Netherlands Enterprise Agency

Baseline Study Wind Energy Bangladesh

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WIND ENERGY POTENTIAL BANGLADESH

Baseline Study

FINAL DOCUMENT

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1 INTRODUCTION

1.1 Scope of report

On behalf of the Netherlands Embassy in Dhaka, Bangladesh, Netherlands Enterprise Agency (RVO) requested Wind Minds to perform a baseline study in order to gain knowledge on the (potential) wind energy sector in Bangladesh. This study is commissioned by The Ministry of Foreign Affairs. The study could not have been done without the outstanding assistance of both the Embassy of Bangladesh in The Hague, as the Embassy of the Netherlands in Dhaka.

The Netherlands is a frontrunner in the technical development of wind energy. Since the 1980's manufacturers and turbine and blade designers developed cutting edge wind turbine technology. Also the expertise of project development and implementing wind energy in densely populated areas was growing. The current developments in offshore wind energy in the Netherlands show a leading position in planning, procurement and stakeholder management, as well as the ability to enhance the reduction of the costs of wind energy.

This baseline study explores the opportunities of wind energy in Bangladesh in general and possibilities of collaboration between the Netherlands and Bangladesh with regards to onshore and offshore wind energy projects. The report will conclude with concrete recommendations to exploit the identified opportunities.

1.2 Aim of the report

The aim of the baseline study is to understand what business opportunities exist to provide services, knowledge, to export technology and materials and to invest in the Bangladeshi wind energy sector, as well as to examine the interest of the Netherlands Wind Energy sector to develop a sustainable wind energy sector in Bangladesh.

To gain understanding of business opportunities this baseline study examines the following aspects:

1. The current Bangladeshi (renewable) energy market (chapter 2)
   - Energy (electricity) supply and demand
   - Grid connection and grid stability
   - Current energy generation projects (fossil and renewable)
   - Governmental policy on renewable energy and wind energy

2. Potential of wind energy in Bangladesh (chapter 3)
   - Wind resources
   - Available space for windfarms
   - Accessibility of the terrain

3. Business opportunities of wind energy (chapter 4)
   - Conclusions on energy market and policy (chapter 1) and wind energy potential (chapter 2)
   - Cost of wind energy and energy pricing
   - Financial resources to finance a windfarm project
   - Administrative and technical support

- Short SWOT-analysis

4. Conclusions (chapter 5)
   - Business opportunities to provide / export services, knowledge, technology and materials
   - Interest of Dutch wind sector in contributing to a sustainable wind energy sector in Bangladesh

Relevant background information is contained in appendices.

Both desk and field study have been conducted in the Netherlands and Bangladesh. In Bangladesh, interviews have been held with representatives of universities and companies, as well as with national government officials. An overview of the interviewed parties can be found in appendix A.

1.3 Introduction to Bangladesh in general

The People's Republic of Bangladesh is a developing country in the Bay of Bengal in South Asia, surrounded by India and Myanmar. Three large rivers run through this country; the Ganges, the Brahmaputra and the Meghna, together forming the Bengal Delta. With over 170 million inhabitants and a total surface of 147,570km^2, Bangladesh is one of the most densely populated countries in the world with the two largest cities being the capital Dhaka and the harbour city of Chittagong.

1.3.1 Development status

Bangladesh is an upcoming development country, but still classified by the UN as a 'Least Developed Country'. The World Bank describes Bangladesh in an overview as 'the country has maintained an impressive track record on growth and development. In the past decade, the economy has grown at nearly 6 percent per year, and human development went hand-in-hand with economic growth. Poverty dropped by nearly a third, coupled with increased life expectancy, literacy, and per capita food intake. More than 15 million Bangladeshis have moved out of poverty since 1992. While poverty reduction in both urban and rural areas has been remarkable, the absolute number of people living below the poverty line remains significant. Despite the strong track record, around 47 million people are still below the poverty line, and improving access to quality services for this vulnerable group is a priority. There are also many people who could fall back into poverty if they lose their jobs or are affected by natural disasters. (…) Sustained growth in recent years has generated higher demand for electricity, transport, and telecommunication services, and contributed to widening infrastructure deficits. While the population growth rate has declined, the labour force is growing rapidly' (World Bank, 2016)

Bangladesh is aiming to become a middle-income country by 2021. This will require an annual growth rate of 7,5% to 8% per year. For this several efforts need to be undertaken, focussing on macroeconomic stability, tackling energy and infrastructure deficits, deepening the financial-sector and external trade reforms.

1.4 Dutch – Bangladeshi relations

Current international cooperation focusses mainly on water management. The Dutch government and experts from private entities make an extensive contribution to the development and organisation of the Bangladesh Delta Plan 2100.

The overall trade relations between the Netherlands and Bangladesh range from agricultural related products, textiles to industrial products and services. Next to this, the Harbour of Rotterdam takes a crucial role in distributing the export through the European Union. Annual growth in the value of imports and exports between the two countries is substantial with 14% over the past five years. In 2015 the Netherlands was one of the top five investors in Bangladesh.

2 ENERGY MARKET

2.1 Energy (electricity) supply and demand

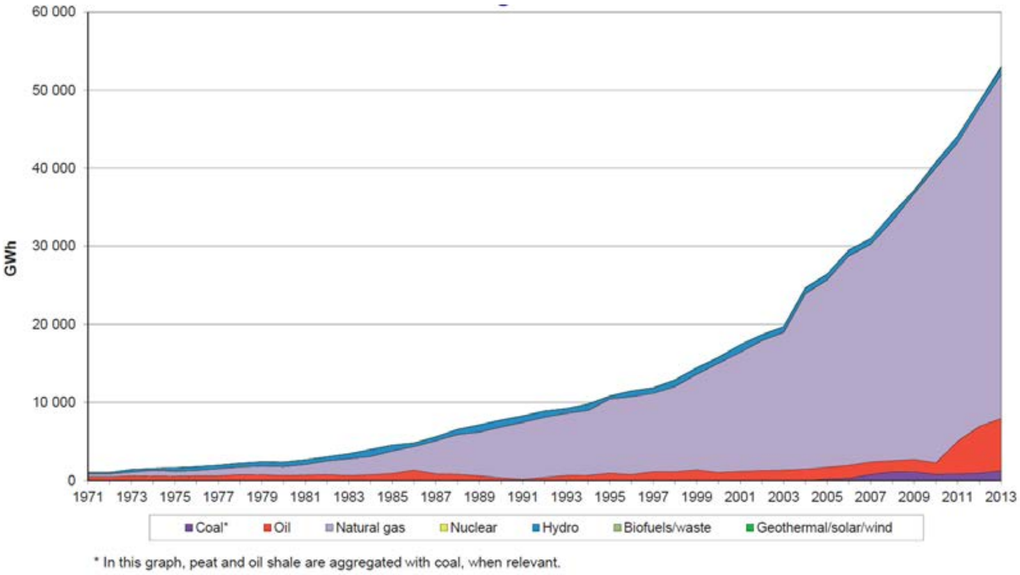
Energy peak demand in Bangladesh is increasing rapidly (more than 10% average over the last 7 years) and energy production cannot keep up with this demand, as shown in table 2.1.

Table 2.1 Peak demand and peak generation 2008 – 2014[1]

	2008	2009	2010	2011	2012	2013	2014
Peak demand (MW)	5.569	6.066	6.454	6.765	7.518	9.268	10.283
Peak generation (MW)	4.036	4.296	4.698	5.174	6.350	7.356	7.817

The primary electricity generation increased rapidly as can be seen in figure 2.1, with natural gas and coal consumption growing at the fastest rates. The amount of natural gas is not enough to support the present energy demand. Moreover, this demand is constantly increasing. To meet actual demand, the Government of Bangladesh (GoB) has established quick rental projects which are mainly dependent on diesel and furnace oil. Besides these fossil resources, there is a small amount of hydroelectric power source in Kaptai (see figure 2.1).

Figure 2.1 Energy generation by source in Bangladesh in 2013 (source: EIA).



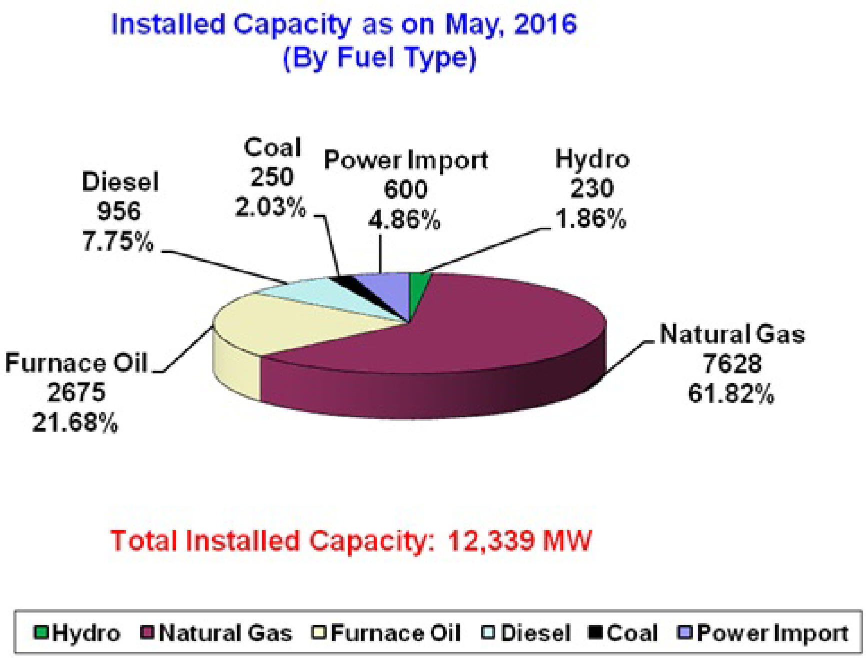
[1] Annual report Bangladesh Power Development Board

The energy sector in Bangladesh is inflicted with several problems such as shortage of natural gas and diesel, unreliable old energy plants and an increasing number of population and energy demand.

It is a major challenge for the government to cope with the yearly approx.. 7% increase of energy demand, while there already is an energy deficit. Table 2.1 shows the demand and production over the period of 2008 to 2014. As it shows, there is a constant deficit in maximum peak in demand and maximum peak in generation. This results in periodic energy fallouts throughout the country.

The installed capacity (as on May 2016) and share per fuel basis is shown in figure 2.2. Bangladesh has been able to fully exploit the natural gas reserves. Nearly two-third of its energy supply depends on natural gas. As can be seen in figure 2.2, renewable energy (hydro) takes up a very small share in total present energy generation.

Figure 2.2 Installed energy capacity in Bangladesh (Source: www.bpdb.gov.bd)



2.1.1 Grid connection and grid stability

There are more than 87,319 villages in Bangladesh, and most of them are not connected to the national grid. Grid connection is rapidly developing as is the national grid itself. GoB has set a target for nationwide electricity access of 90 percent by 2018. The discrepancy between demand and supply and the at some points outdated grid infrastructure lead to problems with grid stability. Appendix B comprises more information about the national grid and the energy market.

2.2 Current energy generation projects

GoB has set a target to generate 24,000 mw electricity by 2021. With this goal the GoB has to increase the number of power plants, transmission lines and distribution lines. In reaching this target, GoB will concentrate on building big base-load power plants to generate electricity from coal as it eyes producing 50 percent of the total electricity from coal. Just recently a Bangladesh-Singapore joint venture signed a number of agreements with different parties to set up a 414MW power plant in Sirajganj. The development and exploitation of this duel-fuel power plant is the first public-private partnership project in the energy sector and is expected to be fully operational in 2018. Besides coal-based power plants GoB has plans to establish a Nuclear power plant in cooperation with Russia that could deliver know-how and training of staff.

2.2.1 Renewable energy projects: wind and solar

GoB is planning to take up more large-scale renewable energy projects, however only small scale grid-connected renewable energy projects are operational or planned for in the near future.

Bangladesh began its first wind power project in 2005. There are two wind power generation projects in Bangladesh, the Muhuri Dam wind power project and the project in Kutubdia Island. Muhuri Dam Project is the first grid-connected wind plant in Bangladesh. The estimated annual production from this 4×225 kW wind plant is about 2 GWh (for an equivalent of 2,500 hours of full load/year). Kutubdia Island is Bangladesh’s other wind battery hybrid project located in Chittagong. It produces 50×20 kW with estimated annual production of 2 Gwh (for an equivalent of 2,500 hours of full load/year).

Ongoing Projects

- Steps have been taken to install a 15 MW Wind Power Plant across the coastal regions of Bangladesh after 1 year Wind Resources Assessment in Muhuri Dam Area of Feni, Mognamaghat of Cox’sbazar, Parky Beach of Anwara in Chittagong, Kepupara of Borguna and Kuakata of Patuakhali. Wind Mapping is going on at Muhuri Dam area of Feni and at Mognamaghat of Cox’s bazar by Regen Powertech Ltd. of India.
- Installation of Wind Monitoring Stations at Inani Beach of Cox's bazar, Parky Beach of Anwara, Sitakundu of Chittagong and at Chandpur under USAID TA project is underway.
- 7.5 MW off Grid Wind-Solar Hybrid System with HFO/Diesel Based Engine Driven Generator in Hatiya Island, Noakhali.

Projects under Planning

The following statements were found at www.bpdp.gov.bd. Further information on scope, planning and actual status is absent.

- BPDB has planned to implement 50-200 MW Wind Power Project at Parky Beach area, Anawara in Chittagong on IPP basis.
- BPDB has also planned to expand onshore wind power plants along the coastline of coastal regions of Bangladesh.

In interviews held in Dhaka, August 2016, it became clear that no large scale wind energy projects are on their way at the moment. Some projects have been started up but have been cancelled due to a lack of mutual understanding between government and developer on the power purchase agreement (PPA).

2.2.2 Pricing of energy in Bangladesh

The pricing of energy is subjected to several factors, amongst which are governmental financial subsidies. GoB has repeatedly expressed its strong desire to rationalise fuel prices and reduce subsidies, in order to promote an efficient and sustainable development process. The implementation of the policy has not been smooth. These price adjustments to energy products in Bangladesh are done by the Bangladesh Energy Regulatory Commission and it does so mostly on an ad hoc basis.

Energy pricing reform is needed for attracting investments in energy in Bangladesh. Bangladesh's electricity market is a vertically integrated natural monopoly in the public sector. The electricity pricing policy is politically sensitive because prices are administered while the providers are public monopolies. The government has taken initiatives to involve private enterprises in the energy sector and has planned to mobilize private and joint venture investment during the Seventh Five Year Plan period (2015/16 – 2019/20). One of the most critical challenges is to diversify the energy-mix for electricity generation.

At the moment electricity prices are relatively low. GoB is spending more than 4 percent of its GDP on energy subsidies more than it spends on health and social welfare programs. Proper pricing of primary fuel and energy is crucial to conserve energy and to attract domestic and foreign private investments in the energy sector. Since the cost of electricity production is expected to rise in the near future due to the installation of high-cost, liquid-fuel-based plants, it is prudent for the Bangladesh Energy Regulatory Commission to gradually raise power tariffs. Similarly, the prices of other fossil fuels should follow actual costs of imports in order to keep subsidies within acceptable fiscal limits.

Tariffs

The tariffs were fixed between 2009 and September 2015 - except the tariff for compressed natural gas (CNG) for automotive use. The 2015 tariff increase was an encouraging step, but it did not affect fertilizer and power plants, which account for nearly half of the total gas consumption, as these end-user continue to pay a mere US$1 per thousand cubic feet (mcf). Energy pricing policy needs to be reformed to encourage efficiency in production and use of primary energy.

2.3 Governmental policy on renewable energy and wind energy

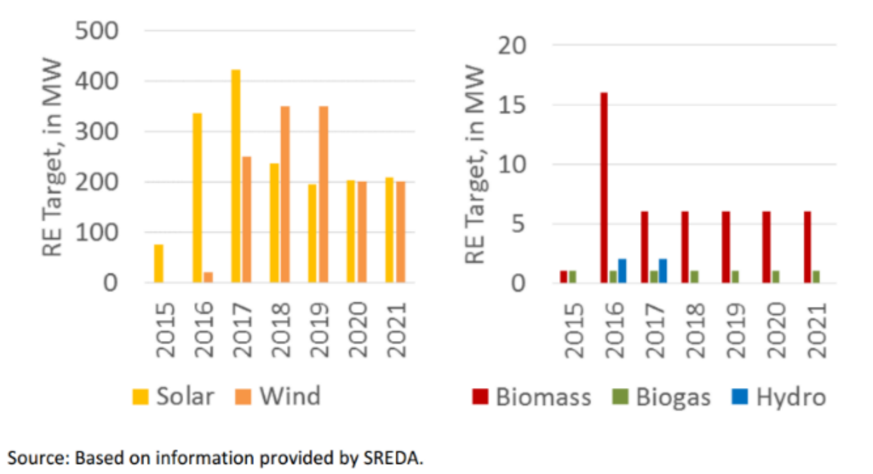
Becoming more and more aware of the necessity of renewable energy to diminish the amount of greenhouse gasses, Bangladesh has set certain renewable energy goals. These renewable energy targets can be realised using biomass, solar and wind energy. Hydropower does not have much potential because no large height differences are present in the country. Because the available land should be mainly utilized for food production, large scale production of biomass is not possible.

Bangladesh claims to have a substantial technical potential for renewable energy generation. GoB states in its Investment Plan for Scaling up Renewable Energy Program (SREP) that Bangladesh could realize over 6,000 GWh of generation from renewable technologies annually, of which a 1250 GWh can be generated from wind resources (SREDA, 2015).

Nonetheless, at the moment renewable energy remains a small portion of Bangladesh's generation portfolio. Installed renewable energy generation capacity is currently 437 MW, with the 230 MW Kaptai Hydro powerplant being the only grid-connected renewable resource. The remaining MWs include off-grid installations and rooftop solar providing site-specific service.

GoB has set renewable energy development targets for several technologies for each year from 2015 to 2021, the "RE Development Targets". These targets require an additional 3,100 MW of renewable energy capacity to be installed by 2021. Most of the new capacity should be provided by solar (1,676 MW, or 54 percent) and wind (1,370 MW, or 44 percent). There are also targets for biomass (47 MW), biogas (7 MW) and hydroelectricity (4 MW). Figure 2.6 shows the RE development targets for each technology from 2015 to 2021.

Figure 2.6 RE Development Targets per source (edited by SREDA)



The targets can be seen as 'challenging'. The targets, especially for wind energy, have proven to be not feasible looking at the figures for 2016 and 2018. The potential of wind energy is further discussed in chapter 3.

2.4 (International) financial instruments and funding

There are several national and international institutions that provide financial services or funding for developments in the energy sector in Bangladesh, focussing on renewable energy. The Bangladesh Bank Refinancing Scheme for Renewable Energy is a revolving refinancing mechanism that provides loans at low interest for renewable energy and energy efficiency projects such as biogas, solar, bio-fertilizer plants, SHS, solar irrigation pumps and wind turbines. The maximum amount of loans for wind turbines is however not enough to finance a modern large wind turbine (costs per turbine of several million US$). Domestic and foreign commercial banks have been the leading participants. In 2014, Domestic commercial banks lent US$ 287.57 million to finance renewable energy projects, 90 percent of the total amount disbursed by the revolving scheme. Foreign commercial banks lent US$ 8.05 million to finance projects, 3 percent of the total amount disbursed by the revolving scheme.

World Bank

The World Bank is actively involved in both energy policy developments as actual development of power plants. The World Bank has supported public-private partnerships to build the Haripur and Meghnaghat power plants. Most grants are being implemented through the Infrastructure Development Company Limited (IDCOL). World Bank is not financing private projects but is focussed on facilitating national governments in reaching their policy goals.

Asian Development Bank

The Asian Development Bank (ADB) has been supporting Bangladesh since 1973. In recent years, the ADB development efforts have also focussed on energy security. A total amount of $4,170.13 million was allocated to energy related projects, being 22,9% of the total investments of the ADB in Bangladesh. ADB states also that for future projects, it will provide assistance for large-scale, transformational infrastructure projects, especially in transport and energy. Specific individual projects are supported via the national government.

Climate Investment Fund

The Climate Investment Fund (CIF) allocated US$110 million in grants (45%) and near-zero interest credits (55%) from the Pilot Program for Climate Resilience (PPCR) to Bangladesh. This will enable Bangladesh government to make strategic investments in critical areas of climate resilience planning and implementation in a manner consistent with its poverty reduction and sustainable development objectives.

SREP (Scaling up Renewable Energy Program)

The SREP in Low Income Countries Program is a funding window of the CIF which aims to empower transformation in developing countries by demonstrating the economic, social, and environmental viability of renewable energy. Total amount of the fund is €728 million, of which $194 million (25% of SREP funding) is approved and under implementation and expecting $1.2 billion in co-financing from other sources. The SREP employs a programmatic approach that builds off of national policies and existing energy initiatives. It is attracting attention from investors, as well as other developing countries. Bangladesh submitted their investment plan of $75 million, which was endorsed in 2015 and is awaiting further allocation.

2.4.1 Current private sector activity

There has been growing private sector activity in off-grid renewable energy technologies for electricity generation. The bio gas which is produced is used as cooking fuel or for power generation. Recently, Purobi Green Energy Limited (PGEL) and Prokaushali Sangsad Limited (PSL) invested and installed the country's first solar minigrid on Sandwip Island. Purobi Green Energy Limited funded 20 percent of the total project costs, while the remaining amount was financed through a grant and loan from IDCOL. The minigrid is the first utility of its kind in Bangladesh and has a capacity of 100kW, and a 40kW back up diesel generator.

There is also some private sector participation in the renewable energy generation investment. Parasol Energy, a subsidiary of the poultry conglomerate Paragon Group, has proposed to build a solar park on one of its poultry farms. As far as known, no wind energy projects of any importance are set up by the private sector at the moment.

3 WIND ENERGY POTENTIAL OF BANGLADESH

3.1 Wind resources

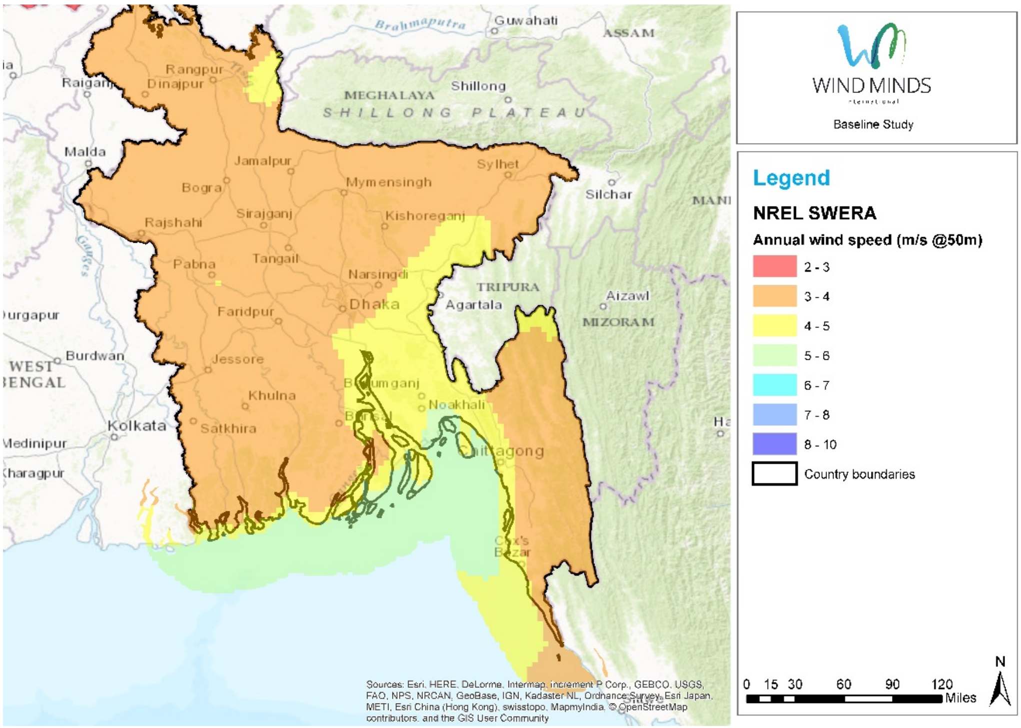
With its sub-tropical climate, with monsoon and typhoon seasons, Bangladesh is confronted with large amounts of rainfall and periodically high wind speeds (gusts) during typhoon season. The mean annual wind speeds in Bangladesh are not well documented and few data is available. The readily available data shows that low wind speeds predominate on the Bangladeshi lands. Next to onshore wind speeds, no (extensive) data is readily available concerning (far) offshore wind speeds.

The ‘Solar and Wind Energy Resources Assessment’ initiative also calculated the annual wind speeds in Bangladesh, this at a height of 50 meter. The data is shown in figure 3.1. The maximum annual onshore wind speeds at 50 meters in Bangladesh do not outreach 5 meters per second, and 6 meter per second for offshore wind. These can be considered as low wind resources. During the typhoon season however, there can be wind gusts with speeds well over 35 meters per second (>126 km/h).

The international program Enhancing Capacity for Low-Emission Development Strategy (EC-LEDS) is part of the USAID LEAD program, which supports and complements the US Government's Enhancing Capacity for Low Emission Development Strategies (EC-LEDS) initiative. EC-LEDS supports developing countries’ efforts to pursue long-term, transformative development and accelerate sustainable, climate-resilient economic growth while slowing the growth of greenhouse gas emissions. Through this initiative, a current operational wind mapping project is funded. This project consists of 9 sites where a two year wind speed metering programme is in progress at heights between 20 and 200 meters (with a metmast at 20, 40, 60 and 80 metres and two SODAR’s up to 200 meters). See appendix F for a short description of the program. The preliminary results of the measurement campaign are still under embargo with the Ministry of Power. Final results of the measurement campaign are expected to become public in 2018. In appendix D a rough map of the wind resources of Bangladesh is included to give an impression of the wind climate.

Also Vestas, a Danish wind turbine manufacturer, has been performing wind monitoring and site assessments in Bangladesh; these results are not made public.

Figure 3.1 Annual wind speeds in Bangladesh (source: NREL, 2007)



3.2 Available space for windfarms

3.2.1 Onshore

Bangladesh is a densely populated country and being situated in the Bengal Delta, which makes large areas not usable for most activities, results in land being a scarce commodity. Figure 3.2 shows the land use of Bangladesh. As can be seen (light blue in the map), the vast majority of the country is used for agricultural purposes (maintained by irrigation processes).

Bangladesh consists mainly of flat lands. Three-quarters of the land has no elevation higher than 30 meters. The north and southeast are more elevated, in which the division of Chittagong is the most elevated land of the country (figure 3.3).

Figure 3.2 Land use (GlobCover, 2009)

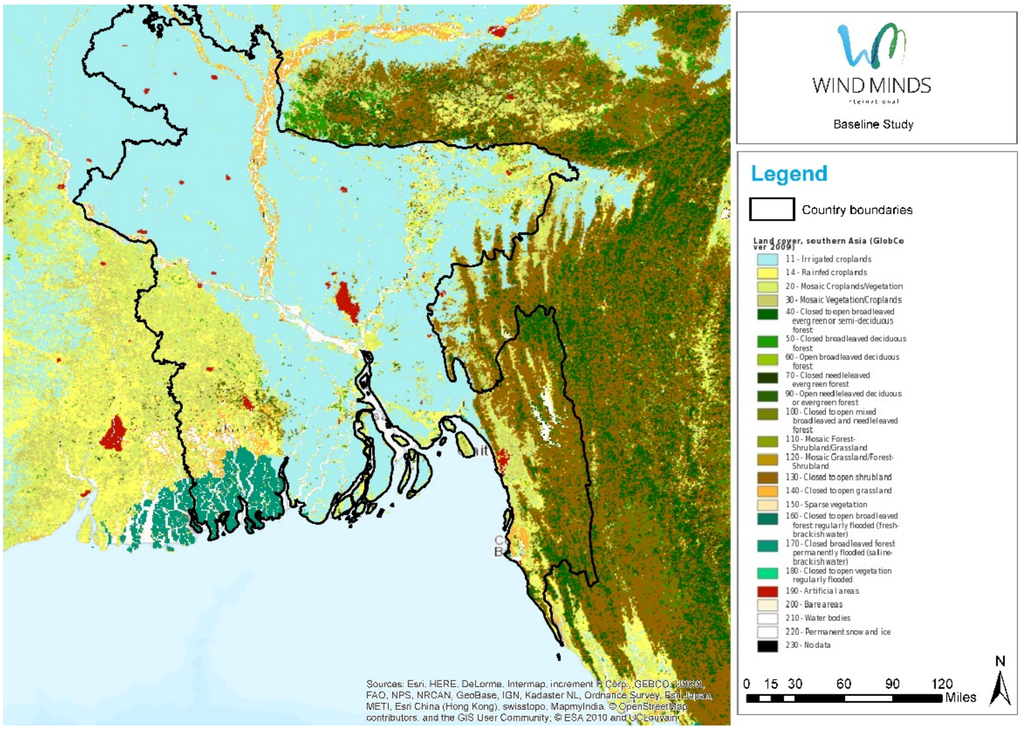
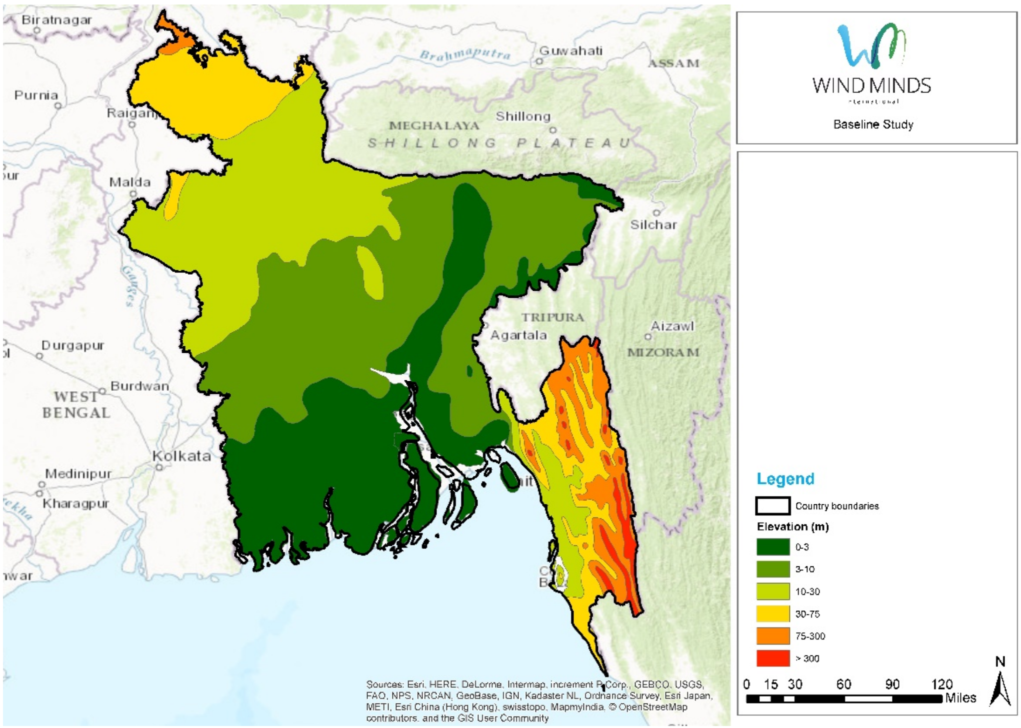


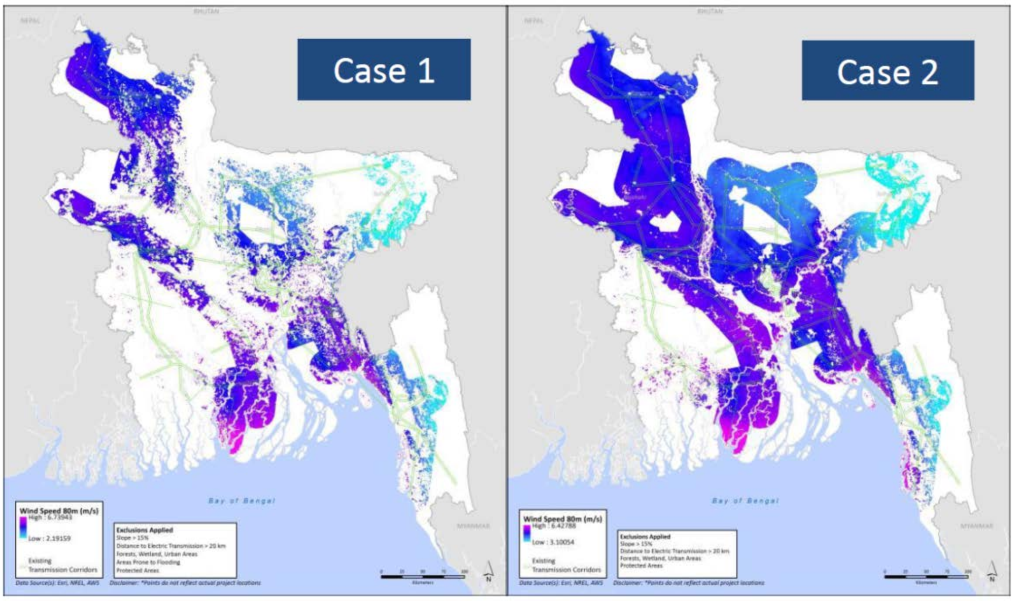
Figure 3.3 Generic land elevation of Bangladesh



Technical site assessment of SREDA

In 2015 an assessment of electricity generating renewable energy technologies was carried out with regards to the Investment Plan for the World Bank 'Scaling up Renewable Energy Program' (SREP). Several potential viable sites were identified and are shown in figure 3.4 Wind data was derived from AWS Truepower Wind Navigator (2015). For a site to be potentially viable it is required to be located within 20 km of a transmission line (see also paragraph 2.2.2). Land not suitable for wind farm installation was excluded from the assessment such as steepness of the land and flooding. Flooding is a concern for wind farms because softening of the soil could compromise the foundation of the turbines. Two cases were developed by combining wind speed data with GIS flood data, showing the resource potential when flood prone land is excluded (Case 1) and when it is included (Case 2).

Figure 3.4 Result of assessment within SREP (Case 1 excl. flood prone land, Case 2 is included)



The resource data is an extrapolation of existing data. Although based on actual measurements, it is not an accurate reproduction of the actual yearly average wind resources. Based on this assessment, and a capacity factor between 20/25% and 25/30%, the following results were presented in the SREP Investment Plan (table 3.1).

Table 3.1 Result of assessment within SREP (Case 1 excl. flood prone land, Case 2 is included)

	Case One		Case Two	
	20-25% Capacity Factor	25-30% Capacity Factor	20-25% Capacity Factor	25-30% Capacity Factor
Buildable MW	624	13	996	37

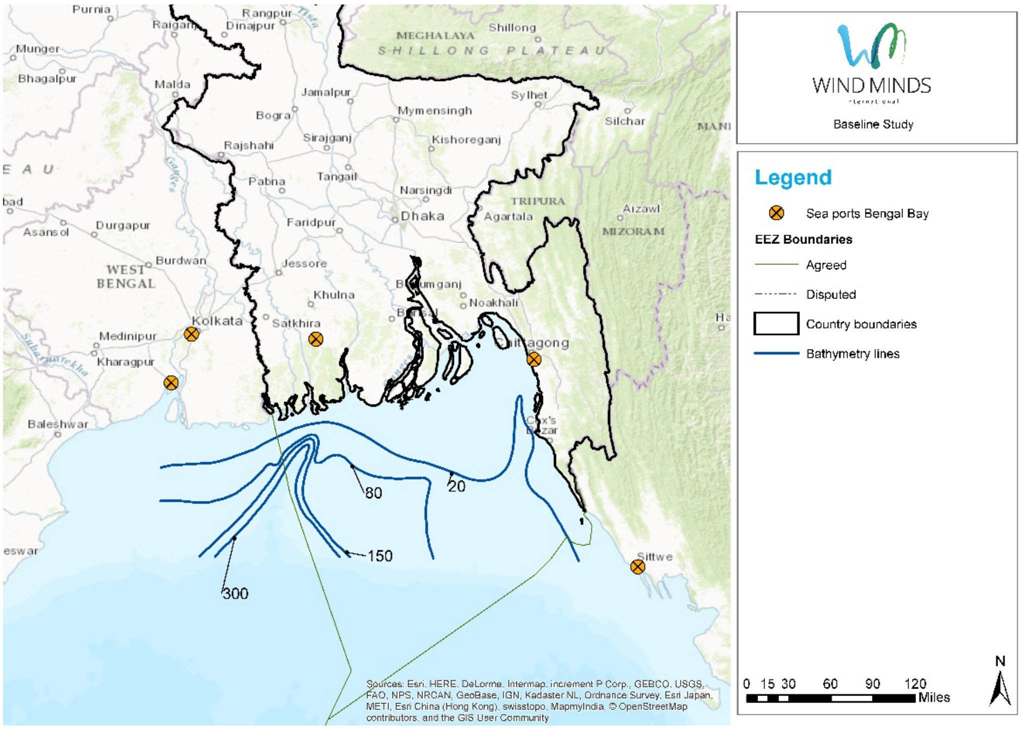
3.2.2 Accessibility of the terrain

Large parts of Bangladesh are not well accessible with large trucks to transport modern wind turbine parts, due to infrastructure limitations. An advantage is however the presence of rivers that might be usable for transportation of heavy and large components.

3.2.3 Offshore

With the active Ganges, the Brahmaputra and the Meghna rivers, fluvial sedimentation processes are current throughout the coastal line, with an exception off of the Chittagong coast. Partly by these processes, the first kilometres from the coast are relatively shallow.
The 20 meter depth line is at its farthest ca. 110 kilometres from the coast of Patuakhali (see figure 3.5). Being fluvial sedimentation, it is anticipated that the soil of the seabed mainly consists of mud and loose sand. Offshore form the Chittagong division, the sedimentation processes seem to be of a lesser strength, but therefore the seabed is deeper, closer to shore. Next to this presumed solid seabed, the harbour of the City of Chittagong is also nearby, which can be a useful base for offshore contractors.

Figure 3.5 Bathymetry lines of Bangladeshi Bengal Bay (source: USGS, 2001)



4 BUSINESS OPPORTUNITIES OF WIND ENERGY

4.1 Wind energy and the energy market

Bangladesh is rapidly developing and by that it has to deal with many challenges typical for developing countries. As discussed in chapter 2 (and appendix B), amongst others the building of an extensive national electricity grid and sufficient power generation is one of these challenges. The demand for electricity is growing rapidly and power generation has difficulties to keep up the pace. At the moment and in the near future power generation is fossil fuel based (coal, natural gas). The development of the national grid is aimed at more stability, enlarging grid access and connecting new (fossil fuel based) power plants.

Grid connection and stability

The power grid of Bangladesh is expanding rapidly. Grid connection of larger wind farms (tens of MW's) is a concern and will need to be considered further for specific locations. Certainly in many remote areas there will be insufficient grid connection capacity available. Also the grid stability is a point of concern. Delivering wind energy is the only source of income for a windfarms, an uninterrupted grid connection is vital. Overseeing this, it can be concluded that in its present status the national grid will not be suitable to connect large scale windfarms. This means that the costs for grid connection of windfarms will be relatively high because of the large distances to nearest suitable national grid connection point (cable costs) and large investments in hard ware (transformer stations, switches, regulators etc.). However connecting eventual future windfarms could be combined with the (already scheduled) development of the national grid in these areas and costs could be ‘socialised’ and not charged at account of the windfarm. Because there is no history or experience in doing so, this has to be sorted out and agreed upon, before the development of a specific windfarm can become concrete.

4.2 Renewable energy targets and wind energy

Becoming more and more aware of the necessity of renewable energy to diminish the amount of greenhouse gasses, Bangladesh has set renewable energy goals. These renewable energy targets can be realised using biomass, solar and wind energy. Hydropower does not have much potential because no large height differences are present in the country. Because the available land should be mainly utilized for food production, large scale production of biomass is not possible. Solar energy has great potential and has had a successful rollout so far. However these solar systems are limited to small-scale generation at household level in areas where no grid connection is available. The big disadvantage of multi-megawatt solar energy plants is that a large area has to be available to establish the PV-panels. This space is hard to find because all the available space in Bangladesh is used for agriculture and food production. Wind energy needs significantly less space and can easily be combined with agriculture and is therefore an interesting option.

GoB has set renewable energy development targets for several technologies for each year from 2015 to 2021, the “RE Development Targets”. These targets require an additional 3,100 MW of renewable energy capacity to be installed by 2021. Most of the new capacity should be provided by solar (1,676 MW, or 54 percent) and wind (1,370 MW, or 44 percent). These targets can be seen as ‘challenging’. The targets, especially for wind energy, have proven to be not feasible looking at the figures for 2016 and 2018.

4.2.1 Small scale wind-solar energy systems

Besides large scale generation of wind energy, the generation of wind energy in a system combining medium scale solar energy, a battery and a mini-grid at the level of a village, could be very interesting as well. Not so much from a commercial perspective, but more from the perspective of providing electricity to people with no or limited grid access and delivering an alternative for the expensive and polluting diesel pumps that are now used widely for irrigation purposes. Because these small-scale systems will be difficult to exploit commercially we will not focus on these type of systems in the present study.

4.3 Wind energy potential

4.3.1 Wind resources

In chapter 3 the potential of using the wind resources of Bangladesh for generating electricity is assessed. The conclusion is that the wind resources are limited. There are no long-term wind assessment studies available based on relevant heights and data with respect to wind energy. An extensive measurement campaign is executed at the moment and results are expected in 2018. Available data (some measurements and satellite data) indicate however that onshore wind speeds are below 5 meters per second average a year. For wind energy purposes this is quite a low wind speed. It will set requirements for turbines such as high hub heights and large rotors. The occasionally tropical storm (typhoon) that hits Bangladesh (wind speeds up to 150-185 km/h) means additional demands on the strength of wind turbines. However, wind turbine manufacturers indicate that under similar conditions wind parks have been realised in other countries.

No measurement data are available on offshore wind speeds, but available satellite data indicates that offshore wind speeds are slightly higher but relatively low as well (approx. 5-6 m/s average).

4.3.2 Available suitable space for wind farms

The pressure on space is high in Bangladesh because of the large number of inhabitants per square kilometre and the mainly agriculture-based economy. However a combination of wind energy and agriculture seems to be possible. Points of attention are the large almost yearly flooded areas. In technical terms wind turbines in these areas are possible but this will come with higher costs. Maintenance and operation will be more difficult in these areas and projects will be more costly because of supplementary technical provisions (foundations, adjusted tower access). Another point of attention with regard to the noise levels of wind farms is the presence of houses/residences close to the wind turbines. This seems insurmountable due to the high population density. Specific legislation in this regard does not exist however.

Offshore limitation in space seems not to be a problem. Interference with shipping traffic is a concern, but this seems soluble considering the practices in the Netherlands (one of the busiest seas in the world in combination with the largest port in Europe and large scale wind farms), but will involve (time consuming) regulation of shipping routes. Offshore soil conditions require further consideration. Water depth is relatively low (a large area has depths up to 20 to 40 metres), however the soil structure (mud, sediment, deeper soil layers) is not yet studied in detail.

4.4 Cost of wind energy and energy pricing

Combining the not very promising wind resources and the expected rather high investments for grid connection, means that wind energy in Bangladesh will be rather expensive. The combination of low average wind speeds and sometimes harsh stormy conditions (typhoons) and floods will require dedicated wind turbine designs, making wind energy even more expensive. This compared to wind energy prices in quite some other countries, and compared to the present fossil fuel based energy prices in Bangladesh, although these prices are kept low with subsidies by the government (see paragraph 2.2.2). On the other hand wind energy needs significantly less space than solar energy, can easily be combined with agriculture and is therefore an interesting option for renewable energy. The economic feasibility of wind energy is therefore a matter of pricing, or maybe better, of amount of available subsidy per kilowatt-hour (kWh) to close the gap between the current market price and the cost price of wind energy. Preliminary contracts reached with developers of 0.12 US $ per kWh have turned out to be not feasible. Only after extensive feasibility study it will be possible to determine a price per kWh which will be location specific. The government of Bangladesh has not yet specified a maximum reimbursement per kWh. Setting up a stable subsidy system with a long term perspective will be crucial to attract investors in wind energy. Such a program is not in development at the moment.

4.5 Financial resources to finance a windfarm project

Besides a steady long term income for wind farms in the form of a price per kWh (for example market price + subsidy) to cover the total costs, financial resources are needed to finance a wind farm. The financial resources and willingness to self-realise large wind farm projects by the government of Bangladesh are expected to be limited. That means that project finance for wind energy projects will be necessary. Another possibility is balance financing wind farm projects by large companies, such as utilities. When a sufficient kWh price can be agreed upon and enough certainty on the realisation and operations of the project can be gained, project finance could be set up with commercial banks combined with contributions from funds of (for example) Asia Development Bank and Climate Investment Fund. Stability and long term certainty with respect to yearly revenues and project execution (see next paragraphs) will be vital for any form of financing, to reach financial close and to keep financing costs reasonable. Despite some funds that are active at the moment in the field of renewable energy, the level of stability is perceived to be limited.

4.6 Administrative and technical support

As mentioned, Bangladesh is classified by the United Nations as a ‘Least developed country’. This means not all aspects are in place to create a stable basis for (international) trade and investments. The Asian Development Bank recently conducted a country performance assessment, in which Bangladesh was ranked fifth place and was clustered with Armenia, Georgia, Mongolia, Pakistan, Sri Lanka, Uzbekistan and Vietnam. This is due to low scores on ‘Trade’, ‘Business regulatory environment’ and ‘Quality of public administration’ (ADB, 2016).

The not entirely transparent system of authorisation and permitting to Western standards can be an obstacle to realise a project. Good and early administrative coordination is essential. Also political support is needed. A positive attitude towards renewable energy projects is increasingly present since the founding of the Sustainable and Renewable Energy Development Authority (SREDA).

Bangladesh has little to no experience with wind energy projects. This is of concern and means that a lot of knowledge and experience has to be brought in from outside of Bangladesh. This offers opportunities for export of specific knowledge and technology, services and materials from countries with a lot of wind energy experience (like the Netherlands[2]). For Bangladesh wind energy projects offer opportunities for technology development, employment and participation by national and local parties (contractors, maintenance technicians et cetera).

4.7 Market potential: SWOT Analysis

Based upon the previous chapters and paragraphs, a SWOT analyses can be performed. The following sub-paragraphs will described the strengths, weaknesses, opportunities and threats of the Bangladeshi market, concerning wind energy developments.

Strength

The high density of its population, alongside with the prosperous economic growth of recent years, can be seen as a strength of the energy market in Bangladesh. Economies of scale can be easily reached, especially given the high energy demand on both short term and long term. Also, the high sense of urgency on the implementation of renewable energy within GoB, the Asian Development Bank and the World Bank can be seen as an asset for the energy market.

Weakness

Given the current available data, wind resources are low in Bangladesh. An average wind speed of ca. 5 meter per second at a height of 80 meters is expected to be standard for onshore locations. Besides these low average wind speeds, many locations also have to deal with occasionally very high wind speeds during typhoons, flooding of land and limited grid connection and stability. The downside of the previous mentioned high density of population, is that (viable) land is a scarce commodity. Also, a limited availability of commercial funding and limited track record on private financing and no local expertise on wind energy developments are of negative influence on the market potential of wind energy in Bangladesh.

Opportunities

The market can be seen as a greenfield development. Several initiatives are starting up, but no large scale development did take place. There is only a small field of competition. Offshore wind

[2] The Dutch Government has some potential funding and financial programs for international business development: see appendix C

shows some potential, off the coast from Chittagong. The Bangladesh Power Development Board intends to tender 100-200 MW offshore wind farm near Chittagong.

Also, off-grid projects show some potential, due to the before mentioned economies of scale and vast agricultural land-use all over Bangladesh (wind energy for irrigation pumps e.g.).

Threats

The current lack of substantial policy incentives for renewable energy (budget for wind energy) and the absence of a comprehensive legal and regulatory framework for renewable energy are of negative influence on the market potential for wind energy. A heard of or perceived threat for trade and market development is corruption, the country status is one of the least developed countries and possible terrorist attacks might occur.

5 SUMMARY AND CONCLUSIONS

5.1 Summary

This study has assessed the possibilities for wind energy in Bangladesh by studying available literature and by consulting people from several organisations and institutions in the Netherlands and Bangladesh. Thought behind this study is that if wind energy has a good potential it might deliver a substantial amount of renewable energy for Bangladesh and promising business opportunities for the extensive Dutch wind energy sector.

As drawn out in the previous chapters, there are several relevant factors in the Bangladeshi energy market when looking at the potential of wind energy. Main factors are the fast growing energy demand, the rapid growth in grid-connected households and the aim of the Government of Bangladesh to install a total capacity of 1.370 MW of wind energy before the year 2022. These factors combined hold a potential for wind energy developments in Bangladesh.

Although the need for renewable energy is felt increasingly in Bangladesh and wind energy can play a role in this, there are some disadvantages. Low wind speeds seem to be the biggest concern at the moment although good insight in average annual wind speeds is still lacking. A wind resource mapping project is in progress at the moment. Other issues are a possible lack of grid connection and flood risks. Finding suitable areas for wind farms is a point of attention because of the density of the population. Political and administrative cooperation is indispensable. If wind resources turn out to be sufficient and sufficient subsidy per kWh comes available and could be granted for a longer term, wind energy projects could be possible, offering opportunities for Dutch companies[3]. Because of the lack of experience with wind energy in Bangladesh, these opportunities lie in the field of providing services and knowledge as well as to export technology and materials to Bangladesh.

5.2 Opportunities for the Netherlands Wind Energy Sector

Last aspect of the study is to examine the opportunities and interest of the Dutch wind sector in contributing to a sustainable wind energy sector in Bangladesh. To the Netherlands' branch organisation Holland Home of Wind Energy the outcomes of this study were presented (on January 19th 2017); see appendix G for the presentation. The audience consisted of several companies operating in the wind energy sector, such as turbine and blade manufacturers, suppliers of various components, developers and consultants. Next paragraphs give a summary of the perceived opportunities on basis of the reactions on that presentation and some discussions afterwards.

5.2.1 Wind resource assessment

One of the first steps for any wind farm project is to obtain insight into the wind resources. This is absolutely vital to be able to determine if wind energy could be a substantial energy source at

[3] Appendix E gives a short overview of the Dutch energy sector

a certain location, what wind turbine is suitable for the specific circumstances and also to be able to calculate the costs per kWh of the produced wind energy.

At the moment an extensive wind resource mapping project is going on (see also paragraph 3.1) measuring wind speeds in several inland locations at heights up to 200 metres. It is advisable to await the outcomes of this wind resource assessment, which are expected in December 2017 (data collection) and April 2018 (data analysis, modelling and preparation of maps). NREL (National Renewable Energy Laboratory, USA) is performing the measurements and analyses. When the outcomes become available the technical and financial feasibility could be determined for specific locations.

For offshore wind energy development a dedicated offshore wind resource assessment should be executed as well. As a first step Offshore wind resources could be assessed more generic on basis of available satellite data to get a more generic impression of the present wind climate. Several Dutch companies are able to perform wind resource assessments or interpret the data from wind measurements.

At the moment some companies in Bangladesh come forward with questions to develop a cooperation in the field of wind power development. These questions anticipate on an expected future development. It may be wise to respond positive to these requests for cooperation to acquire a good market position, ahead of the outcomes of the wind resource assessment. As a first step a pre-feasibility study could be carried out on the potential for wind energy projects in specific locations where the largest wind supply is to be expected.

5.2.2 Opportunities in onshore wind energy

Turbine design

Turbine manufacturers described the turbine that should be available for the Bangladeshi situation. The ideal onshore wind turbine for Bangladesh is a turbine which is cost-efficiently build, light-weighted, reaches high altitudes with a large rotor diameter and a relative small generator to fully use the available winds, and is also resistant to typhoon winds. Such a wind turbine is not a standard product. A opportunity lies therefore in the research and design part of the industry. Logical parties for this opportunity are knowledge institutes (such as TU Delft, ECN), engineering companies and turbine manufacturers (such as Lagerwey, EWT, 2B-Energy).

Small scale pilot project

Considering the lack of experience with wind energy in Bangladesh, starting off with a small scale pilot project with one or a few modern large (multi MW) turbines, seems to be the most logical step ahead. Insight in the wind climate (see paragraph 5.2.1) should be gained first. Followed by a pre-feasibility study, to determine a suitable location and also establish a good picture of all the non-technical issues such as permits, political cooperation and social support. Several Dutch companies could –working together- establish such a pilot project, paying attention to all relevant aspects.

Opportunities in decentralised small scale wind energy systems

The vast majority of land in Bangladesh is used for agriculture which need irrigation. Also, rural areas are mainly not connected to the national grid. Decentralised energy systems can be of great value to provide power for irrigation and households. This shows itself in the success of Solar Home Systems (SHS). However the capacity of such systems is low and therefore not suitable for irrigation purposes. Wind energy – for example in combination with solar - can deliver a higher capacity and could combine in a local grid villages and irrigation systems. Further investigation in potential sites and regions is necessary. Unclear is if these systems could be commercially interesting for Dutch companies. May be funding out of development funds might be a possibility.

Specific Dutch companies that provide small scale wind turbines and even hybrid wind-solar systems showed their interest to look further in this direction.

5.2.3 Opportunities in offshore wind energy

Regarding the prospects of wind resources, offshore wind could be the highest potential in Bangladesh for large scale wind developments. The Government of Bangladesh intends to tender a 100 to 200 MW wind farm east of Chittagong (BPDP, 2016) The actual status and long term prognoses of this project is unclear at the moment. The Government of Bangladesh could learn from the latest developments and experiences in the Netherlands in setting up a tender system. A prerequisite for such a system is an extensive knowledge on wind resources, bathymetry, geo-technical and geo-physical conditions, shipping safety, ecology et cetera. This will require years of study and monitoring. Collaboration in this field could lead to many opportunities for Dutch companies active in offshore wind.

A first step here is also to start wind resource mapping and assessing the feasibility of offshore wind projects. After that a small scale pilot project is a logical follow up. Dutch companies could set up such a wind resource assessment and determine the feasibility of offshore wind energy in Bangladesh.

APPENDICES

APPENDIX A

INTERVIEWED STAKEHOLDERS

In Bangladesh, interviews have been held with representatives of universities and companies, as well as with national government officials. It concerns the following respondents:

Respondents / contacts in Bangladesh and the Netherlands

Institution	Person(s)
Ministry of Power, Energy and Mineral Resources - Power Division	Mr. Mohammad Bazlur Rahman, Joint Secretary (Wind resources mapping)
Ministry of Foreign Affairs	Rear Admiral (Retd).) Md. Khurshed Alam (MAU) and Mr. Mohammad Khorshed Alam Khastagir, DG (Europe division), MoFA
Powercell	Mr. Mohammad Hossain
Asian Development Bank	Paul Hattle
World Bank	Zubair Sadeque
Bangladesh Bank	Mr. Manoj K. Biswas
Bangladesh Solar and Renewable Energy Association (BSREA)	Mr. Dipal C. Barua
UIU (United International University)	Prof.Dr. M Rezwan Khan
BUET (Bangladesh Univeristy of Engineering & Technology)	Dr. Md. Ziaur Rahman Khan
	Dr. Ijaz Hussain (tbd)
	Dr. Mohammad Tamim
SREDA	Mr. Siddique Zobair
Embassy of Bangladesh	Mr. Sheikh Mohammed Belal (Ambassador) and Mr. Kazi Russel Pervez (Counsellor)
Embassy of the Netherlands	Lisette Blüm, Pieter de Vries, Monnujan Kannam

APPENDIX B

ENERGY MARKET OF BANGLADESH

Energy demand and delivery

The energy demand in Bangladesh is increasing rapidly, as shown in table 2.1. The energy sector is mainly dependent on natural gas, found in the eastern zone of Bangladesh.

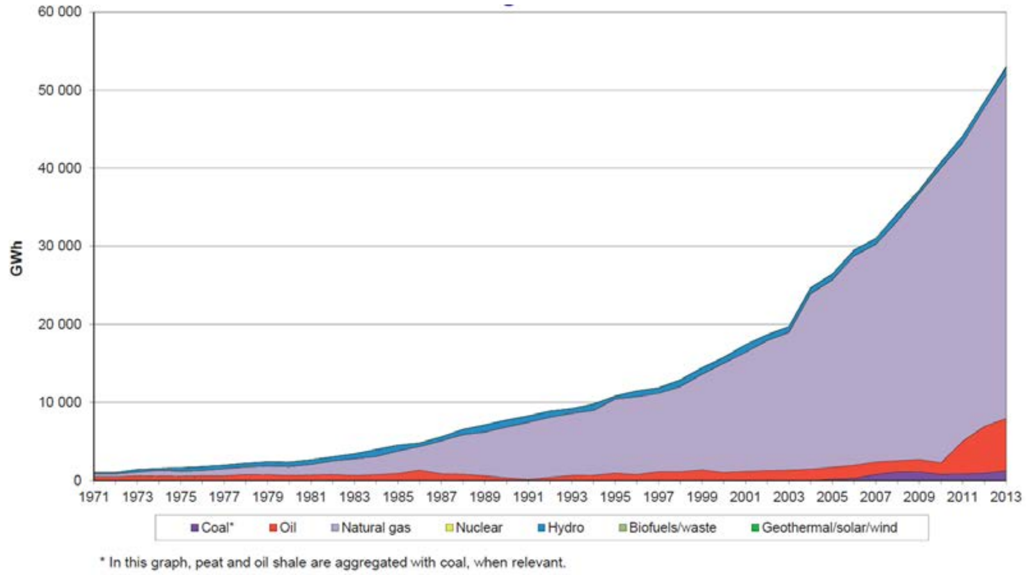
Table 2.1 Peak demand and peak generation 2008 – 2014[4]

	2008	2009	2010	2011	2012	2013	2014
Peak demand (MW)	5.569	6.066	6.454	6.765	7.518	9.268	10.283
Peak generation (MW)	4.036	4.296	4.698	5.174	6.350	7.356	7.817

The primary electricity generation increasing rapidly as can be seen in figure 2.1, with natural gas and coal consumption growing at the fastest rates. The amount of natural gas is not enough to support the present energy demand. Moreover, this demand is constantly increasing. To meet actual demand, the Government of Bangladesh (GoB) has established quick rental projects which are mainly dependent on diesel and furnace oil. Besides these fossil resources, there is a small amount of hydroelectric power source in Kaptai (see figure 2.1).

[4] Annual report Bangladesh Power Development Board

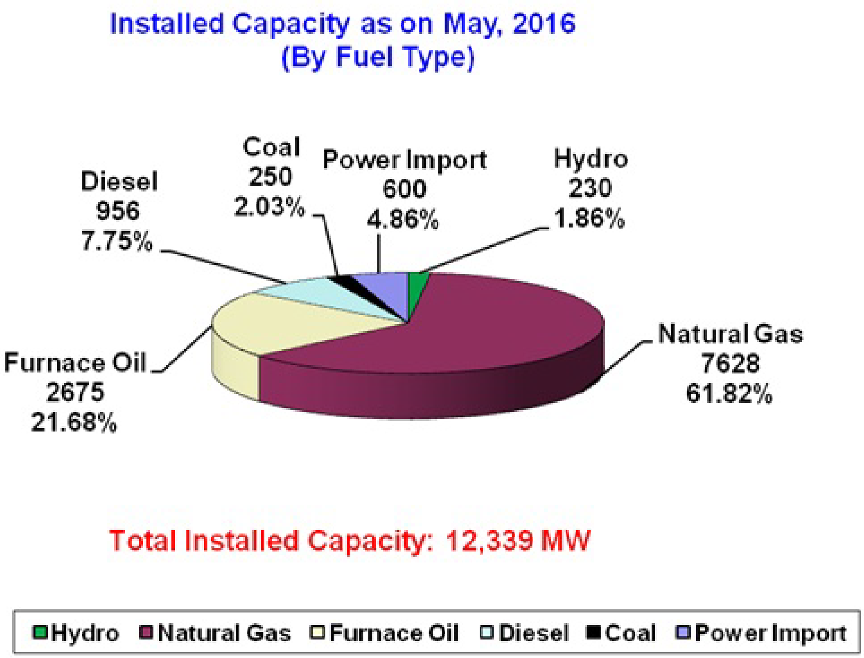
Figure 2.1 Energy generation by source in Bangladesh in 2013 (source: EIA).



The energy sector in Bangladesh is inflicted with several problems such as shortage of natural gas and diesel, unreliable old energy plants and an increasing number of population. There are more than 87,319 villages in Bangladesh, and most of them are not connected to the national grid. It is a major challenge for the government to cope with the 7% increase of energy demand, while there already is an energy deficit. Table 2.1 shows the demand and production over the period of 2008 to 2014. As it shows, there is a constant deficit in maximum peak in demand and maximum peak in generation. This results in periodic energy fallouts throughout the country.

The installed capacity (as on May 2016) and share per fuel basis is shown in figure 2.2. Bangladesh has been able to fully exploit the natural gas reserves. Nearly two-third of its energy supply depends on natural gas.

Figure 2.2 Installed energy capacity in Bangladesh (Source: www.bpdb.gov.bd)



GoB has set a target to generate 24,000 mw electricity by 2021. With this goal the GoB has to increase the number of power plants, transmission lines and distribution lines. In reaching this target, GoB will concentrate on building big base-load power plants to generate electricity from coal as it eyes producing 50 percent of the total electricity from coal. Furthermore, GoB is planning to take up more large-scale renewable energy projects. GoB has also decided to establish three new divisions - coal, renewable and independent energy producer (IPP, as in Independent Power Producer) - to ensure smooth implementation of energy projects.

As can be seen in figure 2.2, renewable energy (hydro) takes up a very small share in total energy generation.

Current energy generation projects

As said GoB will concentrate on building big base-load power plants to generate electricity from coal. Just recently a Bangladesh-Singapore joint venture signed a number of agreements with different parties to set up a 414MW power plant in Sirajganj. The development and exploitation of this duel-fuel power plant is the first public-private partnership project in the energy sector and is expected to be fully operational in 2018.

Besides coal-based power plants GoB has plans to establish a Nuclear power plant in cooperation with Russia that could deliver know-how and training of staff.

Renewable energy projects: wind and solar

Next to fossil and nuclear power generation, small scale grid-connected renewable energy projects are operational or planned for near-future.

Bangladesh began its first wind power project in 2005. There are two wind power generation projects in Bangladesh, the Muhuri Dam wind power project and the project in Kutubdia Island.

Muhuri Dam Project is the first grid-connected wind plant in Bangladesh. The estimated annual production from this 4×225 kW wind plant is about 2 GWh (for an equivalent of 2,500 hours of full load/year). Kutubdia Island is Bangladesh's other wind battery hybrid project located in Chittagong. It produces 50×20 kW with estimated annual production of 2 Gwh (for an equivalent of 2,500 hours of full load/year).

Ongoing Projects

- Steps have been taken to install a 15 MW Wind Power Plant across the coastal regions of Bangladesh after 1 year Wind Resources Assessment in Muhuri Dam Area of Feni, Mognamaghat of Cox'sbazar, Parky Beach of Anwara in Chittagong, Kepupara of Borguna and Kuakata of Patuakhali. Wind Mapping is going on at Muhuri Dam area of Feni and at Mognamaghat of Cox's bazar by Regen Powertech Ltd. of India.
- Installation of Wind Monitoring Stations at Inani Beach of Cox's bazar, Parky Beach of Anwara, Sitakundu of Chittagong and at Chandpur under USAID TA project is underway.
- 7.5 MW off Grid Wind-Solar Hybrid System with HFO/Diesel Based Engine Driven Generator in Hatiya Island, Noakhali.

Projects under Planning

The following statements were found at www.bpdp.gov.bd. Further information on scope, planning and actual status is absent.

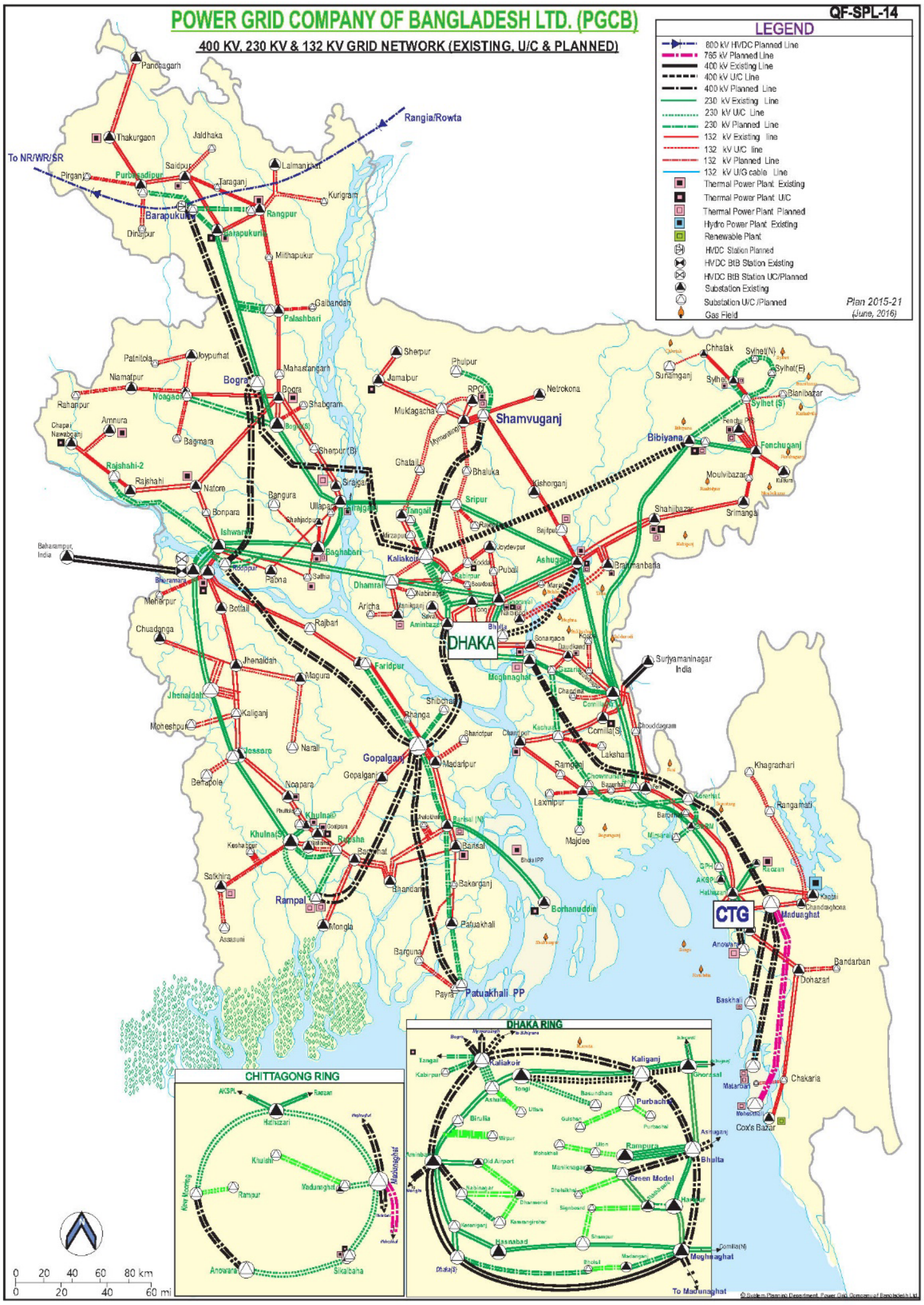
- BPDB has planned to implement 50-200 MW Wind Power Project at Parky Beach area, Anawara in Chittagong on IPP basis.
- BPDB has also planned to expand onshore wind power plants along the coastline of coastal regions of Bangladesh.

In interviews held in Dhaka, August 2016, it became clear that no large scale wind energy projects are on their way at the moment. Some projects have been started up but have been cancelled due to a lack of mutual understanding between government and developer on the power purchase agreement (PPA).

National Grid

The Bangladesh Power Grid Company is responsible for the operation, maintenance and development of the national power grid. Before 2002 the grid was state owned by, amongst others, the Bangladesh Power Development Board.

Figure 2.3 National grid (2015)



Grid development

The World Bank is to finance the Bangladesh Power System Security and Efficiency Improvement Project. The aim of this project is to address some fundamental measures that must be put in place so the energy system can be operated in a secure and economic manner, in line with long term goals to deliver greater quantities of energy throughout the country. The project start is scheduled in 2017 and will take up to 2020. The main objective of the project is to build up necessary infrastructures for reliable transmission of power. The specific objectives are[5]:

1. To construct 100 km 400 kV transmission line.
2. To construct 330.20 km 230 kV transmission line.
3. To construct 334.50 km 132 kV transmission line.
4. To renovate 225 km 132 kV existing transmission line.
5. To construct one 400/132/33 kV substation and extend one existing substation at 400 kV portion.
6. To construct 12 nos. 230/132 kV new substations, to extend 3 nos. of existing substations at 230 kV portion and to upgrade capacity of 7 nos. 230/132 kV existing substations.
7. To construct 28 nos. 132/33 kV new substations, to extend 14 nos. of existing substations at 132 kV portion, to upgrade capacity of 28 nos. 132/33 kV existing substations and to renovate 5 nos. 132/33 kV existing substations.
8. To construct 7 nos. Specialized Engineering Facilities.

Grid connections

Figure 2.4 shows the division of urban and rural population per Bangladeshi Division (dating 2011). Even though rapid urbanisation took place since 2011, most people still live in rural Areas.

Figure 2.4 Population per Bangladeshi division (edited by SREDA)

Division	Population (Millions)	Pop. Density (per km²)	Urban Pop. %	Rural Pop. %
Barisal	8.325	630	16.4%	83.6%
Chittagong	28.423	838	24.3%	75.7%
Dhaka	47.424	1,521	32.9%	67.1%
Khulna	15.687	704	18.0%	82.0%
Rajshahi	18.484	1,018	17.9%	82.1%
Rangpur	15.787	975	13.3%	86.6%
Sylhet	9.910	784	14.8%	85.2%
Total	**144.043**	**976**	**23.3%**	**76.7%**

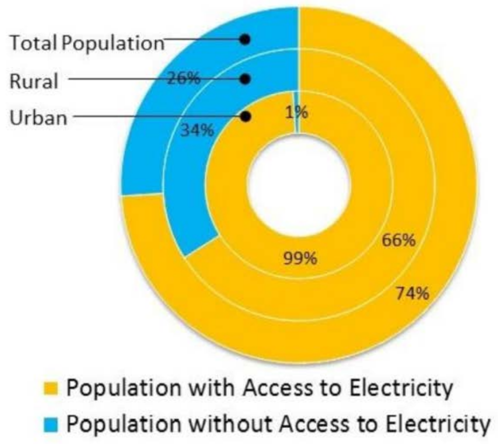
Source: 2011 Census, Bangladesh Bureau of Statistics.

Rapid urbanization is causing the growth in electricity demand, but supply improvements have not been able to keep pace. GoB has set a target for nationwide electricity access of 90 percent by

[5] www.pcgb.org.bd

2018. Nationwide, 74 percent has access to electricity (2015), up from about 20 percent in 1990. Most of the urban population has electricity access (nearly 99 percent). In rural areas electricity access is 66 percent including solar home systems. The Rural Electrification Board (REB) has historically averaged 90,000 new connections per month, but this has increased to nearly 300,000 new connections per month in summer 2015. To achieve the 2018 target, this connection rate has to rise to 450,000 new household connections per month. Figure 2.5 shows electricity access rates for the urban, rural and total population in 2015.

Figure 2.5 Access to electricity in Bangladesh 2015 (edited by SREDA)



Source: World Bank Development Indicators; Power Cell.

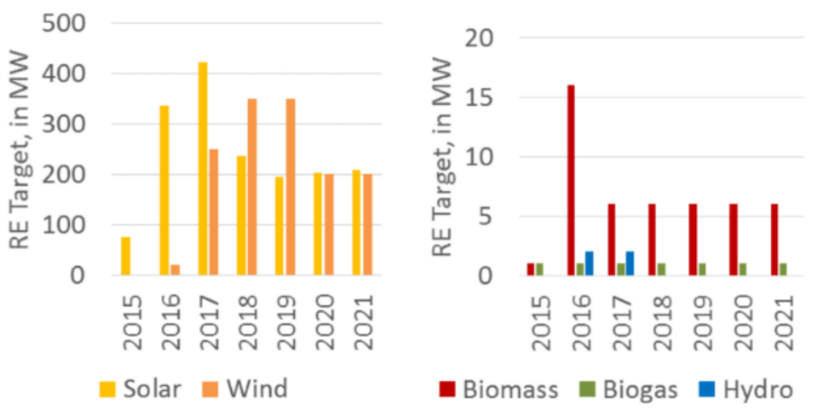
Policy framework

GoB formulated the National Energy Policy (NEP) in 1996. The government has seen the urgency of ensuring proper exploration, production, distribution and the use of energy resources to meet the growing energy demand of Bangladesh. Dynamic changes in global and domestic conditions have forced the EMRD (Energy & Mineral Resources Division) to carry out a program to revise the policies. This new policy describes the role of the energy sector to support sustainable development of Bangladesh. GoB has already identified some issues that cause the slowing down of the development of the energy sector and has put focus on some strategic issues:

1. Put more emphasis on hydrocarbon exploration and development by national companies and international oil companies
2. Reduce dependency on natural gas by developing alternative sources of energy
3. Improve the efficiency of the use of gas and electricity consumption
4. Ensure more transparent transaction of subsidies
5. Make more investment in energy production
6. Establish new power plants and do proper maintenance and rehabilitation of existing power plants
7. Further encourage public-private partnerships, joint ventures and private sector participation
8. Build institutional capacity through legal and administrative reforms and intensive investment programs

These focal points have resulted in GoB setting new renewable energy development targets for several technologies for each year from 2015 to 2021, the “RE Development Targets”. These targets require an additional 3,100 MW of RE capacity to be installed by 2021. Most of the new capacity will be provided by solar (1,676 MW, or 54 percent) and wind (1,370 MW, or 44 percent). There are also targets for biomass (47 MW), biogas (7 MW) and hydroelectricity (4 MW). Figure 2.6 shows the RE development targets for each technology from 2015 to 2021.

Figure 2.6 RE Development Targets per source (edited by SREDA)



Source: Based on information provided by SREDA.

The targets can be seen as challenging. If these targets are feasible will be discussed in chapter 3.

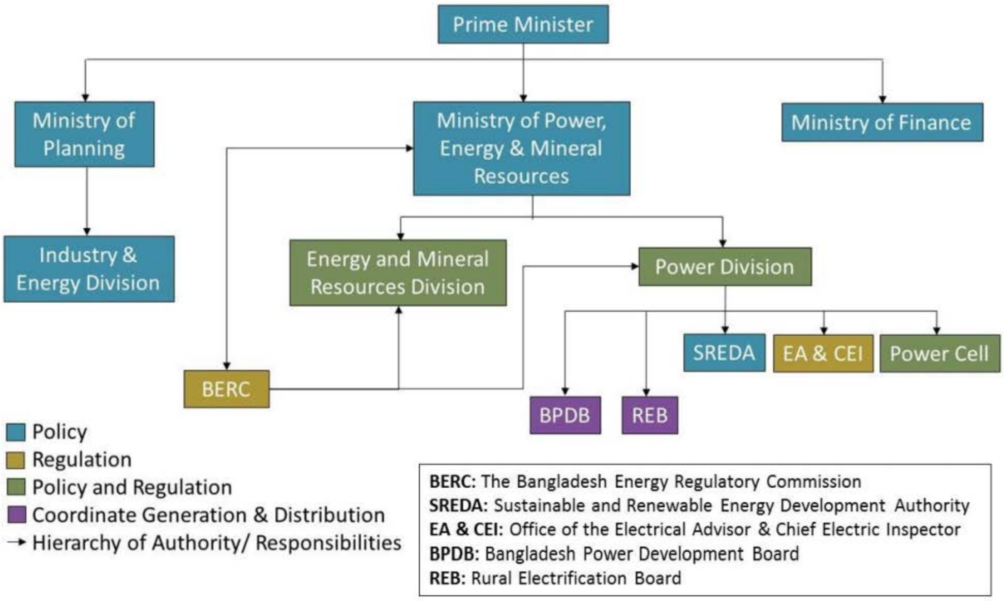
Legal, regulatory and institutional framework

To attain the objectives of electrification through development of conventional and alternative sources of energy, the following policies and legislations are in place:

1. The Electricity Act, 1910 (underway of revision)
2. The Electricity Rules, 1937 (underway of revision)
3. The Electricity Regulations, 1961 (underway of revision)
4. National Energy Policy, 1996 (underway of revision)
5. Private Sector Power Generation Policy of Bangladesh, 1996
6. Policy Guidelines for Small Power Plant (SPP) in Private Sector,2000
7. The Bangladesh Energy Regulatory Commission Act , 2003
8. Policy Guidelines for Power Purchase from Captive Power Plant, 2007
9. Policy Guidelines for Public Private Partnership
10. Guidelines for Remote Area Power Supply System (RAPSS), 2008
11. Policy Guidelines for Enhancement of Private Participation in the power Sector, 2008
12. Renewable Energy Policy of Bangladesh, 2008
13. The Bangladesh Private Sector Infrastructure Guide Lines
14. Sustainable and Renewable Energy Development Authority (SREDA) Act-2012
15. Energy Efficiency and Conservation Rules, 2015 (Draft)

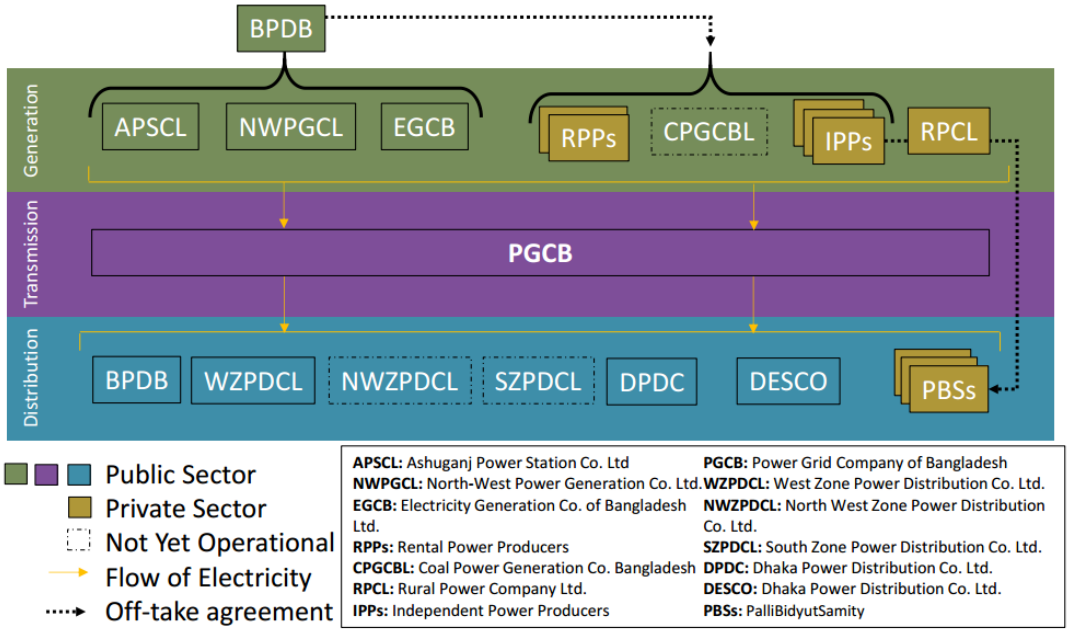
The organisational context in which these policies and legislations are being carried out is shown in figure 2.7. This figure shows the most relevant policy and regulatory bodies of the Bangladeshi energy sector.

Figure 2.7 most relevant policy and regulatory bodies of the Bangladeshi energy sector



This figure can be further drawn out concerning the energy utility companies, which are subjected to the Bangladesh Power Development Board (BPDB). Figure 2.8 shows the energy utility companies in Bangladesh.

Figure 2.8 most relevant institutions and utility companies under the Bangladesh Power Development Board



Note: Although NWZPDCL and SZPDCL are not yet operational, BPDB is still providing distributional services to customers in the Northwest and Southwest zones. Those distribution duties and assets will later be transferred to the individual entities.

APPENDIX C

DEVELOPMENT PROGRAMS DUTCH GOVERNMENT

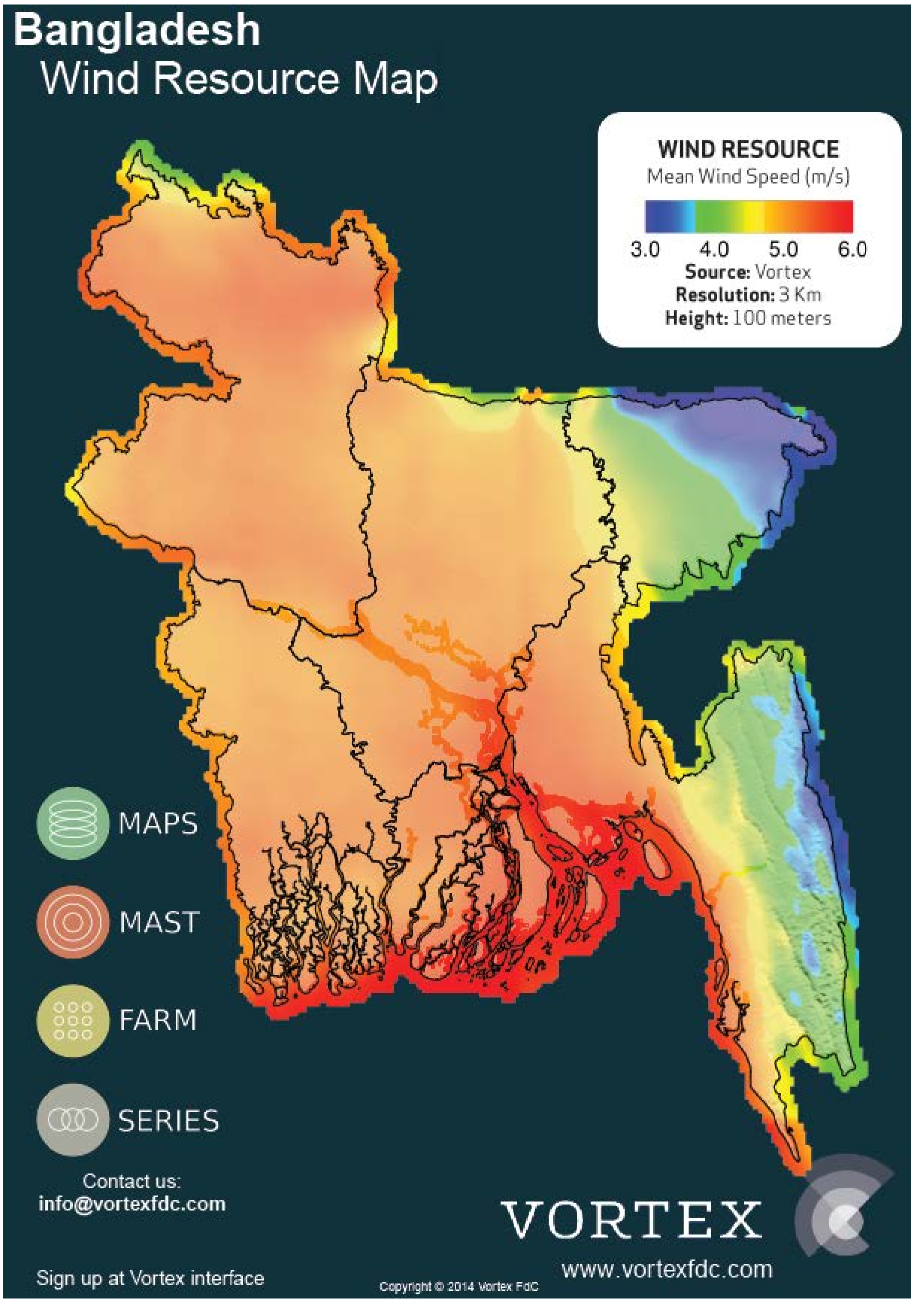
Potential funding or financial programs of the Dutch Government:

1. Develop2Build. Information click here;
2. Subsidieregeling voor demonstratieprojecten, haalbaarheidsstudies en investeringsvoorbereidingsstudies (DHI).
3. Information click here;
4. Development Related Infrastructure Investment Vehicle (DRIVE). Information click here;
5. Dutch Good Growth Fund (DGGF). Information click here;
6. Energising Development Partnership Programme (EnDev. Information click here:
7. Matchmaking facility. Information click http://english.rvo.nl/subsidies-programmes/matchmaking-facility-mmf;
8. WBSO (R&D Tax credit). Information click here.

APPENDIX D

WIND RESOURCE MAP

The preliminary results of the EC-LEDS wind speed metering programme are still under embargo of Ministry of Power. Hereunder you find a rough wind resource map (available at: http://www.vortexfdc.com/assets/docs/vortex_3km_bangladesh_wind_map_resource.pdf).



APPENDIX E

DUTCH WIND SECTOR

The Dutch policy on renewable energy had, until recent years, its main focus on research and development programs. For wind energy, the focus was on the research and development of large and cost efficient wind turbines. Realising its capacity targets on wind energy was not very successful during this period. Previous studies even state that the Dutch wind energy policy was dominated by large R&D subsidies to research institutes and large turbine manufactures. Attention for (potential) buyers (e.g. electricity companies, but also private owners) and market introductions was limited. For many years electricity companies were not interested in wind energy and very sceptical about the potential of wind energy for fossil fuels (Larive, 2014).

In recent years the Dutch wind energy policy altered its course and became more focussed on realising renewable energy capacity targets. The focus on delivering the capacity and meeting its targets resulted in an Energy Agreement in 2013, The target now is set for the year 2023, in which a share of 16% will be generated by renewable sources, with a stepping stone in 2020, in which the target is set for 14%. These targets are to be accomplished by both onshore and offshore wind. In total, 3,2% of these 16% will come from offshore wind energy sources, being a total of 4,5 GW installed capacity. For onshore wind the target is set on 6 GW installed capacity (in 2020).

Onshore wind energy in the Netherlands

In 2013, the national and regional government agreed on the target of 6 GW and the regional allocation of the capacity to meet. The regional governments are set to actively plan for the allocation of its own target. In 2015 the Netherlands have a total of 3.4 GW installed capacity, holding a solid sixth place when compared to all European Union member states.

Offshore wind in the Netherlands

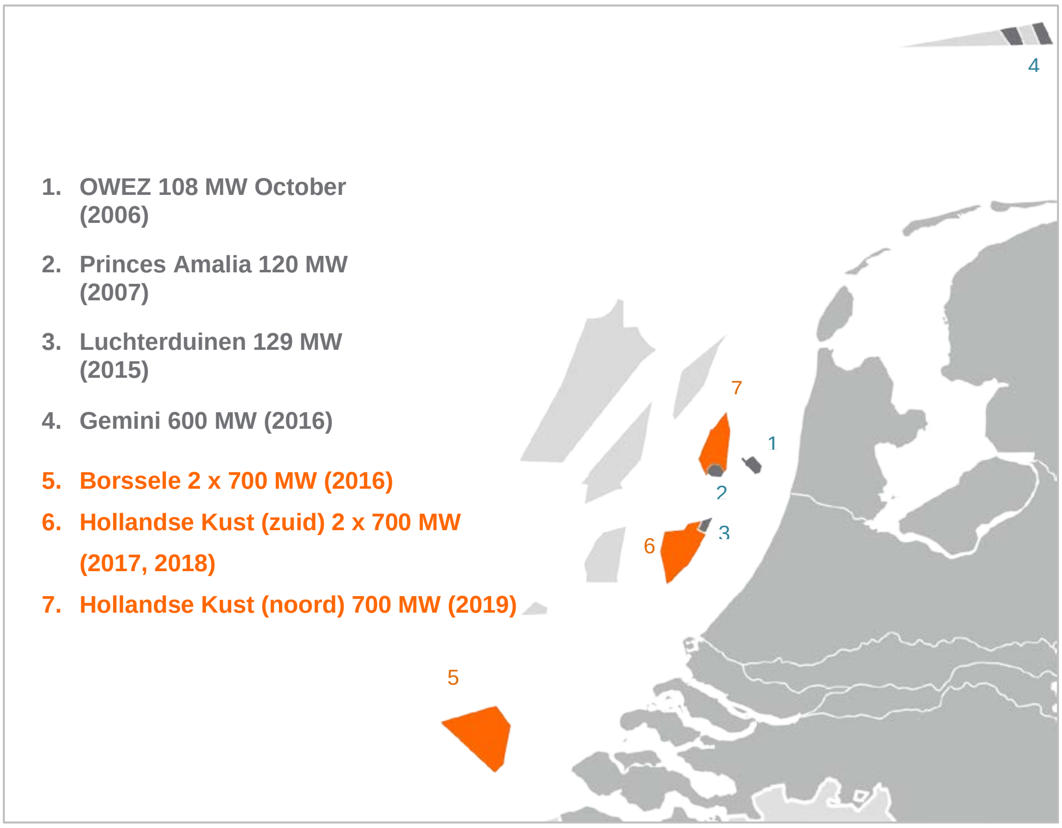
In the last year, the Dutch government made a tremendous step in the realisation of its targets. The first tender was carried out for two offshore wind sites, which is a whole new approach on offshore wind development. During last years, the Dutch government carried out several changes in policy, laws and appointed a separate fund for offshore wind development until 2023. With it so called ‘Road Map’ the route to the foreseen 4,5 GW is planned out. The government appointed three areas in which wind farms will be developed. Each wind farm will be tendered in sets of two, in total five tender will be set out (see also figure 4.1)

The yearly statistics of WindEurope over the year of 2015 show that the Netherlands still hold a fifth place, when compared to its surrounding North-western countries. Table 4.1 shows the numbers of installed wind farms, turbines and capacity by the end of 2015.

Table 4.1 Country statistics offshore wind (WindEurope, 2016)

Country	BE	DE	DK	ES	FI	IE	NL	NO	PT	SE	UK	Total
No. of farms	5	18	13	1	2	1	6	1	1	5	27	**80**
No. of turbines	182	792	513	1	9	7	184	1	1	86	1,454	**3,230**
Capacity installed (MW)	712	3,295	1,271	5	26	25	427	2	2	202	5,061	**11,027**

Figure 4.1 Current situation offshore wind and upcoming developments (source RVO.nl 2016)



Dutch Supply chain

The Dutch onshore wind industry is mostly renowned for its creative solutions, knowledge gathering and design of wind turbines. Companies such as TNO, MARIN, ECN, Technical University Delft, Deltares and IMARES are all institutions that focus on science, innovations and (applied) technologies concerning on- and offshore wind energy. Next to these knowledge institutions, companies such as Lagerwey and MECAL are known for their design and production of wind turbine and wind farm development.

The Dutch share in the offshore wind industry is remarkably high. Figure 4.2 shows the contribution of Dutch companies in the offshore wind supply chain. Dutch companies distinguish themselves particularly in the field of foundations, installation and maintenance of offshore wind farms.

Figure 4.2 Dutch contribution to offshore supply chain (source RVO.nl 2016)

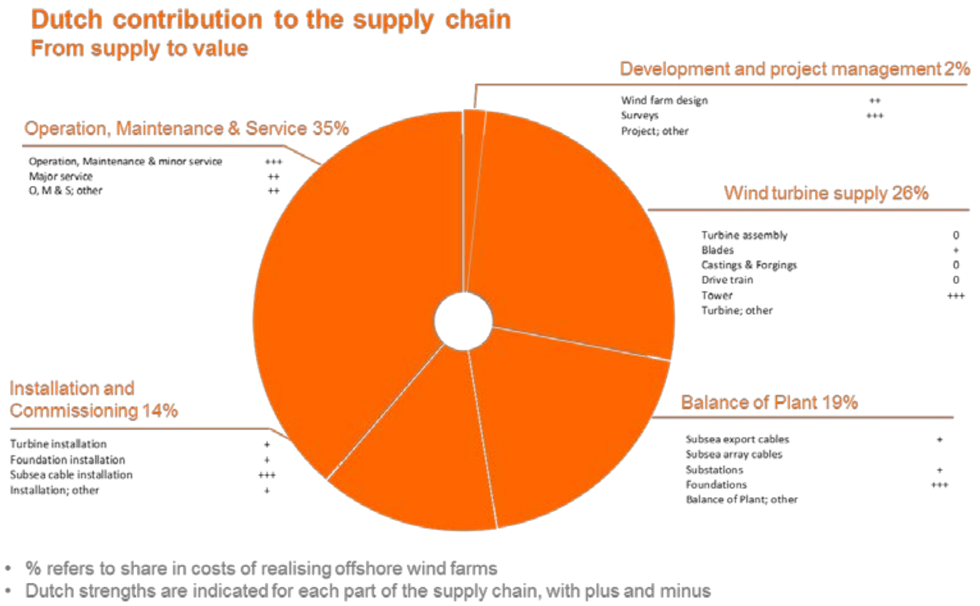
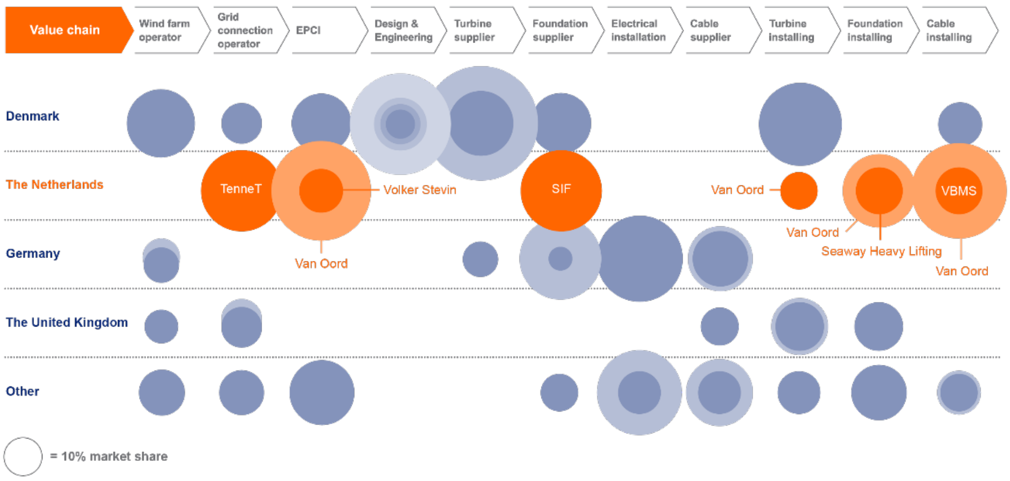


Figure 4.3 Top 5 players of Dutch origin in each section of value chain 2010-2014 (source RVO.nl 2016)



An overview of Dutch expertise on wind energy (onshore and offshore) is as following:

- Wind energy R&D (for example TU Delft, Deltares, Imares);
- Wind turbine design and blades (for example Lagerwey, MECAL, EWT)
- Design & engineering (for example ECN, TenneT);
- Construction & installation (for example Van Oord, IHC Merwede, Smulders Projects);
- Operation & maintenance (for example Van Oord, VSMC);
- Wind farm development & exploitation (for example Ampelmann, Ascent safety, Z-technologies).

APPENDIX F

EC LEDS WIND RESOURCE MAPPING PROJECT

CHASING THE WIND IN BANGLADESH

DECEMBER 2, 2014

With over 160 million people living in an area the size of Louisiana, Bangladesh is one of the most densely populated countries in the world. Only 50% of the population has access to electricity and the cost of energy is significantly subsidized for those citizens that are able to afford it. With limited natural gas resources waning and an inefficient energy subsidy system, the Government of Bangladesh (GOB) is evaluating multiple paths to ensure reliable and affordable power, one of which is to promote coal (under its 2010 Master plan, the goal is to generate 50% of its electricity from coal by 2030, up from about 2 percent now). An alternative, and less carbon intensive, path that is also being evaluated by the GOB involves identifying, quantifying, and exploiting its domestic renewable resources (to support the 2008 Renewable Energy Policy goal of generating 10% of electricity from renewables by 2020). In support of this low emission development strategy, this project seeks to unlock one natural resource that has been largely overlooked in this country—wind.

Like many developing countries, understanding the nation's renewable energy potential has been one of the prime challenges to the expanded use of wind and other renewable energy technologies. The variable nature of the resource and its strict location dependency also imposes additional, and often new, challenges compared with traditional energy technologies. Annual wind maps, developed for Bangladesh over the last 15 years, have been useful in demonstrating national wind potential, but the measurement and modeling methodologies used to create these maps do not adequately represent the wind resource available to modern wind turbines and consequently, are not sufficiently rigorous to attract investors and spur growth in this sector. Today's much more sophisticated tools and techniques—such as validated wind resource models based on years of actual wind data measured at turbine hub height—reduce uncertainty and generate a wealth of data products needed to attract private investors including annual, monthly, seasonal, hourly, and wind distribution data in addition to annual wind speed maps. EC-LEDS is helping the GOB use state-of-the-art methodologies to collect and analyze detailed, regional wind resource data that will pave the way for future wind power deployment.

WIND RESOURCE MAPPING PROJECT

Since 2011, the EC-LEDS *Bangladesh Wind Resource Mapping Project* has been providing technical assistance to support the GOB's goal of promoting wind development as a low emission, domestic energy resource that will meet growing energy needs and stimulate rural economic development within their country. Assessing the large-scale deployment of utility-scale wind technology requires a large investment in measurement campaigns, and a high level of technical knowledge to identify and prioritize potential development opportunities. Wind experts from the National Renewable Energy Laboratory (NREL) are working with in-country partners to install, operate, and maintain state-of-the-art wind measurement systems in nine strategic locations across Bangladesh—first steps to developing the resource informational infrastructure required to develop commercial utility-scale wind projects. Once these measurement systems become operational, two years of wind data will be collected and analyzed using advanced modeling techniques. These systems will generate long-term correlated wind data that can then be used to develop and validate high-resolution wind resource maps and other resource assessment products for Bangladesh. Over the course of the project, wind experts will provide detailed instruction, documentation, and training in wind resource data collection, analysis, and interpretation to build in-country capacity for on-going wind resource assessments beyond the life of this project. To ensure generation of investment-quality wind resource data, the project team is using internationally recognized best practices and state-of-the art measurement and modeling tools to assess Bangladesh's coastal and inland wind power potential.

Transporting Sonic Detection and Ranging (SODAR) device for remote wind measurement in Bangladesh. *Photo by Harness Energy*

Table 1 below outlines a number of tasks and best practices in wind measurement and how these have been applied in Bangladesh. The fourth column describes how these practices and data contribute to better policy design, reduced risk for investors and developers, and better analysis and siting of projects.

Table 1. EC-LEDS Wind Resource Assessment Approaches

Task	Best Practice	EC LEDS Wind Mapping Project	Role in Advancing Growth in the Bangladesh Wind Sector
Identification of wind measurement sites	Available wind and meteorological data and models are used to create a preliminary wind resource assessment map. This provides an initial indication of potential wind speeds, direction, and seasonal wind variability, and can be used to identify appropriate sites for more detailed wind measurement.	Nine sites were selected for collecting wind measurements based on these criteria: potential reflected in existing wind resource maps, proximity to transmission lines, geographic diversity, and developability (as determined by individuals experienced with wind development, modeling, and MET tower installation)	With relatively few wind farms in operation in Bangladesh, measurement sites were selected to ensure an accurate national wind map but also target zones where access to existing transmission would be optimized. Engagement with the GoB and local partners in this effort also raised awareness for local policy makers on need to understand the potential for wind opportunities.
Multi-year wind measurement campaign	Instrumented meteorological towers and remote sensing equipment are used to gather wind resource data at various heights at selected sites across a region. One to three years of actual wind data (wind speed and direction) are required to validate preliminary modeling results and confirm viability of potential project sites.	Once wind measurement equipment is installed, two years of measured wind resource data (20m to 200m) will be collected from nine meteorological sites strategically located across the country. Measuring wind speeds at the turbine rotor's hub height and beyond (up to 200 meters) using remote sensing equipment reduces uncertainty in annual energy production forecasts.	Modern, utility scale wind turbines access wind resources at hub heights of 80m and greater. Wind shear data at multiple hub heights allows for better system design to maximize power production based on turbine type and height. Higher hub height data also often reveals much greater wind resource potential at any given location that is attractive to both developers and potential investors.[1]
Modeling the regional wind resource and generating data-rich wind resource products	Computer models, based on historical data on atmospheric conditions combined with actual measured wind data are used to update regional wind resource assessments. These wind resource models provide an overview of the climatological wind conditions of a region (wind speeds, direction, and seasonal variability), and are useful as a screening tool for the identification and preliminary evaluation of potential wind project sites.	A national wind resource model will be created based on the state-of-the art global Weather Research and Forecasting model, and adapted for wind forecasting applications. Web-based access to a diversity of underlying datasets will be provided for industry analysis, integration into other models and tools, and development of visualization products for policy analysis.	The data products generated from a Bangladesh wind resource model provide a wealth of information including annual, monthly and hourly climate data such as wind speed, shear, frequency distribution and air density. These detailed datasets allow system operators to forecast how the developed resource will address seasonal demand and other grid integration issues, and developers/investors to define the capacity values of their power, improving the economic analysis of the project. In addition, as the industry matures and the developers/investors make decisions as where to invest capital, markets that have more information to answer these questions surrounding grid integration and economic value will attract the first dollar.

[1]This study, *Indiana Energy Group Tall Towers Wind Study Final Project Report*, was funded by the Indiana Energy Group (http://www.in.gov/oed/files/Indiana_Final_Project_Report.pdf). The increased wind capacity is documented in "Installed Wind Capacity," U.S. Dept. of Energy, 3 March 2013 (http://apps2.eere.energy.gov/wind/windexchange/wind_installed_capacity.asp).

USING THE DATA TO EXPAND OPPORTUNITIES FOR WIND

As experienced in both the US and abroad, high quality resource data is a critical building block to informed policy design promoting wind, accurate siting for project prospecting, and detailed analysis to support wind project assessment. Without these foundational data, it is unlikely that a nascent wind industry will gain traction in the local energy market even with appropriate policies in place.

This project addresses two of the key barriers to wind deployment in Bangladesh: lack of reliable meteorological data needed to identify the resource and detailed data products to reduce investment risk. This issue of risk permeates the development process, starting with the initial investments to install measurement equipment and continuing through project development and long-term plant operation. A detailed site measurement campaign, which is a prerequisite for any larger project financing, can cost several hundreds of thousands of dollars. The availability of advanced wind resource products helps reduce development risk, thus spurring wind development.

For the private finance sector, the risk-return profile of a project is the key determinant of whether to finance or not. Project developers, lenders and investors want to make a return proportional to the level of risk they undertake. Quantifying and managing the elements of risk (political, technical, commercial) associated with renewable energy projects, particularly in developing countries, represents a key challenge in obtaining financing. Since Bangladesh is in the relative early stages of wind market development, improved resource data will specifically address aspects of technical risk by providing improved insight on the actual wind potential with a significant degree of temporal and spatial detail. While potential political risk is much harder to measure or address through a technical program like this wind measurement campaign, commercial risk is also mitigated through improved access to high quality data that may allow for power purchase agreements and financing arrangements to be negotiated on a more transparent basis using data that all partners agree is valid.

The EC-LEDS *Bangladesh Wind Resource Mapping Project* is helping to reduce the development and investment risk by providing high-quality comprehensive wind resource data products needed to encourage public and private sector wind energy development and increase investor confidence in the viability of wind energy projects. The validated high-resolution wind maps and associated data products will provide the tools for wind developers looking to find opportunities, reduce wind prospecting timelines, and demonstrate to government officials the wind potential which might aid in future energy policy decisions. Specifically, the data products allow potential developers to conduct detailed pre-feasibility studies, focused on evaluating how the wind resource in a particular region matches up with the local utilities seasonal demand, generating credible estimates of wind production, and predicting the overall potential of a site. Positive results from these studies can be used to justify further investments in project-specific on-the-ground resource wind assessments, expediting the development process and stimulating the wind market.

Over the long-term, the improved wind data products reduce development risk, increase public and private stakeholder confidence in wind energy projects, and expand potential opportunities for wind power, by providing the data needed to evaluate wind projects and incorporate wind resources into a national energy strategy.

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Cleared December 2014

APPENDIX G

PRESENTATION FOR WIND SECTOR (HHWE)

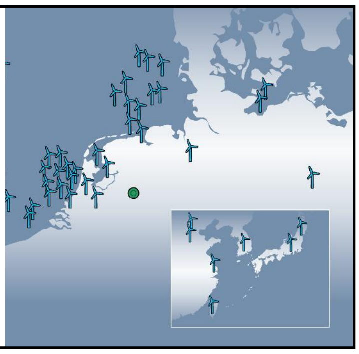
WIND MINDS

international

WIND MINDS

international

- Worldwide
- Full scope service provider
- Engineering and consultancy
- More than 15 years offshore wind experience



Opportunities in Bangladesh

- General introduction of Bangladesh
- Market overview and international relations
- Potential of wind energy
- Business opportunities in Bangladesh

Bangladesh: key figures

	Bangladesh	Netherlands
Population	161 million (8th)	17 million (65th)
Area	148,000 km²	42.000 km²
Trade (% GDP)	42,086	154,174

Bangladesh: Energy market

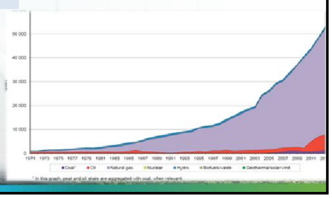
- The current Bangladeshi (renewable) energy market
  - Energy (electricity) supply and demand
  - Grid connection and grid stability
  - Current energy generation projects
  - Governmental policy on renewable energy and wind energy

Energy supply and demand

	2008	2009	2010	2011	2012	2013	2014
Peak demand (MW)	5.569	6.066	6.454	6.765	7.518	9.268	10.283
Peak generation (MW)	4.036	4.296	4.698	5.174	6.350	7.356	7.817

Peak demand and peak generation

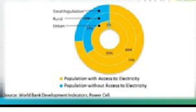
Energy generation by source:
Natural gas as main resource
(ca. 50.000 GWh in 2013)



WIND MINDS

Grid connection and stability

1. High increase of energy demand (7% annual)
2. Unstable grid due to energy deficit
3. Bangladesh Power System Security and Efficiency Improvement Project, funded by World Bank.
4. Nationwide, 74 percent has access to electricity (2015), up from about 20 percent in 1990. Target is 90% to be connected in 2018.



WIND MINDS

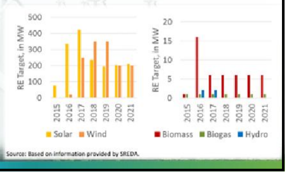
Current projects

1. Two small scale wind projects are operational
    1. Muhuri Dam wind power project (4x225kW)
    2. Kutubdia Island wind power (50x20kW).
2. In interviews held in Dhaka, August 2016, it became clear that no large scale wind energy projects are on their way at the moment. Some projects have been started up but have been cancelled due to a lack of mutual understanding between government and developer on the power purchase agreement (PPA).

WIND MINDS

National policy

GoB states in its Investment Plan for Scaling up Renewable Energy Program (SREP) that Bangladesh could realize over 6,000 GWh of generation from renewable technologies annually, of which a 1250 GWh can be generated from wind resources (SREDA, 2015).



WIND MINDS

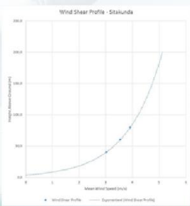
Bangladesh: Wind energy potential

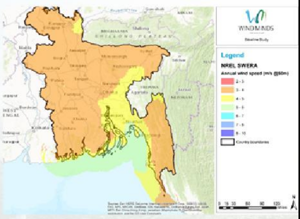
- Potential of wind energy in Bangladesh Wind resources
    - Wind resources
    - Available space for windfarms
    - Accessibility of the terrain

WIND MINDS

Wind resources

- Relative low wind speeds



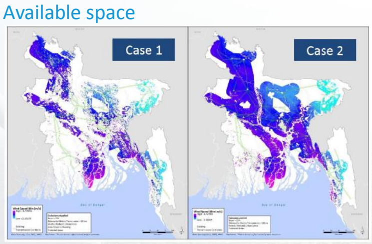


WIND MINDS

Available space

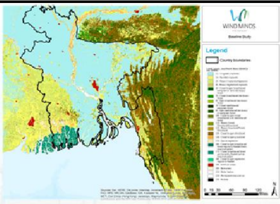
- Proximity of national grid
- Bangladesh as delta area: flooding.
    - Case 1 excl. flood prone area
    - Case 2 incl. flood prone area

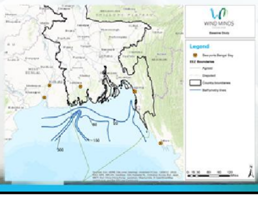
	Case One		Case Two	
	20-25% Capacity Factor	25-30% Capacity Factor	20-25% Capacity Factor	25-30% Capacity Factor
Buildable MW	624	13	995	37



Available space

- High density causes pressure on land use





- Greenfield: offshore wind
  - Low water depths
  - (predicted) soft and erosive soils.
  - Proximity of seaports

Bangladesh: Business opportunities

- Business opportunities for wind energy
  - Cost of wind energy and energy pricing
  - Financial resources to finance a windfarm project
  - Administrative and technical support

Cost of wind energy and pricing

- At the moment electricity prices are relatively low. GoB is spending more than 4 percent of its GDP on energy subsidies more than it spends on health and social welfare programs.
- Tariffs were fixed between 2009 and September 2015 - except the tariff for compressed natural gas (CNG) for automotive use.

Financial resources

- The financial resources and willingness to self-realise large wind farm projects by the government of Bangladesh are expected to be limited.
- Possibility is project finance or balance financing wind farm projects by large companies, such as utilities.
- Despite some funds that are active at the moment in the field of renewable energy, the level of stability is perceived to be limited.

Administrative and technical support

- The not entirely transparent system of authorisation and permitting to Western standards can be an obstacle to realise a project. Good and early administrative coordination is essential
- Bangladesh has little to no experience with wind energy projects. Which means a lot of knowledge and experience has to be brought in from outside of Bangladesh.
- Opportunities for export of specific knowledge and technology, services and materials from countries with a lot of wind energy experience (like the Netherlands).

Bangladesh: Business opportunities

- Onshore wind opportunities:
  - *Turbine design*
  - *Small scale pilot projects*
  - *Small scale decentralised wind energy systems*

Bangladesh: Business opportunities

- Offshore wind opportunities:
  - *Exploration of large scale wind projects*
  - *Site surveys*

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