CHASING THE WIND IN BANGLADESH

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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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