emission coal plants for cost-effective power generation. The plan also targets improved efficiency by reducing transmission and distribution losses, promoting the use of alternative energy sources, including nuclear energy, and exploring cross-border electricity trade with neighbouring countries such as India, Nepal, Bhutan, and Myanmar. Additionally, it advocates for innovative financing mechanisms, such as leveraging support from Export Credit Agencies to fund energy sector development (General Economics Division, 2020).

Box 5: Major focus of 8FYP for the energy sector



Source: Compiled by the Authors from 8FYP

Some key initiatives mentioned in the 8th Five-Year Plan (8FYP) are mentioned below:

- A rapid growth in electricity generation and development of transmission and distribution systems in line with generation.
- Mobilizing private and joint-venture investment in the power sector.
- Diversification of primary fuel for electricity generation, with a special focus on increasing renewable energy generation.
- As part of its pursuit of the strategy of least cost power generation, continue to have some highly efficient, least polluting coal plants
- Improving power sector efficiency and reducing transmission and distribution losses.
- Use of alternative sources of energy and nuclear energy for power generation.
- Exploring electricity-trading options with neighbouring countries (India, Nepal, Bhutan, and Myanmar).
- Use of alternative sources of financing (Export Credit Agency, etc.)

The Renewable Energy Policy 2025 focuses on adapting and developing RE technologies and promoting local manufacturing capabilities to ensure an affordable, scalable, reliable, environment-friendly, and sustainable energy supply in the country. The objectives of the RE Policy 2025 are presented in Box 6.

Box 6: Objectives of the RE Policy 2025

- Reduce electricity tariff and reduce government subsidy.
- Harness the potential of RE resources and dissemination of RE technologies in the country.
- Promote local manufacturing capacities of RE equipment.
- Scale up RE capacity for ensuring energy security, contributing to the RE targets, and reducing the dependence on fossil fuels in the country.
- Attract investment with proper institutionalization, product standardization, cost competitiveness in the RE sector.
- Safeguard the environment by increasing the share of "Green Energy" in the overall energy mix.
- Promote sustainable energy projects across the country and effectively utilize Battery Energy Storage Systems (BESS) to enhance integration of renewable energy into the grid and to ensure grid stability effectively.

Source: Compiled by the Authors from Renewable Energy Policy, 2025

5.2 Assessment of Coherence, Ambition, and Alignment Across Plans

In the energy industry, the current state of the regulatory framework is not satisfactory. The lack of cohesion in the framework is its main flaw (Table 12). For example, by 2041, 20% of total power generation must come from renewable energy (RE), according to the Power System Master Plan (PSMP) 2016. Whereas the Bangladesh Climate Prosperity plan and the Integrated Energy and Power Master Plan (IEPMP) 2023 set the goal of 40% renewable energy by 2041. This also brings up the policy myopia issue. The goal of 40% renewable energy by 2041 is a very lofty target, considering that in 2024, the percentage stood at only 4.44% (SREDA, 2024).

Table 12: Government regulatory frameworks and key features focused on renewable energy

Policy Document	Organization(s)	Renewable Energy Targets
Perspective Plan 2041	GED, MoP	- Initial target of 3% renewable energy by 2021 -Future target projection is absent.
National Solar Energy Roadmap, 2021 – 2041	PD, MoPEMR and SREPGen, UNDP	- 40,000 MW of installed solar capacity by 2041
Bangladesh Climate Prosperity Plan 2022-2041	MoEFCC	- 30% renewable energy by 2030 - 40% renewable energy by 2041 - 100% renewable energy by 2050
Renewable Energy Policy (2008)	PD, MoPEMR	- 5% of total power demand by 2015 - 10% by 2020

Policy Document	Organization(s)	Renewable Energy Targets
Bangladesh Delta Plan 2100	GED, MoP	- 10% renewable energy by 2020 - 30% by 2041
Integrated Energy and Power Master Plan (IEPMP) 2023	JICA, IEEJ, MoPEMR	- 40% of energy from clean and renewable sources by 2041 - 26.2 GW of renewable energy capacity by 2050
Power System Master Plan 2010	PD, MoPEMR, JICA, TEPC	- 5% of total electricity demand with renewables by 2015 -10% by 2020 (510 MW by 2015, 1,760 MW by 2020)
Power System Master Plan 2016	JICA, TEPC, MoPEMR and Others	- -20 % renewable ratio (RE20) by 2041

Source: Adapted from Raihan et al. (2025)

Coherence in energy policies is crucial for both mitigating the effects of climate change and maintaining institutional quality. The Renewable Energy Policy's push for renewable energy must complement other goals, such as lowering dependency on fossil fuels and LNG. Institutional strength may be weakened by misalignment or inconsistencies between the expansion of fossil fuels and the objectives of renewable energy.

Another issue is the discrepancy in regulations. Recent energy sector developments show differently, despite the country's desire to lessen its dependency on fossil fuels and increase the proportion of renewable energy in its mix (Table 13). One such mismatch is the Matarbari Powerplant project. The power plant, which has not yet opened, intends to run entirely on coal that is exported. Even so, the relevant authority asserted that the plant's ultra-critical technology would almost eliminate pollution. Nevertheless, coal is never a clean energy source. Furthermore, the country's declining coal reserves would be further limited by reliance on coal exported from abroad. Those are all in opposition to various legal systems and regulations.

Table 13: List of major power plants and their operating fuels

Sl. No.	Major Initiatives by GoB	Fuel
1	Rampal Power Plant (2010)	Coal*
2	500 MW Solar Program	RE
3	Rooppur Nuclear Power Plant (2013)	Nuclear*
4	Matarbari Ultra Super Critical Coal-Fired Power Project (2013)	Coal*
5	Payra Coal Power Plant Project (2014)	Coal*
6	Bangladesh-India Power Purchase Agreement	Import
7	Banshkhali Power Plant (2016)	Coal*
8	Bangladesh-Adani Power Purchase Agreement (PPA)	Import
9	Bangladesh-India Friendship Pipeline (2017)	Import
10	Floating Solar PV Initiative 2023	RE
11	Payra LNG Power Plant	LNG*

Source: Adapted from Raihan et al. (2025)

* This indicates regulatory misalignment, where policy initiatives and regulatory frameworks fail to support the shift toward renewable energy

6. Economy-wide Impacts of Energy Transition: CGE Model Findings

6.1. The Methodology of the Economy-wide Modelling

This study examines how Bangladesh's climate commitments, particularly the targets under NDC 3.0, can contribute to the country's broader development objectives. The central question is straightforward but important: how would achieving the NDC 3.0 targets help Bangladesh attain its national economic development goals? To answer this, the study applies an economy-wide recursive dynamic Computable General Equilibrium (CGE) model to compare Bangladesh's business-as-usual growth path with alternative scenarios in which NDC 3.0 targets are achieved. The comparison allows the study to estimate the incremental economic, social, and environmental benefits of climate action up to 2035.

The analytical approach begins with a business-as-usual baseline. This baseline tracks the likely evolution of the Bangladesh economy to 2035 without additional policy interventions linked to NDC 3.0. The study then introduces sector-specific climate actions and compares the resulting development outcomes with the baseline. In this way, the model does not simply ask whether climate action reduces emissions. It asks a broader development question: what additional gains could Bangladesh achieve in terms of GDP, employment, poverty reduction, undernourishment, household income, and structural transformation if it implements its NDC 3.0 commitments?

In this paper, the modelling exercise focuses on the energy sectors. This sector was selected through a review of the NDC 3.0 document, with particular attention to which targets could be translated into model-based scenarios. The selection was also informed by a review of relevant literature, expert consultations, policy engagement, and stakeholder discussions. In the energy sector, the focus includes the expansion of solar capacity, hydropower, and improvements in energy efficiency.

The core modelling framework is built around a 2022 Social Accounting Matrix (SAM) for Bangladesh. The SAM provides a consistent economy-wide database that captures the flow of income and expenditure across producers, households, government, investors, and the rest of the world. It allows the model to trace how changes in one part of the economy affect other sectors and institutions. This is particularly important for climate policy analysis, because climate action in the energy sector can generate effects far beyond the targeted sector. For example, investment in renewable energy may affect electricity prices, industrial production, household welfare, government revenue, imports, and employment.

The SAM for the Bangladesh economy has 80 sectors in the database. This level of sectoral detail allows the analysis to capture production patterns and supply-chain linkages with considerable precision. Agriculture is represented through 27 primary products and 17 processed products. The energy sector distinguishes solar and hydropower, while the transport sector differentiates between internal combustion vehicles and electric vehicles. This sectoral structure is important because the transition to a low-carbon economy is not uniform across the economy. Different sectors face different constraints, technologies, emissions profiles, and adjustment costs. A detailed sectoral framework, therefore, helps identify where the largest gains, risks, and trade-offs may arise.

The model also includes a household survey module. The population is divided into 20 household groups, based on rural and urban per capita expenditure quintiles. This makes it possible to assess how climate policies affect different types of households. Such distributional analysis is particularly important for Bangladesh, where climate risks, poverty, food insecurity, and employment vulnerabilities are unevenly distributed across regions and social groups. A policy that raises aggregate GDP may still have unequal effects across households. The household module, therefore, helps the study assess not only the macroeconomic effects of climate action but also its implications for poverty, undernourishment, and household welfare.

Labour markets are also disaggregated by education levels. This feature allows the model to capture the employment implications of climate-related policy shifts. Renewable energy may create new jobs, but the type of jobs created will depend on the skill composition of labour demand. At the same time, some sectors may face adjustment pressures as production technologies and energy systems change. By separating labour by education levels, the model can examine how climate action affects different categories of workers and whether the transition may require complementary investments in skills, training, and labour-market support.

The recursive dynamic structure of the CGE model allows the analysis to move beyond a one-period static comparison. The model tracks the economy over time, linking current outcomes to future economic conditions. Population growth and urbanisation are introduced exogenously, affecting labour supply and household demand. Sectoral capital accumulation is determined endogenously, based on past investment patterns. This means that policy shocks introduced in one period can influence future production capacity, investment, employment, and income. The dynamic structure is therefore well-suited to assessing Bangladesh's development trajectory up to 2035.

A key strength of the CGE framework is that it captures economic linkages across sectors, factor markets, product markets, institutions, and the external sector. Producers use factors such as land, labour, and capital, along with intermediate inputs, to produce goods and services. These goods and services are then sold to households, the government, investors, other producers, or foreign buyers. Some goods are exported, while imported goods enter domestic markets and compete with domestic production. Prices adjust to ensure that supply equals demand across markets. This equilibrium-based structure allows the model to capture both direct and indirect effects of policy changes.

The model also maintains macroeconomic consistency. It keeps track of government revenue and expenditure, savings and investment, and the current account or foreign exchange balance. This is essential for climate policy analysis. Many green transition measures require investment, subsidies, public spending, or changes in imports of capital goods and technologies. These measures may affect fiscal balances, external balances, and investment flows. The CGE model ensures that these economy-wide constraints are reflected in the results rather than treated as external assumptions.

Data reconciliation is a central part of the methodology. The modelling database brings together information from national accounts, balance of payments data, household surveys, labour force surveys, government accounts, public finance studies, firm and industry studies, programme evaluation studies, and firm surveys. Each source contributes a specific element. National accounts provide GDP by sector, product supply and use, and transaction costs. Balance of payments data provide information on trade flows, remittances, foreign investment, and development assistance. Household surveys provide data on consumption, diets, labour income, land and enterprise earnings, taxes, and transfers. Labour force surveys provide information on employment and earnings by sector. These different data sources are reconciled into a coherent SAM and then used to calibrate the CGE model.

The SAM structure links production, income generation, income distribution, consumption, investment, government finance, and external transactions. Activities receive income from marketed output. Commodities are used for intermediate demand, private consumption, public consumption, investment demand, and exports. Factors receive value-added payments, which are then distributed to households as factor incomes. Households also receive transfers and remittances, and allocate their income across consumption, savings, and direct taxes. The government receives revenue from producer taxes, tariffs, VAT, excise taxes, direct taxes, and foreign aid, while also spending on consumption, transfers, savings, and investment. The rest of the world account records imports, exports, foreign payments, remittances, grants, and foreign savings.

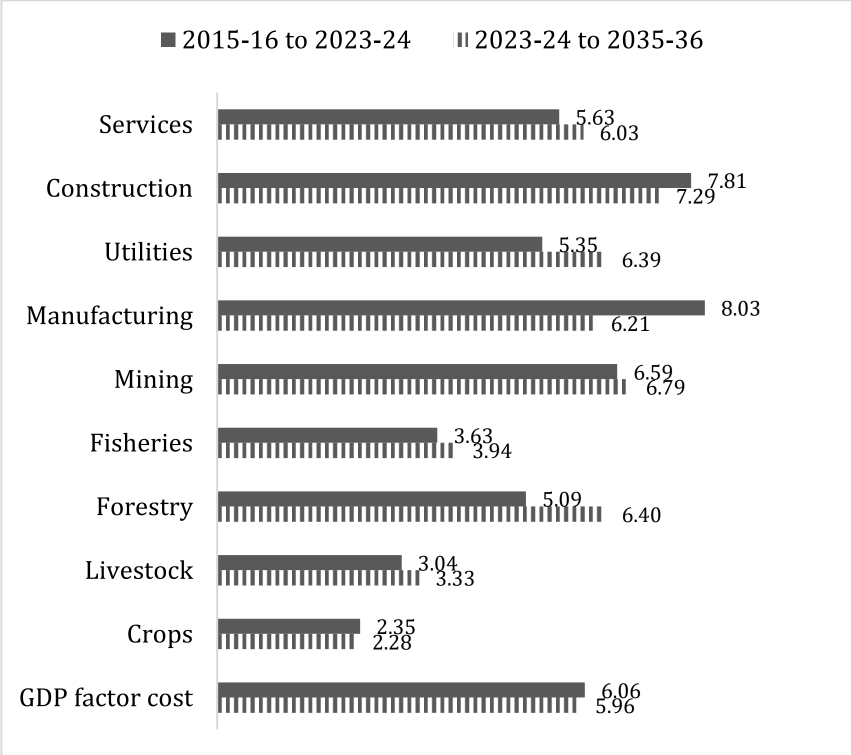
The supply-chain structure of the model is also important. Activities combine labour, land, capital, and intermediate inputs to produce output. This output is then transformed into commodities, which may be sold domestically, exported, or combined with imports to form a composite supply. Composite supply is then used by households, government, investors, and producers. The model allows price-driven substitution in selected parts of the system, while assuming no substitution in others. This structure reflects the fact that producers and consumers can adjust their behaviour when relative prices change, but only within technological and institutional limits.

Through this framework, the study can simulate how specific NDC-related interventions affect the broader economy. For instance, expanding solar energy and improving energy efficiency may affect electricity generation, fossil fuel use, production costs, and industrial competitiveness. This is important because Bangladesh's climate transition cannot be assessed only through emissions reductions. The central issue is whether climate action can support a wider development strategy. If well designed, decarbonisation can reduce vulnerability, improve productivity, create jobs, lower future economic losses, strengthen food security, and support more inclusive growth.

6.2. Baseline scenario

The baseline scenario provides the reference path against which the transport-sector decarbonisation scenarios are assessed. It represents Bangladesh's projected economic trajectory up to 2035 in the absence of additional NDC 3.0-related interventions. Under this baseline, GDP at factor cost is projected to grow at an annual average rate of 6.10% during 2023-24 to 2035-36, broadly maintaining the country's historical growth momentum (Figure 7). The baseline is driven by population growth, productivity growth, and changes in cropped area. Productivity is introduced through the shift parameter in the production function, while labour is assumed to be mobile across activities. Low-skilled workers are allowed to remain unemployed, while high-skilled workers are assumed to be fully employed. Capital, however, is assumed to be immobile across activities.

Figure 7: Baseline and historical growth rate



Source: Dynamic recursive CGE model of Bangladesh

The macroeconomic closure assumptions also shape the baseline. The exchange rate is fixed, and foreign savings adjust to clear the external market. Given the tax rate, the government budget deficit adjusts to balance government accounts. The savings rate is also scaled so that aggregate savings equal aggregate investment. These assumptions provide a consistent economy-wide framework for assessing how transport-sector interventions affect GDP, employment, income, and poverty relative to the business-as-usual path.

6.3. Energy Sector Decarbonisation Scenarios

The energy-sector scenarios are designed around Bangladesh's NDC 3.0 targets for 2035. These targets include raising the share of renewable electricity to 25% of total electricity production by 2035, reducing total transmission and distribution losses to 8%, achieving a 10% improvement in energy efficiency, and saving 10% of household energy use through improved appliances. These interventions are important because Bangladesh's future growth will require a large expansion of energy supply. Yet, if that expansion remains heavily dependent on fossil fuels, it will increase emissions, raise import dependence, and expose the economy to external price shocks.

The energy transition is therefore not only a climate agenda. It is also a development strategy. Renewable energy expansion can reduce dependence on imported fossil fuels. Energy efficiency can lower production costs and improve industrial profitability. Reduced transmission and distribution losses can increase effective electricity supply without requiring equivalent new generation capacity. Household energy savings can reduce electricity demand pressure and improve energy security. Taken together, these reforms can reshape the energy system in a way that supports growth, employment, and macroeconomic resilience.

Scenario building for the energy sector

The energy-sector simulations are built around four individual scenarios and one combined scenario (Table 14). The first is EN_REN, or renewable energy expansion. This scenario assumes that 25% of the total electricity supply will come from solar by 2035. Since the share of solar was around 2% in 2023, this requires a major scale-up of solar production. The scenario also assumes that the non-renewable electricity sector will grow more slowly than in the baseline, while battery equipment, repair, and installation services will expand rapidly. This makes EN_REN both an energy transition scenario and an industrial expansion scenario.

Table 14: Scenario building: Energy sector

Scenarios	Descriptions	Assumptions
EN_REN (Renewable Energy Expansion)	25% of the total electricity supply from solar by 2035 • As of 2023, the share of solar is around 2%	• Massive increase in solar production • Non-renewable electricity sector will grow more slowly than baseline • Battery equipment, repair & installation service will grow rapidly
EN_TRD (Reduce transmission & distribution loss)	Total system loss will be reduced to 8% • Evidence shows, current loss is 10%	• No expansion of solar electricity • The other electricity sector will become efficient

EN_IND (Industrial energy efficiency improvement)	• 10% energy efficiency improvement
	• Concrete brick will replace 40% of the brick demand.
		• Reduce coal use for brick production
		  • Bricks are mapped within the non-metallic mineral production
		• Steady fall in the fossil fuel input use coefficient to meet 10% energy efficiency improvement target.
		  • Evidence shows an increase in TFP due to energy efficiency improvement

EN_HH (Households energy savings)	• Households will save 10% electricity use by adopting energy-efficient appliances	• Households' electricity expenditure falls, but expenditure on electric equipment increases
EN_ALL	Above all scenarios combined	

Source: Model scenario building based on NDC 3.0

The second scenario is EN_TRD, which focuses on reducing transmission and distribution losses. It assumes that total system loss will fall to 8%, compared with the current loss of around 10%. This scenario does not include an expansion of solar electricity. Instead, it assumes that the existing electricity system becomes more efficient. The logic is simple: if less electricity is lost during transmission and distribution, more electricity becomes available for productive and household use without the same level of additional generation.

The third scenario is EN_IND, or industrial energy efficiency improvement. It assumes a 10% improvement in industrial energy efficiency by 2035. It also assumes that concrete bricks will replace 40% of brick demand, reducing coal use in brick production. In the model, bricks are mapped within the non-metallic mineral production sector. The scenario further assumes a steady decline in fossil fuel input-use coefficients to meet the energy efficiency target. This is important because lower fossil fuel use can reduce production costs without reducing output. As a result, industrial profitability improves, and total factor productivity rises.

The fourth scenario is EN_HH, or household energy savings. It assumes that households save 10% of their electricity use by adopting energy-efficient appliances. Under this scenario, household electricity expenditure falls, but spending on electrical equipment increases. The macroeconomic impact is therefore more muted than in the renewable energy or industrial efficiency scenarios. Still, this scenario has value because it reduces pressure on electricity demand and can support energy self-sufficiency.

The fifth scenario is EN_ALL, which combines all four energy-sector interventions. However, the combined impact should not be read as a simple sum of the individual effects. The scenarios interact with each other. For instance, renewable electricity reaches 25% of total electricity supply by 2035, but total electricity supply may fall relative to what it would have been because energy efficiency and demand management reduce electricity demand.

6.4. Simulation Results

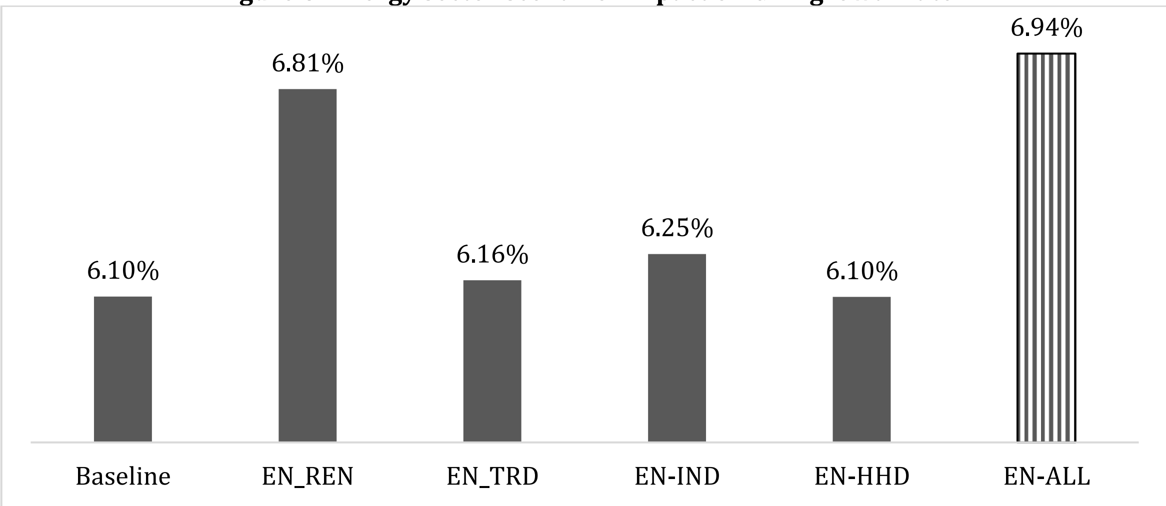
Impact on GDP growth

The results show that energy-sector reforms can generate substantial gains for Bangladesh's growth trajectory (Figure 8). Under the baseline, GDP grows at 6.10% per year. If all energy-sector targets are achieved under EN_ALL, GDP growth rises to 6.94%. This is the strongest growth impact among the three sectoral packages covered in the broader modelling exercise.

Among the individual energy interventions, renewable energy expansion has the largest effect, raising GDP growth to 6.81%. This result reflects the strong economy-wide stimulus created by solar expansion, battery-related activities, installation services, and the slower growth of fossil fuel-based electricity. Industrial energy efficiency also raises GDP growth, though by a smaller margin. Household energy savings, by contrast, do not significantly raise GDP growth. This is because the scenario mainly changes household expenditure patterns and reduces electricity demand, rather than directly expanding production capacity.

The key message is that the energy transition can be growth-enhancing if it is driven by productive investments. Renewable energy expansion is especially powerful because it creates new supply chains and reduces fossil fuel dependence. Efficiency improvements also matter, particularly for industry. Demand-side household savings are useful for energy security, but their direct growth effect is limited.

Figure 8: Energy sector scenario: Impact on GDP growth rate

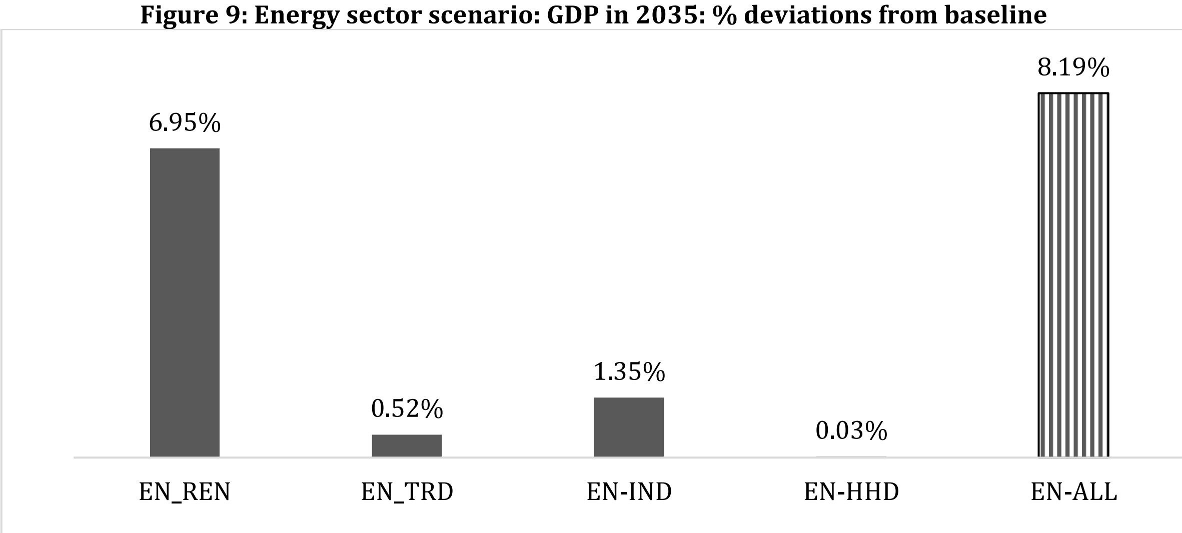


Source: Dynamic recursive CGE model of Bangladesh

Impact on GDP under energy-sector interventions

The GDP deviation results show the size of the economy-wide gains in 2035 (Figure 9). Under the combined EN_ALL scenario, GDP is projected to be 8.19% higher than the baseline. This is a sizeable impact. In monetary terms, if the energy-sector targets are achieved by 2035, Bangladesh's economy is projected to be USD 66 billion larger than under the baseline. Baseline GDP, at constant 2023 prices, rises from USD 474 billion in 2023 to USD 950 billion in 2035.

Figure 9: Energy sector scenario: GDP in 2035: % deviations from baseline



Source: Dynamic recursive CGE model of Bangladesh

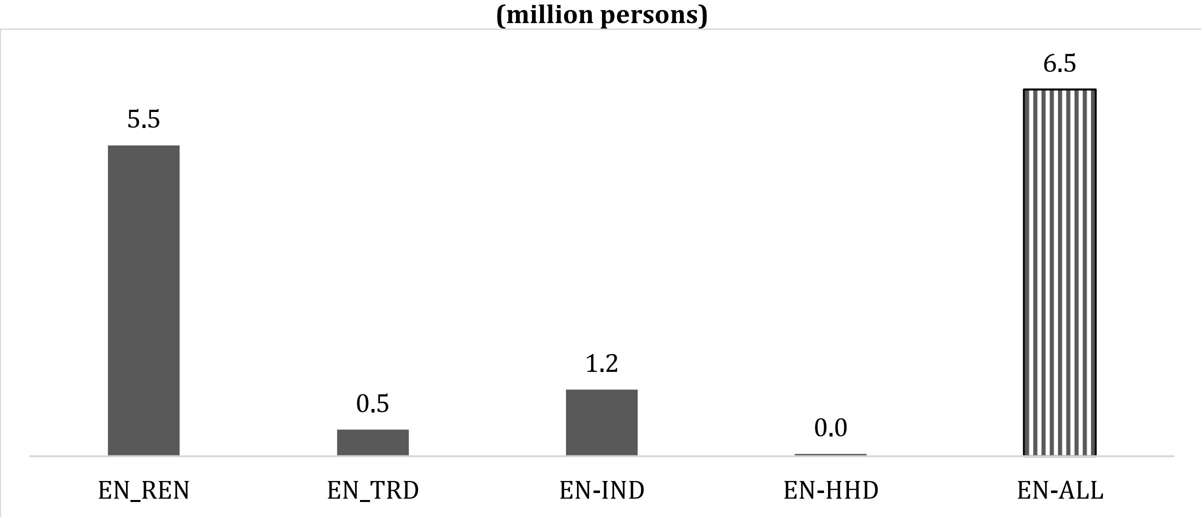
Among the individual scenarios, EN_REN has the largest GDP impact. It raises GDP by 6.95% above the baseline in 2035. This reflects the large expansion of solar electricity, battery equipment, solar PV supply, repair, and installation services. The renewable energy scenario, therefore, works through multiple channels: it expands clean electricity supply, stimulates related industries and services, and reduces reliance on imported fossil fuels.

The EN_IND scenario raises GDP by 1.35% above the baseline. This effect comes from improved industrial energy efficiency, lower fossil fuel input use, and higher industrial profitability. The EN_TRD scenario raises GDP by 0.52%, reflecting the benefits of reducing electricity losses in the transmission and distribution system. The EN_HH scenario has only a marginal GDP impact of 0.03%, as household savings in electricity expenditure are partly offset by higher spending on energy-efficient appliances.

Impact on employment

Energy-sector reform also produces strong employment effects (Figure 10). Under the baseline, total employment is projected to increase from 71 million persons in 2023 to 101 million persons in 2035, implying average annual employment growth of around 3%. Against this baseline, the combined EN_ALL scenario creates an additional 6.5 million jobs in 2035.

Figure 10: Transforming the energy sector: Additional jobs created in 2035 compared to baseline (million persons)



Source: Dynamic recursive CGE model of Bangladesh

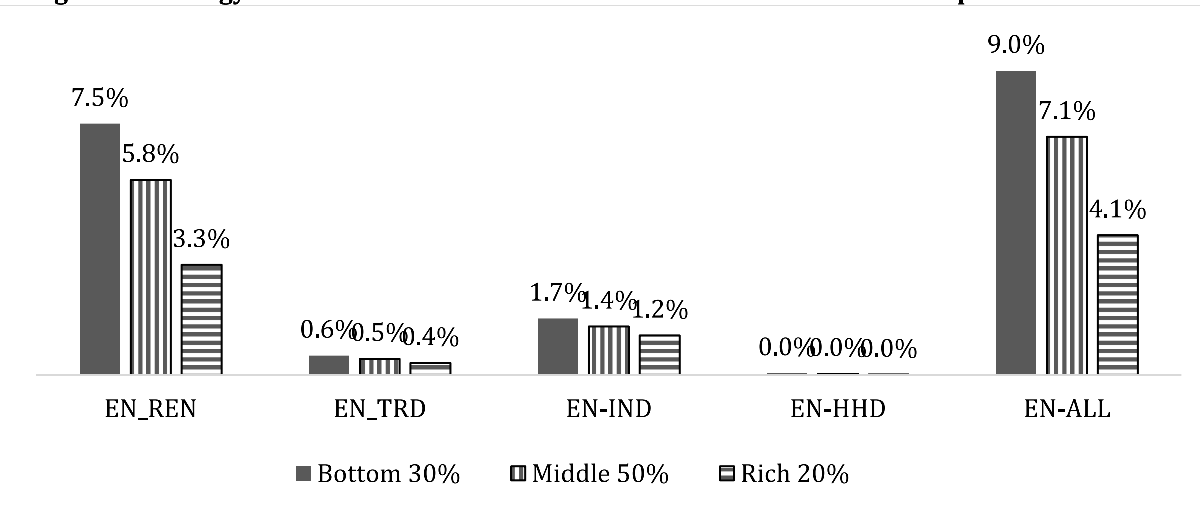
Again, EN_REN is the strongest individual scenario. Renewable energy expansion creates 5.5 million additional jobs by 2035. This employment effect is driven by the expansion of solar production, battery supply, installation services, repair activities, and related value chains. In other words, the employment impact does not come only from electricity generation. It also comes from the broader ecosystem needed to build, operate, maintain, and support a renewable energy system.

The EN_IND scenario creates 1.2 million additional jobs, reflecting the positive effect of improved industrial efficiency and higher production profitability. The EN_TRD scenario creates 0.5 million additional jobs, while EN_HH has almost no employment effect. This pattern suggests that investment-oriented and productivity-enhancing energy reforms create larger labour-market gains than purely demand-side household energy-saving measures.

Impact on household income

The household income results show that energy-sector reforms can generate inclusive gains (Figure 11). Under the baseline, household income is projected to grow between 2023 and 2035 by 5.3% for the bottom 30%, 5.2% for the middle 50%, and 4.9% for the rich 20%. The energy scenarios add further income gains above this baseline.

Figure 11: Energy sector scenarios: Additional income of households as compared to baseline



Source: Dynamic recursive CGE model of Bangladesh

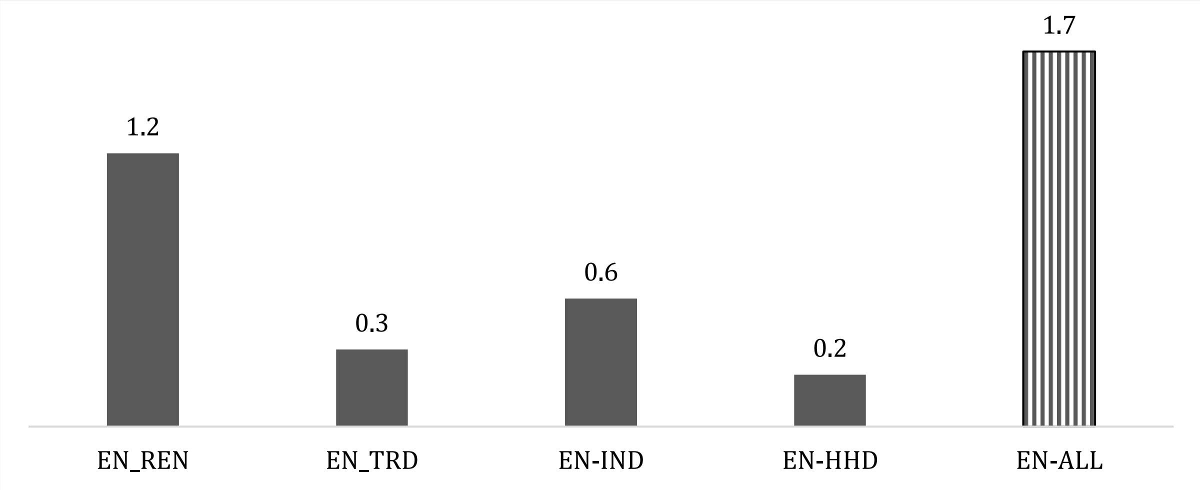
Under EN_ALL, household income rises by 9.0% for the bottom 30%, 7.1% for the middle 50%, and 4.1% for the rich 20%, compared with the baseline. The gains are therefore progressive. Poorer households benefit proportionately more than richer households. This is an important finding because it suggests that the energy transition, if designed well, can support inclusive growth rather than simply raising aggregate output.

Among the individual scenarios, EN_REN generates the strongest household income gains. It raises income by 7.5% for the bottom 30%, 5.8% for the middle 50%, and 3.3% for the rich 20%. The employment effects of renewable energy expansion are likely a major reason behind these gains. EN_IND also raises household income, though less strongly, while EN_TRD has a smaller impact. EN_HH produces almost no additional household income effect, although it may still reduce pressure on household electricity consumption.

Impact on poverty

Poverty results reinforce the inclusive potential of energy-sector reforms (Figure 12). Under the baseline, the number of people below the USD 3 poverty line is projected to fall from 17.49 million in 2023 to 10.06 million in 2035. Energy-sector reforms accelerate this poverty reduction.

Figure 12: Energy sector scenarios: Additional people lifted out of poverty (million persons)



Source: Dynamic recursive CGE model of Bangladesh

Under the combined EN_ALL scenario, an additional 1.7 million people are lifted out of poverty by 2035 compared with the baseline. Renewable energy expansion alone lifts 1.2 million people out of poverty, making it the most powerful poverty-reducing energy intervention. Industrial energy efficiency lifts 0.6 million people out of poverty, while reduced transmission and distribution losses lift 0.3 million. Household energy savings lift 0.2 million people out of poverty.

These results show that the energy transition is not only about emissions reduction or energy security. It can also be a poverty-reduction strategy. The strongest effects come from interventions that expand production, create jobs, and raise incomes among poorer households. Renewable energy expansion is particularly important because it combines clean energy generation with job creation and new economic activity.

7. Strategic Pathways for a Low-Carbon and Resilient Energy Future

The energy sector plays a strategic role in Bangladesh, both for climate change mitigation and sustainable development. It accounts for the largest share of greenhouse gas emissions in the country, but it also has considerable potential alone to cut emissions and build resilience. Recently, despite the previous progress made here and there, Bangladesh still has multiple paths left in front of it that, when traversed, can help redefine its low-carbon and resilient energy future. These pathways consist of short, mid, and long-term measures.

7.1 Short-Term Strategic Pathways

Aligning Renewable Energy Targets: Bangladesh must devise a single, clear vision for renewable energy in the short term. Currently, most national policies contain a variety of competing renewable energy targets. Given that shifting targets would require reallocating essential investment resources across the budget, setting common targets between other goals, such as the 20% renewable energy target in key policies like PSMP (2016) and 40% in relevant strategies such as the Bangladesh Climate Prosperity Plan (IEPMP, 2023), will help ensure planning and implementation are seamless. A transparent path will also attract local and foreign investment in the energy sector.

Enhancing Energy Efficiency: Energy efficiency must be given the utmost priority in the immediate term as it engages default towards emission control and enhanced cost-effectiveness (As and Bilir, 2023). With adequate regulatory push, fiscal incentives, and improvement in technology in sectors such as industry and urban infrastructure, energy-efficiency targets can be achieved. By saving energy and performing environmentally, these measures also mi

RE Incentive Mechanism: Developing an incentive mechanism for investment in renewable energy is essential. These may take the form of subsidies, tax credits, low-interest loans, or other support mechanisms, particularly for small-scale solar and wind energy. These measures will reduce the cost of capital and foster local solutions. In addition, transparent and consistent incentives will also place an element of trust to strengthen the investment pitch for renewable energy in Bangladesh.

7.2 Medium-Term Strategic Pathways

Developing Climate-Resilient Infrastructure: Bangladesh should prioritize the construction of decentralized and climate-resilient energy infrastructure in the medium run (Okesiji 2025). Rooftop solar panels, floating solar systems, and battery storage can provide availability of the power (Silalahi and Gunawan, 2022; Thoroshi et al., n.d.) to people in lands that could easily be flooded by water or cyclones due to environmental pollution. Scaling up these technologies to off-grid and coastal areas will increase access to energy while also facilitating climate adaptation, making at-risk populations much more resilient against disasters.

Carbon Trading Framework and RE Certification: For unlocking the international climate finance, the carbon trading framework is a prerequisite (Amighini et al., 2022). Bangladesh can make money through emission reductions by establishing a carbon credit system, with revenues that can then be used to develop clean energy projects. Furthermore, you encourage a renewable energy certification system that would ensure credibility in renewable financing, thus allowing domestic and foreign tycoons to engage. The economy and the environment would both gain from these two steps, making Bangladesh's role in the global markets more significant.

Mobilizing International Climate Finance: Bangladesh will need to mobilize international climate finance in the medium term, given its energy goals. Certain clean energy projects can be funded via the Green Climate Fund (GCF), carbon markets, green bonds, or other economic mechanisms. This, in turn, will strengthen the ability of local institutions and project developers to attract and manage these resources, which will eventually facilitate the implementation of sustainable energy projects (Falcone, 2023).

Monitoring Framework for Emission Reduction: This will require an emission reduction monitoring framework to be put in place so that the country knows how well it is doing in terms of achieving its renewable energy. It will encompass KPIs in the areas of renewable energy capacity, emissions reductions, and cross-cutting energy access. It will offer vital statistics for policy adjustments in the context of climate action and to enhance transparency and accountability.

7.3 Long-Term Strategic Pathways

Strengthening Institutional Coordination: Strengthening institutional coordination with an eye towards the long-term is key for effective energy, climate, and development policy (Von Lüpke et al., 2023). Right now, however, the progress is hindered by fragmented policymaking across ministries. A core coordinating body, with strong political leadership supported by data-driven planning, will ensure the integration of energy policies with climate and development priorities (Bazzan and Righettini 2023). This will allow for the more effective and unified execution of mission-critical initiatives.

Promoting Private Sector Innovation and Local Manufacturing: In the long term, Bangladesh should enable more effective private sector participation in clean energy development (Song et al., 2024). Domestic production of solar panels, wind turbines, and batteries will reduce reliance on imports while creating local green jobs. Public-private partnerships (PPPs) regarding aspects such as smart grid development and decentralized energy systems could help accelerate the energy transition while making sure it is sustainable and inclusive.

Development of a Macro Assessment Framework: This will help assess the linkages between energy projects and broader economic, environmental, and social outcomes; thereby ensuring that the highest priority projects are aligned with country development goals. Strategies to reflect on the capabilities of renewable energy to combat poverty, create jobs, and others must be corrected or adopted based on a data-driven approach.

8. Conclusion

As Bangladesh finds itself at the nexus of climate and energy challenges, it is imperative to plan effective climate solutions that would set in motion a sustainable development pathway. The energy sector is under strong pressure from rising temperatures, extreme weather events, and sea-level rise. In addition, the continued use of fossil fuels threatens environmental sustainability and slows progress towards long-term climate-development goals. Climate change in Bangladesh is impacting the energy supply side as well as the demand side. Nevertheless, these challenges also present the form of opportunities for an overhaul. By harnessing renewable energy, Bangladesh not only curbs its reliance on fossil fuels but also reduces greenhouse gases and creates a more sustainable system for its population.

Policy coherence, reform, and international engagement are indeed imperative for overcoming these challenges. Coordination within policies, sectoral strategies, and government institutions needs to improve. Energy policies should be integrated with climate goals, such that energy production, energy use, and efficiency measures reinforce each other in a systematized manner. Stronger institutions and better coordination between national and local levels will also be necessary. In addition, international engagement can help Bangladesh access technical support and climate finance to speed up its transition to a low-carbon economy.

Renewable energy is central to Bangladesh's climate-resilient development. Although there is strong potential for renewable energy, especially solar power, this potential is still underused here. However, Bangladesh has made some progress in expanding renewable energy, particularly solar energy. Still, much more needs to be done. In the remote areas, large-scale solar projects and rooftop solar systems can provide cleaner energy and improve access. Greater investment in renewable energy can reduce carbon emissions, strengthen energy security, and create economic opportunities, especially in rural areas.

A climate-resilient future for Bangladesh hinges on the role renewable energy plays in its energy policy. In addition, a just energy transition needs to be undertaken with climate risk in mind alongside social and economic inclusion. This demands policy reform, more investment in renewables, and better global cooperation. When done right, these actions can help unlock the potential of renewable energy to drive economic development, alleviate poverty, and enhance resilience against climate change.

The energy-sector simulations show that Bangladesh's NDC 3.0 energy targets can generate large economic, employment, welfare, and energy-security gains by 2035. The combined energy package raises GDP growth from 6.10% under the baseline to 6.94%, increases GDP by 8.19% relative to the baseline level in 2035, creates 6.5 million additional jobs, raises income, especially for poorer households, lifts 1.7 million people out of poverty, and reduces primary energy imports by 15.08%.

The strongest individual intervention is renewable energy expansion. It delivers the largest gains in GDP, employment, household income, and poverty reduction. Industrial energy efficiency is also highly important, particularly for reducing fossil fuel imports and improving industrial profitability. Reducing transmission and distribution losses produces modest GDP and employment benefits, while household energy savings contribute more to demand management and energy self-sufficiency than to growth.

From a policy perspective, the implication is straightforward. Bangladesh's energy transition should be led by a major expansion of renewable electricity, especially solar, alongside industrial energy efficiency improvements and grid reforms. Household energy savings should remain part of the strategy, but they cannot substitute for productive investment in clean energy systems. A credible decarbonisation pathway for Bangladesh will therefore require coordinated action on renewable generation, battery and installation services, industrial efficiency, grid performance, appliance standards, financing, and institutional implementation. Done well, the energy transition can become not only a climate response but also a powerful driver of growth, jobs, poverty reduction, and energy security.

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