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RENEWABLE ENERGY IN BANGLADESH: ACHIEVEMENTS, POTENTIALS AND CHALLENGES

Abstract

Following the global trend, Bangladesh has declared to meet 10 per cent of its total electricity demand from renewable energy sources by 2021. The article aims to make an assessment of Bangladesh's achievement in renewable energy and identify its untapped potential along with the challenges. In the process, the article also endeavours to assess the existing plans and policies of the country regarding renewable energy. To date, Bangladesh has been able to generate 556MW of electricity from renewables against the target of 2000MW. The article argues that just comparing the target and achievement figures without considering the context may not be a right approach. It argues that considering the context, performance, potentials and challenges of Bangladesh's renewable energy sector, the progress is not discouraging at all. The article shows that the country has started the process of resource mapping which is opening new windows for Bangladesh's renewable energy sector. From the findings of these resource mapping and feasibility studies it seems that Bangladesh has good potential in renewable energy. Finally, the article suggests revising the country's existing plans and policies regarding renewable energy and investing more in resource mapping and feasibility studies.

Keywords: Renewable Energy, Solar Energy, Wind Energy, Wind Mapping, Power System Master Plan (PSMP) 2016, Renewable Energy Policy 2009

1. Introduction

Bangladesh economy has been maintaining a GDP growth rate between 6 to 7 per cent for the last five years. Consequently, energy consumption is increasing at the rate of more than 8 per cent per year; and electricity consumption is growing at a faster rate, 10 per cent per year.[1] Bangladesh is looking forward to be a developed country by 2041. With that purpose the government has prepared a policy document named "Vision 2041" in which power sector is one of the key focuses. It is expected

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[1] Ijaz Hossain, "Where do we stand?", *The Daily Star*, 20 February 2018.

that total demand of electricity of Bangladesh will be 57000 Mega Watt (MW) in 2041. To meet the expected electricity demand, the government has recently adopted Power System Master Plan (PSMP) 2016.

With running out of fossil fuel on one hand and growing concerns over environmental impacts of some conventional fossil fuel like coal and nuclear and climate change on the other hand, countries are now increasingly focusing on renewable energy sources like solar, hydro power, wind, biogas, geothermal and ocean energy. Nowadays, promoting renewable energy, with the objectives of reducing greenhouse gases as well as ensuring energy security, has become an international trend. Following this trend, Bangladesh has also declared the target of having 10 per cent of electricity from renewables by 2021. This target first appeared in Renewable Energy Policy of Bangladesh 2009 and was later incorporated in PSMP 2016.

As the targeted year is not very far, it is essential to evaluate whether the country is on track. Besides assessing the country's progress in achieving renewable energy targets, it is also very important to check whether the country has any untapped potential in this regard. The fact that already there are quite a few studies aimed at identifying potential of Bangladesh in renewable energy does not obviate the need for further attempt to find out the country's potential. This is because technology is always advancing; a country which was considered to have no potential for a particular energy 10 years ago may now be considered to have high potential due to some technological advancement.

Against this background, the article aims to make an assessment of Bangladesh's achievement in renewable energy and identify its untapped potential along with the challenges. In the process, the article also endeavours to assess the existing plans and policies of the country regarding renewable energy. The article is organized as follows. Following introduction, section two sketches the global scenario of renewable energy. Section three presents energy scenario of Bangladesh and status of renewable energy. Section four sheds light on energy plans of Bangladesh including plans for renewable energy. Section five makes an assessment of Bangladesh's achievement in renewable energy. Section six attempts to identify the untapped potentials of renewable energy along with the challenges. Section seven assesses the existing energy plans and policies of the country from the perspective of renewable energy. Section eight concludes the article.

The article uses both primary and secondary data. There are three main uses of energy – power generation, transport and heating-cooling. To keep the discussion focused, the article discusses about use of energy in power (electricity) generation only.

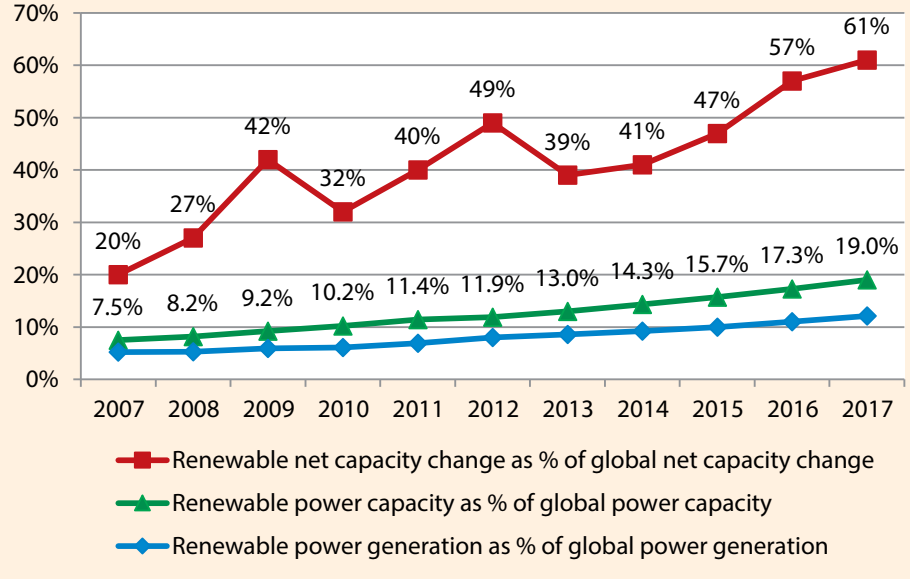
2. Status of Renewable Energy in Global Energy Scenario

Before assessing Bangladesh's achievement in renewable energy, it will be imperative to see the global trend in this regard. The following paragraphs attempt to examine global progress in renewable energy from various aspects.

2.1 *Renewable Energy has become the Driving Force of Global Energy Sector*

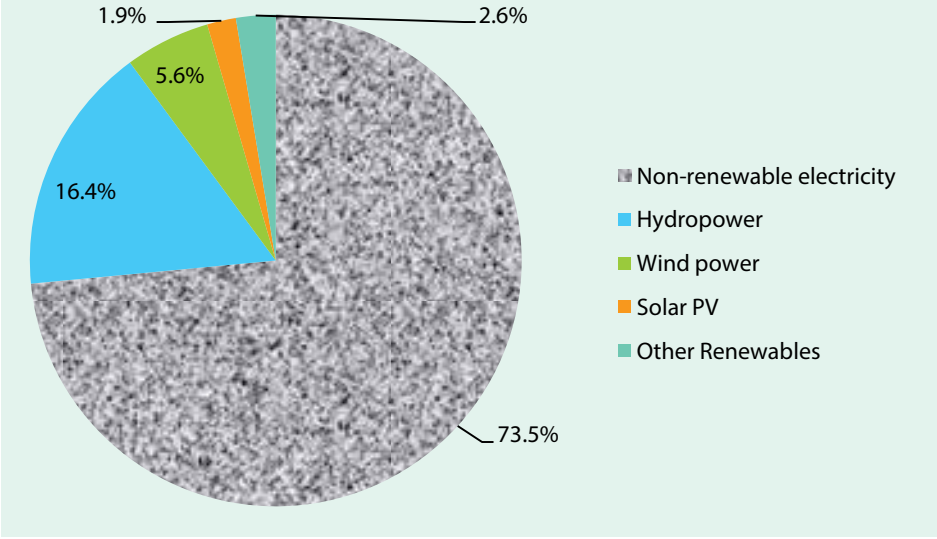
Over the last decade, production of power by renewable energy has grown tremendously. During 2007-2017, total renewable power generation capacity has more than doubled and capacity of renewables excluding hydro has increased more than six fold. As a result of this growth of renewable energy sector, share of renewables (excluding large hydro) in global power capacity has increased from 7.5 per cent in 2007 to 19 per cent in 2017 (see Figure 1). Including large hydro, the share of renewables in global power capacity stands at 26.5 per cent at the end of 2017 (see figure 2).

Figure 1: Share of Renewables (Excluding Large Hydro) in Global Capacity Change, Global Power Capacity and Global Power Generation, 2007-2017



Source: Simon Evans, "Global solar capacity grew faster than fossil fuel in 2017 says Report", *Carbon Brief*, 05 April 2018.

Figure 2: Composition of Global Electricity Production by Source, 2017

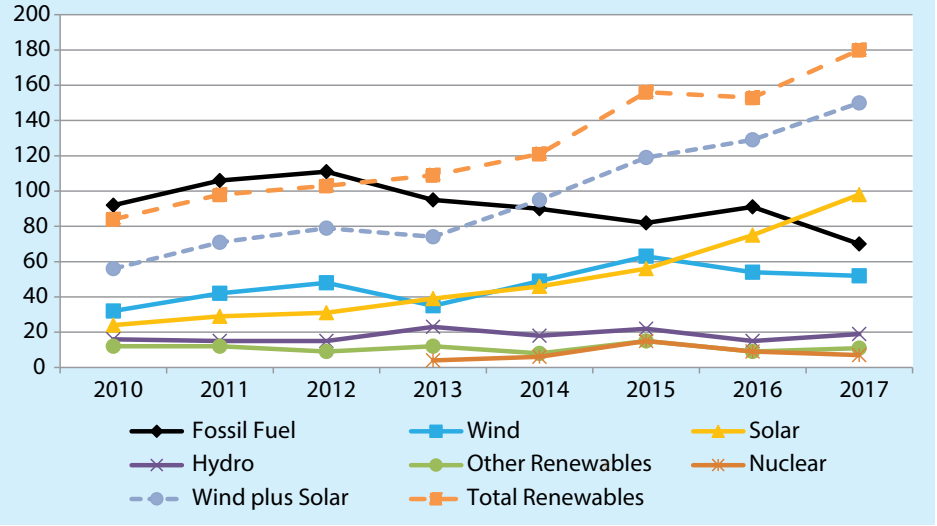


Source: REN21, *Renewables 2018: Global Status Report*, 2018, p. 41.

The rise in share of renewables in global power production is, no doubt, striking. But more striking is the fact that renewable energy, particularly solar and wind energy has become the driving force of global energy sector. Figure 1 shows that in 2017 renewables (excluding large hydro) was the source of 61 per cent of global net capacity change. If large hydro were included, share of renewables would have been even higher.

Figure 3 shows that in terms of net capacity growth, total renewables (solar, wind, hydro and other renewables, not including nuclear) has surpassed total fossil fuel (coal, oil and gas) by 2013. By 2014, solar and wind jointly surpassed fossil fuel and in 2017, net capacity of solar alone surpassed the combined net capacity of fossil fuel. In other words, in 2017, globally, solar energy alone added more capacity than coal, oil and gas did together.

Figure 3: Global Net Capacity Growth in Giga Watt (GW) by Sources, 2010-2017[2]



Source: Simon Evans, op. cit.

As a result of this increasingly higher net capacity growth, since 2002 renewables have been producing electricity almost as much as natural gas. Since 2016, globally, renewables are producing more electricity than natural gas. Coal is still ahead of renewables but the difference is shrinking over time.[3]

Major two causes of the global rise of renewable energy are: 1) rapid advancement of renewable technology including ease of integration of Variable Renewable Energy or VRE (which includes wind and solar) to existing grid system and 2) success of green lobby in influencing governments worldwide to be proactive towards the campaign for replacing fossil fuels by renewables. Lowest ever bid for solar and wind power in several countries and new policies and partnerships in carbon pricing are also helping this campaign.

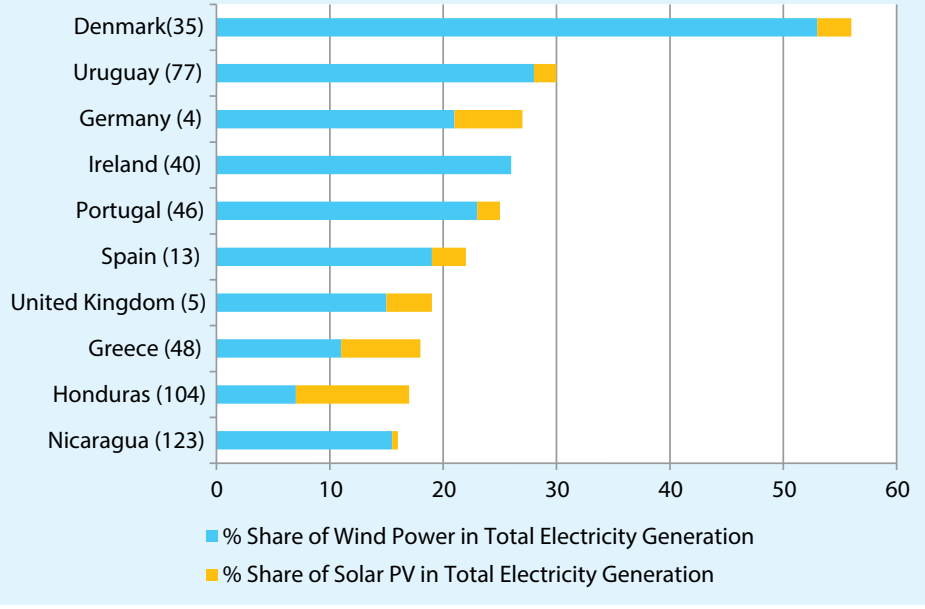
2.2 *Countries are Increasing the Share of Renewables in their Energy Mix*

With continuous technological advancement and resultant fall in cost of renewable energy on one hand, and growing concern over global warming on the other hand, countries all over the world are now increasing the share of renewables in their energy mix. Figure 4 presents the 10 leading countries in the world in terms

[2] Net growth was obtained after accounting for power plants that have retired. Retirement is particularly important for coal (32GW), followed by gas (16GW).
[3] International Energy Agency, *Renewables 2017: Analysis and Forecasts to 2022*, available at https://www.iea.org/publications/renewables2017/, accessed on 20 June 2018.

of share of solar and wind energy in total electricity generation. Numbers in the parentheses beside the names of the countries indicate the corresponding country's rank by GDP out of 194 countries. One can see that in Germany and the UK, the 4th and 5th largest economy of the world respectively, wind and solar generate more than one fourth and about one fifth of total electricity.

Figure 4: Share of Solar and Wind in Total Electricity Generation, Top 10 Countries, 2017



Source: REN21, *Renewables 2018: Global Status Report,* p. 43; World Bank.

Between 2015 and 2017, the number of cities which produces at least 70 per cent of its electricity from renewables increased from 42 to 101, including Auckland, Brasilia, Nairobi and Oslo.[4] Table 1 presents the names of some other big economies which are expecting to generate 10 per cent or more electricity by solar and wind by 2022.

[4] REN21, *Renewables 2018: Global Status Report*, 2018, p. 33.

Table 1: Selected Countries Planning to Increase Share of Solar and Wind in Electricity by 2022

Country	Rank by GDP (out of 194 countries) by World Bank	Share of Solar and Wind in Total Electricity Generation in 2016 (%)	Planned Share of Solar and Wind in Total Electricity Generation in 2022 (%)
Italy	8	14	16
Australia	14	8	13
US	1	6	12
China	2	5	11
India	7	4	11
Brazil	9	6	10
Japan	3	5	9

Source: International Energy Agency, *Renewables 2017: Analysis and Forecasts to 2022*, op. cit.

It is interesting to note that despite their initial lag, developing countries are now making tremendous progress in renewable energy sector. Reversing the past trend, developing countries took the lead in renewable energy investment by 2015 and the trend continued thereafter. Figure 5 shows this change in global trend.

Figure 5: New Investment in Renewable Energy in Developed vs. Developing Countries, 2004-2017, US$ Billion

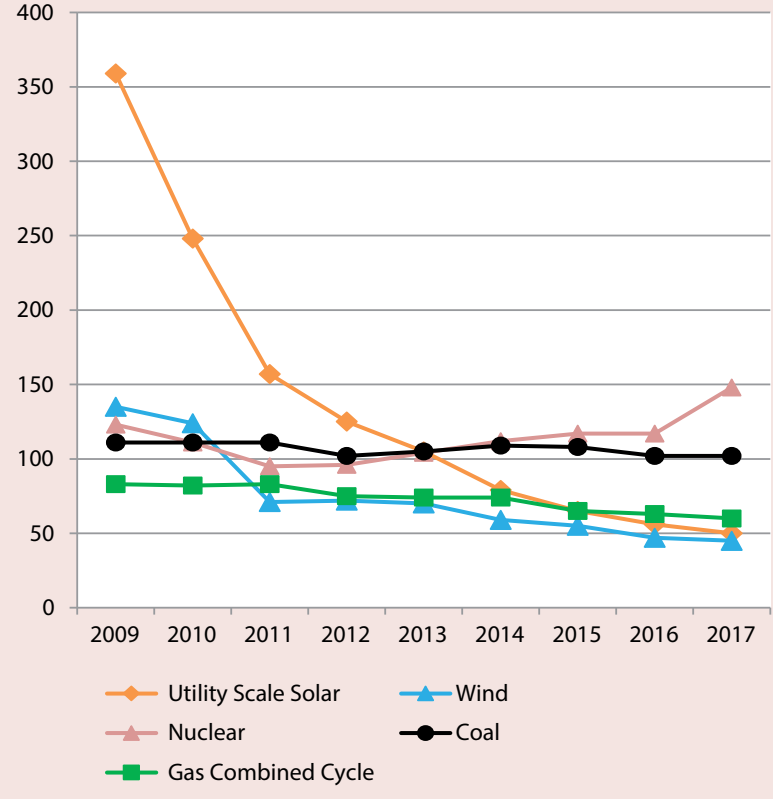
Source: FS-UNEP Collaborating Centre for Climate and Sustainable Energy Finance, *Global Trends in Renewable Energy Investment 2018*, UN Environment and Bloomberg New Energy Finance, p. 15.

2.3 *Renewable Energy has become the Cheapest Source of Power*

The fact that renewable energy is 'a good but costlier option' is not true anymore, in case of wind since 2011 and solar since 2015. The 2017 edition of Lazard's

annual Levelized Cost of Electricity (LCOE) study found that over the period 2009-2017, mean LCOE of solar and wind declined by 86 per cent and 67 per cent respectively, outstripping decline in LCOE of coal (8 per cent) and gas combined cycle (27 per cent). In other words, costs of solar and wind power have been declining more rapidly than coal or gas, making them the cheapest sources of power in today's world.

Figure 6: Mean LCOE for Different Energy Sources (US$/MWh), 2009-2017



Source: Summary Findings of Lazard's 2017 Levelized Cost of Energy Analysis, available at https://www.lazard.com/media/450436/rehcd3.jpg, accessed on 01 July 2018.

In many parts of the US, unsubsidized onshore wind and utility-scale solar are both cheaper now than new coal and are cost-competitive with combined-cycle natural gas on a levelized cost basis. The changing cost dynamic between renewable energy and fossil fuel is spurring coal closures along with new wind and solar installations.[5] Many

[5] Silvio Marcacci, "Cheap Renewables Keep Pushing Fossil Fuels Further Away From Profitability - Despite Trump's Efforts", *Forbes*, 23 January 2018, available at https://www.forbes.com/sites/energyinnovation/2018/01/23/cheap-renewables-keep-pushing-fossil-fuels-further-away-from-profitability-despitetrumpsefforts/#217 e40806ce9, accessed on 01 July 2018.

firms, previously working with coal or gas fired electricity are now turning towards green energy. General Electric (GE) is an example. In its annual results presentation, GE reported a 14 per cent revenue increase for its renewables business, while the group as a whole made a loss for 2017.[6] As a result, the company vowed to close its oil gas subsidiary and focus on its aviation, power and renewable energy divisions.

Globally, renewable Energy has thus become "the cheapest source" of power generation. According to Adnan Amin, Director General of IRENA, "Turning to renewables for new power generation is not simply an environmentally conscious decision, it is now – overwhelmingly – a smart economic one,"[7]

3. Energy Scenario of Bangladesh and Renewable Energy

Over the period 2009-2018, power generation capacity of Bangladesh has increased from 4,942MW to 17,575MW while power generation increased from 10,958MW to 4,162MW. In other words, over the last decade power generation capacity and power generation has increased by 3.5 times and 2.6 times respectively.[8]

In Bangladesh, till now, power generation is heavily dependent on natural gas. Share of natural gas in the country's electricity generation capacity is about 55 per cent, followed by Heavy Fuel Oil (HFO) which contributes about 18 per cent. Table 2 shows the current energy mix in Bangladesh.

Table 2: Electricity Generation Mix of Bangladesh, 2018

Resources	Capacity (MW)	Capacity (%)
Gas	9640.22	54.85
Coal	249.57	1.42
Heavy Fuel Oil (HFO)	3147.79	17.91
High Speed Diesel (HSD)	1158.23	6.59
Renewable	518.48	2.95
Imported	660.84	3.76
Captive	2200.47	12.52

Source: SREDA, available at http://www.sreda.gov.bd/index.php/site/re_present_status, accessed on 21 June 2018.

[6] David Weston, "GE to sell off oil and gas stake", *Wind Power*, 26 June 2018, available at http://www.windpowermonthly.com/article/1486068/ge-sell-off-oil-gas-stake, accessed on 20 August 2018.

[7] Dominic Dudley, "Renewable Energy will be Consistently Cheaper than Fossil Fuels by 2020, Report Claims", *Forbes*, 13 January 2018, available at https://www.forbes.com/sites/dominicdudley/ 2018/01/13/ renewable-energy-cost-effective-fossil-fuels-2020/#25096a574ff2, accessed on 01 July 2018.

[8] Power Division, Government of the People's Republic of Bangladesh, available at https//powerdivision.gov.bd, accessed on 20 June 2018.

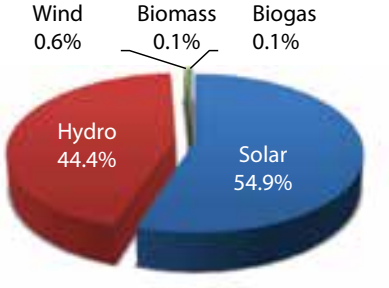
Until now, contribution of renewable energy in Bangladesh's electricity generation has been insignificant – only 2.95 per cent. Table 3 and Figure 7 provide the detail composition of electricity generation from renewable sources. One can see that to date solar and hydro powers have been the major renewable sources of power in Bangladesh. Table 3 also shows that of total solar power generated, lion's share has come from off-grid Solar Home System (SHS). However, recently, government is emphasizing more on on-grid solar electricity and hence on-grid solar electricity has started to increase.

Table 3: Status of Renewable Energy in Bangladesh (MW), 2018

Technology	Off-Grid	On-Grid	Total Capacity
Solar	267.27	17.35	284.62
Wind	2	0.9	2.9
Hydro	-	230	230
Biogas to Electricity	0.68	-	0.68
Biomass to Electricity	0.4	-	0.4
Total	**270.35**	**248.25**	**518.6**

Source: SREDA, available at http://www.sreda.gov.bd/index.php/site/re_present_status, accessed on 21 June 2018.

Figure 7: Composition of Renewable Sources in Electricity Generation Capacity, Bangladesh, 2018



Source: SREDA, available at http://www.sreda.gov.bd/index.php/site/re_present_status, accessed on 21 June 2018.

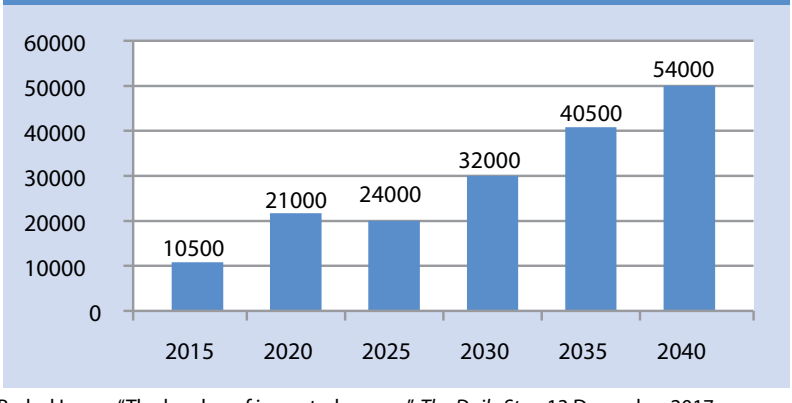
4. Renewable Energy in Energy Plans of Bangladesh

Renewable Energy Policy of Bangladesh 2009 first expressed the vision of having 10 per cent (at least 2000MW) of total power generation from the renewable sources by 2020. The policy proposed to establish Sustainable Energy Development Agency (SEDA) which will promote the development of renewable energy through capacity building, technology and market development and coordinating activities of

other agencies.[9] SEDA was later formed as SREDA (Sustainable and Renewable Energy Development Authority) in 2013.

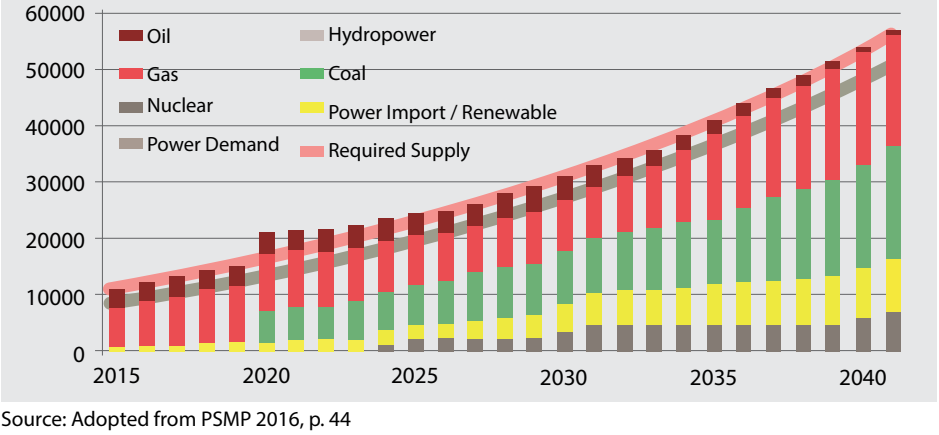
Power System Master Plan (PSMP) 2016, the key policy document detailing the roadmap of the power sector of Bangladesh up to the year 2041, declared the target of increasing renewable power generation to 2,470MW by 2021 and 3,864MW by 2041. Figure 8 shows power generation capacity of Bangladesh targeted by PSMP 2016 while figure 9 shows the energy mix proposed by the Master Plan to meet the projected demand for the years up to 2041.

Figure 8: Power Generation Capacity Target (MW) in PSMP 2016, Bangladesh, 2015-2040



Source: Badrul Imam, "The burden of imported energy", *The Daily Star*, 13 December 2017.

Figure 9: Projection of Power Mix, Bangladesh



Source: Adopted from PSMP 2016, p. 44

[9] Power Division, *Renewable Energy Policy of Bangladesh 2009*, Dhaka: Ministry of Power, Energy and Mineral Resources, 18 December 2008, p. 5.

Table 4 shows the estimate of the renewable energy potential of Bangladesh presented by the Master Plan.

Table 4: Renewable Energy Potential in Bangladesh

Technology	Capacity (MW)
Solar Park	1,400
Solar Rooftop	635
Solar Home Systems, (SHS)	100
Solar Irrigation	545
Total Solar	**2680**
Wind Park	637
Biomass Generation	275
Biogas Generation	10
Waste to energy	1
Small Hydropower Plants	60
Mini-grid, Micro-grid(hybrid)	3
Total	**3,666**

Source: PSMP 2016, p. 61.

To meet the target of generating 10 per cent electricity from renewable sources by 2020, SREDA has made a year-wise plan which is presented in Table 5.

Table 5: Renewable Energy Year-wise Targeted Plan, Bangladesh (MW)

Technology	Achievement up to 2016	2017	2018	2019	2020	2021	Total
Solar	200	120	350	250	300	250	1470
Wind	2.9	50	150	350	300	300	1153
Biomass	0	6	6	6	6	6	30
Biogas	5	0	0.5	0.5	0.5	0.5	7
Hydro	230	-	1	2	2	2	236
Total	**437.9**	**176**	**507.5**	**607.5**	**608.5**	**558.5**	**2896**

Source: SREDA, available at http://www.sreda.gov.bd/index.php/site/page/7b9b-49f7-69fb-40fd-45a3-9e6c-b391-7ba5-31f9-13ee, accessed on 27 June 2018.

5. Bangladesh's Achievement in Renewable Energy: An Assessment

Till 2016, Bangladesh's achievement in renewable energy was 434MW. After 2016, Bangladesh added 118MW more from renewable energy, i.e., in less than two years, Bangladesh enhanced its renewable capacity by 28 per cent.

Table 6 breakdowns the targets and achievements of renewables by sources. One can see that hitherto Bangladesh's achievement in renewable energy has come primarily from solar and hydro. It is also evident from the table that for future development of this sector, the country is currently emphasizing more on solar and wind; success, however, is coming from solar only.

Following paragraphs provide a detail assessment of Bangladesh's achievement in renewable energy. The assessment will be limited to solar and wind energy because for the other sources both target and achievement are insignificant until now. This is, however, not to mean that the other sources 'will remain' insignificant in the coming days too.

Table 6: Bangladesh's Achievement in Renewable Energy vis-à-vis Targets

Technology	Achievement up to 2016 (MW)	Target 2017 (MW)	Target 2018 (MW)	Target 2019 (MW)	Achievement (completed) after 2016 (MW)	Contact signed (MW)	Proposal accepted (MW)
Utility scale grid connected PV power plant					23	552.8	1322.6
Solar Mini Grid	1.6				2.9	2.4	
Solar Roof Top (off grid)					27.1	-	
Solar Roof Top (on grid)					15.7	0.5	0.8
SHS	178.6				39.7		
Solar Irrigation	10.3				9.4		
Total Solar	**200**	**120**	**350**	**250**	**117.8**	**555.7**	**1323.4**
Wind	2.9	50	150	350			70
Biomass	0.4	6	6	6			
Biogas	0.6	0	0.5	0.5			
Hydro	230	-	1	2			
Total	**433.9**	**176**	**507.5**	**608.5**	**117.8**	**555.7**	**1393.4**

Source: SREDA, available at http://www.sreda.gov.bd/index.php/site/re_present_status, accessed on 28 June 2018.

5.1 *Solar Energy*

Bangladesh has made commendable progress in case of Solar Home System (SHS). By installing more than 4 million SHS out of 6 million SHS installed worldwide, Bangladesh became the champion in SHS by the end of 2016.[10]

[10] Mohammad Al-Masum Molla, "Bangladesh leads in solar home systems", *The Daily Star*, 13 June 2017.

This success of SHS took place despite the fact that in Asia the cost of installing SHS has been the highest in Bangladesh. In Bangladesh, to install SHS, a customer has to spend BDT 120 for each watt power. For India, Pakistan and Thailand, the costs are BDT 41, BDT 90 and BDT 86 respectively.[11] It is alleged that profiteering attitude of Infrastructure Development Company Limited's (IDCOL) partner organizations has caused this cost hike which has deprived the people of Bangladesh from enjoying the benefits of falling price of SHS in international market.[12] Even the Department of Power also expressed concern over the excessive price of SHS.[13] There is also allegation that some of IDCOL's partner organizations are selling low efficiency/low quality systems at the price of higher efficiency/ higher quality systems.[14]

Installation of SHS by IDCOL's partner organizations reached its peak in 2013 with the installation number being 8.23 lac and started declining subsequently. This decline is mainly due to increased grid connection. During the fiscal years 2013 and 2014, Bangladesh Rural Electrification Board (BREB) gave power connections to a total of 47.39 lac users, which is almost equal to the sum of number of connections in the preceding ten years. It, thus, appears that the SHS market has nearly saturated, due to rapid expansion of grid connection by BREB.[15]

But there is little to worry about the saturation of SHS. In fact, SHS can be considered as the very first step of Bangladesh's renewable energy sector. After successfully passing this off-grid stage, the country is now looking to success in on-grid solar energy. Starting from 2015, the country has installed on-grid solar capacity of 57.39MW till today which includes utility scale Photovoltaic (PV) power plants of 3MW and 20MW in Jamalpur and Cox's Bazar respectively. Moreover, a good number of utility scale PV power plants are on pipeline. To date, contacts have been signed for 553MW and proposal for another 1323MW have been approved. These projects on pipeline have their challenges but initiatives are also there to solve them. Section six will discuss it in detail.

For areas which are difficult to bring under grid, for example, *chars*, solar mini grids are still being encouraged. Solar irrigation is another important off-grid option of using solar power. Starting from 2012, Bangladesh has brought 1066 irrigation pumps under solar facility, which is saving 19.73MW of electricity. The country plans to save 150MW through solar irrigation by 2020 and bring all of its 1.34 million irrigation pumps under solar facility gradually.[16]

[11] Yamin Sajid, "In Asia the cost of installing SHS is the highest in Bangladesh", *Bonik Barta*, 15 March 2017.
[12] Ibid.
[13] "Let the price be rational", *Bonik Barta*, 16 March 2017.
[14] Faiz Ahmed Taiyab, "Stories and background of solar energy", *Bonik Barta*, 14 January 2016.
[15] Sohel Parvez, "Solar energy dims as grid power expands", *The Daily Star*, 25 August 2016.
[16] SREDA, available at http://www.sreda.gov.bd/index.php/site/page/b801-2127-49bf-12e5-29d6-d4e9-b122-56ac-56cb-5e93, accessed on 25 May 2018.

5.2 *Wind Energy*

It is evident from Table 6 that in case of wind energy, Bangladesh could make no progress at all. The first and foremost reason of this failure is absence of Wind Resource Data. Bangladesh finished Wind Resource Mapping only in 2018. Before that there was no accurate wind resource data for Bangladesh. Yet, some investors expressed interest to establish wind farms here based on data which was not much reliable. Consequently, these projects could not be implemented. Two specific examples can be given.

In May 2014, Power Development Board (PDB) signed a power purchase agreement with US-DK Green Energy Ltd, a joint venture company, to build Bangladesh's first 60MW wind turbine power plant in Cox's Bazar. As per the agreement, the power plant was supposed to start commercial operation from April 2015 but the construction of the plant was repeatedly delayed. According to US-DK Green Energy Managing Director Zahurul Islam Khan, "As wind power is a new concept in Bangladesh, many investors were reluctant to support the project, which led to the delay... . The project investors were changed, and the project faced many challenges including the mapping of wind speed and direction and securing funds."[17] The 100MW wind-based power plant in Anwara in Chittagong, proposed by Consortium of PIA Group LCC, Spain and Bangladesh Alternative Energy Systems Limited had the same fate.[18]

These examples explain why there has been no progress in wind energy thus far. However, after completion of Wind Resource Mapping, Bangladesh is now looking forward to make progress in generation of wind power. In fact, recently completed Wind Resource Mapping Project hints that the country may now think of not only fulfilling the target of wind power generation but also of revising the wind power target upward. Section six will explain this in detail.

5.3 *Is Bangladesh's Achievement in Renewable Energy Discouraging?*

Given the target of generating at least 2000MW from renewables by 2020, Bangladesh's achievement in renewable energy might seem quite discouraging. A closer examination of the context, performance, potentials and challenges of Bangladesh's renewable energy sector reveals that there is no reason to be discouraged; rather there are several reasons to be optimistic.

Firstly, just comparing the target and achievement figures without considering the context may not be a right approach. This is because, although Bangladesh

[17] Aminur Rahman Rasel, "Wind power fails to take off in Bangladesh", *Dhaka Tribune*, 03 October 2017.
[18] Authors' interview with S M Sanzad Lumen, Executive Engineer, System Protection and Testing Commissioning, Bangladesh Power Development Board (BPDB) on 11 July 2018.

declared the target of generating at least 2000MW by 2020 in as early as 2009, the country took no significant action immediately afterwards. SREDA, the authority responsible for development and promotion of renewable energy, was formed in 2013 and it is only in recent few years that the country is taking significant steps to enhance its renewable capacity. Therefore, it is not the case that Bangladesh has been trying to enhance its renewable capacity for a decade but could not meet even half of its target. Rather, considering this context and taking into account the inertia and lack of preparedness at initial stage, it is appreciable that the country has been able to increase its renewable capacity by 28 per cent (from 434MW to 556MW) in less than two years after its declaration of year-wise goals in renewable energy sector.

Secondly, although the capacity of completed projects is 556MW only, solar projects of a considerable capacity (1876MW) are on pipeline. If these projects can be materialized solving land management problem, Bangladesh can soon meet the target of 2000MW renewable power from solar only.

Thirdly, the country has started the process of resource mapping, the most important task in enhancing renewable capacity. These resource mapping and feasibility studies are opening new windows for Bangladesh's renewable energy sector. Section six will deal with it elaborately.

6. Untapped Potentials and Challenges

The various feasibility studies that Bangladesh has been conducting for the last few years are opening new horizons for the country's renewable energy sector. This section attempts to identify the potentials of various renewable energy sources in Bangladesh which have so far been unidentified and unutilized.

6.1 *Wind Energy*

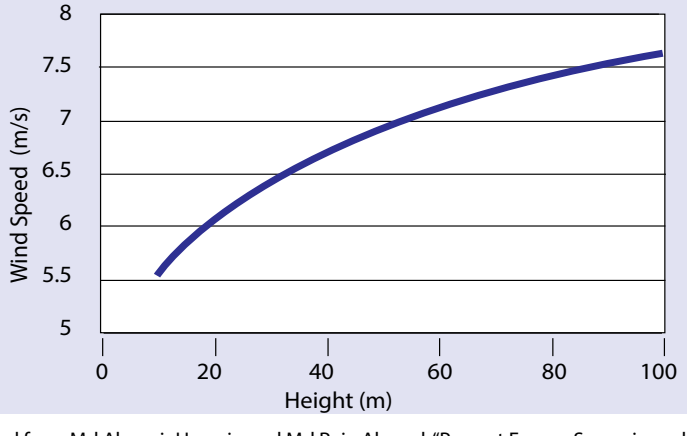
In Bangladesh, a widely held view was that the country has no or little potential of wind energy. Till 2014, all studies conducted here to measure wind potential concluded that Bangladesh does not have good potential in wind energy (see Table 7). Very recently this view has been challenged by a study titled Wind Resource Mapping Project (WRMP), conducted by National Renewable Energy Laboratory (NREL), US with support of Power Division, Bangladesh. In connection to the WRMP study, the experience of China can be mentioned. The country's experience described in Box 1 shows how a proper feasibility study changed the energy scenario of the country.

Box 1: China's Experience with Wind Energy

Before 2004, people of China would believe "wind power is good, but there is no wind potential in China". In 2004, they attended 1st International Renewable Energy Conference in Bonn where they were encouraged to see the success of Germany in renewable energy sector. They declared their pledges to take initiatives to promote renewables and passed Renewable Energy Act in 2005. As the first step, they conducted a feasibility study in 2007 under which they monitored wind speed at 400 spots at a height of 70m, 100m and 120m. Wind potential in China was found to be 2.6 Tera Watt (TW). China set target to achieve 30 GW wind power by 2020 but their wind power capacity crossed 168.7 GW by December 2016, far before the targeted year.[19]

Before going into detail of findings of WRMP study, it would be constructive to see why earlier studies did not find good wind potential in Bangladesh. There are several reasons. First, most of the earlier wind energy researches used data collected from Department of Meteorology or other departments which lacked in systematic recording of all necessary inputs required for forecasting wind potential.[20] Second, all the previous studies collected wind resource data on a low height. Table 7 shows that the height of previous studies was 20-30 metre on average and 50 metre at best, compared to 80 metre in WRMP study. As lower altitude gives lower wind speed, the previous studies which were done on lower height, found lower wind speed in Bangladesh. Figure 10 shows how wind speed increases with height.

Figure 10: Wind Speed and Heights



Source: Adopted from Md Alamgir Hossain and Md Raju Ahmad, "Present Energy Scenario and Potentiality of Wind Energy in Bangladesh", *International Journal of Energy and Power Engineering*, Vol. 7, No. 11, 2013, p. 1467.

[19] M A Gofran, "Prospects of Wind Energy in Bangladesh", Presentation made at SREDA, 09 January 2018.
[20] M. M. Alam and Abul Kalam Azad, "Unusual Wind Speed Pattern of Sitakunda, a Wind Coastal Location of Bangladesh", *International Journal of Advanced Renewable Energy Research*, Vol. 1, Issue. 1, 2012, p. 89.

Table 7: Wind Mapping Initiatives in Bangladesh

Year	Place	Measurement height (m)	Annual average wind speed (m/s)	Organization	Available technology in corresponding period	
					Hub height of turbine	Cut in speed
1996-97	Kuakata	25	4.54	Conducted by Bangladesh Centre for Advanced Studies (BCAS), with support of Local Government Engineering Department (LGED), funded by Department for International Development (DFID)	60 m (in 1999)	20 m/s (in 1999)
	Kutubdia	25	4.18			
	Char Fassion	10/25	3.28/4.07			
	Patenga	25	3.84			
	Cox's Bazar	25	3.34			
	Teknaf	25	4.18			
	Noakhali	25	2.96			
1995-97	4 sites in Southern Bangladesh	20		Conducted by Bangladesh Atomic Energy Commission (BAEC), with support of German Society for International Cooperation (GIZ)	60m (in 1999)	20 m/s (in 1999)
1999-01	St. Martin	25	4.69	Conducted by Bangladesh Council of Scientific and Industrial Research (BCSIR)	60m (1999) 70m (2002)	20m/s (1999) 17m/s (2002)
	Teknaf	25	4.56			
	Meghnaghat	25	4.8			
2003-05	Patenga	50	6.70	Conducted by Pan Asia Power Services Ltd., with support of BPDB	90m (2003)	13m/s (2003)
	Feni	50	6.20			
	Kuakata	50	6.89			
	Kutubdia	50	6.73			
	Mognamaghat	50	7.10			

Table 7: Wind Mapping Initiatives in Bangladesh (Continued)

Year	Place	Measurement height (m)	Annual average wind speed (m/s)	Organization	Available technology in corresponding period	
					Hub height of turbine	Cut in speed
2005-07	Kuakata	30	4.23	Conducted by Bangladesh University of Engineering and Technology (BUET), with support of LGED, funded by United Nations Development Programme (UNDP)	100m (2005)	5m/s (2005)
	Pakshy	30	2.78			
	Khagrachari	20	3.28			
	Naogaon	20	1.92			
	Panchagarh	20	3.00			
	Kishoreganj	30	2.37			
	Kutubdia	20	3.58			
	CUET	20	2.33			
	Munshiganj	40	6.26			
	Sitakunda	30	4.15			

Source: Md Alamgir Hossain and Md. Raju Ahmed, "Present Energy Scenario and Potentiality of Wind Energy in Bangladesh", *International Journal of Energy and Power Engineering*, Vol. 7, No. 11, p. 1467 and Wenping Cao, Ying Xie and Zheng Tan, op.cit.

Third and most important reason is that wind power technology has improved tremendously over the last 10 years. Hence, a wind speed which was not technically or economically viable for generating power 10 years ago, is now capable to produce power with improved technology. Table 8 shows how hub height[21], rotor diametre[22], cut in speed[23] and production capacity[24] – the four critical characteristics of wind turbine have evolved overtime.

Table 8: Improvement in Wind Turbine Technology, 1999-2010

	1999	2002	2003	2005	2010
Capacity (MW)	1	2	3	5	10
Hub Height (m)	60	70	90	100	120
Rotor Diametre (m)	60	70	90	120	160
Cut in Speed (m/s)	20	17	13	5	3

Source: Wenping Cao, Ying Xie and Zheng Tan, *Wind Turbine Generator Technologies,* Intech Open Access Publisher, 2012, p. 178.

Comparison between 3rd and 7th column of Table 7 reveals that all the previous wind resource measurement projects of Bangladesh got wind speed to be much lower than the cut in speed of turbine technology in the corresponding time. For example, cut in speed of wind power technology was as high as 13 m/s until 2005, which made the previous studies conclude that wind speed, found in Bangladesh, is unsuitable for generating wind power. By 2010, cut in speed of wind power technology has declined to as low as 3 m/s. With the latest technology it is now technically possible to generate wind power in Bangladesh even with the low speed obtained by the previous studies.

Table 9 summarizes the findings of WRMP study conducted by NREL. In the Table, 2nd column shows the gross amount of land (not excluding land that is already developed or is environmentally sensitive) at each wind speed and 3rd column shows estimated amount of wind electricity which can be generated in that amount of land.

[21] The wind turbine hub height is the rotor's height above ground. The higher the height, the more wind speed it gets and the more is its potential of generating power.
[22] Rotor diametre of a turbine is the diametre of its blade. The larger the diametre of its blades, the more power it is capable of extracting from the wind.
[23] Cut in speed is the level of speed at which the wind turbine starts to produce energy.
[24] Capacity of producing wind power of a single turbine.

Table 9: Potential of Wind Power in Bangladesh		
Wind Speed Range (m/s)	**Square Kilometre (Km^2) under the Wind Speed Range**	**Potential Electricity Generation in MW (based on 0.6 km^2/MW)**
4.00-4.75	14,769	Producing electricity will be technically viable but may not be economically viable in this speed
4.75-5.25	51,966	
5.25-5.75	37,728	
5.75-6.25	12,276	20,214
6.25-6.75	6,093	10,033
6.75-7.25	2,196	3,616
7.25-7.75	162	267
Total	**20,727**	**34, 130**

Source: WRMP Report Executive Summary, Presented at SREDA on 24 May 2018.

Modern turbines have a cut in speed around 3 metres per second; i.e., at 3 m/s wind speed, the turbines start to produce energy. But at 3 m/s, wind resource may not be economically viable. At present, 5-6 m/s wind speed is considered as the minimum wind speed needed for initiating a wind project.[25] If wind speed of 5.75 m/s is taken as the minimum, the economically viable wind electricity potential of the country stands at 34,130MW using gross land of 20,727km^2. Exactly how much of this potential can be realized, will depend on the actual amount of land which can be brought under wind power generation. Removing restricted land (environmentally sensitive land, land already developed for other purposes etc.) through further GIS analysis can help to arrive at a more precise estimation of land which can be used for wind power generation. It is important to note here that unlike solar or hydro, while developing wind power, the country need not worry about losing agricultural land because land used for generating wind power can simultaneously be used for other purposes like agriculture. If even one tenth of the wind power potential is realized, wind power capacity will stand at 3000MW which will be a great achievement for Bangladesh.[26]

Based on the experiences of other countries with similar wind resources, Jacobson et. al. estimate the LCOE of wind power in Bangladesh to be US$45-116/MWh (BDT 4.23-9.8/KWh) depending on wind speed and level of installation cost.[27]

[25] Interview of Mark D. Jacobson, Wind and Water Senior Project Leader of NREL, USA, Taj Capozzola, Managing Director of Harness Energy, USA and Jared A Lee, Project Scientist of NCAR, USA, published in New Age, 13 June 2018.

[26] Mark D. Jacobson thinks that for Bangladesh generating 5000 MW through wind power is easily possible. He, however, reminds that the exact figure will depend on installation cost which is still not known. See, interview of Mark D. Jacobson, Taj Capozzola and Jared A Lee, op.cit.

[27] Mark D. Jacobson et. al., "Enabling Wind Energy Development with Innovative Data Products", Presentation

This is lower/slightly higher than unsubsidized cost of power generated by non-renewable sources other than gas (coal - 8.23 BDT/KWh, HFO – 17.01 BDT/KWh, Diesel – 31.06 BDT/KWh) but higher than cost of power generated by gas (2.67 BDT/KWh) which is, as mentioned before, heavily subsidized.[28]

While examining cost effectiveness of wind power, two things must be considered. First, cost effectiveness of wind power depends on the realization of economies of scale.[29] The larger the wind power plant, the higher is the cost effectiveness. Second, to see whether wind power is cost effective, one must compare its cost with the unsubsidized cost of power generated by fossil fuel. In 2017, Bangladesh government supplied gas to the power plants at a price as low as BDT 2-2.5/m^3 while the market rate was 35-40 BDT/m^3. While calculating competitiveness of power generated by different sources, one must take this subsidy into account.

Choice of appropriate technology is another important concern in making wind power cost effective. Example of the existing wind based power plant at Feni can be given in this regard. Experts observe that the plant is over-designed. As a result, a turbine is generating less energy than it is supposed to do.[30] Other major concerns regarding cost of wind power in Bangladesh are transportation and transmission cost. These costs can be reduced by harmonizing the existing plans of transport and electricity transmission with the future plan of wind power generation.

WRMP project thus reveals huge untapped potential of wind power in Bangladesh. Upon completion of the project, the government of Bangladesh has also been aware of this potential. Proposal is on the table to form a Working Committee whose responsibility would be:

- To determine to what extent the findings/suggestions of WRMP study can be implemented
- To determine the mode of implementation of wind projects – whether to follow solicited or unsolicited procedure
- To make the tariff policy and framework for wind projects
- To make a guideline for wind projects, policy for grid integration etc.

made at SREDA on 24 May 2018.

[28] Bangladesh Power Development Board, *Annual Report 2016-17*, p. 103.

[29] Interview of Mark D. Jacobson, Taj Capozzola and Jared A. Lee, op. cit.

[30] Authors' interview with Atiqur Rahman, Executive Engineer, Bangladesh Power Development Board (BPDB) on 03 July 2018.

Besides, proposals of three site specific feasibility study for wind projects have been submitted as a component of the project "Scaling up Renewable Energy" funded by World Bank.[31] Thus, wind resource mapping has opened a new horizon in Bangladesh's energy sector. Bangladesh is looking forward to unlock this potential and has started its preparation thereby. Materializing the wind potential in the areas identified by the WRMP study should be a priority of energy sector of Bangladesh.

6.2 *Solar Energy*

As Bangladesh is a land scarce country, land availability is the greatest challenge for expansion of solar power. The utility scale PV power plant projects (of total 1876MW capacity) which are now on pipeline, are struggling with this challenge. In many cases, interested investors had to abandon their projects even after finance has been insured only because they failed to manage land.[32] To solve this problem, SREDA, on test basis, has taken an initiative of land development in Kushtia over an area of 150 acres. There, SREDA will develop land, establish sub-station and then will call tender for solar power plants. This will not only help to manage land problem but also will encourage investors by reducing risk factor and lowering price. If this Kushtia model succeeds, it will boost investment in solar power plants to a great extent.[33]

To address the challenge of land availability, experts suggest identifying land which has no possibility to come under cultivation in the near future. Examples include *char*, government acquired land, barren land etc. In Bangladesh, till today, no such feasibility study has been conducted. Instead, SREDA has issued letter to Deputy Commissioners of 64 districts to inform them about the barren land in their respective districts but till now, rate of response is very low.[34] However, at present government is considering forming a Committee to check the feasibility of establishing solar park in 5000 acres *char* of the Padma in Rajshahi.[35] It is expected that the solar parks/ utility scale PV power plants will be able to produce 3000-3500MW by 2025.[36]

Regarding land management problem for solar energy, Japan's experience can be mentioned. As Japan is a land scarce country and most of its areas suitable for large scale solar power plants are already utilized for other purposes, the experts there were looking for other places to install the PV systems. One solution that Japan

[31] Authors' interview with Md. Tanvir Masud, Assistant Director (Wind and others), SREDA on 01 July 2018.
[32] Authors' interview with S M Sanzad Lumen, op. cit.
[33] Authors' interview with Md. Tanvir Masud, op. cit.
[34] Authors' interview with S M Sanzad Lumen, op. cit.
[35] Authors' interview with Atiqur Rahman, Executive Engineer, Bangladesh Power Development Board (BPDB) on 03 July 2018.
[36] Authors' interview with Mr. Shahriar Ahmed Chowdhury, CEA, Director, Centre for Energy Research, United International University, on 24 September 2018.

came up with was "solar sharing" – a method in which solar panels are installed over agriculture land in such a way that it does not hamper agricultural activities or agricultural productivity.[37] This "solar sharing" method got popularity among the farmers in Fukushima after the power crisis caused by nuclear power plant accident.[38] In some places of Japan, even rice and vegetables are grown in solar sharing method.[39]

Another great opportunity for solar energy is net metering. In net metering process, an electricity consumer (household/enterprise) generates its own electricity from solar panels. The amount of electricity it produces by solar panels is deducted from its total consumption of power and this deduction offsets its electricity bills accordingly. Furthermore, if the household/enterprise can produce excess electricity, it can supply the extra power to the grid and is remunerated thereby. This opportunity is expected to encourage the households, businesses, industries and all other enterprises to use roof-top solar panels.

In a feasibility study conducted by German Technical Cooperation Agency (GTZ), it was found that a household/enterprise currently spends BDT 15-25/unit for captive power while net metering will cost them BDT 8-9 for each unit.[40]. According to some experts, the cost of net metering will be even lower (BDT6-7/unit).[41] Thus, even compared with present industrial price of electricity (which is BDT9-10/unit), net metering of solar roof top might be a profitable option for industrial and business enterprises. SREDA has formulated a policy on net metering. Once the policy is finalized, the government will run awareness raising programme with a view to encourage people to use solar power. Net metering is expected to add 1000-1500MW in national grid.[42]

There is concern over price of solar energy. It is said that considering the extent of subsidies and incentives provided by the government, the customer price of electricity sold by solar mini grids and solar parks/utility scale grid connected PV power plants are higher in Bangladesh compared to other neighbouring countries like India. In Bangladesh, solar power costs BDT 9.5/unit while in India it costs as less as BDT 4/unit. Some notable reasons for this higher price are – higher price of land in Bangladesh due to land scarcity, lack of experience and uncertainty over market.[43]

[37] "Solar sharing in Japan: Efforts and Hurdles", 15 August 2014, available at https://www.japanfs.org/en/news/archives/news_id035010.html , accessed on 25 August 2018.
[38] "Solar sharing spreading among Fukushima farmers", *The Japan News*, 26 June 2013, available at http://news.asiaone.com/News/AsiaOne+News/Asia/Story/A1Story20130626-432406.html, accessed on 25 August 2018.
[39] "Solar Sharing in Japan: Efforts and Hurdles", op. cit.
[40] Authors' interview with Md. Tanvir Masud, op. cit.
[41] Authors' interview with Mr. Shahriar Ahmed Chowdhury, op. cit.
[42] Authors' interview with S. M. Sanzad Lumen, op. cit., authors' interview with Shahriar Ahmed Chowdhury, op. cit.
[43] Badrul Imam, "Why is solar power development so slow in Bangladesh", *The Daily Star*, 11 April 2018.

With continued production, many of these factors like experience, economies of scale and market uncertainties are likely to moderate and then price of solar electricity might come down. In fact, experts believe that in Bangladesh price of solar energy will fall to BDT 5-6/unit within a few years which is well below the present unsubsidized cost of power produced by gas.[44]

6.3 *Hydro and Others*

As Bangladesh is overall a flat land and lacks in hilly rivers with strong current, the country has limited potential in hydro electricity. This is well reflected in renewable energy targets of Bangladesh. Although hydro electricity produced by Kaptai Dam is contributing significantly in the national grid, its social cost had been high enough to make the country cautious about such projects. PSMP 2016 also mentioned about this aspect of hydro power development in Bangladesh.

Surveys of Japan International Cooperation Agency (JICA) conducted at the time of formulation of the Master Plan found that Ordinary Hydropower Plant (Ordinary HP) and Small Scale Hydropower plant (SSHP) potential sites along the Sangu main river can cause large-scale resettlements due to gentle slope of river. Moreover, potential sites on the tributaries of the Sangu River have limited water flow in the dry season and hence are not financially viable for development of hydropower projects.[45] Hence, potential of hydro power seems to be low in Bangladesh.

In case of biogas, feasibility studies have been conducted in six municipal areas. It was found that major cities of Bangladesh including Dhaka are generating about 20,000 tons/day. It is possible to build biogas plants with the capacity of 2 million m^3 gas/day to utilize these wastes. This amount of gas can generate 2666MWh electricity every day.[46] It implies that using the municipal waste Bangladesh can generate at least 111MW power.[47] Besides generating electricity, these biogas plants may also contribute in waste management of the country's mega cities. It can be noted here that in a feasibility study, German Development Agency (GIZ) found that using the waste of Keraniganj of Dhaka, a 4-5MW power plant can be installed. Power Division has already assigned BPDB to implement a 1MW Waste to Energy Pilot Project in Keraniganj.[48] Nothing can be said about potential of geothermal and tide energy in Bangladesh because no feasibility study has been conducted yet.

[44] Authors' interview with Mr. Shahriar Ahmed Chowdhury, op. cit.
[45] Power System Master Plan (PSMP) 2016, p. 57.
[46] Calculation by Mr. M A Gofran, Member of Board, SREDA and Chairman, Bangladesh Biogas Development Foundation (BBDF).
[47] Authors' calculation based on the estimate of Mr. M A Gofran.
[48] SREDA, available at http://www.sreda.gov.bd/index.php/site/page/6b72-7470-54bd-6140-f5b3-40c8-6b8a-b8e6-cc5c-7aa6, accessed on 09 April 2018.

It can be concluded that Bangladesh seems to have good potential in renewable energy. Realizing those potential should now be the priority of Bangladesh if the country intends to fulfill its renewable energy target. The country should also invest on renewable resource mapping projects which will help it to identify new opportunities.

7. Renewable Energy Policies of Bangladesh: An Assessment

Appropriate policy is crucial for success of any sector. And, change in the context may call for change in a policy. In light of the context in which Bangladesh's renewable energy sector operates, its successes, challenges and potentials, which have been described in the previous sections, this section endeavours to see whether the country requires revisiting its policies regarding renewable energy or not. To do so, this section first deals with the achievability of the existing renewable energy target. In other words, it will seek answer to the following question: should Bangladesh revise its renewable energy target downward? Then it will offer an assessment of PSMP 2016 with respect to renewable energy which will be followed by an assessment of Renewable Energy Policy 2009.

7.1 *Renewable Energy Target: Should it be Revised Downward?*

With only about 3 per cent of electricity coming from renewables and 2 years remaining, a question arises inevitably – should Bangladesh abandon its target of generating 10 per cent of electricity from renewables by 2020 or revise it downward? Several facts suggest that this might not be necessary.

Firstly, as mentioned in section five, in Bangladesh it is not the case that the country has been trying for a long time to meet its renewable energy target but has failed. In reality, the country has been effectively trying to develop its renewable energy sector only for a few years. And, given the lack of preparedness and inertia in initial stage, adding 118MW in less than two years is obviously appreciable.

Secondly, given that the process of development of renewable energy has gained momentum in recent years and that a number of resource mapping and feasibility studies showing huge potentials (of wind power plant, net metering and waste to energy plant) are now in hand, one can reasonably expect that meeting the renewable target would not be difficult. Experts are also of the opinion that it might take 2022 or 2023 instead of the year 2020 but Bangladesh surely can achieve 2000MW from renewables.[49]

[49] Authors' interview with Mr. Shahriar Ahmed Chowdhury, op. cit.

Last but not least, globally, technology in renewable energy sector is improving tremendously increasing the cost effectiveness of renewables more rapidly compared to conventional sources. Worldwide, countries are therefore raising the share of renewables in their planned energy mix. It would be self defeating for Bangladesh if the country goes just in opposite direction.

7.2 *PSMP 2016 and Renewable Energy: An Assessment*

Despite its declaration of "maximization of green energy and promotion of its introduction" as one of its five key viewpoints, PSMP 2016 does not seem to be much optimistic about the prospect of renewable energy in Bangladesh. Potential of renewable energy in Bangladesh, as presented by the plan, is low compared to the electricity demand of the country. As said by the plan, even if solar Photovoltaic (PV) and wind potential is developed to the maximum, Bangladesh will gain about 4,200GWh per year which is very low compared to total grid generation energy estimated at 82,000GWh in 2020 and 307,000GWh in 2040.[50]

Section 1.4.2 of the plan says, "... importing power from neighbouring countries using hydroelectric power generation has much greater possibility than supplementation programs for the limited degree of renewable energy introduction in Bangladesh."[51] Therefore, although in its proposed energy mix, PSMP 2016 recommends having 15 per cent energy from renewables and power imports, in the plan it emphasizes more on import and detail the plan for preparedness for import more elaborately.

One of the interviewees explains why PSMP 2016 is not so optimistic about renewable energy. The reasons identified by him are: First, renewable energy technology is improving very rapidly. Back in 2014, when the task of formulating PSMP 2016 started, renewable energy technology was less efficient compared to current status. Second, in Bangladesh there was lack of resource mapping and feasibility studies then. Third, at that time the expertise in the country was not at the level as it is today. Fourth, the environment of the energy sector was also not as conducive to development of renewable energy as it is today. There was less enthusiasm about renewable energy and less encouragement from the government. According to him, all these contributed to make the expert groups, who were involved in formulating the Master Plan, not much optimistic about the potential of renewable energy in Bangladesh.[52]

The situation now has changed. Energy experts are now much more optimistic about the future of renewable energy in Bangladesh. In the words of Shahriar Ahmed

[50] Power System Master Plan 2016, p. 61.
[51] Power System Master Plan 2016, p. 6.
[52] Authors' interview of Mr. Shahriar Ahmed Chowdhury, op. cit.

Chowdhury, "By 2040, renewable energy will become the mainstream energy not only globally but also in Bangladesh."[53] Experts, therefore, are of the opinion that a favourable condition has now been created in Bangladesh for renewable energy and PSMP 2016 should not stand on the way to develop this thriving sector.

Interestingly, the fact that advancement in technology can bring about change in the prospect of renewable energy in Bangladesh is recognized by PSMP 2016. It says, "... Investment cost for the use of renewable energy, which is larger than that for the use of conventional energy sources, is expected to reduce in future with technological advancements and extension of its use in society. When this condition has been met, a shift to the active use of renewable energy and a reduction in the consumption of fossil fuel shall have to be realized, following the global trend, with the aim of increasing the use of zero-emission power sources."[54] With 75 per cent and 50 per cent fall in the price of solar PV module and wind turbine respectively and with the drastic fall in installation cost of wind and solar energy over the period 2007-2017, reaching to the higher end of the installation cost of conventional energy, as depicted in Table 10, perhaps the time has come for Bangladesh to rethink about renewable energy – in policy and in action.

Table 10: Evolution of Cost of Different Energy Sources, 2010-2017

	Source of Energy	2010	2017	Change over the period 2010-2017
Price	Solar PV Module			–75%
	Wind Turbine			– 50%
Mean Levelized Cost of Electricity (LCOE) (USD/KWh)	Utility Scale Solar	0.25	0.05	–80%
	Wind	0.12	0.04	–66%
	Coal	0.11	0.10	–9%
	Gas Combined Cycle	0.08	0.06	–25%
Installation Cost / Capital Cost (USD/ KW)	Utility Scale Solar PV	4394 (IRENA)	1388 (IRENA) 1100-1400 (Lazard)	–68%
	Onshore Wind	1843 (IRENA)	1477 (IRENA) 1200-1700 (Lazard)	–20%
	Gas Combined Cycle		700-1300 (Lazard)	

Source: For Price: International Renewable Energy Agency (IRENA), *Renewable Power Generation Costs in 2017*, Abu Dhabi, 2018, p. 4; for LCOE: Lazard's 2017 Levelized Cost of Electricity Analysis; for Installation Cost/Capital Cost: IRENA, *Renewable Power Generation Costs in 2017* and Lazard, Levelized Cost of Energy Analysis Version 11.0.

[53] Ibid.

[54] Power System Master Plan 2016, p. 56.

Table 11 presents new estimates on potential of renewable energy in Bangladesh collected by the authors from different sources mentioned in previous sections. The Table shows that the new estimates calculate the renewable energy potential of Bangladesh to be 7,487-8,487MW compared to 3,666MW mentioned in PSMP 2016. In fact, the potential would be even higher if the following facts are taken into account.

- Potential of solar park and solar irrigation mentioned in the Table are estimated to be achieved by 2025 and 2020 respectively. Total potential is expected to be higher.

- The estimated potential of 7,487-8,487MW does not include potential of floating solar and off-shore wind energy, in which Bangladesh is expected to have good potential but no feasibility study have been conducted yet.

- Renewable energy technology is advancing rapidly. For example, over the last five years, efficiency of solar panel has increased from 18 per cent to 24 per cent.[55] In other words, five years ago, in 1 M^2 area, solar panel could produce 180 Watt; at present in the same 1 M^2 area, it is possible to produce 240 Watt. It implies that in the area which will come under solar power generation in the coming years, it will be possible to produce more solar power in future than it is estimated today. Putting simply, with technological advancement, solar power potential will be higher than estimated today. Same can be said about wind and other sources of renewable energy.

Table 11 thus suggests that with technological development at global level and completion of some important resource mapping and feasibility studies at national level Bangladesh can now hope for generating more power from renewables than is suggested by PSMP 2016. Therefore, the policy makers may consider revising the potential of renewable energy upward and making relevant changes in the Master Plan.

[55] "Understanding solar panel efficiency", available at http://businessfeed.sunpower.com/articles/understanding-solar-panel-efficiency, accessed on 17 April 2018.

Table 11: Renewable Energy Potential of Bangladesh Mentioned in PSMP 2016 vis-à-vis New Estimate of Potential					
Technology	**Resource**	**Potential mentioned in PSMP 2016 (MW)**	**Present status (completed + contact signed + proposal accepted) (MW)**	**New estimate of potential (MW) and source**	**Source of difference between the two estimates**
Solar Park	Solar	1,400	1898.4	3000-3500 (by 2025) Source: Interview with solar expert	Technological advancement (increasing efficiency and falling price), increased government support
Solar Rooftop	Solar	635	42.8	1000-1500 Source: Interview with BPDB and SREDA personnel and solar expert.	Increased grid connection, technological advancement, increased government support
Solar Home Systems (SHS)	Solar	100	218.3	218.3	
Solar Irrigation	Solar	545	20	150 (by 2020) Source: SREDA Website	
Mini-grid, micro-grid	Hybrid	3	6.9	6.9	
Total Solar		**2683**	**2186.4**	**4375.2 – 5375.2**	

Table 11: Renewable Energy Potential of Bangladesh Mentioned in PSMP 2016 vis-à-vis New Estimate of Potential (Continued)

Technology	Resource	Potential mentioned in PSMP 2016 (MW)	Present status (completed + contact signed + proposal accepted) (MW)	New estimate of potential (MW) and source	Source of difference between the two estimates
Wind Park	Wind	637	72.9	3000 Source: WRMP Study, Interview of WRMP Study Team	Completion of Wind Resource Mapping Project
Biomass Generation	Rice Husk	275	0.4	0.4	
Biogas Generation	Animal Waste	10	0.6	0.6	
Waste to energy	Municipal Waste	1	1	111 Source: Interview with biogas expert, GIZ study	Completion of feasibility study
Small Hydropower plants	Hydro-power	60	0	-	
Total Renewable		**3,666**	**2261.3**	**7,487.2-8,487**	

Source: PSMP 2016 and authors' calculation from studies and other sources mentioned in the article.

7.3 *Renewable Energy Policy 2009: An Evaluation*

Experts are of the opinion that Renewable Energy Policy 2009 needs major improvement. At present state, the policy is nothing but the declaration of achieving 10 per cent electricity from renewables along with a few suggestions about how to encourage renewable energy sector. However, one of the major recommendations of the policy, namely formation of SREDA has been materialized and the latter has been contributing significantly in the development of renewable energy sector.

The policy, however, needs to be more detailed. For example:

- The policy should clearly state the target for each source of energy. If it declares to achieve 10 per cent or 2000MW power from renewable energy, it must also break down the contribution of all renewable energy sources (like solar, wind, biogas, waste to energy etc) in this 2000MW.

- The policy should indicate which sources should get priority and to develop those sources what should be the line of action to develop them over short, medium and long term.

- It should elaborately state how the government would encourage various sources of renewable energy.

- It should recommend how Bangladesh can develop expertise in renewable energy sector.

- It should provide a list of rules and regulations which are yet to be made to meet the target of renewable energy.

It, therefore, can be concluded that Bangladesh needs to revisit its policies regarding renewable energy. It need not revise its renewable energy target downward; rather, if the country is on the right track, it might need to revise the renewable energy target upward in not so far future. Due to some developments at global and national level, policy makers may consider revising the potential of renewable energy upward and making relevant changes in the Master Plan. Finally, Renewable Energy Policy 2009 should go through major development.

8. Conclusion

In recent days, renewable energy has become the driving force of global energy sector. Following the global trend, Bangladesh has also declared the target of achieving 10 per cent of its power generation from renewables by 2020. For achieving the renewable energy target, Bangladesh has been

emphasizing mainly on solar and wind; success, however, has come from solar only. Bangladesh has made commendable progress in case of Solar Home System (SHS) and ranked first in the world in this regard. After successfully passing this off-grid stage, the country is now looking to success in on-grid solar energy through net metering of solar roof top panels, establishment of solar park and utility scale PV power plants. To date, 57MW of on grid solar power has been installed, contacts have been signed for 553MW and proposal for another 1323MW have been approved. No progress could be made in wind energy due to lack of wind resource mapping data.

The fact that hitherto the country could generate only 2.95 per cent of its total electricity from renewables might seem discouraging. A closer examination of the context, performance, potentials and challenges of Bangladesh's renewable energy sector reveals that there is no reason to be discouraged, rather there are several reasons to be optimistic. Firstly, although the target was declared in 2009, the country started taking significant steps to enhance its renewable capacity only very recently. It is appreciable that the country has been able to increase it renewable capacity by 28 per cent in less than two years after its declaration of year-wise goals in renewable energy sector in 2016. Secondly, although the capacity of completed projects is 556MW only, solar projects of a considerable capacity (1876MW) are on pipeline. If these projects can be materialized solving their challenges, particularly regarding land management, Bangladesh can soon meet the target or 2000MW renewable power from solar only. Thirdly, the country has started the process of resource mapping, the most important task in enhancing renewable capacity. These resource mapping and feasibility studies are opening new windows for Bangladesh's renewable energy sector.

Recently completed WRMP study has opened a new horizon in Bangladesh's energy sector. Knowing that there is huge wind energy potential, Bangladesh is looking to unlock this potential and has started its preparation thereby. Indeed, materializing the wind potential in the areas identified by the WRMP study should be a priority of energy sector of Bangladesh. To enhance its solar power capacity, Bangladesh is trying to solve the land management problem in a number of ways. Besides, net metering and solar irrigation are emphasized. Feasibility study on waste to energy has also been conducted and found good potential.

Bangladesh need not revise its renewable energy target downward; rather, if the country is on the right track, it might need to revise the renewable energy target upward in not so far future. It is shown that with technological advancement at global level and increased preparedness at national level (which includes resource mapping, formulation of various rules and regulation

and growing expertise), the country can now hope to generate more renewable power than is suggested by PSMP 2016. Therefore, the policy makers may consider revising the potential of renewable energy upward and making relevant changes in the Master Plan. Finally, Renewable Energy Policy 2009 should go through major development.