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Renewable Energy for Sustainable Growth and Development: An Evaluation of Law and Policy of Bangladesh

Mohammad Ershadul Karim [1,*], Ridoan Karim [1,2], Md. Toriqul Islam [1,3], Firdaus Muhammad-Sukki [4,*], Nurul Aini Bani [5] and Mohd Nabil Muhtazaruddin [5]

1 Faculty of Law, University of Malaya, Kuala Lumpur 50603, Malaysia; ridoankarim@um.edu.my (R.K.); toriqul@siswa.um.edu.my (M.T.I.)
2 School of Business Administration, East Delta University, Abdullah Al Noman Road, Noman Society, Mozaffor Nogor, East Nasirabad, Khulshi, Chittagong 4209, Bangladesh
3 Department of Law and Justice, Bangladesh University of Business and Technology, Dhaka 1216, Bangladesh
4 School of Engineering, Robert Gordon University, Garthdee Road, Aberdeen AB10 7GJ Scotland, UK
5 Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia, Kuala Lumpur 54100, Malaysia; nurulaini.kl@utm.my (N.A.B.); mohdnabil.kl@utm.my (M.N.M.)
* Correspondence: ershadulkarim@um.edu.my (M.E.K.); f.b.muhammad-sukki@rgu.ac.uk (F.M.-S.); Tel.: +60-187-693-629 (M.E.K.)

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Abstract: Bangladesh's constant growth with an annual 6% plus Gross Domestic Product (GDP) for more than the last two decades and achievements in other socio-economic metrics in recent times is impressive and recognized by various global authoritative bodies. The extent of overwhelming economic ventures in the private sector coupled with the commitments of the government clearly demonstrates the transformation of the country from a primarily agro-based economy to one influenced by the manufacturing and service sectors. Bangladesh is fortunate to have fossil fuel reserves on a limited scale, though these are not enough to run the ongoing massive scale development activities, both in private and public sectors. Thus, the constant and uninterrupted supply of energy at an affordable price remains a serious concern for the successive governments. Therefore, this issue of supply of constant energy has turned to be an important part in the national development agenda. Besides, the country is one of the worst victim nations of the devastating effects of global warming and climate change. As Bangladesh is geographically located in a favorable place in the world map with the availability of plenty of renewable energy sources (RES), the policymakers started to take initiatives leading to exploiting these sources to meet the energy demand of the country. There are both prospects and administrative, legal, technological, socio-cultural and environmental challenges. To address these challenges, it requires comprehensive policy initiatives. A good number of technical and scientific research containing findings and recommendations are available. This paper, which is based on adopting a qualitative research methodology where the contents of secondary sources were analyzed, is an initial attempt to highlight the renewable energy developments in Bangladesh, and subsequently, to evaluate the relevant legal and policy initiatives in the light of international best practices. We advance several recommendations that the stakeholders can consider exploiting RES effectively to attain inclusive, equitable and sustainable development in Bangladesh. These include, *inter alia*: (1) Enhancing government participation to lead the development of renewable energy (RE); (2) ensuring localization of RE technology; (3) reducing the expenses of energy generation through RES and providing assistance in initial investments; (4) introducing comprehensive legal and regulatory policy for the development of RE industry in Bangladesh; and (5) conducting effective public awareness.

Keywords: RE prospects and challenges; RE regulations and policy; RE in Bangladesh

1. Introduction

Energy generated from fossil or traditional fuel sources, such as natural oil, gas and coal, etc., causes negative impacts on our surrounding environment as they produce greenhouse gases (GHGs) which are responsible for climate change and global warming. Climate change has devastating effects and consequences on the existence and survival of human beings, biodiversity and ecosystems on this earth. Therefore, the reduction of emission of GHGs in order to mitigate climate change has turned out to be an important concern for almost everyone. The global community has proposed and adopted various policy initiatives which advocated to shift the energy production from fossil fuels to energy generated from renewable energy sources (RES), such as solar, geothermal, biomass, wind, biogas, hydro-power, etc., since these are reported to be cleaner, more sustainable and relatively less pollutant [1].

Bangladesh's constant growth with an annual 6% plus Gross Domestic Product (GDP) for more than the last two decades and achievements in other socio-economic metrics in recent times is impressive and recognized by various global authoritative bodies. Bangladesh is frequently projected as an agricultural country that encounters various catastrophic natural disasters every year. However, in recent years, it aims to transform from an agro-based nation to an industrial one, and this is reflected through a slow, but massive industrial growth. The extent of overwhelming economic ventures and the commitments of the government clearly demonstrates Bangladesh's economic shift. The country is fortunate to have fossil fuel reserves on a limited scale, and these are not enough to run the ongoing massive scale development activities, both in private and public sectors. Thus, the constant and uninterrupted supply of energy at an affordable price remains a serious concern for the successive governments. Therefore, this issue has been getting importance in the development agenda constantly.

The Government of Bangladesh has promised and has taken initiatives to ensure quality energy production and supply to every door by 2020. In implementing this high ambition, the government set plans to generate 10% of its power's demand through energy generated from RES by 2020 [2]. Fuel diversification seems to be an exclusive approach for ensuring sufficient electricity supply and stimulating economic advancement of the country. Consequently, Bangladesh has adopted this fuel diversification program for extending its renewable energy (RE) industry and ensuring the ever-increasing electricity demand. In 2008, the government formulated the Renewable Energy Policy. Public-private investment is welcomed in promoting the RE ventures to replace the fossil fuel-based energy generation to the RE contributing to the national grid [3]. Government's Renewable Energy Policy presumed to generate 5% of energy from the RES by 2015 and to increase a total of 10% of the total electricity generation by 2020 [4]. Meanwhile, the government has launched a new project "500 MW Solar Power Mission" to satisfy the escalating need for energy consumption [5].

Bangladesh has signed the Paris Agreement to the United Nations Framework Convention on Climate Change (UNFCC) on the 21st September 2016 and ratified the same on the 4th November, 2016. The Paris Agreement is not like the Kyoto Protocol that puts an obligation toward the advanced nations of mitigating emissions of GHG. It is a bottom-up treaty that obliges every country to undertake essential efforts for the protection of the environment and keeping climate stable [6]. Having ratified the Paris Agreement, the country has pledged to reduce its GHG emissions by 5% below 'business-as-usual' level by 2030 using domestic resources regardless of the country's GDP. In such a context, Bangladesh is also responsible to the establishment, development and implementation of the legal framework for addressing the environmental concerns, formulate rules and policies for reducing the GHG emissions, and realize a sustainable economic strategy to generate electricity [6].

Although the government wishes seriously to expand a significant portion of RE contribution in the national grid, such expansion can only be achieved if fundamental challenges encompassing the RE projects are properly addressed. Despite the execution of comprehensive policies and development

strategies, which eventually worked as the catalyst for RE penetration in power generation, RE projects and green technologies still face the financial, technical and even political barriers. Even though many scholars, researchers, bodies, and agencies from both public and private sectors have shown interests and great concerns about the scientific and technical challenges encircling the expansion of RE in Bangladesh, there is a dearth of literature on this issue, particularly, from the legal point of view. This paper is primarily legal in nature which purports to share the prospects of RES and problems in exploiting the RES in Bangladesh context. In doing so, it has attempted to identify the key obstacles within the existing legal and regulatory mechanisms and suggest some solutions that are based on international best practices. To this end, this paper is divided into seven parts, including the introduction and conclusion. Part 2 of the paper will discuss the basics of RE and its growing importance, while Part 3 will highlight the prospects of RE in Bangladesh context and Part 4 will share some challenges for RE in Bangladesh context. Part 5 of this paper covers discussion on the legal, regulatory and policy aspects of RE in Bangladesh and Part 6, finally, proposes some suggestions and recommendations.

2. Renewable Energy Basics and its Growing Importance

Energy generated from RES, such as solar, wind, biomass, thermal or hydro, etc., is theoretically considered as renewable as each one could yield an infinite amount of energy [7]. Uses of energy generated via these sources are not new and ancient people successfully utilized these also. For example, the Egyptian Nile civilization used to utilize the wind to move ships, grain-grinding facilities, and boat propellers. Even the Chinese and Japanese started using wind-run water pumping systems in the historical past, leading to cost minimization dramatically [8]. The succeeding civilizations opted to use windmills as alternative sources, since it is accessible and comparatively less expensive [9]. In fact, in recent times, the increasing energy crisis and stringent enforcement of carbon emission laws for reducing the GHG emissions has forced many nations to think about alternative supplies of energy [10]. This segment will highlight some basics about RES, RE, their importance and relevant concerns in exploiting them.

2.1. Renewable Energy: Definitional Challenges

Generally, a universally accepted definition of RE and RES are difficult to pinpoint because of divergent understanding of these terms by various stakeholders. As a result, various definitions of RE can be found in both scholarly works and in jurisdiction specific literature. For instance, the definition of RE can be found in Article III of the Statute of the International Renewable Energy Agency (IRENA) [11], the EU Directive 2009/28/EC [12] on the development and progression of the utilization concerning electricity from sustainable resources, the Glossary of Statistical Terms of Organization for Economic Co-operation and Development (OECD) [13], and the International Energy Agency (IEA) in its 2010 Renewable Information Report [14], etc. A cautious look at these definitions will reveal that these have incorporated specific attributes of either RE or the RES, i.e., RE means the electricity produced from solar sources, wind, geothermal, biomass, and hydropower assets, etc.

The notion of the definition is essential not only to get an agreement on a term's meaning and scope, but also to delimit its parameters. Moreover, it is critically significant in matters of jurisprudence and the regulatory frameworks too. The absence of consensus on specific lawful definition of 'RES' creates much confusion and invites more questions. Various definitions of the same term in authoritative literature invites heated debates as the stakeholders may reveal unexpected contradictions, while undertaking RE-related activities [15]. Since the significance of RE has been emerging increasingly as a result of its inherent benefits and prospects, the global community should reach a consensus regarding the relevant definitions for legal and administrative purposes, which is imperative for its ultimate success.

In the domestic level of Bangladesh, according to section 2 of the Sustainable and Renewable Energy Development Authority Act, 2012 (Act No. 48 of 2012) [16], "renewable energy" is defined as

the energy and power originated from biomass, biofuel, biogas, hydropower, solar energy, wind power, hydrogen cell, geothermal, tide and wave or energy and power generated from any other sources declared by the government as renewable energy in the official gazette notification. The same section further defines 'sustainable energy' and 'non-renewable energy' too. It is provided that "non-renewable energy" is the energy and power produced from mineral gas, coal, peat coal, natural oil, any other fossil fuel, nuclear power, and any other non-renewable energy resources declared by the government as non-renewable energy in the official notification gazette notification [16].

While defining any term(s) and/or phrase(s), the words either 'means' or 'includes' are used in legal texts. The use of the word 'means' denotes exclusivity, i.e., the definitions are exclusive and cannot be expanded. On the other hand, the word 'includes' is used to mean flexibility to allow to consider similar kinds of things. It is evident that in both the definitions of the words 'renewable energy' and 'non-renewable energy', the word 'means' is used, which indicates that it is not possible to include any things else other than those included in the definition. This legal definition of RE will eventually help to understand the regulatory measures in describing the prospects and challenges of RE of Bangladesh in this paper.

2.2. Renewable Energy Sources: Importance and Concerns

RES, due to the utilization of indigenous assets, can possibly give energy with near-zero discharges of both air toxins and GHG emissions [17]. That is why, clean energy, environmentally friendly power energy, sustainable energy, alternative energy, green energy, etc., are used as the synonyms of RE. The importance of this type of energy is documented in many scientific and policy research. Aside from the researchers and specialists, even the legal experts have embraced the significance of RE for the preservation of the global environment and combating climate change [6]. In the case of *Preussen Elektra AG v Schhleswag AG* [2001], *Case C-379/98*, the Court of Justice of the European Union (CJEU) reiterated that the use of sustainable energy resources for generating power is paramount in connection with saving the planet because of its undeniable role in reducing GHGs, which scientists ascribe to be the chief driver of climatic doom [18].

Environmental experts and legal researchers have been campaigning for a shift toward the concentration from finite non-RES to renewables to maintain the development activities, despite the fact that there are some inherent initial concerns [19]. Nevertheless, these concerns are not exceptional in this sector alone; rather, they are generally present whenever any new technological developments are introduced [6]. With the entry of, and advance in every sector, triggered by the scientific advancements, the global community has understood the significance of improvement of the RES in a practical, scalable, and capable ways [20].

In the global context, the first and formal, even though indirect, talk on RE started in the 1970s, in particular, in the United Nations (UN) Stockholm Declaration on the Human Environment 1972 [6]. While sharing on the dangers of depletion of non-renewable materials, the world leaders emphasized on the utilization of RES [21]. Subsequently, the UN and many other global and regional agencies stressed using RE resources, especially, in power generation in an environment-friendly and sustainable manner. Numerous international bodies, forums, non-governmental organizations (NGOs) and instruments, are established and developed to concentrate on promoting RE resources for securing sustainable energy solutions in the context of global warming and climate change.

Above all, the international endeavor proceeded steadily for moving forward through many initiatives. A list of such initiatives include, but not limited to, World Commission on Environment and Development Report, 1987 [22]; Nairobi Program of Action for the Development and Utilization of New and Renewable Sources of Energy, 1981 [23]; Intergovernmental Panel on Climate Change (IPCC), 1988 by United Nations Environment Program (UNEP); World Meteorological Organization (WMO), 1988; UNFCCC (Rio Earth Summit) 1992; the 3rd Conference of the Parties (COP3), 1997; Kyoto Protocol to the UNFCCC; UN Secretary General's declaration, 'Sustainable Energy for All (SE4ALL)' to attain 30% of the global RE target by 2030 [6]; Resolution 65/151, UN General Assembly's declaration on 'International

Year of Sustainable Energy for All, (2012)' by 2014–2024 [24]; UN Sustainable Development Goals (SDGs), 2015, especially, the goals No. 7 and 13, and finally, the Paris Agreement to the UNFCCC, 2016.

Since the late 1970s, the worldwide network's dependence on RE has been emerging over 10% every year [25], and starting from 2014, more than 164 nations have embraced the renewables targets [26]. In 2012, the utilization of RES helped to provide up to 13.2% of the worldwide essential energy supply. The same figure rose to 22% of worldwide power usage in 2013. It was estimated that this number is expected to rise to 26% in 2020. To share this in a practical setting, this number is greater than the current overall power demands of Brazil, Russia, India, China and South Africa (BRICS) nations put together [27]. Figure 1 shows the world's total primary consumption from 2007 until 2016, illustrating the rising trend of RE share.

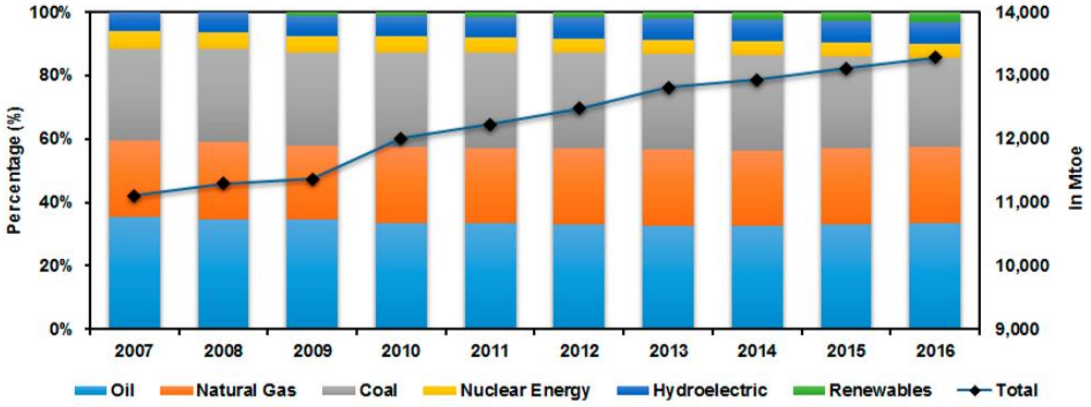

Figure 1. Total primary energy consumption (2007–2016). Adapted from British Petroleum (BP) Statistical Review of World Energy [28–32].

Despite the positive outlook and promises, worldwide demand for RE has been expanding at an underwhelming rate, especially, compared to fossil fuel-based energy demands. About USD 16 billion and USD 17 billion were put for RE resources in 2015 and 2016, respectively [33]. This figure is marginally lower than the normal interest in 2014, which was USD 19 billion. Such a circumstance has urged the private sector entrepreneurs to approach to dedicate resources to creating power utilizing renewables. The dedication of the private sector commitments—including speculation—is additionally obvious as the interest in the RE limit exceeding that of hydrocarbon incumbents demonstrating a steady trend of difference for the fifth year in a row [34].

Experts believe that RE frameworks perform best at little to medium scale and are perfect for rural and geographically disadvantaged regions where it is difficult to cover these territories through traditional fossil-based energy sources [35]. RE frameworks offer an attractive alternative prospect in such regions. Besides, the energy generated utilizing renewables is less vulnerable to the volatility of price and value, which is generally suffered by the oil and gas markets [36]. Thus, buyers can remain certain about the supply of energy and can additionally be profited through—among other things—delivering and exchanging additional energy. On the other hand, a few administrative and policy-oriented difficulties, consumption payments, tax benefits, and other surfeit expenses tend to depress the investors of RE projects compared to investment in fossil fuel-based projects [37].

Asides from the concerns raised above, many years of systemic abuse of the RES have led to a plethora of worries stemming from the lack of adequacy of productivity of the existing power management framework as the energy bills are still quite high. Moreover, private contractors are raking in enormous financial benefits, and the cash spent to help the exercises of various foundations—such as controllers, transport framework administrators, open utilities and universal organizations—further magnify the battle of competing with fossil-based power sources [38]. Disheartening as these worries may be, there are still signs of hope. In recent times, there are signs that the RE projects that have been utilizing the RES judiciously are overcoming these challenges leading to financial improvement [39].

Furthermore, it should additionally be appreciated that the issue of initial outflow relating to the capital expenses is not limited only to the RE, rather any power development project has to incur similar initial high up-front costs.

Renewables are taking a consistently growing pace in the overall energy industry with an evolving number of driving organizations focusing on aggressive inexhaustible power targets [40]. Unfortunately, even such growth cannot decrease the level of GHG emissions that the world desires. Hence, effective, consolidated and synergic strategies and efforts from the stakeholders are required to utilize RES across the board at a quicker pace. Moreover, the significance of an all-inclusive concession to the environment, as advocated by the Paris Agreement, holds guarantees for a feasible eco-accommodating development and progression of the world for the future.

3. Prospects of Renewable Energy in Bangladesh

Fossil-fuel sources, more specifically natural gas, oil and coal, play the lead role in electricity generation in Bangladesh [3]. The electricity demand in the country increased considerably from 0.4 to 1.38 quadrillion between 1997 and 2016 [41] and the country so far could not provide 100% access to electricity, due to *inter alia*, the inadequate volume of energy sources [42]. The total coal assets in Bangladesh were only 1063 million tons, whereas, the natural gas reserve demonstrated to be available with a volume of 9.7 trillion cubic feet (TCF) according to the statistics of 2013 [43]. Besides, to supply fuel in different industries, including energy, Bangladesh imports nearly 1.2 million tons of crude oil and 2.6 million tons of refined petroleum commodities every year [44]. Bangladesh absorbed approximately 2.132 million metric tons of coal, 175.69 kilo barrels of oil per day and 28.37 billion cubic meters of natural gas in 2018 [45].

Energy application in the country has expanded significantly, and the generation altogether relies mainly upon non-RES. Energy production through these ways adds practically 40% of the absolute carbon dioxide (CO_2) discharges by the nation [46]. In 2018, Bangladesh generated energy amounting 7,418 MW, whereas the demand was 11,534 MW. Such a gap between supply and demand results in the impediment of the financial and innovative advancement of the nation. Such a situation has influenced the policymakers to officially undertake activities to utilize the RES to alleviate the energy needs while maintaining the ecological effects.

Bangladesh is blessed to have a generous amount of RES and the effective exploitation of these promises to satisfy the energy need of the country. Among the accessible energy assets, biomass is considered as the significant RES available in the country, which can reduce the utilization of and reliance on non-RES. Solar energy is also very promising as the country gets an immense scale of sunlight, due to its geographical location. It may be pertinent to share that the rural and coastal areas of Bangladesh have been enjoying the benefits of the installed solar photovoltaic (PV) panels. Besides, several government agencies and NGOs undertook some activities for delivering electricity from small scale hydro plants and wind turbines despite the fact that the country is not very suitable to consider hydropower and wind for power generation. Hence, the RE resource, such as biomass and solar can be utilized to ensure energy security.

RES are the assets that are renewed persistently through natural transformations and can be reused because of their inherent properties. The RES incorporate biomass, solar, wind, geothermal and hydropower energy, but exclude conventional nuclear fuels. Figure 2 exhibits a preview of various RES available for electricity or power generation [47].

From the discussion above, it can be revealed that an immense volume of RES is available in Bangladesh. Even though the use of RE technology has become a worldwide trend, the country yet greatly struggling to utilize these sources. From among the list, biogas, biomass, and solar are regarded as the probable, favorable and productive sources for the sustainable energy generation in the country. Table 1 provides a review of RE resources and potentials in Bangladesh [46].

Even with the availability of all these RES, it is a matter of great concern that only 1.0% of the nation's cumulative electricity generation originates from RE resources; however, RE estimates

to provide approximately 19% of cumulative global electricity supply [48]. In this given context, the Government of Bangladesh has formulated and adopted some strategies and policies to utilize RES for electricity production up to 10% by 2020 [4]. The following segment will provide a brief survey of the available RES in Bangladesh.

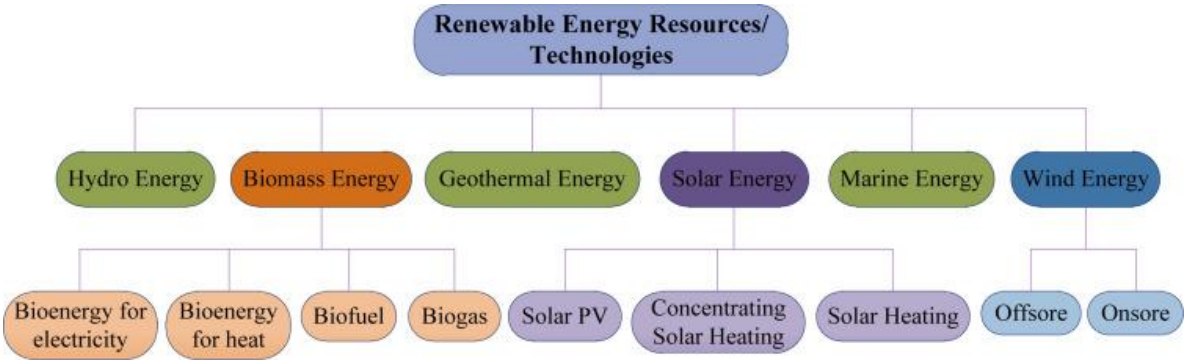

Figure 2. An overview of renewable energy sources (RES) and technologies.

Table 1. Renewable energy (RE) potential in Bangladesh.

Resources	Potential	Entities Involved
Solar	Enormous	Public and private sector
Wind	Resource mapping required	Public sector/PPP
Hydro	Limited potential for micro or mini-hydro (max. 5 MW). Estimated hydro potential approximately 500 MW	Mainly public entities
Domestic biogas system	8.6 million m3 of biogas	Public and private sector
Rice husk-based biomass gasification power plant	300 MW considering 2 kg of husk consumption per kWh	Mainly private sector
Cattle waste-based biogas power plants	350 MW considering 0.752 m^3 of biogas consumption per kWh	Mainly private sector

3.1. Biomass

The natural substance originating from living or dead life forms like the plant, yields, tree and its deposits are considered as biomass. Biomass is contemplated as an outstanding, reliable and sustainable energy source. Biomass absorbs CO_2 for photosynthesis within the sight of sun-based energy to deliver natural mixes required for its development. However, it is well documented that biomass discharges CO_2. Hence, even though biomass is a sustainable energy source, it is not relatively so clean for the environment. Notwithstanding, on the planet, approximately 2.6 billion individuals rely upon biomass for purposes, such as heating or cooking [49].

Being a primarily agricultural country, Bangladesh has an enormous volume of biomass assets that incorporates rice shell, animal waste, crop sediment, timber, municipal waste, jute stock, sugarcane residue and additional complementary springs because of the country's rainforest, the ecological and biological system. In Bangladesh, practically 64% of all-out lands are utilized for agricultural reasons [50]. Along these lines, the nation has a huge extent of agricultural deposits from different harvests, including sugarcane, rice, vegetables, jute, wheat, beets, maize, coconut, cotton groundnut and millet developed all the year round. As a result, practically 70% of individuals, immediately or discursively, depend on biomass energy in Bangladesh [51].

Other than biomass, biogas is created by anaerobic processing that can be utilized for cooking, lighting, and power production and the residue can be utilized for fertilizer, fish feed and compost. Thus, Bangladesh has a tremendous opportunity concerning biogas production from current build-ups

and waste assets. It was affirmed that it was possible to utilize 2.91 billion m^3 biogas in Bangladesh in 2012–2013, which was equal to 1.455 billion liters of diesel [52].

Bio-fuel creation is still on the embryonic step in Bangladesh in which ten pyrolysis plants were set up to deliver bio-oil from different biomasses [53]. Be that as it may, the plants are not operating legitimately because of the absence of suitable support and specialized technology [54].

The Renewable Energy Policy of Bangladesh 2008 intends to outfit the possibilities, expansion and utilization of RES. For instance, it is provided for biomass gasification and clean energy advancement, discouraging the use of energy generated from fossil fuel sources. Clean energy from biomass can result in relatively less carbon emission contrasted with the reliance on fossil fuel substances. Therefore, biomass has great potential in Bangladesh for achieving the clean environment goals set by the government.

3.2. Solar

Solar-based electricity is the most popular, infinite and effective energy source which is well-accepted everywhere throughout the world. Concentrating solar power (CSP) and solar PV are very promising advancements, and the solar-based home system can deliver power using solar-oriented radiation. In the case of Bangladesh, there is a tremendous extent of possibilities to use solar-powered radiation because the country is situated in the topographical area [55]. The country gets a normal daily solar irradiation of 4.2–5.5 kWh/m^2 that can create roughly 1,862.5 kWh/m^2 per year (see Figure 3) [56].

Solar oriented PV panels assume a significant job in the worldwide power sector and offer about 0.7% of complete energy production. Solar PV provides approximately 7.8% of annual electricity creation in Italy, 5% in Germany and 6% in Greece [57]. Japan and China are the Asian driving nations creating around 13.6 GW and 20 GW sun-oriented power individually [58]. Similarly, modern technological advancement in solar home-system and solar-based innovations are progressively appealing and compelling in Bangladesh.

Bangladesh has already experienced a few success and fruitful execution of solar-based energy usage [59]. The nation has very nearly 234 MW energy production potential from sunlight-based home frameworks [60]. Bangladesh possesses a capability of 50,174 MW electricity generation from solar PV, as displayed in Table 2 [61]. With about 5 million Solar Home System (SHS), Bangladesh has the world's largest SHS. Be that as it may, the nation is creating and delivering just 3 MW from rooftop top panels to the national grid. Nevertheless, Bangladesh Power Development Board (BPDB) is attempting to additionally introduce joined solar cycle plants and LED road light, in order to reduce the necessary electricity demand. Very recently, the country has successfully inaugurated the largest solar power plant in Teknaf area with a capacity to produce 28 MW, which can feed 20 MW to the local substation. With regards to concentrated solar power (CSP), this is a promising technology for power generation in which the solar radiation is concentrated to generate high temperature for producing steam in a solar thermal power plant [62]. A number of researchers have identified the potential of using CSP in Bangladesh [63–67]. In 2011, the State Minister for Power, Energy and Mineral Resources mentioned that the Asian Development Bank (ADB) was willing to finance a 10 MW to 20 MW capacity CSP plant inside Kaptai Hydro-electric Plant which was expected to be ready by 2016 [68]. In 2014, Reliance Power commissioned a 100 MW grid-connected CSP plant in Rajashtan, the largest CSP that utilized Fresnel technology [69].

Table 2. Solar energy potential in Bangladesh [3].

Technology	Potential Power (MW)
CSP (Concentrated solar power)	100
Grid-connected solar PV	50,174
SHS (Solar home systems)	234

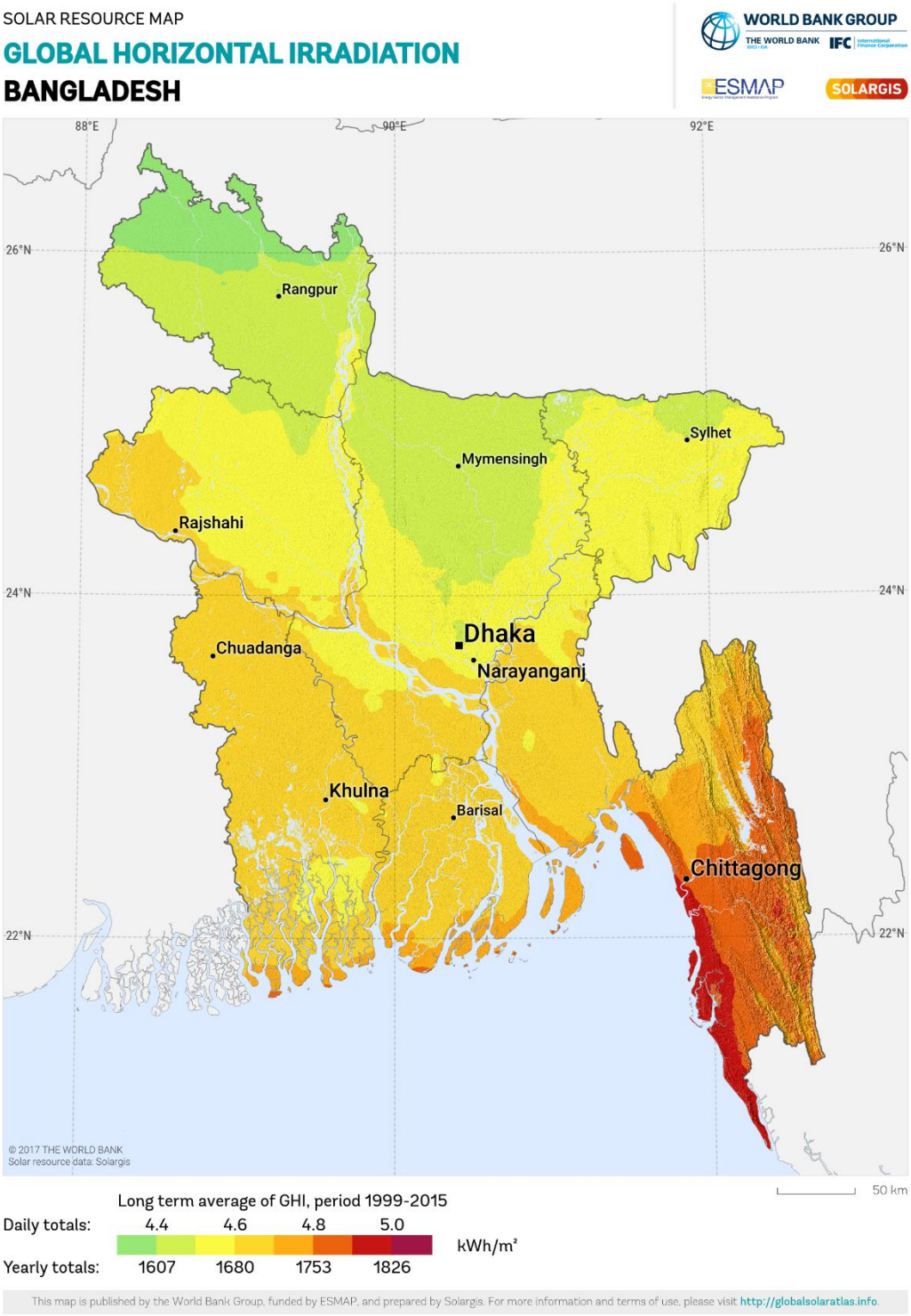

Figure 3. Global horizontal solar irradiation in Bangladesh [56].

3.3. Hydro

Hydro energy implies a type of sustainable power source which utilizes the force of water stream to generate electricity. The massive flow of water transforms its energy into electricity. Bangladesh is blessed with various rivers and waterways; henceforth, the country holds a decent extent of possibilities for hydropower extraction. BPDB and Bangladesh Water Development Board (BWDB) identified some proper micro-hydropower production places where the hydropower installations may provide

a satisfying amount of energy in the future. Table 3 provides a summary of such identification of suitable sites.

Table 3. Potential of micro-hydropower sites in Bangladesh identified by Bangladesh Power Development Board (BPDB) and Bangladesh Water Development Board (BWDB) [3].

District	Potential	Entities Involved
Chittagong	Foy's lake	4
	Choto Kumira	15
	Hinguli Chara	12
	Sealock (Chittagong hill tracts)	81
	Lungichara	10
	Budiachara	10
Sylhet	Nikhari Chara	26
	Madhab Chara 1500 ft. from fall	78
	Rangapani Gung	616
Jamalpur	Bhugai-Kongsa at 2 miles U/S. of Nalitabari	69 for 10 months
	Marisi at Dukabad near Jhinaigati	35 for 10 months
Dinajpur	Dahuk at Burabari	24
	Chawai at U/S of Chawai L.L.P	32
	Talam at U/S of Talam L.L.P	24
	Pathraj at Fulbari	32
	Tangon at D/S of Nargun L.L.P	48
	Punarbhaba at Singraban	11
Rangpur	Buri Khora Chikli at Nizbari	32
	Fulkumar at Raiganj Bazar	48

Sustainable Rural Energy additionally ventures and investigates more conceivable destinations for miniaturized scale hydropower plants in Bangladesh. According to their assessment, Chittagong possesses huge potentials with an expected electricity generation of 135 kW from its rivers and lakes [70].

In 1962, BPDP introduced the first hydro plant in Bangladesh which consists of two units of limit 40 MW, and each one was installed in the Karnafuli stream. Three additional units of limit 50 MW were introduced constantly in 1988. The Kaptai power plant is known as the hydroelectric power plant that utilizes a vertical hub Kaplan turbine [71]. Bangladesh owns huge hydropower potential in Karnafuli waterway, Matamuhuri basin, Sangu stream and in Brahmaputra river [72].

3.4. Wind

Wind energy is known for its eco-accommodating nature and considered as the best sustainable power source that outfits for future energy solutions. The dynamic electricity is created from the moving air as the kinetic energy of wind provides the turbine shaft. The geographical situation of Bangladesh makes the country suitable for little scale wind turbines [73]. BPDB introduced four units of the primary wind power plant at the Muhuri dam zone of Sonagazi in Feni district with a generation capacity of 0.90 MW. Likewise, BPDB introduced another 1 MW wind power plant at Kutubdia Island in the year 2008 which comprises 50 wind turbines of 20 kW limit each [74].

In addition, various government agencies and non-government organizations have introduced some initiatives to establish more wind plants in the country [75]. The country has also consented to an arrangement for a joint project with US-DK Green Energy (BD) Ltd. Which proposes the assistance

of the USA and Denmark to introduce the nation's biggest ever wind control plant of limit 60 MW at Cox's Bazar [3].

3.5. Other Renewable Resources

Bangladesh can consider utilizing the prospects of other RES, e.g., tidal electricity, oceanic wave and geothermal energy for power generation in the future in addition to biomass, wind, solar and hydro energy [3]. Ocean waves and tides can be considered as a few tornados hit in the Bay of Bengal consistently. Nevertheless, the prospects of these resources are still under scrutiny, and pragmatic endeavors need to be taken in this regard. All these options are yet to be utilized, due to the absence of appropriate information, innovation, and instruments [76].

4. Renewable Energy in Bangladesh: Issues and Challenges

Bangladesh has a high potential to move towards a better and more sustainable country with greener energy without compromising the country's economic efficiency, human dignity, standards of living, and financial development. Nevertheless, considerable development activities, including a sustainable power source and green arrangements in Bangladesh have had limited accomplishments and are confronting various challenges which are mostly financial, technical, and regulatory in nature [77]. It may be pertinent to share here that these challenges are not unique in Bangladesh's context, rather these present in most jurisdictions.

Since RE projects are more complex, unpredictable and full of unforeseen risks and dangers, the investors in this field may face serious financial challenges having impacts on future development and commercialization of the projects and technologies [78]. For the investors, it is difficult to convince the financial institutions and other financers to get the necessary support. Since they use new technologies that are uncertain, this may cause the payback period to exceed their expectations [79]. Hence, it acts as an impediment to innovative projects. This vulnerability results in high financing expenses for research, improvement and preparation in this sector. Thus, this deceptively raises the cost of clean energy generation, postponing their full assimilation into the energy market.

Sometimes, different RE related projects require huge initial investments. This is again very challenging for the entrepreneurs, since there are already available standard, but cheaper alternatives in the market [80,81]. Besides, there are geographical factors that have effects on the performance of RE projects. Hence, it can be concluded that an already successful RE project in one country probably will not be realistic to another nation for the presence of sunlight-based variables, biomass, wind and sea between nations in the tropical and other areas.

Usually, RE project entrepreneurs are small companies with limited resources [82]. The eagerness for their undertakings depends on the capacity to support the improvement at an insignificant expense contrasted with the gigantic Independent Power Producers (IPP) [83]. In any case, the output of RE projects run by the small companies is not necessarily the same when compared to financially feasible and promising projects, run by the IPPs. Thus, the financial strength of the company is important. All these above-mentioned challenges are crucial for Bangladesh to develop and promote RE in the future. Without addressing these financial barriers, Bangladesh cannot achieve its national goals relating to RE. Some other relevant challenges are discussed as follows.

4.1. Employment of Advanced RE Technologies

Technological constraints plague the RE sector worldwide, and this phenomenon is not limited to Bangladesh alone [84]. Hence, these constraints are hindering the growth of innovation within the sustainable energy sector.

To begin with, the unreliable power supply with respect to Bangladesh's geographical variables makes it difficult and vulnerability for RE's sustainable advancement [85]. Likewise, uncertain technological innovation ensures the development of the RE industry with negative intensity, whereas, the orthodox methods of energy generation still offers a financially feasible choice to the energy

stakeholders [86]. Furthermore, there is restricted expertise when it comes to productive practices and hardware aspects of RE [87]. The deficiency of qualified labour and skilled workers with adequate engineering or technical training additionally blocks the pace of the innovative improvement in the sustainable energy industry in Bangladesh. In particular, the inefficiency of human resources with engineering and technical skills in handling the equipment hinders security issues on the RE supply. To prepare the industry for these challenges, it is necessary to train and equip the workforce with necessary facilities though such facilities add additional costs to the RE projects. Moreover, due to the technical issues, there has been ample evidence of time-delays in generating sufficient energy through renewable means, and in such cases, the financers lose the interest to invest in RE projects.

The insecurity of available renewable source supplies for long-term and the price instability is making the situations more vulnerable for the biomass energy projects in Bangladesh [88]. Besides, although the government policy promised to introduce tax incentives in the development of RE projects, however, other than the feed-in-tariff (FiT) system provided by the Bangladesh Energy Regulatory Commission Act, 2003 (Act No. 13 of 2003), no other financial relieve system or tax incentive measures have been formulated so far [83]. Such a position also indirectly discourages entrepreneurs in investing in this sector.

4.2. Policy Related Institutional Barriers

Although the government's intention to promote RE through institutional, legal and regulatory frameworks is appreciable, the policies relating to RE are not firm and comprehensive [89]. The financing bodies in RE projects are more concerned with the heavy return of profits, while the Government of Bangladesh is worried about the allocation of subsidies to bear to achieve the ultimate objective of fuel diversification policy [90]. Hence, the government has to deal with different and conflicting interests with the potential industry players [3]. Such disparities in the RE industry create negative impacts on the investment of RE projects.

Additionally, financial investors find themselves in a continuous dilemma because of the unreliable fuel supply in the industry. Moreover, the stakeholders face several investment barriers, due to lack of practice and governance-related discrepancies, because the regulation of the energy sector in Bangladesh, like in most jurisdictions, is both fragmented and inconsistent [91]. Regulatory expertise is lacking too at times, due to the dearth of technical know-how. In practice, the arrangements relating to RE development and strategy execution in Bangladesh are viewed as isolated exercises as there are more than one authority that deal with this issue and no single authority is made responsible for monitoring the implementation of the Policy.

In general, the sustainable and RE policies are formulated at Ministerial and Parliamentary political process, and, then, such policy is conveyed and executed by the local governments and other agencies which are equipped with specialized technical tools, administrative arrangements, and regulatory structures for proper implementation. However, this top-down methodology seems non-functional in Bangladesh.

The participants and stakeholders in the energy business in Bangladesh additionally seem, by all accounts, to be less organized. There is no proper forum that listens to their perceptions. Even though they are heard occasionally by way of a public hearing before taking any policy initiative by the regulators, their inputs are less counted in the policy-making process, and the whole process is turned as a routine exercise without any significant impact. There is no other better alternative to develop without addressing the issues of active engagements of the potential stakeholders of the RE industry. Additionally, inputs from experts, producers, consumers, and engineers should also be counted to upgrade the ability of RES.

4.3. Legal and Regulatory Concerns

With respect to the legal and regulatory barriers, genuine and significant initiatives are missing toward the advancement and extension of RE in Bangladesh. Without addressing the regulatory

concerns, the policy related to fuel diversification can never be achieved. The Bangladesh Energy Regulatory Commission Act, 2003 (Act No. 13 of 2003) and subsequent amendments directly or indirectly support to implement a FiT scheme to develop the RE industry in the country. However, such laws have limited enforcement and impact in the practical field as a FiT scheme functions in a project-to-project basis. Hence, there is no positive output on such regulations. Additionally, the government needs to consider several other incentives in the RE industry, such as higher selling tariffs and tax reductions or tax relief, etc. Associated administrative and regulatory bodies should reallocate the subsidies from conventional energy generation to RES to sponsor the existing efforts of the RE industry. Such initiatives may progressively reduce the burden of different stakeholders and play a significant role in the growth of the sustainable energy industry.

In the case of regulatory and administrative difficulties to cope with the complex issues of RE, two remedies may be considered. It is important to note that although the Government of Bangladesh initiated several policies to support RE, such policies are not found successful and effective, due to the fact, *inter alia*, that Bangladeshi enterprises still do not consider the RE industry as a suitable place for investment [92]. Hence, the first task of the regulatory bodies is to review and evaluate the policies comprehensively and make necessary practical amendments to refocus the country's target of achieving energy fuel mix to offer significance to the sustainable energy source.

The regulators need to consider distributing subsidies for RE utilization. The subsidies for traditional fossil fuel source ought to be periodically eradicated, as well as converted and reallocated to RE assets to develop the sustainable energy industry establishments [93].

Furthermore, the second task of the regulatory bodies is to address the issues relating to the institutional framework relating to the industry. The absence of an efficient working institutional framework on RE must be overwhelmed by empowering joint exertion between government organizations and private establishments with the ultimate objective to explore the financial and technical viability of RE generation. Enhancing the institutional network between government leaders, enterprises and utilities promise to implement carefully designed RE policies. In addition, a portion of the policies and strategic activities need reviews or explicit clarifications on how the existing or newly incorporated legal and regulatory system and standards would approach and direct the execution of such adopted policies.

4.4. Lack of Awareness

There are likewise various social difficulties relating to RES and green innovations. There is a lamentable, but noticeable absence of public awareness and participation with respect to feasible advancements in the energy industry in Bangladesh. The public participation programs, particularly in the rural areas relating to RE development within the country, is not satisfactory [50]. Public participation and awareness about the energy sector promise to deliver the required advancement and development of the commercialization process of the energy industry. Hence, the viability of public awareness programs needs to be increased and boosted with the goal to raise public support for the advancement of RE, which promises to prompt effective usage of sustainable power policies and green approaches ultimately [94]. Relevant government organizations can also come forward to help and guide the potential beneficiaries of RE to motivate them to engage and disseminate positive information relating to the industry.

5. Renewable Energy in Bangladesh: Legal, Regulatory and Policy Aspects

It has already been shared that energy production, management, and supply to the people have become a serious concern for the Government of Bangladesh. Therefore, the government has formulated various policies and adopted regulatory measures [42]. In this context, the contribution of RES in the energy mix can be an exceptional accomplishment that would influence the economic development of the nation significantly.

In 2008, the National Renewable Energy Policy was introduced to promote RE by encouraging distinctive private and public platforms concerning the investment in the RE industry in place of the fossil fuel-based power sources. Since then, the uses, development, preparation, and research on the domestic RE industry have been accelerating; though for exploiting the commercial benefits of these, it will still require a comprehensive strategy.

In recent times, the domestic RE generation and the government's participation in expanding electricity generation through RE increased approximately 560 MW [95]. Bangladesh attempted to increase the electricity supply up to 16,000 MW by 2016 and subsequently, set the target to obtain up to 39,000 MW by 2030 according to the adopted the Power System Master Plan 2010 (PSMP) [96]. The electricity generation target as encapsulated in the PSMP is presented in the following Table 4.

Table 4. Power System Master Plan 2010 [97].

Year	MW
2016	16,000
2021	24,000
2030	40,000

In order to meet these targets, the Government of Bangladesh initiated multiple projects, including the utilization of coal as a commanding energy source for electricity generation and supply in the future [98]. Accordingly, two large coal energy plants with a target to produce 1320 MW are under construction at Khulna and Chittagong. Moreover, the government has undertaken major policy decisions to set-up nuclear energy plants to ensure reliable and environment-friendly electricity for the future [99]. The atomic power plant is anticipated to add another 2000 MW by 2020, and the government wishes to increase to 5000 MW by 2030. In implementing those wishes, the government initiated the process of installation of nuclear power plants in the country. Accordingly, the long-cherished nuclear power plant, with the technological support of Russia, is under construction at Rooppur in the Pabna district [8].

Despite the adoption of so many energy policies, it seems that the government may not be successful in achieving the desired objectives unless it exploits the RES to produce energy. The Government of Bangladesh, hence, concentrated on electricity production up to 500 MW by RE within 2015; but failed to succeed.

Fortunately, the government recognized the reality, revised the existing policies and strategies and attempted to formulate pragmatic strategies for the sector. Consequently, the policymakers of Bangladesh aim to achieve its objectives by producing 10% of its total electricity demand by 2020 from RES [46]. Now Bangladesh is producing around 560 MW of power from renewables which contributes 2.95% of the cumulative energy generation of the country. Specialists figure that achieving 10% of the aggregate supply with around 2000 MW of electricity by the next two years will be a challenge for the country. In accomplishing the goals, the government has initiated numerous endeavors particularly, to achieve the energy-specific objectives.

The government attempts to fostering the cooperative approaches within private and public sectors in reaching that milestone. Accordingly, different government organizations, such as BPDB, Bangladesh Rural Electrification Board, Bangladesh Council of Scientific and Industrial Research and Local Government Engineering Department, started executing numerous RE related activities. Infrastructure Development Company Limited, on the other hand, is a private NGO, is trying to develop the market competitiveness by commercializing RE in rural areas of Bangladesh.

Securing access to electricity for all is one of the prime visions of Bangladesh since its independence, which has been evidenced by incorporating the State's promise in the Fundamental Principles of the State Policy (FPSP). Rural development and agricultural revolution are important FPSP as enshrined in article 16 of the Constitution of the People's Republic of Bangladesh, 1972. In this article, Bangladesh

has given words of undertaking adequate measures to bring radical change in rural areas by introducing a revolution in agriculture, ensuring rural electrification, developing cottage and other industries, and improving the education system. In addition to these, it is further provided that the State shall endeavor to develop the communication and public health systems with a view to removing the disparity of living standards between rural and urban settings. The provision of affordable and continuous energy is instrumental to achieve this.

Nonetheless, since independence to date, Bangladesh is suffering in ensuring 100% access to electricity for all. In addition, the findings of various scientific studies have revealed that domestic fossil fuel sources are either depleting or will naturally be depleting in the course of time. Therefore, the promotion of RE has been taken as an alternative source in the Renewable Energy Policy, 2008 for the long-term energy sustainability, pollution control and electricity generation. Because fuel diversification contributes to sustainable electricity production [100], and consumption within the socio-cultural and economic parameters, Bangladesh is in great need to promote energy production through renewable means.

By assessing the international environmental obligations, the country made in the international forum, Bangladesh should design the national policies and regulatory frameworks for RE. From various initiatives taken by the Government of Bangladesh, it is evident that the government truly values sustainable development [101]. For example, the Government of Bangladesh has signed and ratified most of the international environmental law instruments and have been submitting the required state reports regularly. Additionally, the government has enacted national laws and taken policy initiatives to give effect to the provisions of these international instruments.

In order to understand the energy policies of the country, it will be relevant to share here energy-related legal and policy instruments. In the undivided India when present Bangladesh was part of it, the Electricity Act, 1910 (Act No. IX of 1910) was enacted containing provisions, *inter alia*, on grant of licenses for the supply, transmission and use of electricity. That law provides for punishments for a number of offences such as dishonest abstraction of energy, installation of artificial means, maliciously wasting energy or injuring works, theft of line materials, tower members, equipment, etc., from any electric supply system, dishonestly receiving stolen property, unauthorized supply of energy by non-licensees, illegal or defective supply or for non-compliance with order, illegal transmission or use of energy, etc. After more than a century, the government repealed the law and enacted the Electricity Act, 2018 (Act No. VII of 2018) containing similar but updated provisions on these matters to meet the continuously increasing demands of electricity. It will be pertinent to mention here that the law does not contain provisions on the sources of energy, i.e., energy generated from fossil-fuel sources or RES, rather the main focus of the law is to ensure the supply, transmission and use of electricity.

After the independence of the country, the government enacted the Rural Electrification Board Ordinance, 1977 (Ordinance No. LI of 1977) to establish the Rural Electrification Board that will primarily be responsible to take measures for effective use of electrical power for development of the rural economy of the country. This Ordinance of 1977 was also repealed, and the government enacted the Rural Electrification Board Act, 2013 (Act No. 57 of 2013). Same as with the Electricity Act, 2018 (Act No. VII of 2018), the provisions of the law are mainly concerned about the supply, use and transmission of electricity in the rural area and the sources used to produce electricity is not the primary concern. The law provides to establish a body known as Bangladesh Rural Electrification Board (BREB) to this end. Most importantly, this Board has been playing a pivotal role in the promotion and utilization of RES in the rural area of the country as it has taken various initiatives [42], including the introduction of SHS for the first time in the country in 1993 through the project 'Diffusion of Renewable Energy technologies' with the financial assistance of France. In the agro-based economy, BREB is now working to install 2000 solar irrigation pumps.

Moreover, a list of such instruments include: Policy Guidelines for Small Power Plants in the Private Sector, 1996, Private Sector Power Generation Policy, 1996, the Bangladesh Energy Regulatory Commission Act, 2003, Import Duty Exemptions for Solar and Wind of Bangladesh (Statutory

Regulatory Order), 2004, Renewable Energy Policy, 2008, the Sustainable and Renewable Energy Development Authority Act, 2012, Scaling Up Renewable Energy Program for Bangladesh, 2015(SREP Bangladesh), Bangladesh Energy Regulatory Commission (Tariff for Roof Top Solar PV Electricity) Regulations, 2016 (Draft), etc. Some of these are evaluated and discussed below-

5.1. Policy Guidelines for Small Power Plants in the Private Sector (1996)

In fulfilling the promises encompassing energy supply as enshrined in the Constitution, the Government of Bangladesh has taken numerous policies on power production, supply and consumption. Even though Bangladesh has to depend on large-scale nationalized efforts to produce sufficient electricity for the national grid, it has also been encouraging privatized endeavors. In line with the aims, the Government has formulated a Policy Guidelines for Small Power Plants in the Private Sector, 1996 allowing private investors to install Small Power Plants (SPP) at the earliest possible time for generating electricity on a commercial basis. Accordingly, private parties could generate power for their own and sell the residue, if any, to anybody else. Initially, the plant size was fixed for producing up to 10 MW and allowing, even more, based on necessity, demand and loading capacity [102].

To encourage private entrepreneurs in power production, the Policy suggests that Petrobangla, a government-owned national oil company of Bangladesh, may supply natural gas to those power plants on a commercial basis with a usual rate if the SPP is not located too far from the gas supply reticulation (section 3). To ease the business, the Policy also provides that the sponsors can use the extant transmission and distribution systems if there is no problem in terms of capacity though the owner of SPP or the sponsors will have to pay a mutually set wheeling charge for using transmission/distribution facilities (section 4). Moreover, it is also provided that the government would not interfere in pricing; rather, it would be fixed on negotiation between the sponsor and the consumers (section 5).

The provisions of 'fiscal and other incentives' for national and foreign investors are included under the heading of "Captive Independent Power Producer' and 'Captive Power Generation' policies in sections 5 and 6, respectively. Moreover, the Policy provisions clarified that the government has no obligation of purchasing the power produced by SPP. Nevertheless, the government may, if it considers essential, purchase the power from the SPP (section 9). Globally, community-based energy production and supply systems are gaining momentum. Many scholars suggest that Bangladesh can consider even the household level system of energy production and distribution in resolving its energy crisis though which it may add sufficient power into the national grid [103].

5.2. Private Sector Power Generation Policy (1996)

The Government of Bangladesh formulated the Private Sector Power Generation Policy (PSPGP) in 1996 with a view to ensuring the participation of the private bodies in the power generation leading to promoting the economic growth of the country. The PSPGP set several specific objectives, such as ensuring the access to electricity for all; increasing the annual per capita generation of power; reaching and sustaining minimum 6-7% annual GDP growth; achieving desired socio-economic progress by alleviating poverty; securing adequate electricity supply at an affordable cost by expanding the production of electricity as a whole.

Starting from 11666 GWh, the Policy set a target of generating 16500 GWh power within 2000 and 24160 GWh by 2005, which figured out that an average of 300 MW of power has to be generated more annually. It was estimated that a total of US$ 6.6 billion would be required for expanding, reinforcing, transmitting and distributing electricity (section 1.3).

Other provisions of the said Policy include: Formation of a power cell for facilitating the promotion, improvement, execution, commissioning and operations of private energy production schemes (section 2.0); modality for implementation of private power projects (section 3.0); financing arrangements (section 3.3); security package (section 3.4); tariff for bulk purchase of power at busbar (section 4.0); fiscal incentives (section 5.0); other facilities and incentives for foreigners (section 6.0), and right of interpretation (section 8.0) [104]. Taking the advantages of the Policy, the first private power plant

was installed in October 1998, having a capacity of producing 110 MW power to add in the national grid [105].

In Bangladesh, there was no engagement of the private bodies in the energy generation and distribution sectors in the early 1990s. Since 1996, the Government of Bangladesh undertook several reforms plans under the National Energy Policy to offer competition, bring foreign investment with a view to increasing the energy generation and distribution. One of the key Policies was the Policy Guidelines for SPP in Private Sector, 1996 discussed above [106]. During the period, some private energy generation schemes were established as the IPPs selling power to the BPDB. However, due to the friendly investment policy of the government, now private enterprises dominate the energy sector contributing a total of 54.35% in the national power generation [107].

5.3. The Bangladesh Energy Regulatory Commission Act, 2003

With a view to achieving some broad goals, especially, making provisions for the establishment of a self-governing and fair energy regulatory commission, the Parliament of Bangladesh enacted the Bangladesh Energy Regulatory Commission Act, 2003 (Act No.13 of 2003). One of the prime objectives of the Act was to establish the national regulator Bangladesh Energy Regulatory Commission (BERC) for regulating the electricity, gas, and petroleum commodities in Bangladesh. The vision of the BERC was to foster an amicable environment to establish an efficient, properly organized and sustainable energy sector in Bangladesh for ensuring energy at a fair and sensible price, and to secure the interest and satisfaction of the customers by fair practice [108].

Major provisions of the Bangladesh Energy Regulatory Commission Act, 2003 are as follows: The establishment of the BERC as a legal person (section 4); functions of the BERC (section 22); emergency power of the government to control energy use (section 25); settlement of disputes (section 26); issuance of license by the BERC (section 28); renewal, revision and cancellation of license (section 30); tariff (section 34); emergency provision (in favor of the BERC) (section 36); restrictions on publishing information (section 39;) arbitration-settlement by BERC (section 40); appeal against the decision of inspector (section 41); penalty (section 42); penalty for stealing energy (section 44); penalty for obstruction of the construction during the installation or repair of electric line or gas pipeline, etc. (section 45); jurisdiction of trial court (section 50); collection of fee, fine and charges (section 56); power to make rules (section 58) and regulations (section 59), and provisions for issuance of license during transitional period (section 66).

The duties and responsibilities of the Commission include, but not limited to: Creating a conducive atmosphere for the private investors in power generation activities; ensuring transport, transmission, and promoting the petroleum products; maintaining transparency in every sphere of the sector, and finally, to protect the rights of the consumers by creating the competitive market [109]. However, the BERC is conducting widespread activities in line with its missions and visions as a major regulatory body since its inception in 2004.

5.4. Bangladesh (Statutory Regulatory Order), 2004

The government framed the Import Duty Exemptions for Solar and Wind of Bangladesh (Statutory Regulatory Order), 2004 [110] targeting certain resources, such as solar, SPV, solar thermal, solar heat, wind in the electricity, heating and cooling sector. It is applicable for both small- and large-scale ventures of RE project. Through the provisions of this Order, the National Board of Revenue and the regulatory code 155, an exemption in import duties for certain RE products, in particular, the solar cells, modules and lanterns are offered. Additionally, according to this instrument, the rate of duties imposed for other RE resources is comparatively inexpensive too. Moreover, these duty exemptions are not limited to the national companies only, rather extended to foreign companies also. As a result, the duly registered foreign companies also enjoy the same facilities as are enjoyed by the locally owned companies [110].

5.5. The Renewable Energy Policy of Bangladesh, 2008

The Power Division, Ministry of Power, Energy and Mineral Resources, Bangladesh formulated the Renewable Energy Policy on 18 December 2008 [4]. The Policy identified the following three reasons of global crisis encompassing the energy, e.g., the gradual decline of fossil fuel, and the consequent price fluctuation because of the gap between the demand and supply; the necessity of reducing global emissions (up to 80% by 2050) in responding to the climate change, and the continuous demand for energy security.

The objectives of the Policy are to put to use the potentials of RE resources and technologies everywhere; encourage and facilitate both public and private sector investors in RE sectors; scaling up the power generation; conducting training facilitating the use of RE in each unit of energy usage; providing encouragement, legal and environment assistance in the use of RE, etc. In particular, the ultimate goal was to produce 5% of the total electricity demand utilizing RES by 2015 and to increase the portion up to 10% by 2020 [4], which means that 2000 MW has to be generated from RES. Some of the main provisions of the Policy include: Institutional arrangements (section 3); provisions regarding the resource, technology and program development (section 4); investment and fiscal incentives (section 5); regulatory policy (section 6), and the right to interpretation (section 7), etc.

It may appear that the production costs of RE are comparatively higher than the fossil fuels; however, they can be economically viable if all other ancillaries (eco-friendliness, beneficial to health, low operating costs) are taken into consideration. In recent years, Bangladesh is witnessing commendable progress in the RE sector because of the implementation of several policies, particularly, the Renewable Energy Policy of Bangladesh, 2008. Recent statistics show that the country is generating a total of 404 MW of electricity from the RES (see Table 5). Meanwhile, the solar home system has appeared as a success story and getting popularity gradually, principally in the off-grid areas [111].

Table 5. Contribution of the RES in Bangladesh [5].

Method	MW
Installation of Solar Home System (3.5 million)	150
Installation of Rooftop PV at Government/Semi Government offices	3
Installation of PVs on commercial buildings and shopping centers	1
Installation of PVs by the consumer during new electricity connections	11
Installation of Wind-based power plants	2
Installation of Biomass-based power plants	1
Installation of Biogas-based power plants	5
Solar Irrigation	1
Hydro Electric power generation	230
Total	**404**

5.6. The Sustainable and Renewable Energy Development Authority Act, 2012

To secure the energy security, the government established the Sustainable and Renewable Energy Development Authority (SREDA) though the enactment of the law—the Sustainable and Renewable Energy Development Authority Act, 2012 (Act No. 48 of 2012). While enacting the law, the policymakers of Bangladesh realized the need to control global warming, prevent the misuse of energy, reduce the hazard of natural disasters and gradually reduce the dependence of fossil fuel in power generation by promoting the use of RE.

According to this Act, energy refers to power generated using both the renewable and non-RE sources [section 2(5)]. The law bestows legal personality to the authority, i.e., SREDA [section 2(2)]. Some other relevant provisions of the law include: Responsibilities and functions of the authority

(section 6); the power of the authority to impose fees (section 7); the constitution of the board of directors (section 9); fund, budget, and accounts and audit (sections 19–21); power to make rules and regulations (sections 26–27), and abolition of Energy Audit Cell, etc. (section 28).

In spite of having diverse plans, so far, Bangladesh achieved a limited success encircling the RE sectors because of numerous reasons, and principally, the lack of project execution experience; lack of strong institutional capability; financial challenges; land constraint; project development challenges, etc. Keeping all these in context, the Government of Bangladesh established the SREDA in 2014 to promote the RE sector and achieve energy efficiency [112]. Since its inception, the SREDA is actively operating multiple action plans with a view to ensuring electricity for all within 2020 by increasing the RE share 1.5% to an increase of 50% in grid supply [113].

5.7. Bangladesh Energy Regulatory Commission (Tariff for Roof Top Solar PV Electricity) Regulations, 2016 (Draft)

The government has recently drafted the Bangladesh Energy Regulatory Commission (Tariff for Roof Top Solar PV Electricity) Regulations, 2016 [114]. Once approved, the provisions of the Regulations shall apply to all new RE power plants operated for generating and promoting the sale of electricity produced in such RE power plants. It is also provided that in the Draft that in the current RE power plants, all terms and conditions, tariffs, etc. shall be administered by the prevailing notifications, of course, with the prior approval of the BERC. All terms and conditions required for getting a license are governed as per the provisions of the Bangladesh Energy Regulatory Commission Act, 2003, Renewable Energy Policy, 2008, and the subsequent amendments thereof. In addition to these, no license is required for a plant installed for producing up to 5 MW, and in such a case, a waiver certificate shall have to be taken subject to the fulfillment of the conditions determined by the BERC [114].

BERC remains as authority to govern specific tariffs concerning RE production. The BERC has been working to conceive similar laws and regulations pertaining to the specific FiT system, especially for solar and wind energy ventures. The government in their several policies and laws has mentioned that a broad range of RE projects may serve the country with prosperity that can additionally address four key intentions, i.e., Efficient Energy Access, Energy Security, Industrial Advancement and Environmental Protection.

The draft Regulations imply to undertake FiTs as the primary common essential measure to promote RE in Bangladesh. Such a system is assumed to provide an outstanding result relating to the innovative investments in the RE industry. To improve the RE industry, and enhance the grid-connected electricity production, it is essential to have an efficient administration and the adoption of recent innovative technologies. Such a contribution of RE can deliver advantages concerning every stakeholder in the energy industry of Bangladesh.

The Draft Regulations of 2016 is a substantial foundation to initiate supplementary innovations for reliable and affordable energy solutions. The draft Regulations proposed for a universal FiT concerning the special model of RE technology managed by BERC on a specific basis that is presumed to initiate assistance for new investors. Such a universal approach is much effective than the existing project-by-project strategy. This approach concerning universal FiT for diverse RE exercises has produced concrete outcomes in several nations. Such a method is also capable of reducing excessive profits of private energy enterprises. Nevertheless, the regulations have been in the draft stage since 2016, and have not been enforced yet.

In achieving the desired goals, the Government of Bangladesh has planned to generate electricity by the following means and approaches:

- Development of domestic primary fuels;
- Energy efficiency improvement;
- Private and joint venture participation;
- Coal as a main source of energy;

- Use of alternative energy;
- Use of nuclear energy;
- Cross-border power trade;
- Fuel diversification;
- Construction of effective and efficient infrastructure;
- Low carbon emission;
- Construction of effective and efficient infrastructure.

Net energy metering (NEM), also known as net metering, which allows the prosumers to use the produced electricity anytime of personal need, is gaining popularity all over the world. Such an initiative encourages the prosumers to produce more energy using RES. It is a matter of great hope that the Government of Bangladesh has actively been considering to introduce the NEM system in the country and has released the draft of the Guidelines with the aim to support the government to develop a net metering policy for individual energy generation. It is anticipated that such an initiative, when successfully be implemented, will encourage the consumers to use their self-produced electricity reducing the dependency on the grid power. Thus, such an initiative offers various benefits - the consumers will need to spend less on their electricity bill, emission of GHGs will be reduced, government needs to spend less on the import of fossil-fuel sources for energy production and the so save national money can be used for other socio-economic development activities.

Recently, the BERC has formulated the Electricity Grid Code, 2018 to govern the boundary between the licensee and users, and to establish the procedures for operations of facilities that will use the transmission system. This Grid Code specifies criteria, guidelines, basic rules, procedures, responsibilities, standards and obligations for the operation, maintenance and development of the electricity transmission system. It is anticipated that this Code will help to ensure a transparent, non-discriminatory and economic access and use of the grid, whilst maintaining a safe, reliable and efficient operation which will facilitate to provide a quality and secure electricity supply as reasonably as practicable. Most importantly, this Code contains provisions on RE.

Finally, it can be submitted that the policies, such as policies on fuel diversification, energy efficiency improvement and low carbon emission, can never be achieved without promoting RE in the country. Hence, the government is firmly committed to bringing every possible solution to increase the contribution of the RE industry in the national energy mix and thus, has taken various initiatives. While the initiatives taken by the government can be applauded, there are still avenues to improve the situation and therefore, we have advanced some suggestions and recommendations in the following segment.

6. Suggestions and Recommendations

6.1. Government Leadership

Achieving green and RE goals require the presence and coordination of synergic move by the stakeholders under the auspices of the appropriate regulatory watch. The Government authority is fundamental in planning proper RE approaches. Bangladesh has organized different activities to advance a sustainable power source [115]. However, there is correspondingly a need to give arrangements and support to outstanding business people, enterprises and the business networks in supporting the practicable power drive. This requires a wide understanding and contribution at different dimensions.

Bangladesh still battles to keep its international promises to enhance the usage of renewable resources to promote a green environment. The heavily anticipated Renewable Energy Policy leads Bangladesh's change into a green country and latches onto the prospects of practical improvement. Nevertheless, although the policies attempted to develop the RE industry in Bangladesh and achieve its sustainable goals, there remain many failures on the part of the government agencies in exploiting RES to generate energy.

The awareness regarding environmental sustainability and the need for creative alternative sources for the energy sector are a global phenomenon. Whatever the case, it is imperative for the policymakers of Bangladesh to categorically execute the propelled tasks and plans successfully. It has been seen from historical encounters that there remains an immense mismatch in accomplishing the goals of power designs. Along these lines, the Government of Bangladesh should take the lead position with the end goal to advance RE and execute the undertakings that create RE inside its regional area for the benefit of its citizens.

As the economy of Bangladesh is shifting toward industrialization and the shifting into industry-based economy produces increased earnings to the citizens and stimulated urbanization. Fast accelerating commercial ventures, including increasing income levels, produced an immense need for transportation settings, particularly in immediately developing metropolitan cities. Thus, the country is also increasing its contribution to polluting the environment within the region.

While the economy is fast developing, a difficult assignment remains for the Government of Bangladesh, i.e., to fulfill its expanding need for electricity. It is a fact that the costs of fossil fuel sources far and wide are unpredictable. The lack of adequate natural gas reserves in the country intensified the situation further. In total, these two forces increase Bangladesh's electricity demands. At present, Bangladesh supplies her electricity prerequisites overwhelmingly through gaseous petrol, additionally supported by a bunch of coal and oil plants. Consequently, because of the shortage of gas, coal and oil assets, sustainable power source surfaces as a precise vital alternative for Bangladesh's future advancement plan. Nonetheless, a productive, sustainable power source program involves a broad framework. Therefore, the Government of Bangladesh should take a leadership position in order to promote RE and implement the projects that help develop RE within its territory.

Other than the traditional approaches, the Government should also focus on the modern technical and regulatory approaches to overcome the challenges that they have been facing. Building codes, energy rating schemes, supportive grid connection arrangements, etc. can also be very useful tools in promoting the RE industry. Building codes are the significant mechanism which provides indirect incentive to promote RES. For instance, Australia has been using energy rating schemes that provide criteria for calculating the credit system for PV and solar water heaters to empower new buildings or substantial renovations with the capacity to generate electricity [116]. Such set up in commercial buildings generally implement solar PV to achieve higher energy ratings, which then helps them to achieve higher rentals. It cannot be ignored that for such construction with RE tools, the owners had to make the huge initial investment; however, such appearance helps the construction firms with tax incentives from the government and add to high resale value, especially in the countries where the requirement of energy rating on building sales is mandatory. Hence, building codes and rating schemes can help to promote a green environment and reduce electricity needs with limited public investment. Additionally, regulating little categorized generators like residential PV linking with grid connection can enhance the energy efficiency of the country. Such specific regulation can be a significant step to reduce the skepticism and danger encountered by private sector investors and also reduces management expenses of the energy industry.

6.2. Ensuring Renewable Energy Development through Technological Means

To achieve public procurement on RE and to enhance the output of technology, it is important to encourage research, especially when the government intended for the localization of foreign imported technologies. Advancement of confined clarifications and explanations on innovative technologies or methods can frame civic perspectives, including public participation. Additionally, RE establishments in Bangladesh are designed by regional corporations, including external specialists. Information and technology directions are prerequisites to encourage the potential raising in the RE industry and to support the progressive growth for long-term goals even though such technology is imported by foreign ventures and experts.

The idea of RE and energy efficiency could be brought into the curricular exercises in conventional educational and vocational institutions, such as schools and colleges. One of the major challenges relating to RE is the scarcity of sufficient human resource with relevant skill, expertise and technical knowledge in regards to, *inter alia*, handling of equipment [115]. This is further exacerbated by inefficient energy practices, the reluctance of administrative and regulatory bodies, and lack of culture embracing innovations.

Hence, instruction developed and programs preparation on sustainable energy at the tertiary training level promise to facilitate the advancement of RE in the country. Such advancements and developments seem pre-requisites for achieving the sustainable goals of Bangladesh.

6.3. Minimization of Renewable Power Generation Cost and Promoting Market Competitiveness

The costs of generating and transmitting power in the modern age despite all the technological advancements are staggering [117]. The matter is manifold complicated for the RE sector as the industry yet does not benefit from economies of scale. When RE is compared with existing fuel-based energy sources, the economic benefit is prospectively and considerably diminutive [118]. Hence, the major challenge relating to the RE is the difficulties in anchoring the investment in the industry.

In any case, the bankers and financial investors seem to have a lack of confidence to make required speculation about the RE industry. Additionally, the long process of granting bank loans for RE demotivates the participants to engage in business [119]. In this manner, the Government of Bangladesh needs to build up a worthwhile, practical, and controllable subsidized legal, regulatory or political instrument for RE projects.

Because of the absence of such instruments, both the financial specialists and industry players consider it monetarily not lucrative to invest in the RES activities and advancements. Consequently, lack of coordination and non-responsive attitude on the part of the administration decreases the chances of prospective foreign or local investments on RE projects.

Other project motivators, for example, tax incentives, research funding or any other technological support from the part of government can bring down the expense of RE innovation [120]. European nations have embraced such sponsorships and motivating forces as a major aspect of their advanced techniques to build such a complex industry like RE [121]. Financial help, dedicated lessons and embracing the RE experts to create a comprehensive RE study syllabus for universities, colleges and even in schools might catalyze the discourse about advancement, exhibition and systematic awareness-raising campaigns related to the sustainable energy source and green innovations.

In Bangladesh, until now, RE significant ventures have been actualized with the project-to-project base assessment. Specific separate investors invested, and the government fixed the tariff-based on power purchase agreements (PPAs). The countries which have long experiences of RE production, such as Germany, India, China or Spain, have never followed project-by-project contracts. Instead, a market approach was established to drive the considerations and regulation of energy generation stipulations. With the establishments of FiT regime, private sectors of the said countries plan for their investments, based on the offerings of RE premiums (the extra amount in addition to the market price for electricity) or RE PPAs. Furthermore, the outcome of certain applications has been enormous, covering the preceding ten years concerning the penetration of the RE industry as reducing the expenses associated with it.

6.4. Creating a Comprehensive Policy, Legal and Regulatory System

The regulatory framework plays a significant role in the advancement and development of RE technologies within a country's existing energy formation. The regulatory direction is necessary to enhance the competitiveness of the energy market. Such a regulatory framework is also vital to ensure that the stakeholders comply with the established rules and regulations for energy trading. Any deficiency in the regulatory structure may cause a threat to the market liberalization process.

Likewise, the regulatory framework ought to increase public awareness about RE technologies and incentive mechanisms to promote investment in the RE industry.

World Bank's 'Turn Down the Heat', and The Intergovernmental Panel on Climate Change's 'Fifth Assessment Report' were two reports which uncover large haul suggestions for Bangladesh and its kin from likely cataclysmic effects of environmental change. The two reports draw a terrible situation to face in the future if the environmental changes are not addressed.

The Government of Bangladesh has been allocating funds in the research targeting the control of environmental degradation. Regardless of these activities, as all examinations call attention to, Bangladesh will remain helpless, and its kin will confront extreme monetary difficulties from environmental consequences in the future. Accordingly, Bangladesh should approach all countries to target a low-carbon economy dependent on sustainable power source supply. Such a request can only be considered positive, given that Bangladesh itself change approaching towards environment-friendly ventures.

The Government of Bangladesh has schemed different innovative approaches, for example, the Renewable Energy Policy 2008. Be that as it may, there must have a subsequent execution of the components set up by the Policy. Other than that, there must have severe courses of events for each strategy for achieving administrative success.

Financial experts urged that a fruitful sustainable power source framework needs long haul security to recuperate the costs of investors and to support their revenues. The draft Regulation released by BERC in 2016, includes remarks and commitments from various partners, which appears coordinating and immensely conducive in preparing an appropriate structure. Nevertheless, the most critical part of any policy for achieving success is its unwavering quality and dependability. Ventures need a considerate long-haul connection between proprietors of these offices in one hand, and the circulation or transmission matrix between administrators is necessary to deal with the price of electricity produced, on the other. This dependability must be demonstrated in the policies also and ought not to be influenced by political insecurity or regime change. Policies, in general, should incorporate every statutory and legal term relating to the grid technology, including energy reliability, security and essential expansions.

Grid access, including a flexible licensing system, for RE is vital concerning advancement in the treatment of solar PV and wind power. Additionally, complementary measures for the RE generation, such as land acquisition, preparation of human resources, tax exemptions or tariff system, etc. should be comfortable to procure. The draft Regulation of 2016 containing provisions on FiT is promising as the provision contains no fees for licensing in the installations of RE plants with the capacity up to 1 MW. Notwithstanding, a special provision ought to additionally render the guidance on the usage of lands, tenancy contracts, operational standards, availability of equipment and the technological expectancy.

Furthermore, to improve the monetary appeal of RE, there should be no retroactive reduction of tariffs or modification of practices for existing plants under the agreement. To identify every single installation correctly, a registry should be created, preferably by SREDA containing the publicly available information on the type of equipment, year of installation/grid connection, the expiry date of FiT contract, etc. Such registry should be declared "protective" against retroactive changes by law or regulation. Concerning the vulnerable situation in Bangladesh for the energy industry, advanced policy and comprehensive regulatory framework are essential to obtain all possible solutions.

6.5. Increasing Judicious Public Relation Work to Spur Public Awareness

The government's decision to tackle climate change crises and developing energy in a sustainable fashion is receiving more traction. From nearly two decades onwards, the Government of Bangladesh has adopted various policies and action plans to promote implementing greener and RE as an alternative source. In spite of continual strides made within this field, developing true renewable sources is not yet able to fulfill its utmost potential. Such a sluggish response is holding back the achievement of broader energy goals [122].

The tepid acceptance of renewable alternatives by the general public is another important factor for diffusion and solidification of RE development [8]. This is why a certain necessity exists for raising the general public's awareness regarding the pros and cons of using fossil fuel generated energies and the benefits of using sustainable and RE. For this to happen, appropriate campaigns and programs should be designed with the help of modern information and technological communication tools. Furthermore, education and material propagation tied to RE should be made as part of the curriculum and education course design at all levels of schooling. Without a proper introduction to the costs and benefits of RE resources and technologies, the public cannot be expected to be conscious about achieving the nation's broader goals.

This process can be helped through government-subsidized programs and initiatives. Besides, once the public comes to know the pivotal role played by RE, research and development programs will most likely be receiving greater funding leading to the development of more efficient and cheaper technology. In this regard, the Government of Bangladesh may want to prioritize budget allocations for the research and development of technologies in engineering and relevant environmental science disciplines [123].

7. Conclusions

The planet-wide impacts of environmental change and the nature of global warming urge to adopt 'hard' International law and relevant arrangements so as to advance electricity generation through a sustainable manner. Notwithstanding, there is no urgent or explicit authoritative decision that binds the countries legally to advance the local utilization of RES to generate electricity [6], though the provisions of the recently adopted Paris Agreement to UNFCCC encourages the use of RE. The scarcity of universal legal arrangements on RE does not, in any case, undermine the significance of its utilization to limit environmental degradation. Henceforth, a binding international instrument, alongside the positive activities and mutual cooperation of the stakeholders worldwide, regional and municipal players in terms of financial and technological information exchange, may assume an instrumental job in the advancement of RE [6].

Since independence, Bangladesh remained extremely reliant on fossil fuel sources to generate electricity, and these sources are depleting naturally. Continuous reduction of these fossil fuels sources, increasing expenses of such sources, energy security and international attention on GHG emissions drive Bangladesh, like many other countries, to consider sustainable policies for the electricity industry. The Government of Bangladesh is constitutionally obliged to eliminate specific inequality in living standards within the metropolitan and rural areas. Moreover, the government is constitutionally bound to achieve a specific end of development by ensuring rural electrification [124]. Therefore, the government has taken various initiatives, including the formulation of the Renewable Energy Policy 2008, aiming at promoting RE. Besides, the government has adopted policies to establish the SREDA with the prime purpose of obtaining sustainable advancement and improvement of the RE industry. Besides, Bangladesh adopted other policies, *inter alia*, to advance the industry by providing subsidies and tax incentives to draw investors into the industry. The investment relating to RE are commonly expensive in comparison with fossil fuel-based power plants, though RE plants can be profitable if one considers every external opportunity that RE offers, such as environmental protection, sustainability and inclusive social development, etc.

Achieving the goals of sustainable and greener development of energy infrastructure in Bangladesh is constrained by several issues in terms of the development and frameworks. A practical breakthrough is necessary to surmount the high upfront costs borne by developing a fresh market to let the RE market growth. This will have the effect of scaling up the renewable sector and drives down the cost of technology. In order for Bangladesh to make headway in building a low carbon society, legal instruments on RE are in dire need of institutional patronage to ensure level playing fields for all key players, the stakeholders, and the general public. Since it is undeniable that energy is the key antecedent for wide-scale development in the global arena, ensuring this development is

sustainable and counters inequality and remains inclusive for all segments of the population is equally relevant [125]. The government agencies are not the only ones who should make efforts. The private sector should also be more corporate, socially responsible and make compromises by accepting longer payback periods in RE projects.

Globally, energy is imperative to pursue any type of development, and for attaining sustainable and all-inclusive development [6]. In addition, creating a friendly green climate for the future remains a challenge for every country, not particularly, for Bangladesh [126]. To mitigate climate degradation and to achieve the SDG goals, Bangladesh should lead its energy sector into renewable sources. Providing an equitable opportunity to its citizens and to promote inclusive development for the society, choosing RE is one of the most strategic options that Bangladesh has in its hand now.

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