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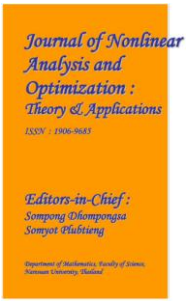

An Overview of Bangladesh's Sustainable and Renewable Energy Sources

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A B S T R A C T

Bangladesh's electricity industry is reliant on fossil fuels, including coal, natural gas, diesel, and furnace oil. In Bangladesh, electricity was produced in the 2019–20 fiscal year mostly from natural gas (71.82%), furnace oil (13.25%), diesel (0.20%), coal (4.16%), and renewable energy sources (1.23%). Roughly 9.34% of the electricity produced this year was imported from the closest nation via a grid line. On May 29, 2019, power plants in Bangladesh produced 12,893 MW of electricity, setting a new record. This record-breaking generation occurred in contrast to the anticipated demand of 14,796 MW. Produced power typically cannot meet the nation's summertime demand, which acts as a hindrance to industrial output and the growth of socioeconomic infrastructure.

1. Introduction

Every day a significant amount of power needs in the world and energy to sustain its advancement activities with increasing population (Owusu et al., 2016). Energy can convert into various forms that transferred from one place to another.

The energy policy in Asia has confirmed that the energy needs to use carefully and efficiently because its sources are limited. Different sources of energy can transform into useable forms that can use in industries and for other purposes.

Provide and establish a required electricity plant for its peoples is the significant goal of the developing countries. In the South Asia part, Bangladesh is a highly populated country.

Bangladesh is also a developing country, which has too much population and does not have proper supply the electricity in many remote areas. Some years ago, the government of Bangladesh initiative for this purpose.

Bangladesh Power Development Board (BPDB) started its operation with an install capacity of only 200 MW in 1972. Recently, BPDB has taken a massive capacity expansion plan to produce electricity in Bangladesh. For this circumstance, on 29 May 2019, the install capacity increased to 20,000 MW.

However, with an install capacity of 20,000 MW, maximum electricity produced 12, 893 MW against the demand of 14,796 MW in 2019. Recently, Ban- gladesh's electricity generation capacity reached 23,436 MW, where more than 97% of the population has come under electricity coverage.

Not all power generation in Bangladesh against demand is efficient, which is an obstacle for the country's development and advancement. Fig. 1 shows the primary grid system of Bangladesh.

Bangladesh's national beauty has potential renewable energy re- sources that solar energy, hydroelectricity, wind energy, and biomass. Ferdous Ahmed et al. (2013) presented the energy scenario, alternative energy sources, and future prospects in the power sector of Bangladesh.

The authors compiled some literature in terms of thesis, journal articles, conference proceedings, and reports on sustainable energy sources in Bangladesh.

The paper has discovered the different factors that are essential to policymaker the existing power supply crisis. Finally, they recommended renewable and sustainable energy resources to fulfill the power demand in Bangladesh. A.K.M. Sadrul Islam et al. (Sadrul Islam et al., 2006) discussed the effective utilization of renewable and sustainable energy resources in Bangladesh. The authors suggested the solar PV systems could gain more acceptances for providing electricity to small business enterprises and households in remote rural areas. M.

Nomenclature

BPDB	*Bangladesh Power Development Board*
IDCOL	*Infrastructure Development Company Limited*
OREL	*Omera Renewable Energy Limited*
SHS	*Solar Home System*
SIP	*Solar Irrigation Pump*

Rofiqul Islam et al. (2008) have studied sustainable energy resources and technologies for development activities in Bangladesh. There is an electricity problem in the rural areas. The authors concluded renewable energy could be used as a primary power source of energy in rural areas to overcome these problems. M.J. Khan et al. (2008) presented the progress, prospects, and challenges for the energy conversion system that technical and economic feasibility.

They provided technological advancements in the relevant field. Shariful Islam Sharif et al. (2018) investigated the prospect of renewable energy resources in Bangladesh. The government of Bangladesh is devoted to investment in both public and private sectors in renewable energy projects to substitute contem- poraneous non-renewable energy resources. The authors recommended the contributions of renewable energy based on electricity generation.

In this country, there are many natural resources, such as natural gas, petroleum, and coal. In Bangladesh, the prime source of power and energy is natural gas. Recently, the government has issued its intention and policy assertion with the plan to provide electricity service to cover the country by the year 2021.

The country government has the plan to increase electricity production beyond expected to meet the demand of a growing middle-class

country and to help propel growth in the export- oriented economy. Sustainability trends in the power and energy sector play a pivotal role in achieving sustainable development in any country in the world (Rezaei et al., 2013).

Mohammad Ershadul Karim et al. (2019) presented an evaluation of the law and policy of Bangladesh through renewable energy resources of sustainable development. Md Faruque Hossain et al. (2017) suggested in terms of sustainability and commercial viability within the renewable energy program initiated by the government through the private sector and micro-finance in- stitutions expand the solar energy program.

On these issues, the renewable and sustainable energies developing in Bangladesh will play a crucial impact. In comparison with the world energy situation, the pri- mary energy resource of Bangladesh is not satisfactory.

Reservation of the natural resources is limited in Bangladesh. For this circumstance, the country can require to develop renewable and sustainable energy sources. Recently, Bangladesh has many opportunities to utilize renewable and sustainable energy resources for generating electricity.

The key to Bangladesh's development has the renewable and sustainable energy resources. The government has already achieved significant progress to distribute electricity for the country's population both in urban and rural areas by using these energy sources. The prospect of renewable and sustainable energy in Bangladesh is promising in the case of solar energy.

Solar energy is the popular sustainable energy source, which used in the rural, hilly, and coastal areas in Bangladesh (Ibrahim et al., 2002). S.M. Najmul Hoque et al. (2013) presented the status of solar home and photovoltaic micro-utility systems in Bangladesh. They recommend upgrading and expansion of rural electrification through renewable energy resources.

The reservoir of water and dam is the pri- mary purpose for generated hydroelectricity. Bangladesh has already established micro and mini-hydropower projects (Wazed et al., 2008). One of the potential renewable energy sources in Bangladesh is biomass.

The sources of biomass energy are animal manure, agricultural crop residues, and municipal solid waste (Halder et al., 2014). Theconversion of wind energy is wind power into electrical or mechanical energy with the help of wind turbines, which is directly proportional to the velocity of the wind.

Wind energy is another renewable resource in Bangladesh that mini and micro-wind generation sites are suitable for electricity generation (Shaikh et al., 2017). Bangladesh has a target to generate the electricity 24,000, 40,000 and 60,000 MW by 2021, 2030, and 2041, respectively.

The country faces some difficulties in attaining its previous target, but it has gained momentum since then. We hope that it would be possible if the renewable and sustainable energy can expand in electricity production purpose.

Day by day, the cost of solar cells in Bangladesh is declining. Now the time for Bangladesh to consider appropriate renewable and sustainable energy sector investment by reducing overall infrastructure cost, which can be improved energy security systems.

The facility is more suitable for renewable and sustainable energy sectors in Bangladesh. Renewable and sustainable energy resources are natural resources that can meet up the energy crisis in Bangladesh.

Therefore, renewable and sustainable energy can play a crucial role in electricity generation in Bangladesh (Liza et al., 2020). The basic need of human life is electricity. Md. Abdullah hil Baky et al. (2017) presented the potentials of the renewable energy sector in Bangladesh through updated information.

Pobitra Kumar Halder et al. (2015) assessed the biomass energy resources and practiced its related technologies in Bangladesh. M.S. Islam et al. (2011) discussed renewable energy technologies that can reduce energy shortage, environmental degradation, and climate change effects in Bangladesh.

Md. Tasbirul Islam et al. (2014) examined overcome the power crisis by utilizing sustainable energy resources, such as solar, wind, hydropower, and biomass energy, in the context of Bangladesh. K M Nazmul Islam et al. (Islam et al., 2016) evaluated the potential sus- tainable electricity production by using municipal solid waste in different city areas.

Mahadi Hasan Masud et al. (2020) summarized the present power situation of Bangladesh and examined the available renewable energy resources and their future prospect.

Md. Alam Hossain Mondal et al. (2010) analyzed the barriers and strategies for imple- mentation of the sustainable energy technologies in rural areas in Bangladesh. Dewan Mowdudur Rahman et al. (2012) studied the renewable energy resource related socio-economic aspects for ensuring energy security in Bangladesh.

Moreover, this dynamic field required continuous assessment for the comprehensive and prospective initiative to produce electricity in this country.

In this review paper, as per the context of Bangladesh has discussed, the present status and future prospect of renewable and sustainable energy resources to incorporate with various private and governmental projects plan to fulfill electricity demand in this country. It would provide advance advice about these sectors to the government's plan to finish successfully.

2. Renewable and sustainable energy resources in Bangladesh

The sea level is going up, the forest areas are declining, and the climate is changing rapidly due to the quick civilization in Bangladesh. Global warming and climate change are natural disasters to the affective issues in the frequently happening in Bangladesh. In changing the global climate, fossil fuel is one of the top effects.

The stock of fossil fuel has been declining tremendously. The part of energy security and reduce greenhouse gas emission can promote renewable and sustainable energy resource in Bangladesh (Karmaker et al., 2020).

The social-economic status in developing countries was involved with these energy sources. Many countries have adopted theses energy sources for promotion pol- icies in the world to fulfill their electricity demand. Renewable and sustainable energy resources are the expected to continue development tasks.

Thus, worldwide every country emphasizes the importance of increasing these energy utilities. This energy policy in Bangladesh has to harness the potential of resources and technology dissemination in peri-urban, urban, and rural areas.

Encourage, facilitate, and enable both government and private sector investment in these development projects. It can develop sustainable power supplies to substitute indigenous the traditional power supplies by scale up the contributions of these energies to electricity production and heating purpose (Chen et al., 2019).

The Bangladesh government has attempted to reduce dependence on natural gas for electricity production and made plans for the energy to depend on coal and nuclear power plants by the year 2030. The present development of these energy resources in Bangladesh is not adequate for producing electricity. Until now, the efficient utilization of these energy resources has not sufficient influence on this issue in Bangladesh. Recently, these energies are inevitable considering the prevailing energy crisis and global demand for green energy. To this trend, Bangladesh is not an exception.

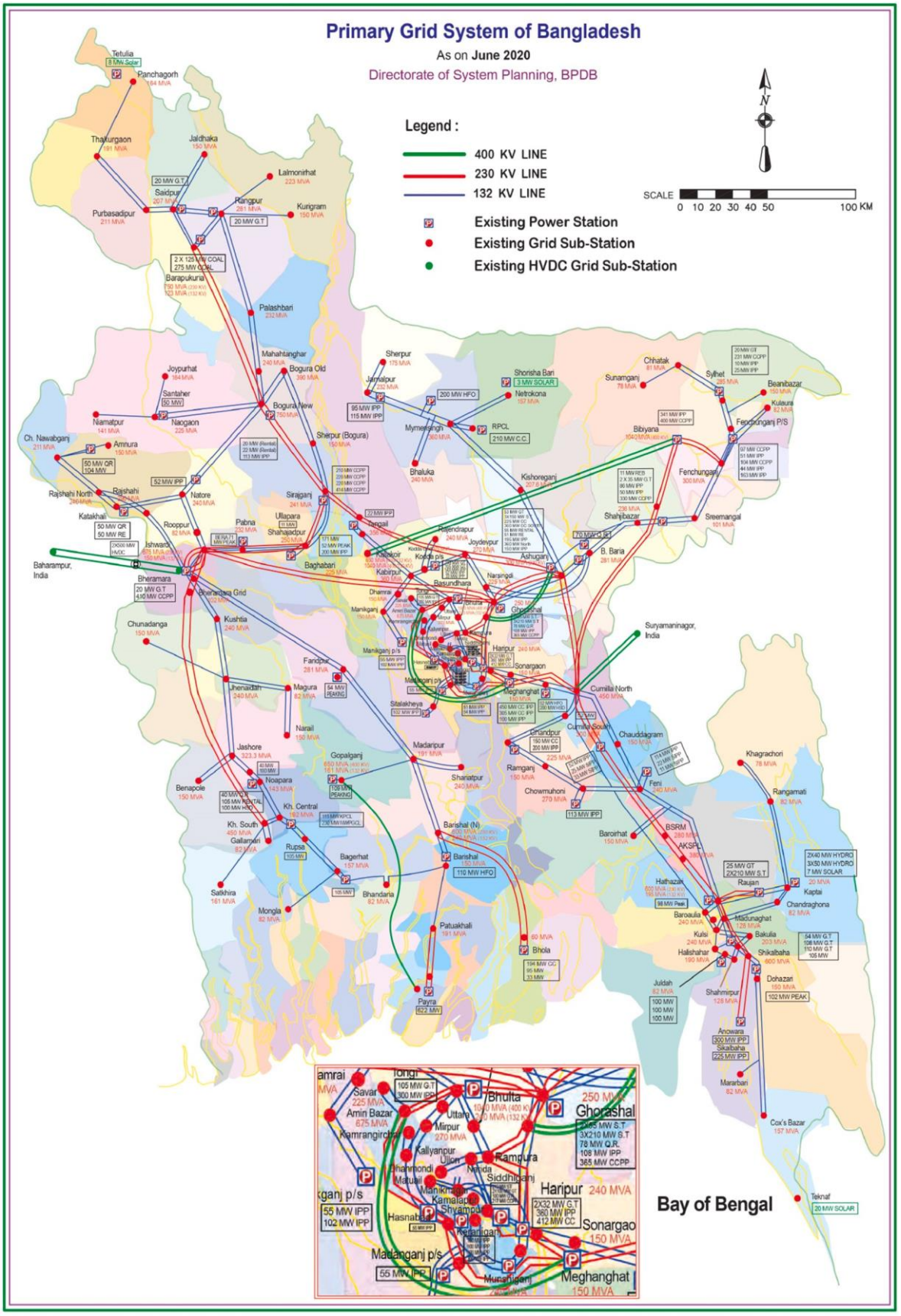

Fig. 1. The primary grid system of Bangladesh (Hossain, 2020).

The government's plan that their vision 2021, the renewable and sustainable generation capacity share would become 10%. The expectation for maximum renewable and sustainable energy generation would be potential around 3700 MW by this vision. Expect renewable and sustainable energy potential in Bangladesh has shown in Table 1.

Table 2 shows the compare of the renewable and fossil fuel energy resources in Bangladesh. The grid-connected renewable and sustainable energy generation, network, and operation capacities need to improve in Bangladesh.

Different renewable and sustainable energies will develop to the maximum level by connecting to the grid line that can gain more electricity to fulfil their demand. This energy has quite limited in comparison with grid generation power. In addition, it re- quires developing the different rules and regulations for grid-connected renewable and sustainable power generation in Bangladesh. The main renewable and sustainable energy resources in Bangladesh are solar energy, hydropower, wind power, biomass and biogas energy, geothermal energy, and tidal power.

Fig. 2 shows the solar resource map of Bangladesh of global hori- zontal irradiation. It is the amount of terrestrial irradiance falling on a surface horizontal to the surface of the earth. According to the map, Bangladesh is in the South Asia part that is located in latitudes 23.6850° north and longitudes 90.3563° east. Therefore, for proper utilize the solar energy benefits, the location is an ideal place.

The daily direct normal solar irradiance from 4.3 to 4.9 kWh/m^2 in Bangladesh. In order to the solar irradiation map, we can recommend that the Chittagong region can be more effective than any other region in Bangladesh to utilize solar energy. Solar energy usage is known as the reliable, secure, and affordable supply of energy utilization. Possible implementations of solar technologies like solar thermal energy and photovoltaic cells are one of the new opportunities for the prospects of solar energy to Ban- gladesh's perspective (Rahman et al., 2017).

Pabitra Kumar Halder (2016) demonstrated solar energy prospect, status, and dissemination schemes of solar home systems (SHS) in off-grid and coastal areas of Bangladesh through government and non-government organizations. Satoru Komatsu et al. (2013) analyzed the primary development agenda of the characteristics of households installing solar photovoltaic that SHS in Bangladesh where rural electrification within sustainable development. Md. Alam Hossain Mondal et al. (2011) estimated the potential and viability of the grid-connected solar PV system in Bangladesh. Mohammad Ziaur Rahman et al. (Rahman, 2012) demon- strated a critical interpretation about the multitude of progress in the solar PV research works and utilizations in Bangladesh. Hence, solar energy is very affordable, so that it can be a vital solution for the elec- tricity crisis in Bangladesh. Another source of clean energy is hydro- electricity. The electricity after the sunset for more poor people on a hilltop and surrounded by higher hills is their dream. The tiny hydro- power plans can light up these remote hill tracts in Bangladesh. The first hydropower plant has established in Bangladesh at Kaptai, Rangamati. Hydroelectricity can be one of the other viable prospects of electricity to create opportunities in Bangladesh (Razan et al., 2012). Himadry Shekhar Das et al. (2016) proposed a PV/tidal powered micro-hydro and diesel hybrid system in the southern part of Bangladesh. They analyzed system cost comparison of the other system of similar capacity. Tanvir Shahriar et al. (2019) optimized the modeling of wave energy converter based hydroelectric power generation for Saint Martin's Island in Bangladesh. Wind energy is one of the growing sectors when renewable energy sectors are considered in Bangladesh. Worldwide this energy resource is available, and they are one of the zero emission energy sources. Bangladesh has potential in the wind power system in different zones, such as Chandpur's Kachua, Khulna's Mongla, Patuakhali's Kuakata beach, and Cox's Bazar Inani beach. The coastal zones (where wind flows at high speeds) can be more effective than any other region in Bangladesh to utilize wind energy. These zones should be kept on focus in Bangladesh for wind power to produce electricity (Nandi et al., 2010). Abul Kalam Azad et al. (2015) analyzed the wind energy prospect for power generation by different distribution methods. Shafiuzzaman Khan Khadem et al. (Khadem and Hussain, 2006) studied a pre-feasibility of wind resources in Kutubdia Island, Bangladesh.

Fig. 3 shows the wind resource map of Bangladesh. In general, a minimum wind speed between 12 and 14 km/h is required to begin the

Table 1
Expect renewable and sustainable energy potential in Bangladesh by 2021 (PSMP, 2016).

Technology	Energy resource	Capacity (MW)
Solar park	Solar	1400
Solar rooftop	Solar	635
Solar home systems	Solar	100
Solar irrigation	Solar	545
Wind park	Wind	637
Biomass generation	Rice husk	275
Biogas generation	Animal waste	10
Solid waste	Municipal waste	1
Small hydro power plants	Hydropower	60
Mini-grid, Micro-grid	Hybrid	3
Total potential capacity		**3666**

Table 2
Compare the renewable and fossil fuel energy resources in Bangladesh (Miskat et al., 2021; Chowdhury, 2020; Energy Scenario, 2019; Jacobson et al., 2018; Nahian et al., 2016; RRP Economic Analysis, 2014).

Renewable energy resources	Resource capacity/ potential/ reserve	Environmental impact	Land use (km^2)	Costs
Solar	40,000 MW	Eco-friendly	670	US$ 0.170 /kWh
Hydro	2228 MW	Eco-friendly	–	US$ 0.018/ kWh
Wind	30,000 MW	Eco-friendly	20,000	US$ 0.300/ kWh
Other	1848 MW	Minimum impact	–	US$ 0.150/ kWh
Fossil fuel energy resources				
Natural gas	28.69 Tcf	Minimum impact	29 fields	US$ 0.024/ kWh
Furnace oil	1.399 MMT	Minimum impact	— —	US$ 0.210/ kWh
Diesel	5.5 MMT	Carbon emission	— —	US$ 0.440/ kWh
Coal	3100 M tons	Carbon emission	5 fields	US$ 0.074/ kWh

Tcf→ Trillion cubic feet; MMT→ Million metric tons;M tons→ Million tons; MW→ Megawatt.
kWh→ *kilowatt-hour*.

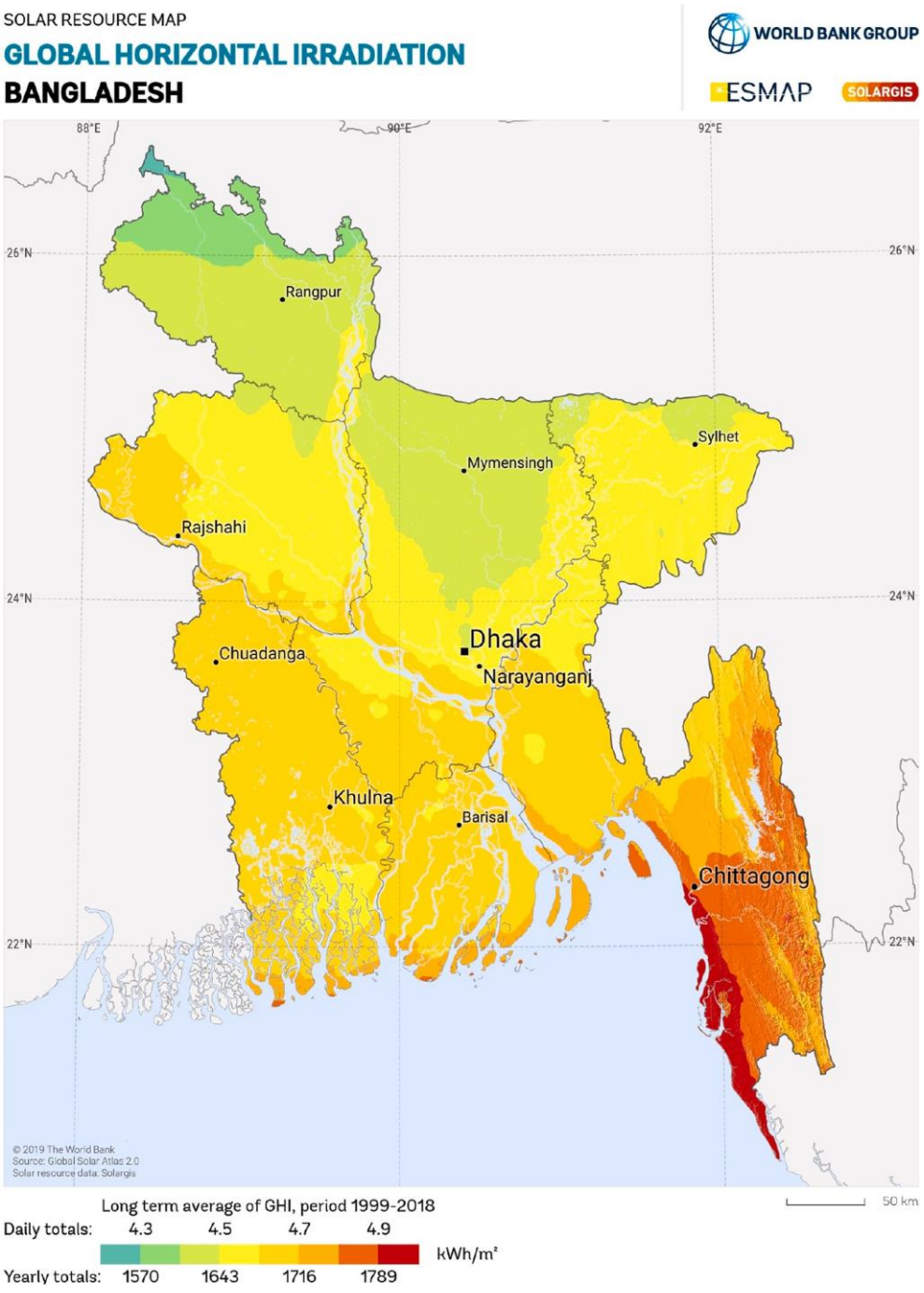

Fig. 2. Solar resource map of Bangladesh (Global Solar Atlas, 2019).

turning and can generate electricity through the wind turbine (Deep et al., 2020). The wind speed between 50 and 60 km/h can generate electricity at maximum capacity. Coastal regions of Bangladesh, the average wind speed of 6 m/s (21.6 km/h). The capacity factor of wind turbines would be very low; perhaps the small wind turbine can generate electricity through this speed.

According to the wind resource map, we can recommend that coastal areas can be more effective than any other region in Bangladesh to utilize wind energy. Biogas can be a common trend for utilizing tradi- tional biomass to generate electricity in Bangladesh. Traditional biomass like agricultural residues, wood wastes, and animal dung is used as the energy source in Bangladesh. Mohammad Nasir Uddin et al. (2019) presented the power scenario and prospect of Bangladesh. They recommend that renewable energy generation is decreasing the global pollution by different power sector utilizations. Md. Mosaddek Hossen et al. (2017) assessed the availability and potential utilization of biomass energy in Bangladesh. Mosharrof Hussain Masud et al. (2019) presented the perspective of biomass energy conversion in Bangladesh. Sakib Bin Amin et al. (2019) generated biogas from household level farming in Bangladesh. Municipal solid waste can also be considered an important source of biogas production (Hasan et al., 2019). Recently, geothermal energy has become popular worldwide because it is sus- tainable, cost-efficient, safe, and clean (Ananno et al., 2020). It is one of the most promising renewable energy sources in Bangladesh. There is a great chance to generate electricity from geothermal energy in the northern districts of Bangladesh (Hasan et al., 2017). Geothermal energy

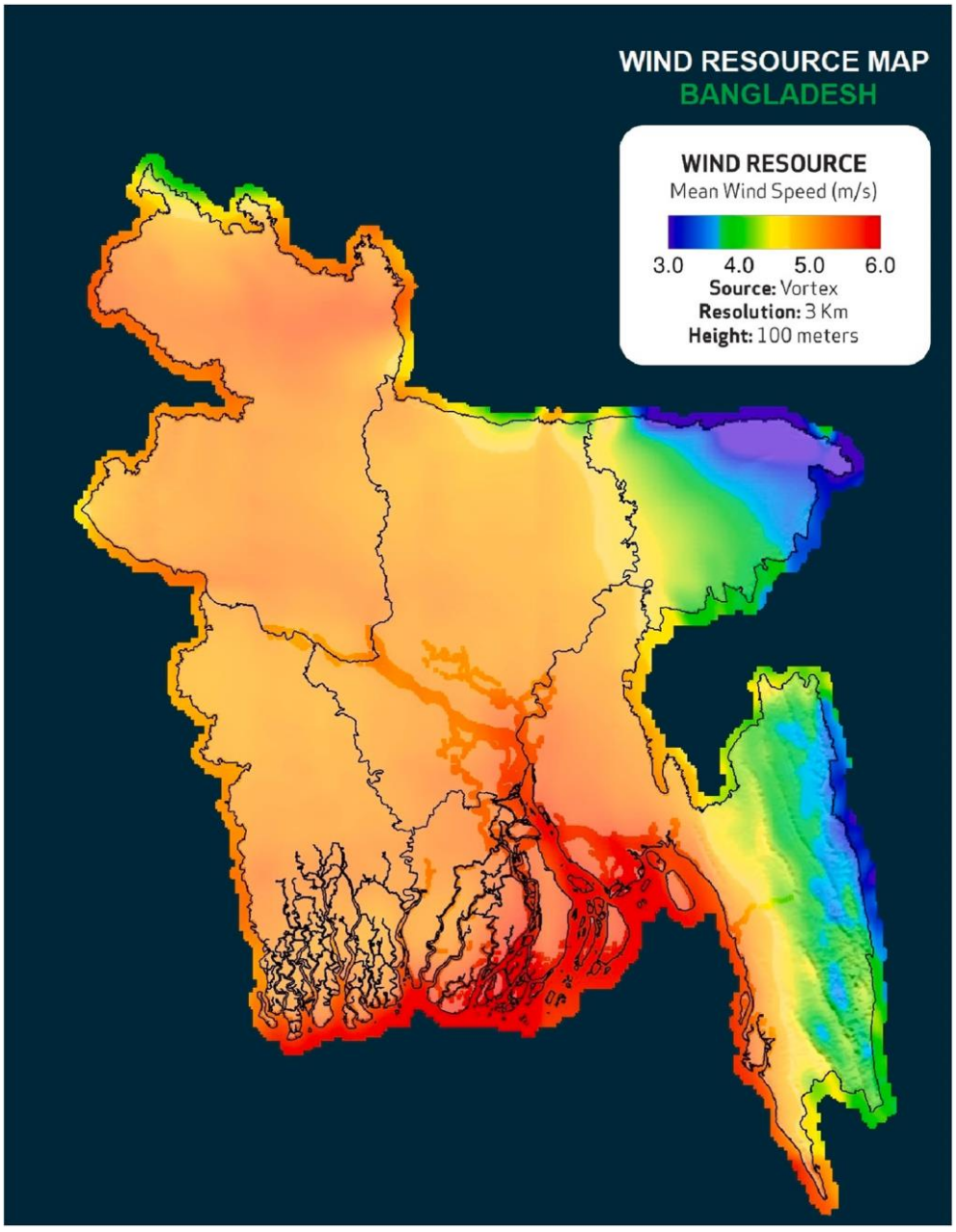

Fig. 3. Wind resource map of Bangladesh (Vortexfdc, 2014).

can generate enough electricity in the national grid to get rid of the electricity crisis of Bangladesh (Hasan et al., 2013). Md. Hassanuzzaman et al. (2014) discussed geothermal energy and its scope in Bangladesh. Kamruzzaman Khan et al. (2015b) reviewed different scopes of the po- tential geothermal energy in Bangladesh. Asif Bin Karim et al. (2018) analyzed the promising aspects of geothermal energy sources in Bangladesh. According to the moon rotation around the earth, the tide closely follows the moon. The coastal water can be trapped in a basin, and this water head can be used to a turbine during high tide and pro- duce a large amount of reliable and continuous power. Tidal energy is one kind of potential renewable energy. It has many advantages over solar and wind energy. The availability of tidal energy is highly pre- dictable, and it is not dependent on the impact of weather conditions. The density of the tidal energy is also higher than solar and winds energy densities. Mohammad Tawhidul Alam et al. (2012) investigated tidal power production in Bangladesh through the tidal barrage by using low headwater turbine systems. Tausif Ali et al. (2012) developed an ideal mode for analyzing the potentiality of tidal power in Swandwip by using different power generation technology. However, high demand in technology and capital investment has retained for the development of tidal energy in Bangladesh (Haque et al., 2017). Moreover, Bangladesh has a good chance to get tidal power from the Bay of Bengal (Rashid et al., 2016).

3. Present renewable energy status in Bangladesh

3.1. Solar energy

The power crisis becomes severely unbearable in rural areas in Bangladesh because these areas are settled far away from the power distribution line (Ahmed et al., 2014). Supplying the grid power system in coastal and hill track region is a more expensive and challenging issue. In Bangladesh, some people have deprived of electricity connec- tivity because they do not have access to grid electricity. In the absence

of electricity, approximately fifteen million rural people use kerosene lamps in their homes (Muzammil and Ahmed, 2019). In this situation, a perfect solution to supply energy in those rural areas can be the SHS (Khan et al., 2020). In rural areas, people can get some benefits imme- diately by installing SHS onto the rooftops of their houses (Khan et al., 2015a). It enables people to have light in their houses, easier for their children to study at nighttime, and they can watch TV. Furthermore, by reducing the uses of kerosene, it can minimize the household air pollution. Thus, SHS can easily contribute to lowering carbon dioxide emissions. Conventional energy sources are not responsible for envi- ronment pollution, but they are also limited. On the contrary, solar energy is available and eco-friendly everywhere in Bangladesh. Bangladesh is an undisputable tropical country for solar radiation. For installing, the SHS there is good news. To encourage people to use the SHS in rural areas in Bangladesh, the government has taken some important initiatives. Infrastructure Development Company Limited (IDCOL) started the SHS program in January 2003. The electricity for all citizens of Bangladesh by 2021 will confirm the government's plan by IDCOL. The company is a Bangladeshi government establishment owned by a non-banking financial institute that financed the installation of more than 4.13 million SHS in rural areas in January 2019 (Source: *IDCOL Projects and Programs*). Bangladesh should show further attention to increase the effect of SHS in the financial and economic aspects of market performance (Hossain et al., 2021). First, the beneficiaries of SHS have their ownership by making a down payment of only 10%. A monthly installment is prepared through micro finance institutions (MFI) to pay the remaindered money.

Fig. 4 shows a map of the installation of SHS in Bangladesh. The program has ensured to supply solar electricity around 12% people of the country's total population (about 18 million people). It has a target to install about six million SHS with the capacity of 220 MW of elec- tricity in rural areas of Bangladesh within the year 2021. The highest SHS (1,30,000 to 2,25,000) installments are in Sunamganj and Patua- khali district. There are some disadvantages in SHS like high installation cost and short back up time. It is possible to overcome the disadvantages of the situation if all people in rural areas with a cost-effective instal- lation exponentially accept the SHS. Day by day, the field of off-grid renewable energy has become successful in Bangladesh, and the SHS slowly become a global model.

The irrigation process by using water is the most important of any developing country for agricultural crop cultivation. The process can influence a vital role in the agricultural sector in Bangladesh, which locates in a tropical delta region. The solar irrigation process holds a huge potential in Bangladesh, and it can provide sustainable develop- ment without requiring any fuel (Islam et al., 2017). The Solar Irrigation Pump (SIP) is a new way of agricultural cultivation in Bangladesh (Hossain et al., 2015). The uninterrupted electricity supply is the success of the irrigation process. Recently in Bangladesh, the crop cultivation lands have expanded through irrigation processes that result in increased agricultural development. Therefore, excess of the agricul- tural crop would develop the social economic infrastructure in Bangladesh. Previously the northern part of Bangladesh was not suitable for paddy cultivation. The lack of water just for one day can severely affect the crop quality and yield that timely irrigation is a vital point. Most of the farmers in this region were dependent on the expensive diesel water pump for irrigation. A diesel pump run by diesel to grow crops on the land can require in every Boro season. However, the pump could not supply enough water due to the insufficient water of the place, and they used to have a poor harvest. For getting rid of these problems, there was a challenge for the farmers. Sometimes, they would spend their entire days in the local market to get the pumps. They would pay the high rents for the distribution and the diesel fuel. Often the diesel price was going up in the local market, and they would pay more than the government has approved rate. For paddy cultivation, it was the common problem of the northern part of Bangladesh. In October 2015, solar-powered irrigation reached for their whereabouts. Now, this technology can establish near their land. One SIP can easily cover up for about 12 ha of the land and provide 500,000 L of water per day. All the farmers share the cost of a SIP, which provides water for their fields. Their irrigation cost has almost halved by using the way. With the installed SIPs, water can supply without trouble now and make sufficient profit than before from their lands. Previously, they are waiting to collect diesel for their pumps for a long duration to the irrigation pur- pose. SIPs improve the quality of lifestyle for farmers of the northern part of Bangladesh. Now they have more time for other productive purposes. SIPs can contribute to the resilience of climate change in the agriculture side and make food security stronger in Bangladesh. Supply water for irrigation without any trouble can support agricultural pro- ductivity increase. In the remote areas far from the grid, the farmers have remained worried about getting water for a good harvest by irri- gation. The World Bank supported the government's work to install 11, 500 SIPs by 2018. Later, after identifying the aspects of SIPs and their acceptance among farmers, the aim has revised to 50,000 for 2025. This means about a quarter million diesel water pumps will be placed in Bangladesh. The place has been well suited for the country's flat terrain and abundant sunshine by using low-cost technology. The rural elec- trification is guiding solar-powered irrigation solutions with a public-private partnership model. Shakti solar pump plays a prominent function in installing these pumps for irrigation in Bangladesh. This pump is a partner organization (PO) of IDCOL that provided 15 MW SIPs so far and intends to improve this amount to 50 MW by the end of 2020. The implementing agency, IDCOL channels grant and credit funding to the non-government organizations and private financiers who set the SIP. So far, about 925 SIPs have been in operation mode benefiting more than 3300 decimals of land for paddy and 1815 decimals of land for vegetable cultivation. The farmers think it is more affordable and easier to install SIPs than installing traditional diesel pump systems. They have no moving parts, function without pollution or noise, and need little maintenance. The solar irrigation process in Bangladesh authorities should replace diesel-based water pumps with SIP. It will be possible to produce three types of crops during the year. We recommend that some initiatives should take to find private-sector sponsors to install more SIPs in the country, because, more SIPs mean more production, profits, and development for Bangladesh. Moreover, Bangladesh will be able to reduce carbon emissions if the SIPs are in operation mode.

In order to gain 10 percent of electricity from renewable energy sources by 2021, the government of Bangladesh initiative some solar power plant projects around 1070 MW capacity. Tamal Chowdhury et al. (2020b) developed and evaluated a stand-alone hybrid power system for the Rohingya refugee community in Kutupalong camp, Ukhia, Cox's Bazar, Bangladesh. For maximum energy gain, the mag- netic flux and solar irradiation are combined through modern technol- ogy. Ohirul Qays et al. (2020) have developed the technology based on solar power and magnetic field prototype in Bangladesh. Recently, 200 MW Teknaf solar park, 50 MW Sutiakhali, Mymensingh solar park, and 32 MW Sunamganj solar park in Bangladesh, and other utility scale solar PV farms have been proposed. A solar power plant has started its operation with a power generation capacity of 28 MW in Teknaf of Cox's bazar. Technaf Solartech Energy Ltd. (TSEL) has set this power plant in Teknaf by getting benefits from 116 acres of land. Currently, the power plant has been giving the national grid 20 MW energy. The authority of TSEL has informed that this power plant itself is capable of providing 80 percent of the power demand of Teknaf Upazila. The Aukhali area in Hinla union of Teknaf Upazila, this power plant is situated. The Cox's bazar-Teknaf autobahn on the east side, it's located. Totally 86,000 solar panels have been used to build up the plant, and it has five sub-stations. The construction of a 20 MW on-grid solar park has been a proper step for Bangladesh in the right direction to reduce the dependence on non-renewable energy sources (Liza and Islam, 2020). The state-of-the-art facility has been set up by using panels brought from outside the country. The government allows tax and vat-free imported solar machinery, which helps the country for green energy production.

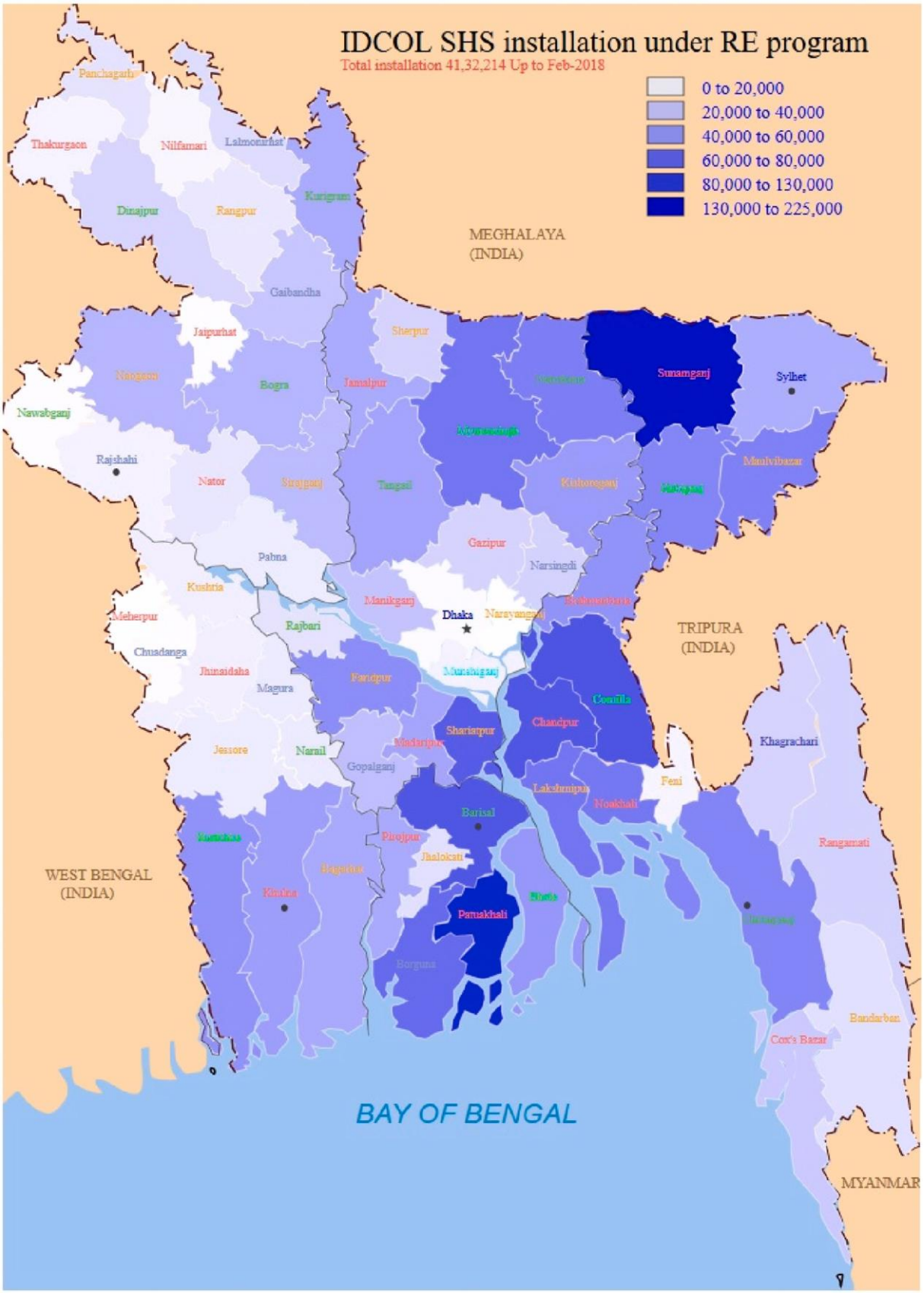

Fig. 4. Solar home system installation map in Bangladesh (Infrastructure Development Company Limited (IDCOL), 2014a).

Kazi Meharajul Kabir et al. (2020) designed a grid-connected hybrid power system with constant supply. Hasan Masrur et al. (2020) analyzed the techno-economic-environmental suitability of an isolated micro-grid system located on a remote island in Bangladesh. Around one million people and thousands of small and medium business places are getting benefits by using this solar power plant in this region. Another solar power plant is being constructed around 100 km north of Dhaka in the Mymensingh district of Bangladesh. Under a power purchase agreement, the generated power will be supplied for the BPDB. This solar power plant is the second largest solar power plant among approved plans in Bangladesh. This plant will also contribute to easing the power shortage in the country. CO_2 emission reduction will increase by using the latest heterojunction solar PV modules with superior performance (Ahmmed et al., 2020). Korea-Bangladesh consortium is going to construct a 32 MW solar power plants with the fast supply of power and energy in the Sunamganj district. The consortium that includes Korea based on Edison Solitec Company and on Haor Bangla Korean Green Energy will estab- lish, own and run the solar power plant. A 35 Km long 132 KV trans-mission line will be constructed up to the Netrokona national grid point by being paid by the consortium. This solar power plant will play a significant role in the development of the hoar area according to the master power development plan. Currently, several attempts have been made of fuel diversity in Bangladesh by using solar PV systems (Das, 2020).

In Bangladesh, the rooftop solar system is one of the most important applications of solar energy (Jamal et al., 2014). Recently, this system has opened up a new opportunity for industrial consumers by utilizing their idle roof spaces for power generation (Shafique et al., 2020). By using the rooftop solar system, it is possible to reduce the dependence of grid electricity (Chakraborty et al., 2014). Kazi Wohiduzzaman et al. (2014) studied a socio-economic impact by using rooftop solar panels conducted in the rural areas of greater Sylhet, Bangladesh. They explored the improvement in lifestyle by introducing rooftop SHS. The solar power system has become as competitive as conventional energy by increasing technological advances. We hope that day by day it will become cheaper, compared to grid electricity for industrial consumers. The government of Bangladesh launched net metering guidelines to incentivize the rooftop solar power system on July 28, 2018. Net metering allows electricity consumers to connect their rooftop solar systems to the distribution grid line (Miah et al., 2020). Thus, any sur- plus electricity from the rooftop solar system can easily be supplied for the country's grid line. They can be an immense opportunity to host rooftop solar power systems for their industrial operation purpose. The huge volume of rooftop space is available in Bangladesh's garment in- dustry for electricity generation by using the rooftop solar system. Recently, the government of Bangladesh has pledged rooftop power generation on all high-rises buildings. They expect to add 300 MW of rooftop solar power system within the next four years. The high-rise owners can install rooftop solar power systems themselves for self-consumption. Four government buildings, such as children and women directorate building, education building, food department, and Shilpakala academy have already completed the 250 KW rooftop solar power systems. Basundhara Industrial Complex in Dhaka has decided to install the rooftop solar power system with a 2.46 MW electricity gen- eration capacity. Recently, the government has aimed to add 10 percent power to the national grid line from renewable energy sources. Ac- cording to their requirements, the Omera Renewable Energy Limited (OREL) targets to produce 200 MW of electricity from rooftop solar in- stallations by 2021.

3.2. Hydro energy

Always it has been true, and it will remain true that the secure, reliable, and affordable supply of electricity is important for the indus- trial and economic development of any country in the world. The flowing water creates force, which can convert into electrical energy. The force of flowing water based on gravity is the most common use of renewable energy in the worldwide now. Water flowing is used as a clean energy source of hydroelectricity generation (Amin et al., 2019). Recently, the global hydropower install capacity has reached up to 1267 GW that forms the largest share of electricity gained from renewable energy sources. Hydropower energy is an eco-friendly, clean power generation process. Bangladesh has categorized a subtropical zone monsoonal climate where abundant rainfall. Most of the land has spread around the Bay of Bengal on the Indian subcontinent along the delta area. These lands are lower than 9 m above the sea level. There are many rivers, tributaries of main-river, and canals have well tiny waterfalls having good potential for setting up mini or micro hydropower units. For this circumstance, here has relatively limited hydropower plant even though the abundant water resources. The hydroelectricity capability in Bangladesh is one of the foremost primary energy resources because the source of hydro energy (lakes and rivers) remains untapped, but the current utilization of this energy is very limited yet (Islam et al., 2013). In Bangladesh, Karnafuli hydropower station in the Chittagong hill tract area, the hydropower plant has been established with an installed ca- pacity of 230 MW. There are five units in this power plant. The JICA (Japan International Cooperation Agency) has extended the helping hand to set up two new units, each of which has 50 MW generation capacities. There are some problems around for this power plant. The environmental impact assessment was not attained during establishes. This problem has happened with conflicts between the indigenous and migrated people who were living around this power plant. One caused was a compensation issue during established the Dam. The entry to the area has restricted due to law-and-order problems. Despite these causes, the government of Bangladesh establishes other hydropower plants for power system stability. In Barkal Upazila of Rangamati district, a 50 kW micro-hydro power plant was settled in 2005. Now this power plant rehabilitation continues. At Mirershorai Chittagong, another micro hydro power plant of 50 kW capacities is in the construction state. This power plant is known as Mohamaya irrigation-cum-hydropower project. Another hydropower plants BPDB identified in Bangladesh are on two sites as Matamuhuri (75 MW) and Sangu (140 MW).

The generating and supplying electricity from hydropower plants is a cheaper way. It is cheaper than solar energy and easier to maintain. For this reason, recently worldwide, it is well known as the leading renew- able resource for electricity generation. It offers a viable form of elec- tricity generation for remote areas where the water flow is available. In Asian hydropower production, Bangladesh has the lowest capacity compared to other countries. The hydropower plant appears to be limited due to the flat terrain of land in Bangladesh. Moreover, the government is working to increase capacity by commissioning more projects. Hydropower electricity generation has limited potential in Bangladesh without the Chittagong hill tracts region. For this reason, they also plan to establish a tiny hydropower plant for remote villages in the Chittagong hill tracts area. They surveyed the potential hydropower sites for ordinary and pumped storage hydropower plants. Fig. 5 shows the location map of potential sites for pumped storage hydropower plants in Bangladesh. The sites were conducted based on the results of this survey. The preferable potential sites 17 and 13 has evaluated and selected for pumped storage hydropower plant project. However, the projects will difficult at present conditions because acquisition to the compensation for land due to local people live. In the future, expected the selected potential sites would develop gradually to increases the stability of the power system.

Fig. 6 show the potential sites of small-scale hydropower plants location map in Bangladesh. The assumption came to the JICA survey team by the number of sites for limited visits that most of the potential sites due to the relatively gentle flow along the Sangu main river may cause large-scale resettlements. According to the technical and eco- nomic viability, there are some prospective sites. It may not be a pref- erable site to implement in order to the social impact and environmental aspects.

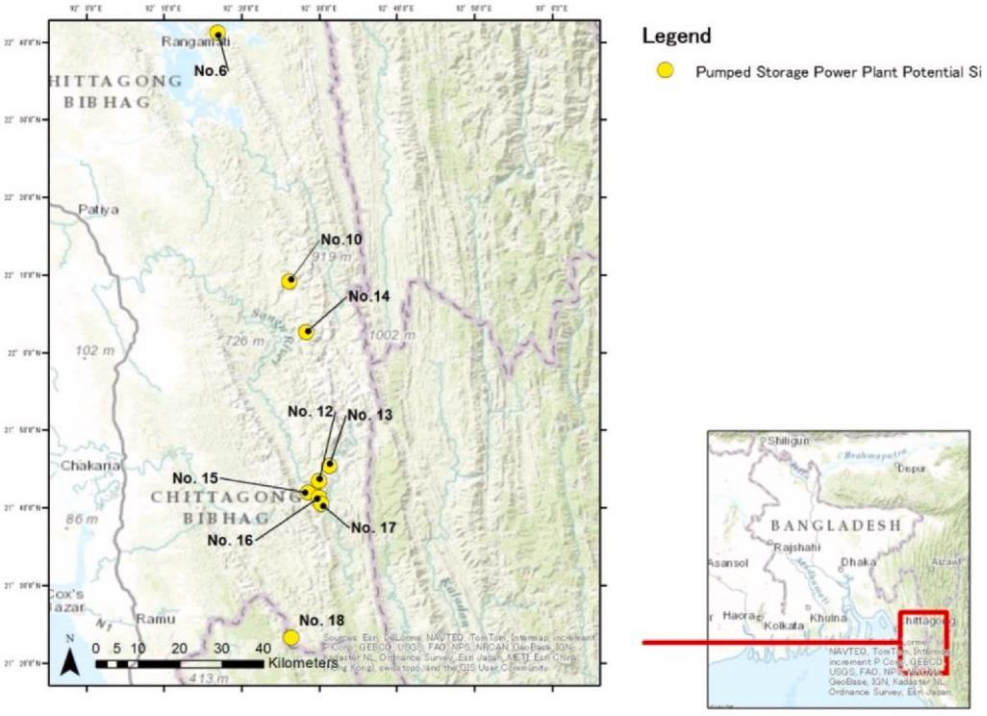

Fig. 5. Location map of potential sites for pumped storage hydropower plants in Bangladesh (PSMP, 2016).

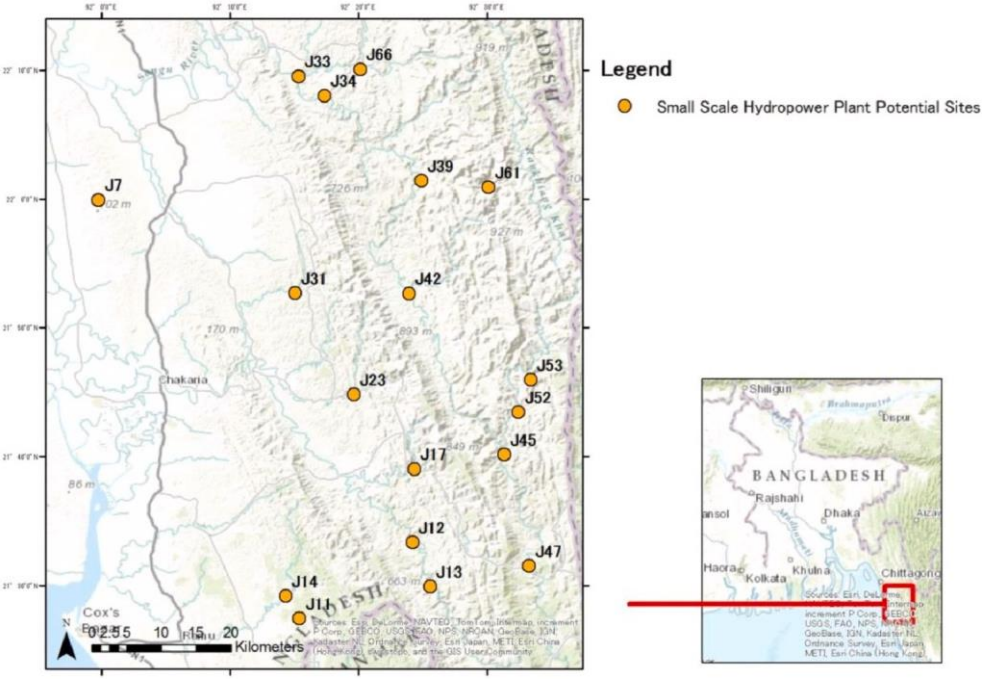

Fig. 6. Location map of potential sites for small-scale hydropower plants in Bangladesh (PSMP, 2016).

The potential sites on the tributaries of the Sangu River are antici- pated, particularly in the dry season, it has limited water flow. Thus, the sites seem not a financially viable site. In this circumstance, these sites seem unfavourable for the establish of hydropower plant projects. The targets can be achieved for optimization of the hydropower plant in this area under as follows:

- The initial survey and planning of the development is required the topographic maps for infrastructure with water flowing facilities.
- The authority should develop and arrange detailed maps essential for conceptual design and further planning.
- The implementing agency requires finding out a solution for the local people and gain to understanding for the necessity of hydropower plants.
- In this region, the authority should reduce concerns over security.

The road map can be settled to the development of these hydropower plants by 2030 under as follows:

- As soon as possible, Chittagong hill tract areas topographic maps should be prepared.
- The field study, design, capacity build-up, and establish the organi- zation engaged in the hydropower development plants should be completed.
- Human resource development will also be required.
- Any implementing organization should be provided the required training about power plants to responsible staff and operators.
- A significant function has stabilization by the power system.
- The commencement of these power plant constructions should start soon to overcome the electricity crisis.

We hope that the pumped storage or small-scale hydropower plants between 30 kW and 5 MW through the government's renewable energy plan would be established soon to overcome the electricity crisis.

3.3. Wind energy

The rotational force of a fan blade through the wind created wind energy that is one of the renewable energy sources. A conversion form of wind velocity can convert mechanical to electrical energy. North and south western part of Bangladesh, geologically, it occupies the mountain area. The Bay of Bengal is situated in the southern part of the country. There is more wind speed is found in the month June–July while it low in the month October–February. It is observe more than 4.5 m/s in the north-eastern zone and around 3.5 m/s in rest of the country (Ram- achandra et al., 2005). For this reason, it has a great possibility to generate wind energy to mitigate the power crisis. Only a few years ago, research about the field of wind energy began in coastal areas in Bangladesh, and it showed good potential in this country. There have many opportunities in the island and coastal areas for utilized wind energy to generating electricity. The small wind generator has been installed by non-government agencies in coastal areas. The wind is available during the monsoons period in Bangladesh. It flows generally on the coastal areas such as Patenga, Cox's Bazar, Teknaf, Char Fassion, Kutubdia, Sondwip, Kuakata, and Mongla region of Bangladesh (Chowdhury et al., 2018). The cyclones approaching these areas usually increase substantially. It can play an important influence as a sustain- able solution to overcome the electricity crisis in Bangladesh. The wind turbine can establish in these areas by proper investigation and analysis. The Bay of Bengal of Bangladesh has numerous small-sized islands and a long coastline area of about 725 km. There is wind flowing at high speeds in the southern part of Bangladesh in the summer period. In the winter period, there is wind flowing at minimum speeds in the northern part of Bangladesh. Fig. 7 shows the basic wind speed map of Bangladesh (Khan, 2017).

There is a chance of generating electricity by using the wind turbine in the coastal areas, riversides, and offshore islands where the wind is strong. Primarily 22 potential sites were selected by BPDB for getting wind power energy in Bangladesh. BPDB installed four units of wind power plant having the capacity of 900 kW to provide the electricity need in Bangladesh. Grid connected wind power plants are installed on the Muhuri Dam area of the Sonagazi in Feni district. Bangladesh Centre for Advanced Studies (BCAS) installed a wind pump (Chittagong) with a 12-blade rotor of 40 ft high tower in Patenga, where the flow of water about 8000 L/day in the periods between November and January. We expect an annual 150 kW wind power from Kutubdia and Kuakata that the energy will increase from 133 to 160 MWh. Another plan of BPDB is to build up a wind power plant with a capacity of 50–200 MW in the Parky Beach area, Anwara, Chittagong. They are also planning a hybrid power plant based on wind energy and diesel, which will have a capacity of 7.5 MW in Hatiya Island, Noakhali. Moreover, Bangladesh Banking Company (BBC) has installed four hybrid wind power plants that consist of wind turbines and diesel generators. The wind turbine power gener- ator that is able to work water pump, light, fan, etc. is connected to four cyclone shelters. One of them is particularly used as a cyclone shelter, and others are used in Grameen Bank branches. BBC also settles two wind generators having capacities of 300 W and 1 kW at the Chakoria Shrimp Farm and four small wind generators (3 × 1.5 kW + 10 kW) in Barguna. In addition, in many seasides, Bangladesh Rural Advancement Committee (BRAC) has already built up some small wind turbines. Government targets to produce around 650 MW of electricity from wind energy by 2021. The realization of wind energy can develop in the Chittagong hilly and coastal areas under as follows carefully:

- Assessment of all wind resources should be completed within the short term.
- Proper installation and utilization of mini wind turbines could be cost-effective for our economy.
- The wind energy should be connected to the national grid line.
- The government can be achieved the maximum potential power by wind energy utilization.
- The wind energy can be an effective opportunity for stabilizing the power system and improving power policy.

Within this issue, wind energy will have a significant contribution to the global climate change and carbon concept solution under the changed circumstances in Bangladesh. The target achievement has not been established yet in Bangladesh. However, all of the issues have some potential activities. Take the necessary initiative in determining target achievements because, day by day, it will become more difficult. The required frequency quality should be standard because it maintains the relationship between cost and benefit for consumers. The failure of power generators with wind efficiency has sufficient for chronically decreases the capacity.

The variability problem of renewable energy such as solar and wind energy can be solved by the following key solutions:

- Policy and government support
- Land for renewable energy development
- Grid network
- Renewable energy resources and potential
- Renewable energy finance
- Procurement
- Capacity development

The policy interventions are useful, such as tax incentives and the promotion of private participation in the power generation sector. The majority of its guidelines are formulated if they were to have any ben- efits for developers and investors. The government targets outline not achieved in the short-term policies. They can provide clarity on long- term renewable energy development planning. They can also create an integrated master plan for consideration the least-cost and energy se- curity plan for low carbon emission around the country. Government institutions can ensure the plan through their proper activities. Bangladesh is a densely populated country. The people rely heavily on the land for agriculture. Land availability has the development of utility- scale of this energy utilization. The non-agricultural land in Bangladesh has situated on the floodplains of rivers and in coastal areas. The experience of solar energy developers is erosion protection is often necessary. It has carefully considered that it can support private de- velopers. Solar and wind power used land very differently. Wind power has to perfect onto non-agricultural land areas. Recently, approval for erosion protection measures is required from multiple government agencies. The government required the idea of using land that identifies options for the land used for utility-scale renewable energy. The gov- ernment needs to study to identify the grid capacity of renewable energy plants. The future renewable energy plants are expected to the con- nected far from the existing grid transmission line. Renewable energy

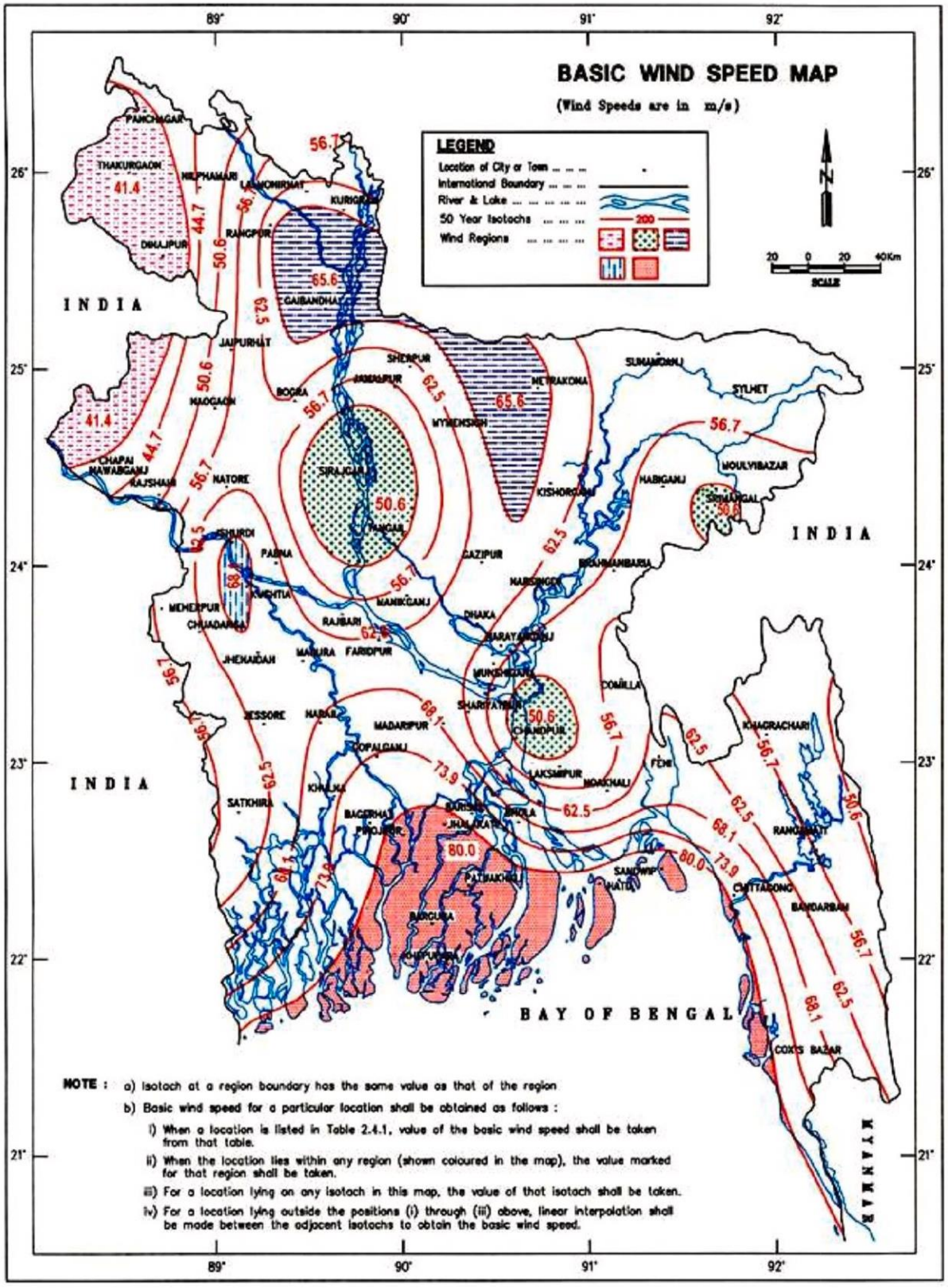

Fig. 7. Basic wind speed map of Bangladesh (Khan, 2017).

resource potential in Bangladesh has been an effort to make the map. Some non-government authority has assessed this energy. In Bangladesh, research work needs to be done by involving international agencies. The research units at government universities can increase capacity building. Develop the private utility-scale renewable energy projects are financing from commercial banks. Day by day, the renew- able energy sector in Bangladesh has developed by institutional capacity.

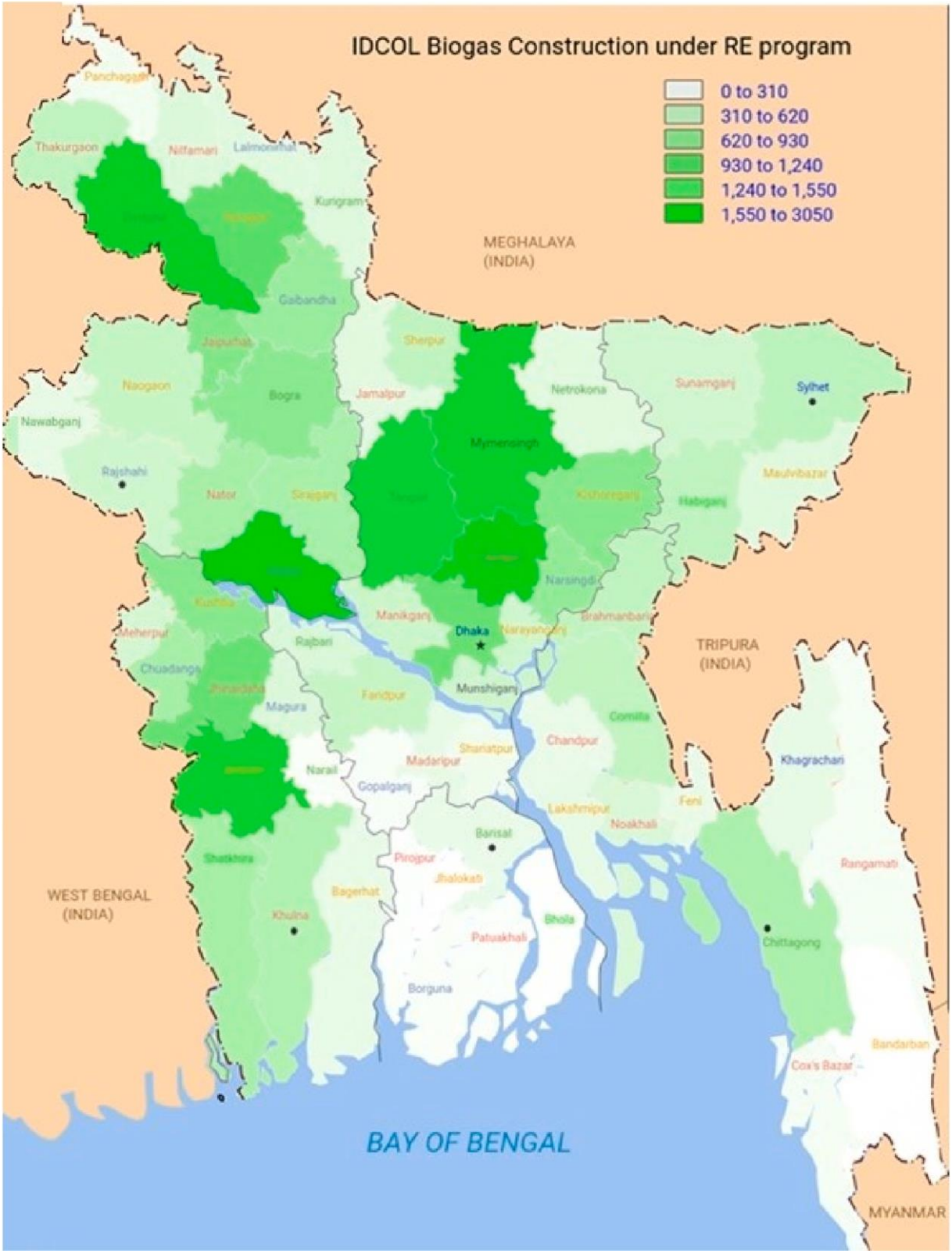

Fig. 8. IDCOL biogas construction map in Bangladesh (Infrastructure Development Company Limited IDCOL), 2014b).

3.4. Other renewable energy

In the world, many things have changed within the last three de- cades. Science and technology have shown progress at a tremendous speed within time. Up to now, an alternative environment friendly and safe technology of bio-fuel has not been developed, but we hope it will be in progress rapidly. In the worldwide, technological advancement of hybrid systems for power generation is one of the most promising as- pects (Chowdhury et al., 2020a). Ummey Sufia Mousumi et al. (2021) proposed techno-economic evaluation of hybrid supply system for sus- tainable powering the Saint Martin Island in Bangladesh. The individual users in rural areas of any part of the world the photovoltaic-biomass hybrid systems have become extremely popular with off-grid applica- tions. In rural areas, this system is an effective outcome with the use of natural resources that cost-effective and sustainable. The Rohingya refugee migration from Myanmar to Bangladesh has drawn attention to utilizing electricity. The government of Bangladesh plans to accommo- date them to shift on the off-grid coastal area of Bhasan Char. The solar-wind hybrid power process is a promising solution for this area of electrification (Ali et al., 2020). They can also use a parabolic solar cooker in this refugee camp for the household's cooking purpose (Ahmed et al., 2020). Now the whole world is thinking about their household and industrial waste management. Worldwide, poultry waste management is a big issue that challenges for the poultry farming sector. Poultry farm waste is not properly handled, so it becomes harmful to the environment. In Bangladesh, there are many people using cattle waste or cow dung. People have learned about settling small biogas plants at home with the usage of cow dung that helps them cook and get elec- tricity. However, many farmers get benefit from poultry waste by using it as an organic fertilizer in their agriculture areas. In Bangladesh, fulfill their electricity demand the industrial waste management can cooperate with agricultural farm waste management (Mosharraf et al., 2020). New technology is needed to actualize this. If this system of power generation from this waste is gained by large poultry farms, the electricity needs of a part of the country may be provided from this sector. Everybody would be aware and to work hard in these sectors. The waste management will open up the door of immense possibilities in a short period. Fig. 8 shows the IDCOL biogas construction map in Bangladesh. Nowadays, devel- oped countries are fulfilling their electricity demand from biogas power plants that have two important aspects. First, they can play a dominating role in waste management. Second, they can provide a spectacular amount of electricity for the national grid. In the country's energy consumption of the rural area, biogas still plays an important role. En- ergy gained from any form of biomass like bio-heat, bio-power, and bio-fuel is known as bio-energy. In the early 1970s, Bangladesh Council of Scientific and Industrial Research (BCSIR) and Bangladesh Agricul- tural University (BAU) launched biogas technology in the country. About 50,000 plants have been established against an estimated po- tential of four million biogas plants throughout the country so far. Until now, two rice husk-based power plants in Gazipur and in Thakurgaon having the capacity of generating 250 KW and 400 KW energy have been established with the help from IDCOL.

Other seven poultry waste-based power plants on different sites with assembled the capacities outreaching 1 MW have been built up at the initiative of the private sector with help from IDCOL. IDCOL financed the building of over 53,200 biogas plants all over the country with the help of its 38 partner organizations until December 2019. The program has reduced the use of 45,000 tons of chemical fertilizer, and it provides 3,16,000 tons of organic fertilizer and saves 51,000 tons of firewood every year. It can also reduce 2,04,000 tons of CO_2 consumption per year. In Bangladesh, IDCOL has a plan to install 60,000 biogas plants by 2021. The Paragon Poultry Limited, located in Gazipur district, produces 350 KW of electricity from the waste of 250 thousand parent stocks of chicken. This power plant has able to meet the need for 14-h of elec- tricity into the farm. At the same time, poultry waste is used to produce organic fertilizer for the cultivation of different crops. This management process is completely automated, so there is no labor cost requirement. Among all these renewable and sustainable energy resources in Bangladesh, solar energy utilization is highly suitable, and it can grow fast to the geographical location of Bangladesh. The backbone of a renewable energy process can form by solar energy (Gulagi et al., 2020). In this country, direct solar irradiance is sufficient that hits every day in maximum place, so it can utilize the whole year. We recommend that by using this great renewable energy source be required to produce elec- tricity to overcome the energy crisis. The advantages and disadvantages of solar energy mention under as follows with compared other resources:

Advantages

- The cleanest solar electrical energy is available every day of the year, even cloudy days.
- Solar energy is the pollution free energy source that causes no emission greenhouse gases.
- Develop energy can be connected by a national grid line to overcome the power crisis.
- It has no dependence on oil and fossil fuels to develop clean electrical energy.
- It can be utilized to heat water, power for homes and building, even for cars.
- With minimum maintenance, the solar panels last over around twenty years.
- The investment returns because the utility bill is not required.
- To utilize at night time, it can store extra power by batteries.
- It can help the rural economic infrastructure.
- It has safe than traditional electric power.
- It can install virtually everywhere.

Disadvantages

- The size of solar panels varies for power generation depending on geographical location.
- The initial costs are high for material and installation.
- Require lots of space for this purpose.
- It cannot produce massive power.
- The efficiency is not high yet.

In Bangladesh, sustainable improvement has forwarded the advancement in the overall standard of the people living in rural areas with access to clean and renewable energy. Sufficient and secure energy has lacked in rural areas that face some difficulty for economic growth and development. Solar energy in this area can foster economic activ- ities and create various functions for livelihood status. In rural areas for proper living people, solar electrification has been increasing various advantages by economically efficient and environmentally clean power sources. Solar electrification can improve the standard environment by reducing household pollution from used the traditional sources of en- ergy for beneficiary households in rural areas. To continue this advan- tage, it is essential to utilizing solar energy resources for electricity generations.

4. Discussion

Bangladesh has the main constraints for renewable and sustainable energy expansion because of its land availability and meteorological conditions. To overcome the concern about climate changes and envi- ronmental pollution in Bangladesh the renewable energy can consider for generating electricity (Rahman and Rao, 2020). The contribution of solar energy resources toward sustainable development is uncontested in Bangladesh. The majority of rural populations have deprived to grid electricity connectivity. Infrastructure development of grid connectivity is required more investment to supply the electricity in rural civilization. A promising alternative is renewable and sustainable energy resources

that can provide electricity needs of non-electrified rural populations. Some of the barriers of renewable and sustainable energy utilization in Bangladesh mention under as follows:

- There are many lacks such as institutional platform, technical knowledge among stakeholders, and involvement of the financial side for the promotional activity to utilizing these energy sources.
- The authority has permitted some limited private organizations to help for providing and implementing these energies.
- Target marketing raised of prevailing the impediments, including a higher cost of installation.
- The low power electronic appliances are performed by using these energy resources.

Some of the challenges of renewable and sustainable energy utili- zation in Bangladesh mention under as follows:

- The consultants, engineers, banking professionals, contractors, and educated rural communities can function for future renewable en- ergy ventures with regard to the power sector in Bangladesh.
- The existing energy authority can design the power requirements of rural peoples through small-scale conventional power plants by using these energy sources.
- The existing machinery for extending rural power development by using these energy sources can be reduced cost with imported free of tax.
- The technology with operations concentrated around these energy sources can be up-scaled by several attempts.

In our earlier reports; some of the materials, such as $AgGaSe_2$ thin films for optical absorption characteristics (Bhuiyan and Hasan, 2006), optical properties (Bhuiyan and Hasan, 2007), valence-band character- ization (Bhuiyan et al., 2008), structural and electrical properties (Bhuiyan et al., 2009), annealing effect on structural and electrical properties (Bhuiyan et al., 2011); substrate temperature effect on the optical properties of thermally evaporated ZnS thin films (Bhuiyan et al., 2010); Bi_2Te_3–based materials for review on performance evaluation (Bhuiyan et al., 2021), review the Bi_2Te_3 nanostructure (Mamur et al., 2018a) and cost-effective chemical solution synthesis on bismuth telluride (Bi_2Te_3) nanostructure for thermoelectric applications (Mamur et al., 2018b), characterization of Bi_2Te_3 nanostructure (Mamur and Bhuiyan, 2020); synthesis and characterisation of CdSe QDs by using a chemical solution route (Akter et al., 2020) have been developed for the solar cell and thermoelectric device manufacturing purposes. These materials are capable utilize the sunlight and heat to produce electricity. The renewable energy sector has developed by producing these mate- rials. The renewable and sustainable energy resources have developed for the most important strategies of deriving the part of fuel programs (Sohag et al., 2020). It has a significant contribution to the global climate change problem with the carbon-trading concept. It will not only reduce the carbon emission, but it will also provide a significant socio-economic infrastructure development. Clean renewable, energy resources are the sun, wind, water, and tidal. Solar, wind, hydro energy lead towards the main renewable energy resources because we can easily get these in nature. Providing solar electricity for lighting pur- poses of rural and hill track areas can bring several positive impacts, including increasing income, employment opportunities, and improve- ment of the quality of people's lives. For this reason, rural electrification through solar energy can be a model in Bangladesh. Demonstration of the solar energy system is created interest among rural and hill track area people and demand from other locations observed at this time to utilize these systems. In Bangladesh, rural people are not aware of solar energy utilization. Therefore, a demonstration is necessary to bring the information to these people. Appropriate financial support is necessary for the rural area people to afford the system. In a developing country like Bangladesh, solar energy utilization has essential for future prospects. In the present situation of this country, electric vehicles based on solar thermal energy are deeply needed. Future prospects might be applied for rural electrification, road lighting systems, solar powered transportations, solar cold storage and dryers, battery charging stations, and traffic signals through solar energy systems. These prospects can greatly influence our socio-economic condition. We hope that solar energy technology will take the attention of the government of Bangladesh to initiative these prospects to reach electricity crisis solu- tions. The scope of hydropower electricity generation is limited in Bangladesh because of its plain terrains except the some hilly areas in the northeast and southeast parts of this country. In Chittagong hill tracts areas; there are many tributaries of main rivers and canals as well as tiny waterfalls having suitable conditions for setting up the mini or micro hydropower electricity plant. The coastal areas can be a promising solution to support the national grid by establishing the wind turbine to produce electricity. There are a lot of hilly regions and isolated islands in Bangladesh besides these places. The coastal zone can be used for the promising prospect of electricity produces by the wind turbine in Bangladesh. Future prospects can establish the wind turbine to produce electricity in the hill track areas in Bangladesh. An enormous store of energy is the biomass in Bangladesh. Most of the people reside in both rural and suburban areas. For the domestic cooking purpose, it uses firewood, vegetation, animal excreta, and agricultural residues. In the context of social, economic, technical, and resource endowments the biomass energy can evoke great importance and its future prospect to produce electricity in Bangladesh. Finally, we recommend that by ensuring these prospects, we can overcome our electricity crisis, and ensure a green environment for our future generations in Bangladesh.

The thermal sources meet their demand in periods of climatic adversity by using renewable energy resources. Low carbon emission is performed by developing energy storage solutions in this system through batteries. It is essential in Bangladesh to encouraging electricity generation from renewable energy sources to maintain the electricity supply stability. In government policies need to encourage the expan- sion of renewable energy resources as alternatives to cut the dependency on non-renewable energy sources and give security to the electricity development sector. Future research is necessary to overcome the existing problem among the electricity generating sources. It is impor- tant to increase the grid transmission through the construction of new generating centers with solar photovoltaic panels. Recommended through this review to the government is a modernization of existing grid transmission by using renewable energy resources to stability electrical supply for low carbon emission.

5. Conclusions

There is limited use of renewable and sustainable energy due to not being a clear concept to the people of Bangladesh. Mostly, they exag- gerate the price of this type of energy. For this reason, these energy technologies cannot mature enough to become viable options. Conse- quently, negative perceptions are persisting for this energy. The people of Bangladesh can overturn the doubts with the best practices and reli- able information about these energies. The perspective plan was pro- vided the road map for accelerated growth for the eradication of human deprivation. The task of implementation within specific strategies is articulated through the government plans. The Bangladesh govern- ment's vision 2021 has declared the articulation to be in renewable energy sources in keeping with those aspirations. We provided some guidelines about renewable and sustainable energy sector development for successfully end the governmental vision by 2021. Some of the guidelines about these energy sources to provide energy security for the development and welfare of Bangladesh has mentioned as follows:

- Bangladesh government should be careful of this energy resources utilization.

- Wind and solar energy utilization should be established in proper places to fulfil the energy demand.
- Private sector investment in renewable energy projects should be facilitated and encouraged.
- Scale up contributions to these energies for electricity generation should be enabled.
- The facilities of these energies in rural areas for electricity generation should be increased.
- The government and non-government organizations should be controlled the waste recycling and management.
- Develop the integrated energy sector in Bangladesh that will be the key driver of the sustainable economy.
- The awareness and training should be provided to the rural people to utilizing these energy sources.
- Development of local technology in these fields should be promoted.
- The government should be supported for capacity build-up to tech- nology improvement for electricity generation from renewable en- ergy sources.
- Imported the renewable and sustainable energy related machinery should be tax-free.

The goals of long-term stability and prosperity cannot be achieved without sound governance. The fundamental principle of good gover- nance is to ensure the rule of law and build a society free from corrup- tion. These guidelines can be followed for the implementation of development programs.

Finally, we conclude the renewable and sustainable energy can offer affordable, reliable, and more secure supply of electricity for socio-economic infrastructure development. In our opinion, electricity sup- plies from fossil fuels are likely to stay adequate for a few next genera- tions. The policymakers of Bangladesh can take the necessary initiative to assess the renewable energy sources for electricity generation to give the survival of our next generation. In conclusion, we recommend that large-scale energy security can obtain in Bangladesh by properly utilize solar, hydro, wind, and biomass energy resources.

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