PROPOSED

10 MW WIND PARK PROJECT
MAHESHKHALI, COX'S BAZAR
BANGLADESH

Date: April 20, 2008

Submitted BY

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ANNEXES

Version Number	Date	Description and reason of revision
01	21 January 2008	Initial adoption
02	19 April 2008	Revised

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SECTION A. General Description of the project activity

A.1. Title of the project activity:

10 MW wind energy project of TEK Energy Ltd (TEK) at Moheskhali, Cox's Bazar, Bangladesh.

Proposed Start Date: January 01, 2009

Proposed Operation Date: November 1, 2009

A.2. Description of the project activity:

TEK proposed to setup a 10 MW wind power plant in the Villages of Uttar Nolbila, Saflapur & Kalarmarchar of Moheskhali Upzilla under Cox's Bazar in Bangladesh. The project consists of eight Wind Turbine Generators (WTG), each with 1250 KW generation capacity. The project will be implemented in a phased manner. 4 of the WTG installation will be completed and commissioned in September 2009 while the rest 4 WTG was commissioned in December 2009. The power generation will be evacuated to the National Grid and a Power Purchase Agreement with PDB (or POLLIBUDDUT) to the effect will need to be signed.

Purpose

The purpose of the project is to generate electricity using wind energy and to export it to the National Grid. The project is also aims at sustainable economic growth, conservation of environment through use of wind as renewable source and reduction of Green House Gas (GHG) emission. TEK has adopted an efficient and modern technology, which is costlier than conventional technologies and has employed 1250 KW WTG for maximization of power generation with higher utilization factor during implementation period of the project. To be competitive in the open market economy of Bangladesh, TEK has explored the options to avail the benefits under the Clean Development Mechanism (CDM) of United Nations Framework Convention for Climate Change (UNFCCC) for sustainable operation of the project.

Sustainable Development:

The Project contributes to sustainable development in the following manner:
- Sustainable development through generation of eco-friendly power
- Bridging Bangladesh's energy deficit and increasing the share of renewable energy power generation in the regional and national grid
- Providing national energy security, especially when global fossil fuel reserves threaten the long term sustainability of the Bangladesh economy.
- Strengthening Bangladesh's rural electrification coverage
- Essentially reducing GHG emissions compared to a business-as-usual scenario
- Reducing other pollutants (SOx, NOx, PM etc.,) resulting from thermal power industry
- Contribute towards reducing power shortage especially in the Cox's Bazar Zilla;
- Demonstrate and help in stimulating the growth of the wind power industry in Bangladesh;
- Enhancing local employment in the vicinity of the project, which is a rural area;

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Capacity building and empowerment of vulnerable sections of the rural communities dwelling in the project area;
Power generation from Renewable Energy sources paves way for energy security of future generations
Conserving natural resources including land, forests, minerals, water and ecosystems;

The National strategy for sustainable development also aims at providing access to clean energy with the objective that increased availability of power in the rural areas will lead to industrial activity aimed at generating employment and reduce poverty. For these reasons, the wind power project of TEK is fully in line with the overall goals for sustainable development of the Government of Bangladesh (GOB) and the requirement of Greater Chittagong Division.

Contribution of the project activity to sustainable development in view of project participant

The project proponent believes that the project activity has contributed to sustainable development in following manners:
i) Social well being
ii) Economical well being
iii) Environmental well being
iv) Technological well being

i) Social well being

Social well being by providing job opportunities to the local population during erection and operation of the wind farms contributing in poverty alleviation of the local community and development of basic amenities to community.

ii) Economic well being

The wind farms need large area. The cost of land appreciated benefiting the landowners and local community directly. These lands were generally were unproductive. Most of the wind energy potential areas are in remote areas and are largely unfertile. These lands generally command low prices. Due to land demand for wind farms, the land price increased leading to economic well being of the local community. The project activity also contributes in economic well being of the nation’s economy by reducing import of coal and other fossil fuel for electricity generation in hard currency.

iii) Environmental well being

Environment friendly electricity generation project with no significant impact on the environment. Additionally, the project activity generates electricity from a renewable source of energy where the source gets replenished and is available for use.
Therefore, the following environmental benefits are derived from the project activity:

- Produces electricity without GHG emissions.
- Produces electricity from a renewable energy source.
- Rural development as the project activity location
- Nil impact on the environment due to the project activity.

iv) Technological well being

The project activity has higher capacity windmills of 1250 kW which is technologically advanced to conventional smaller capacities.
Other technological well beings of the project:

- improved power quality in the vicinity
- reactive power control;
- mitigation of transmission and distribution congestion,

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All the above are the contributions of the project activity for the sustainable development.

A.3. Project participants:

Names of Parties involved: Bangladesh

Project Participants: TEK Energy LTD, Bangladesh (a JV of Techno International Corporation) in association with GreenTek Energy USA Inc (Private Entity)

http://www.tek-energy.com and http://www.techno-international.com/tekenergy

A.4. Project Location:
TEK proposes to establish wind farm at Villages of Uttar Nolbila, Saflapur & Kalarmarchar of Moheskhali Upzilla under Cox's Bazar Zilla in Bangladesh are 21* 37' N and 37* 58 E. The nearest airport is at Cox's Bazar. The Survey Numbers for the site along with the Wind Turbine numbers, a unique identification number provided by TEK is provided in the table below:

WTG No	Survey No	Village	UpZilla	Capacity	
				KW	
WEG 101	361 (P)	Saflapur	Moheskhali	1250	
WEG 102	373 (P)	Saflapur	Moheskhali	1250	
WEG 103	1390 (P)	U Nolbila	Moheskhali	1250	
WEG 104	1652 (P)	U Nolbila	Moheskhali	1250	
WEG 105	1681 (P)	U Nolbila	Moheskhali	1250	
WEG 106	5604 (P)	Kalamchara	Moheskhali	1250	
WEG 107	5910 (P)	Kalamchara	Moheskhali	1250	
WEG 108	6925 (P)	Kalamchara	Moheskhali	1250	

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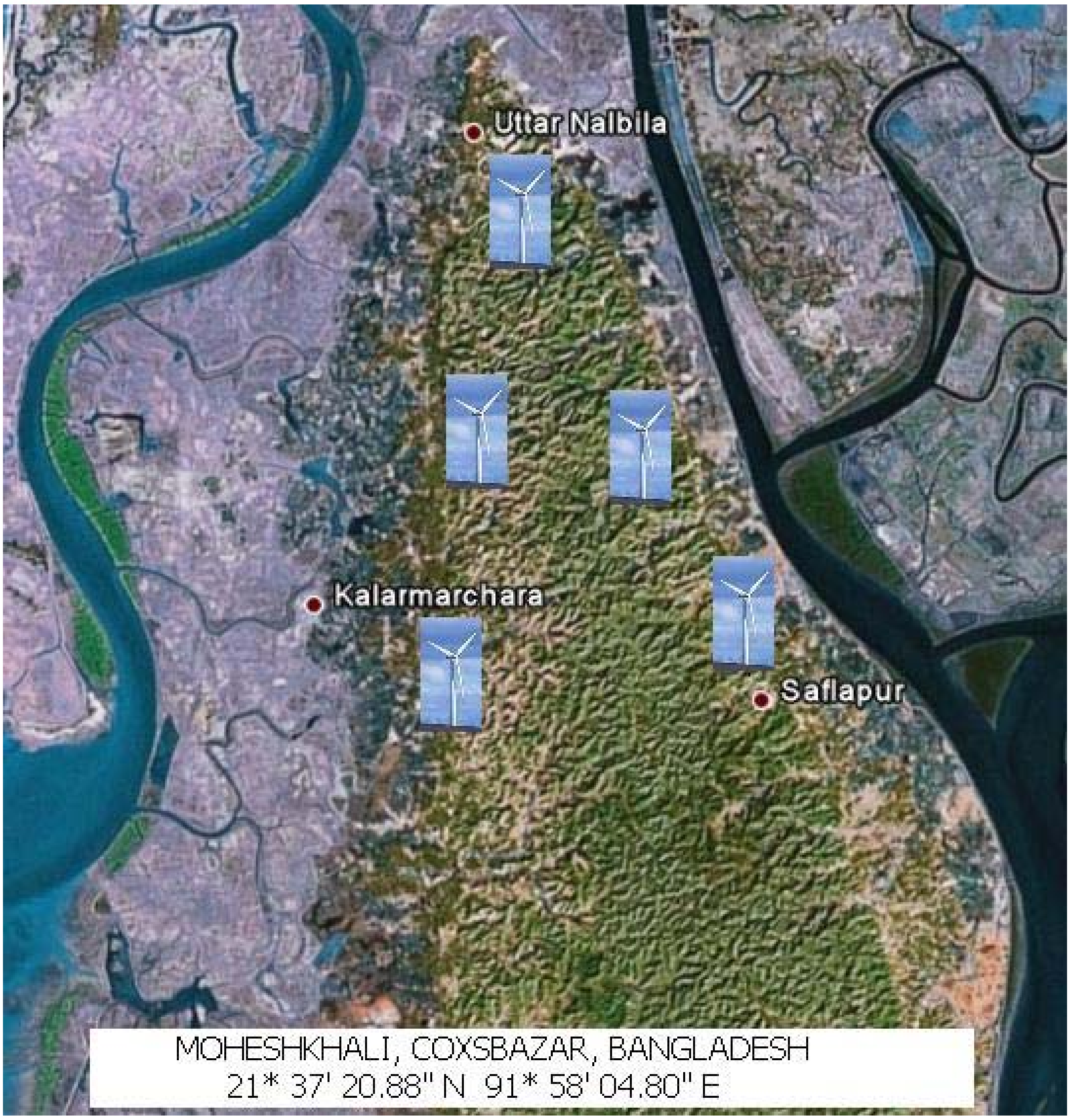
Map: Proposed Project Location

Type: Renewable Energy Project (Small Scale)
Category: Grid Connected Renewable Electricity Generation
Technology/Measure: Wind Based renewable energy generation unit supplying electricity to and/or displaces electricity from an electricity distribution system that is or would have been supplied by at least one fossil fuel fired generating unit.



A.4.3 Estimated amount of emission reductions over the chosen crediting period:

Year	Emission Reduction Tonnage (CO2)	
2009-2010	22917	
2010-2011	22917	
2011-2012	22917	
2012-2013	22917	
2013-2014	22917	
2014-2015	22917	

2015-2016	22917	
2016-2017	22917	
Total	183336	
Number of Credit Year	7	
Avg Credit Period Tonnage of CO2	22917	

A.4.4. Public funding of the small-scale project activity:

No public funding from parties included in Annex I is available to the project.

A.4.5. Confirmation that the small-scale project activity is not a de-bundled component of a large scale project activity:

According to Appendix C of Simplified Modalities & Procedures for small scale CDM project activities, 'Debundling' is defined as the fragmentation of a large project activity into smaller parts. A small-scale project activity that is part of a large project activity is not eligible to use the simplified modalities and procedures for small-scale CDM project activities. A small-scale project activity shall be deemed to be a debundled component of a large project activity if there is a registered small-scale CDM project activity or an application to register another small-scale CDM project activity:
- With the same project participants;
- In the same project category and technology/measure;
- Registered within the previous 2 years; and
- Whose project boundary is within 1 km of the project boundary of the proposed small- scale activity at the closest point. In TEK's case, it does not fall under the debundled category and qualifies as a small scale CDM project. It is the single such project of the promoters. The conditions in paragraph 2 of Appendix C confirm that the proposed small-scale project activity is not a debundled component of a larger project activity.

SECTION B. CDM Application of a baseline and monitoring methodology

B.1. Title and reference of the approved baseline and monitoring methodology applied to the small-scale project activity:

The small scale methodology applicable to the project activity is
Type I – Renewable Energy Projects,
Subset D - Grid connected renewable electricity generation
Version: 1 (December 2009)
Reference: The project activity meets the eligibility criteria to use the simplified modalities and procedure for small-scale CDM project activities as set out in paragraph 6 (c) of decision 17/CP.7. Details of methodology for baseline calculations for CDM projects of capacity less than 15 MW are available in the "Appendix B of the simplified modalities and procedure for small scale CDM project activities". Reference has been taken from indicative simplified baseline and

monitoring methodologies for selected small scale (CDM projects less than 15 MW) project activity categories.

B.2 Justification of the choice of the project category:

The project activity is a 10 MW Wind Power project which is less than the specified limit of 15 MW for Small scale Project activities. The project proposes to export the power generated to the Cox's Bazar Electricity grid. Hence the small scale methodology applicable to the project activity is Type-I Renewable Energy Projects Subset D – Grid Connected renewable electricity generation.

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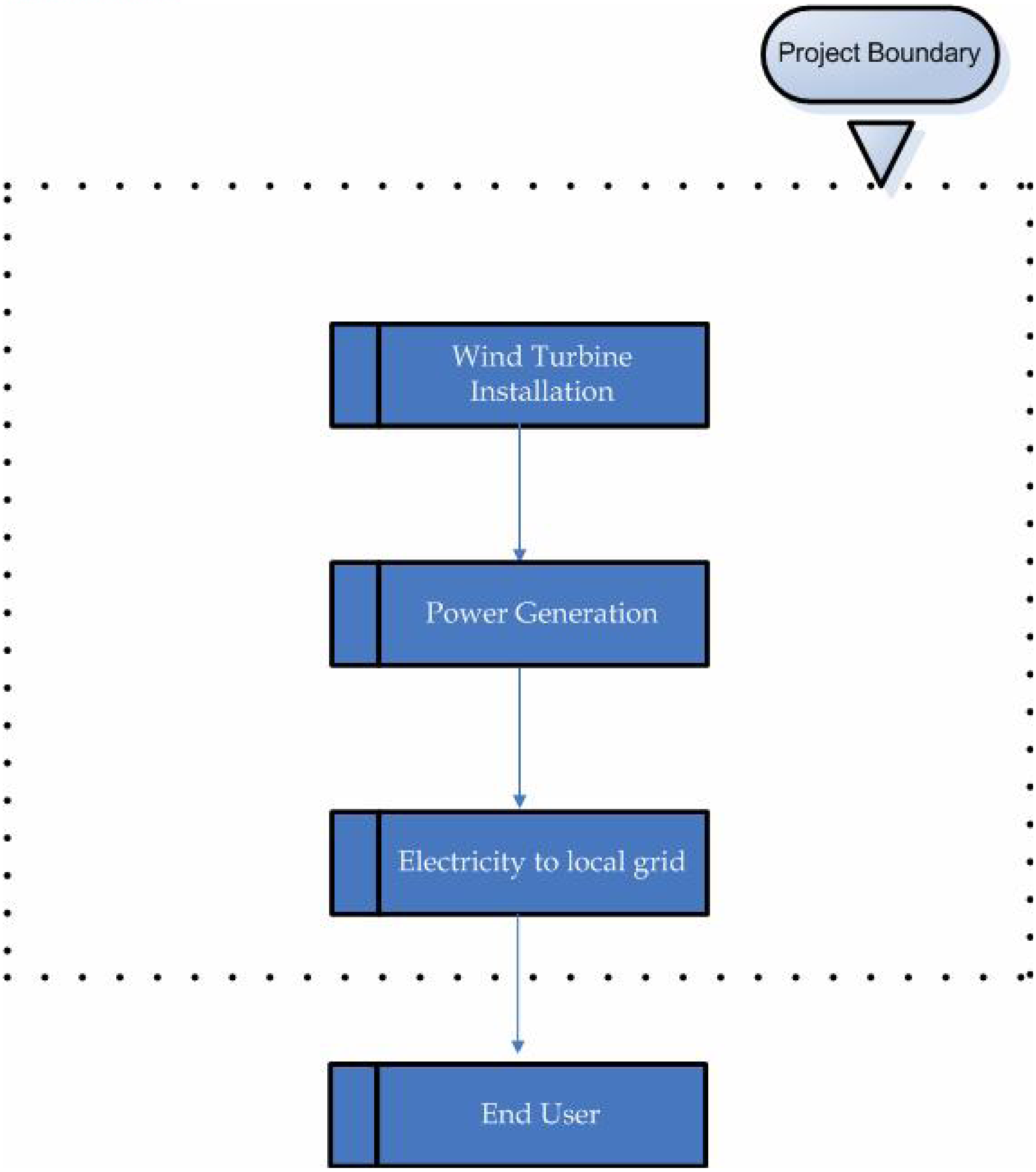

B.3. Description of the project boundary:

As per the guidelines mentioned in Type I. D. of Annex B of the simplified modalities and procedures for small-scale CDM project activities, project boundary encompasses the physical and geographical site of the renewable generation source. The project boundary includes the electricity generation equipment at the site and the transport through the electricity grid to the

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PDB (OR POLLIBUDDUT) substation. Hence, project boundary is considered with in these terminal points.

B.4. Description of baseline and its development:

The baseline methodology has followed the one specified under Project category I.D in Appendix B of the Simplified M&P for small scale CDM project activities. The Power Cell Under Ministry of Energy & Mineral Resources, Government of Bangladesh, has estimated the operating margin and the Build margin for the Southern grid, the details of which are available on the following website. Version 1.0 of the database has been used.

As per the guidelines in AMS I.D (Version 10) to estimate the baseline emissions, the emission factor is calculated as per the procedures laid in paragraph 9 (a) & (b). The project activity does not involve addition of renewable units to an existing facility and hence paragraph 10 of AMS I.D (Version 10) is not applicable to the project activity under consideration. The project activity does not seek to retrofit or modify an existing and hence paragraph 11 of AMS I.D (Version 10) is not applicable for the project activity under consideration. As this methodology suggested adopting the procedures laid in ACM0002, the same has been considered for calculations. The baseline emissions and the emission reductions from project activity are estimated based on the quantum of electricity to be exported by the project activity to the grid and the **Baseline Emission Factor (BEF)** of the southern regional grid calculated as a **combined margin (CM)**, consisting of the combination of **operating margin (OM)** and **Build margin (BM)** factors and using the default weights to be used for wind projects. The project proponent wishes to calculate the Operating Margin and the Build Margin using the data provided by the Central Electricity Authority Ex-ante, and has fixed the same for the first crediting period.

The Simple Operating Margin has been calculated as the generation weighted average emissions per electricity unit (tCO_2/MWh) for all generating sources, excluding the low operating cost and must run power plants, serving the system . The formula applied for the calculation of the Simple Operating Margin is

$$EF_{OM,y} = \frac{\sum_{i,j} F_{i,j,y} . COEF_{i,j}}{\sum_{j} GEN_{j,y}}$$

Where

$F_{i,j,y}$ is the amount of fuel i consumed by the relevant power sources j in the year y,
j refers to the power sources delivering electricity to the grid excluding the low operating cost and must run power plants but including import to the grid.

$COEF_{i,j,y}$ is the CO2 emission coefficient of fuel i (tCO2/mass or volume unit of fuel), taking into account the carbon content of the fuels used by the relevant power sources j and the percent oxidation of the fuel in year y.

$GEN_{j,y}$ is the electricity delivered to the grid by source j.

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COEFi has been arrived using the formula: the carbon content of the fuels used by the relevant power sources j and the percent oxidation of the fuel in year y.

$GEN_{j,y}$ is the electricity delivered to the grid by source j.

COEFi has been arrived using the formula:

$$COEFi = NCV_i * EF_{CO2i} * OXID_i$$

Where ,
NCVi is the net calorific value (energy content) per mass or volume unit of fuel i,
OXIDi is the net calorific value of the fuel as provided in 2006 Revised IPCC guidelines for default values.

EF_{CO2i} is the CO_2 emission factor per unit of energy of the fuel i.

The CO_2 Emission Factor database (Version 3.0) of POWER CELL has been used for arriving at the Baseline Emission Factor. The details have been provided in Annex 3.
As provided in the database, the Simple Operating Margin for the Southern Regional grid of 1.0 and a Build Margin of 0.71 has been used for the estimation of the Emission Factor.

Therefore, OM= 1.00 and BM= 0.71

According to ACM0002, for wind projects, the default weights to be assigned are 0.75 and 0.25 for the Operating Margin and Build Margin respectively.

$$W_{OM} = 0.75 \quad W_{BM} = 0.25$$

Hence, the Baseline Emission Factor is calculated as below:

$$EF = W_{OM} * OM + W_{BM} * BM$$
$$= 0.75 * 1.0 + 0.25 * 0.71$$
$$= 0.93 \text{ kgCO}_2\text{/kwh}$$

Thus, the Baseline Emission Factor, calculated ex ante as 0.93 for the first crediting period will be used for the calculation of the Emission Reductions. The net electricity exported to the grid per annum is expected to be around 24.6419 Million units. Hence the baseline emission is calculated as below

$$\text{Baseline Emissions} = \frac{24641900 \times 0.93}{1000}$$
$$= 22917 \text{ tones of CO}_2$$

B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered small-scale CDM project activity:

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The project activity meets the eligibility criteria to use simplified modalities and procedure for small-scale CDM project activities as set out in paragraph 6 (c) of decision 17/CP.7. As per the decision 17/CP.7 Para 43, a CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity. Further referring to Appendix A to Annex B document of indicative simplified baseline and monitoring methodologies for selected small scale CDM project activity categories, project participants shall provide a qualitative explanation to show that the project activity would not have occurred anyway, at least one of the listed elements should be identified in concrete terms to show that the activity is either beyond the regulatory and policy requirement or improves compliance to the requirement by overcoming the following barrier(s) ;

Investment Barriers: The wind power development in the country has historically been supported by government preferential tariff policies and mixed credits on favorable terms from various sources like financial institutions, donor countries etc. However even with this support the developer realized CDM funds would be needed to make the project an attractive investment due to the reasons as outlined below:

a) **Rate of Return**: Wind power projects provide lower rate of return as compared to thermal (coal) power plants. Wind power projects in Bangladesh are yet to attain the cost-competitiveness levels attained in the US and Europe[1]. Per MW cost for setting up of wind power projects is much higher than their counterparts. This acts as an entry barrier for the private players and consequently, the wind potential available in the country remains under utilized. The project proponent incurred a total cost of TK 500 Million (TK 50 Million per MW) in setting up its power project in Cox's Bazar. The high cost per MW combined with the low return on investment on account of low utilization factor act as an impediment to the setting up of wind power projects in the country. However, the carbon benefits make wind power projects from being financially non-viable to that of investment grade.

Assuming a CUF of 35%, the expected post tax equity IRR for the project was 6.65%Since the date of commissioning, the project will have, till May 2010 achieved a PLF of around 8 to 9%.

The assumptions made for calculating the IRR are listed below.
1) PLF of 35%
2) Operational days- 365 days
3) Auxiliary consumption of 0%.
4) Rate per KWh as TK. 4.00
5) O&M Cost for the first two years is zero and the second year as 10 Lacs per WTG. year on year Escalation of 5%
6) Interest rate of 10% on long term debt.
7) Repayment of Interest in 60 installments.
8) Interest rate of 10% on working capital. (if applicable)
9) Insurance cost of 0.75% till the fifth year. Year on year reduction of 0.5% from the 6th till the 20th year.
10) Depreciation
    a. As per Income Tax Act- 80% for the first year and 18.75% for the rest of the years by WDV method
    b. As per Companies Act- 10.34% by SLM and 27.82% by WDV for plant and machinery.

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11) Income tax of 30% with 10% surcharge and 2% education cess amounting to 33.66%.
12) Minimum Alternate Tax of 10% with a surcharge of 10% on MAT amounting to 11%
13) Service Tax of 12% along with 2% surcharge on service tax amounting to 12.24%.
However, the project proponent considered receipt of carbon benefits during the financial appraisal of the project as the project would lead to reduction of 22917 tons of carbon. With the receipt of CDM funds the equity IRR is expected to improve to over 14%[2] (Assuming a CER Price of 12 Euros Euros and TK. 100 Conversion Rate).

[1] mnes.nic.in/Rene%202005_new.pdf
[2] There is uncertainty with regards to carbon funds.

Wind speeds are variable and therefore wind is an intermittent source of electricity. During periods of low wind, turbines cannot generate electricity and at extremely high speeds have to be shut down to prevent damage. This variable nature of wind results in low capacity utilization and reduces its attractiveness for private sector players. The project proponent expects to achieve a capacity utilization of 35%, as each turbine is expected to generate 3.65 Million Units in a year. However, the intermittent nature of the wind may result in lower realization. The return the project is expected to generate is sensitive to the CUF, as has been demonstrated in the following paragraph and has the potential to adversely affect the returns from the project. However, at the time of the project appraisal, the project proponent took into account the CDM benefits.

The following table demonstrates the sensitivity of the IRR to the change in CUF. The sensitivity analysis has been carried out assuming a CER price of 12 Euros and a Conversion rate of TK.105.

Capacity Utilization Factor	Pre-Tax TKR (W/O CDM)	Pre-Tax TKR (W CDM)	Post Tax TKR (W/O CDM)	Post Tax TKR (W CDM)	
33	12.43	19.62	10.32	17.97	
31	10.37	17.5	8.35	16.01	
29	8.29	15.39	6.35	14.03	
27	6.19	13.29	4.32	12.07	
25	4.09	11.18	2.24	10.1	

From the above table it may be concluded that the returns generated by the project are sensitive to the CUF. The expected returns expected from the project activity are 6.35% at a CUF of 35%. If the CUF reduces by even 2% from the expected utilization, the post tax return on equity will only be 4.32%. In order to be financially sustainable and to attract other private players to the sector, CERC acknowledges that a post tax return of 15% is essential[3]. With a CUF of 35%, the project activity would generate a post tax return of over 15%.

b) Poor Financial Health of PDB (OR POLLIBUDDUT): The state government of Cox's Bazar's limited financial support to the PDB (OR POLLIBUDDUT) along with free power provided to farmers has resulted in increasing subsidy burden every year on PDB (OR POLLIBUDDUT), thus undermining the commercial viability of the power sector in the state. The state government is

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still to adhere to the targets mandated by the Electricity Act, 2004, which had proposed reforms to encourage private sector participation in the power sector. Also, the Cox's Bazar Electricity Board is faced with high gearing, increase in accumulated losses, lower revenue cost coverage[4]. As on March 31st 2008, PDB (OR POLLIBUDDUT) had accumulated losses of Rs.4 billion. The poor financial health of the PDB may adversely affect the cash flow of TEK which is dependent solely on PDB OR Govt Funds for its revenues. Delay in receipt of revenues, coupled with a low rate of return can jeopardize the financial sustainability of the project.

B.6. Emission reductions:

Baseline
The Power Cell Under Ministry of Energy & Mineral Resources, Government of Bangladesh, has estimated the operating margin and the Build margin for the Southern grid, the details of which are available on the following website.

The data provided in Version 1.0 of the POWER CELL database has been used for the calculation of the Build and the Operating margin has been provided in Annex 3. For the purpose of estimation of CERs, the Combined Margin of 0.93 will be used during the first crediting period. The baseline emissions as calculated in Section B.4 are 22917 tones.

Baseline Emissions = 22917 tones of CO_2

Project Emissions
The wind power project set up by the project proponent is not expected to result in any anthropogenic emissions.

Therefore, Project Emissions = 0 tones of CO_2

Leakage
TEK has identified no anthropogenic greenhouse gases by sources outside the project boundary that are significant, measurable and attributable to the project activity. Hence, no leakage is considered from the project activity.

Therefore, EL= 0 tones of CO_2

Emission Reduction

$ER = (TP_{exp} \times BEF) - PE - EL$

Where
ER Emission reduction per annum by project activity (tones/year)
TP_{exp} Total clean power export to grid per annum
BEF Baseline Emission Factor.
PE Project Emissions
EL Emission leakage (tones/year) (= 0)

The total clean power exported to the grid per annum at the time of verification would be calculated from PDB (OR POLLIBUDDUT) billings. However for ex-ante calculations of emission

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reductions TP_{exp} has been calculated assuming a Plant Load Factor of 35% with the plant operating for 8760 hours.

B.6.2. Data and parameters that is available at validation:

Data / Parameter:	NEF_B
Data Unit	tCO2/KWh
Description	Baseline Emission Factor
Source Line data Used	Power Cell, Ministry of Energy & Mineral Resources
Justification of the choice of data or description of measurement methods and procedures actually applied :	The Ministry of power intends to achieve 100% rural electrification by the year 2012. Bangladesh has large coal and gas reserves which provide a ready and economical resource and ensure energy security. Hence, coal has been identified as the mainstay fuel for power generation till 2012. Few Large Power Project need to be commissioned by the year 2012 to achieve the goal. Hence, in the coming years, the contribution of fossil fuel based power plants is expected to increase and hence the baseline may be considered conservative.
Comments	Based on Latest Data available in South Asia, Bangladesh, NASA

B.6.3 Ex-ante calculation of emission reductions:

Based on the methodology and formulas detailed in the above section, the Carbon Emission Reductions have been calculated and are provided in Appendix C

B.6.4 Summary of the ex-ante estimation of emission reductions:

SL	Year	Project Activity Emissions (tCO2e)	Leakage Estimation (tCO2e)	Baseline Emissions (tones of CO2e)	Emission Reductions (tCO2e)	
			0			
1	2009-2010	0	0	22917	22917	
2	2010-2011	0	0	22917	22917	
3	2011-2012	0	0	22917	22917	
4	2012-2013	0	0	22917	22917	
5	2013-2014	0	0	22917	22917	
6	2014-2015	0	0	22917	22917	
7	2015-2016	0	0	22917	22917	
8	2016-2017	0	0	22917	22917	
	Total			183336	183336	

B.7 Application of a monitoring methodology and description of the monitoring plan:

B.7.1 Data and parameters monitored:

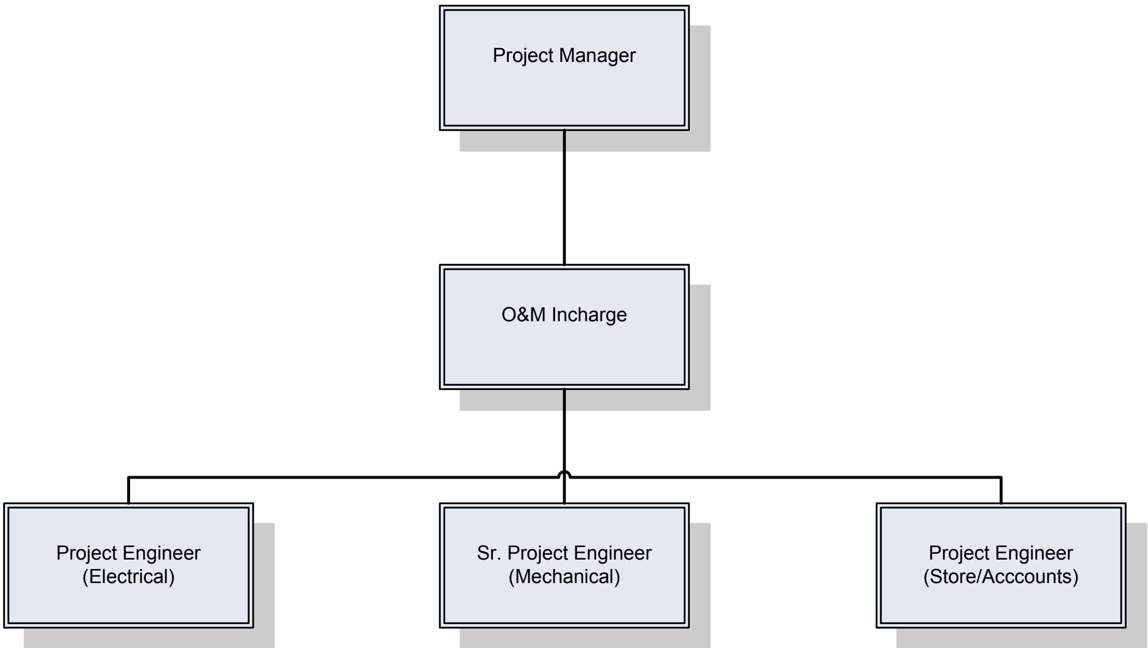
Data / Parameter:	Power Exported
Data Unit	KWh per annum
Description	Power exported to the grid by the power plant during the crediting period.
Source Line data Used	Monthly billing records of the Power Cell (Cox Bazar PDB Subdivision) electricity supplied to the grid.
Value	36.5 Million per annum
Description of measurement methods and procedures actually applied :	Power exported will be recorded at the plant using energy meters For billing purposes, the meter readings will be taken every month by PDB (OR POLLIBUDDUT) officials in presence of company representatives and readings will be jointly certified..
QA/QC procedures to be applied:	Detailed in Annex-4
Comments	Power exported has been calculated for ex ante purpose assuming a plant load factor of 35% and 8760 working hours in a year.

Data / Parameter:	Power Imported
Data Unit	KWh
Description	Power imported from the grid by the power plant for start up purpose during the crediting period.
Source Line data Used	Meter to be Installed
Value	0
Description of measurement methods and procedures actually applied :	The data will be directly measured and monitored at the project site using meters installed at the plant site.
QA/QC procedures to be applied:	Detailed in Annex-4
Comments	The power to be imported is very low as compared to the power generated. For extant estimation of CER, power imported is assumed to be zero.

B.7.2 Description of the monitoring plan:

Monitoring methodologies / guidelines mentioned in the UNFCCC document of “Annex B of the simplified modalities and procedures for small scale CDM project activities” for small scale projects (Type I: D) is considered as basis for monitoring methodology for the activity. The project proponent will monitor the electricity generated using energy meters. The project proponent may use electricity from the grid for start up purpose and the electricity imported will be monitored as well. Further details have been provided in Annex 4.

The wind power plant will be under the supervision of an O&M In-charge- a Manager. An Engineer with exposure in operation and maintenance of major mechanical and electrical equipment can suffice the purpose of Site In-charge. A team of three Project Engineers at the site shall supervise the wind power plant operating under the guidance and Instructions of the Site In-charge. Project Engineers could be Diploma holders in mechanical or electrical engineering. The Site In-charge shall be responsible for the Operation & Maintenance of all wind turbines, maintaining logbooks, preparing periodic summary reports and also for maintaining and issue various spare parts and consumables. The Site In charge would report on a monthly basis to the Project Manager at the Headquarters. The organization structure is provided below. TEK has also entered into a comprehensive O&M agreement with Suzlon to provide operation and maintenance service for the project activity. The organization structure for monitoring is provided below



Emergency Preparedness Plan

The operational staff’s main task is to keep a close watch on a day to day basis on the functioning of the wind turbines. In the event of adverse grid condition of grid failure, the turbine would stop functioning and would restart automatically on resumption of healthy conditions. However there may be faults which will require pre-checking the machine condition before restarting. The operating staff would also document the downtime and operating hours for each turbine along with the reasons for the downtime. The operating staff would summarize the logbook data on a monthly basis and provide the same to the head office.

Suzlon, the O&M service provider will deploy maintenance staff at the plant to ensure minimal breakdown of the machines. Additionally, it will ensure supply of sufficient quantity of critical and essential spares and consumables for the requirement of the machines. These critical and essential spares and consumables shall be stocked at the project site to reduce the machine repair downtime. A complete set of tools and tackles will be maintained at the site at the project site by the O&M service provider and will be provided to the project site staff. The site in-charge together with the staff would ensure that periodic maintenance checks are performed on all major components like gearbox, generator, rotor blades, control panels, transformers, control panels etc.

B.8 Date of completion of the application of the baseline and monitoring methodology and the name of the responsible person(s)/entity(ies)

September 30, 2009
Tek Energy LTD, Bangladesh (Project Proponent).

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

January 01, 2009

C.1.2. Expected operational lifetime of the project activity:

25 Years

C.2 Choice of the crediting period and related information:

The project promoter intends to apply for a **Renewable Crediting Period**

C.2.1. Renewable crediting period

C.2.1.1. Starting date of the first crediting period:

01/01/2010
(If the registration of the project is after 01/01/2010, the date of registration would be considered as the start date for the first crediting period. The project participants will not commence the crediting period prior to the date of registration.)

C.2.1.2. Length of the first crediting period:

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07 Years

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

Unknown at this point

C.2.2.2. Length:

Unknown at this point

SECTION D. Environmental impacts

D.1. If required by the host Party, documentation on the analysis of the environmental impacts of the project activity:

The project is a wind based power project and is not listed in the notification released by the Ministry of Foresty, Government of Bangladesh. Hence it is not required by the host party.

D.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party

The environmental impacts are not considered to be significant by the project participant or the host party.

SECTION E. Stakeholders' comments

E.1. Brief description how comments by local stakeholders have been invited and compiled:

The local stakeholders were identified based on the impact or the possibility of impact due to the project activity. The Plant management and the Corporate Headquarter together identified the following as their local stakeholders:
a) Office bearers and residents of the neighboring villages, b) Representative of PDB (OR POLLIBUDDUT) c) Local employees, d) Social workers active in the local region.

The opinion of the institutional stakeholder about the project activity is reflected in the approvals received by TEK. However, in order to provide the local villagers, an opportunity to express their view on the project activity and build a rapport with the local population, TEK decided to conduct a stakeholder meeting in its plant on the 20th of December 2006 and invitations were sent in advance intimating them about the day, time, venue and the purpose of the meet. In the meeting, the Senior Project Manager of TEK, welcomed the stakeholders and provided them a brief idea on the project activity. He also explained them about the causes and effect of global warming and how it could possibly affect the planet. He also introduced them to the concept of CDM and explained as to how the project activity would help in reducing greenhouse gas emissions. Then the stakeholders were invited to present their views on how the setting up of the project activity had affected their lives and their expectations from TEK. A summary of the comments received has been provided in the section E.2.

E.2. Summary of the comments received:

The stakeholder meeting was conducted at TEK's plant site and was attended by the office bearer and the residents of the nearby villages, the employees of TEK and representative of PDB (OR POLLIBUDDUT). Summary of the comments received from the stakeholders

Local Population: The villagers and the office bearers their expressed pleasure with the setting up of the power project as it had provided the rural population with permanent employment opportunities. The villagers expected creation of indirect employment opportunity for some of them due to the project activity. Also, they expected the power situation in their village to improve after the commissioning of the plant. The increase in the land prices subsequent to the setting up of the project has resulted

Representative of PDB (OR POLLIBUDDUT): Stated that the power situation in the region has improved with the setting up of the power project and now there is no need for load shedding. Also, the setting up of the power project has helped in reducing the transmission & distribution losses.

Employees: The local population hired for the project activity is pleased with the employment opportunity and expect that with the commissioning of the plant and with training of the employees, their skills would improve thus providing them with an opportunity to gain higher wages.

Social Worker: A retired school teacher who is an active social worker attended the meeting. He stated that the project has not only provided employment opportunities in its plant but has created opportunities for many others indirectly. The petrol pumps opened in the locality subsequent to the setting up of the power project has obviated the need for the local people to travel 30 to 40 kms to get diesel for their pumps. The teacher also stated that, with comparatively higher salaries being offered to the locals employed for the project activity, they would be able to send their children to school. Thus the project activity may assist in reducing child labor as well.

E.3. Report on how due account was taken of any comments received:

All comments received were positive. No improvement opportunities were identified. No negative comments were received from any of the stakeholders which mandated an action.

ANNEX 1

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Bangladesh:		
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ZipCode	1214	
Telephone	880-28849179	
Fax:	880-28849197	
Email	info@tek-energy.com	
Website:	www.tek-energy.com	
Contact	Zahir Uddin Ahmed, General Manager	
Personal email:	zahir.uddin@tek-energy.com	
USA		
Organization	GreenTek Energy USA, Inc (a JV of Techno International Corp)	
Address	31-08, 30 Ave, G Floor	
City, Country	Astoria, New York, USA	
ZipCode	11103	
Telephone	1-718-274-6500	
Fax:	1-718-274-6502	
Email	info@techno-international.com	
Website:	www.techno-international.com	
Contact	Jamil Uddin, Vice President	
Personal email:	jamil.uddin@techno-international.com	

Annex 2
BASELINE INFORMATION

The Power Cell Under Ministry of Energy & Mineral Resources, Government of Bangladesh, has estimated, the Build Margin and the Simple Operating Margin for the Southern grid, the details of which is available on the following website and is detailed below as well:

http://www.powercell.gov.bd

Version 1.0 of the database has been used for the estimation of the Baseline Emissions.

Gross Generation Total (GWh)
2000-01 2001-02 2002-03 2003-04 2004-05
South 128,983 131,902 136,916 138,299 144,086
Net Generation Total (GWh)
2000-01 2001-02 2002-03 2003-04 2004-05
South 121,144 123,612 127,780 128,165 134,691
20% of Net Generation (GWh)
2000-01 2001-02 2002-03 2003-04 2004-05
South 24,229 24,722 25,556 25,633 26,938
Share of Must-Run (Hydro/Nuclear) (% of Net Generation)
2000-01 2001-02 2002-03 2003-04 2004-05
South 28.1% 25.5% 18.3% 16.2% 21.6%
Net Generation in Operating Margin (GWh)
2000-01 2001-02 2002-03 2003-04 2004-05
South 87,100 92,085 104,441 107,396 105,584
Net Generation in Build Margin (GWh)
2000-01 2001-02 2002-03 2003-04 2004-05
South 27,195
Emission Dat
Absolute Emissions Total (tCO2)
2000-01 2001-02 2002-03 2003-04 2004-05
South 88,728,956 92,484,478 104,180,940 108,406,007 105,960,087
Absolute Emissions OM (tCO2)
2000-01 2001-02 2002-03 2003-04 2004-05
South 88,728,956 92,484,478 104,180,940 108,406,007 105,960,087
Absolute Emissions BM (tCO2)
2000-01 2001-02 2002-03 2003-04 2004-05
South 19,525,581
Emission Factor
Simple Operating Margin (tCO2/MWh) (incl. Imports)
2000-01 2001-02 2002-03 2003-04 2004-05
South 1.02 1.00 1.00 1.01 1.00
Build Margin (tCO2/MWh) (not adjusted for imports)
2000-01 2001-02 2002-03 2003-04 2004-05
South 0.72

Annex 3
MONITORING INFORMATION

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The calibration of monitoring equipment will be maintained as per the requirement of PDB (OR POLLIBUDDUT) and the same will be done regularly. Power exported to the grid and imported from the grid will be recorded on a monthly basis and the same will be verified and approved by Project Manager. These records will be sent to the Head Office for review by the Director and for corrective actions if necessary.

Internal Auditors will also verify the monitoring data. As per the advices of the Internal Audit team, corrective actions will be taken up for more accurate future monitoring and reporting system.

The Plant is equipped with energy meters/export meters for monitoring and control purpose. These meters are installed next to the WTG in the switchyard. The meter will account for the energy imported from the grid as well and hence, the readings shown would be for the net energy exported. The energy meters will be tested and calibrated utilizing a standard meter by PDB (OR POLLIBUDDUT). The standard meter will be calibrated once in a year at the approved laboratory of Govt. of Bangladesh or Govt. of Cox's Bazar as per terms and conditions of supply. The testing of the meter will be jointly conducted by authorised representatives of TEK and PDB (OR POLLIBUDDUT) and the results and correction so arrived at mutually will be applicable and binding on both the parties. The energy meters will not be interfered with, tested or checked except in the presence of representatives of company and PDB (OR POLLIBUDDUT). If any of the meters is found to be registered inaccurately, the affected meter will be immediately replaced. If during the test checks both the meters are found beyond permissible limits of error, both the meters will be immediately replaced and the correction applied to the consumption registered by the main meter to arrive at the correct energy exported for billing purposes for the period of one month up to the time of test check, computation of exported energy for the period thereafter till next monthly reading will be as per the replaced meter. Corrections in exported energy will be applicable to the period between the two previous monthly reading and the sate and time of test calibration in the current month when error is observed.

Power exported and imported will be recorded at the plant from the installed meters. However, for billing PDB (OR POLLIBUDDUT), the meter readings will be taken every month by PDB (OR POLLIBUDDUT) officials in presence of company representatives and readings will be jointly certified.

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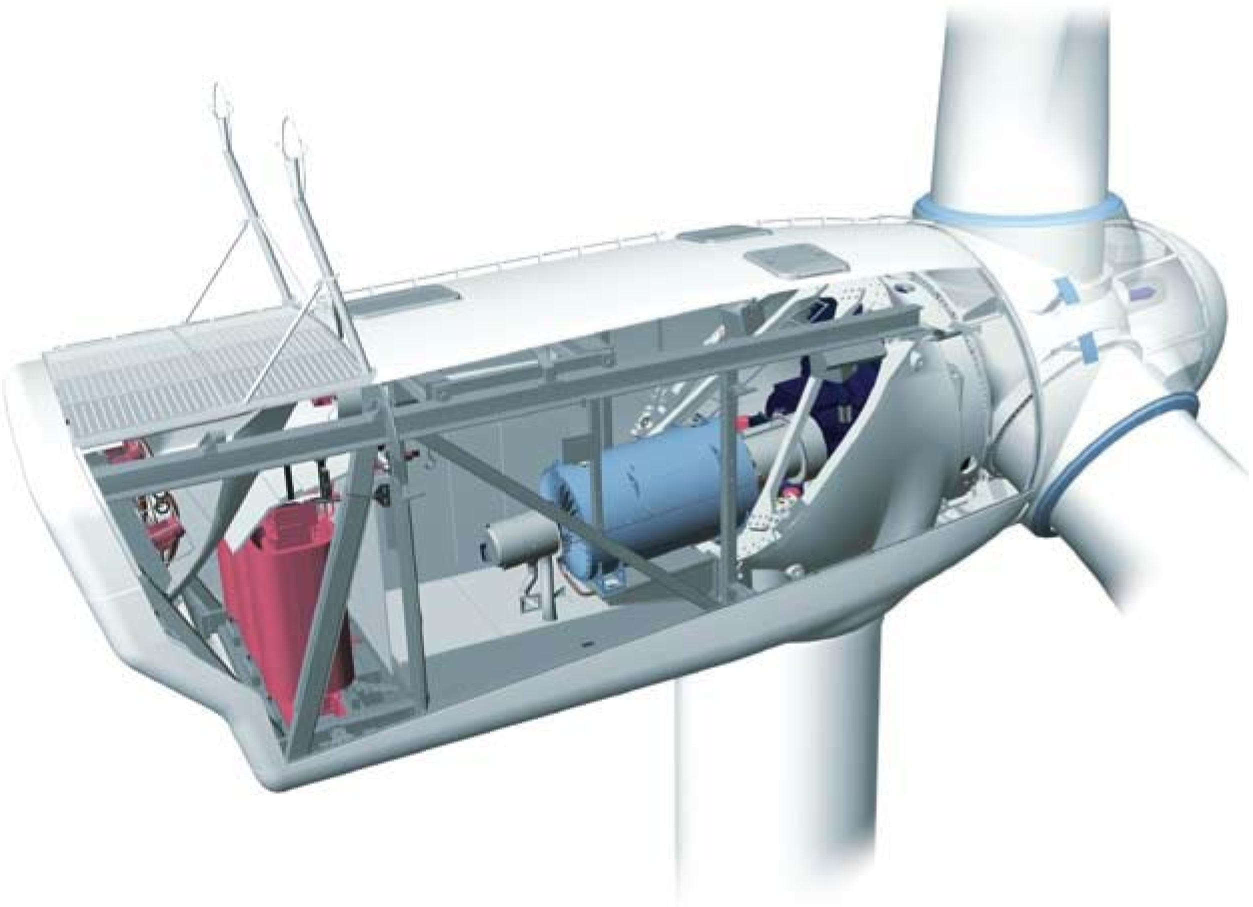
Appendix A
A Wind Turbine (Model Vestas V90)



Technical specifications

1) Oil cooler
2) Water cooler for generator
3) High voltage transformer
4) Ultrasonic wind sensors
5) VMP-Top controller
6) with converter
7) Service crane
8) Generator
9) Composite disc coupling
10) Yaw gears
11) Gearbox
12) Mechanical disc brake
13) Machine foundation
14) Blade bearing
15) Blade hub
16) Blade
17) Pitch cylinder
18) Hub controller

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SUZLON Turbine Specification:

model	capacity	blade length*	hub ht†	total ht	area swept by blades	rpm range	max blade tip speed	rated wind speed
Suzlon S.64/1250	1.25 MW	32 m (105 ft)	73 m (240 ft)	105 m (344 ft)	3,217 m^2 (0.79 acres)	13.9/20.8	156 mph	12 m/s (27 mph)

Appendix B
Abbreviations

BEF Baseline Emission Factor
BM Build Margin
CDM Clean Development Mechanism
POWER CELL Power Development Authority
CER Certified Emission Reductions
CM Combined Margin
Cm Centimeter
CO_2 Carbon Dioxide
CUF Capacity Utilization Factor
DPR Detailed Project Report
GHG Greenhouse Gas
GoI Government of India
IPCC Intergovernmental Panel on Climate Change
IPP Independent Power Producers
IREDA India Renewable Energy Development Agency
IRR Internal Rate of Return
Kcal Kilo Calories
Kg Kilogram
KM Kilometer
KP Kyoto Protocol
KW Kilowatt
KV Kilovolts
kWh Kilowatt hour
TEK Tek Energy LTD
LP Low Pressure
MNES Ministry of Non-Conventional Energy Sources
MT Metric Tons
MU Million Units
MW Megawatt

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NGO Non Government Organizations
NOC No Objection Certificate
OM Operating Margin
PDB Power Development Board of Bangladesh
PDD Project Design Document
PLF Plant Load Factor
PM Particulate Matter
PPA Power Purchase Agreement
QA Quality Assurance
QC Quality Control
RE Renewable Energy
SO Supplementary Order
STG Steam Turbine Generator
T&D Transmission and Distribution
TJ Tera Joule
UNFCCC United Nations Framework Convention on Climate Change
WTG Wind Turbine Generator

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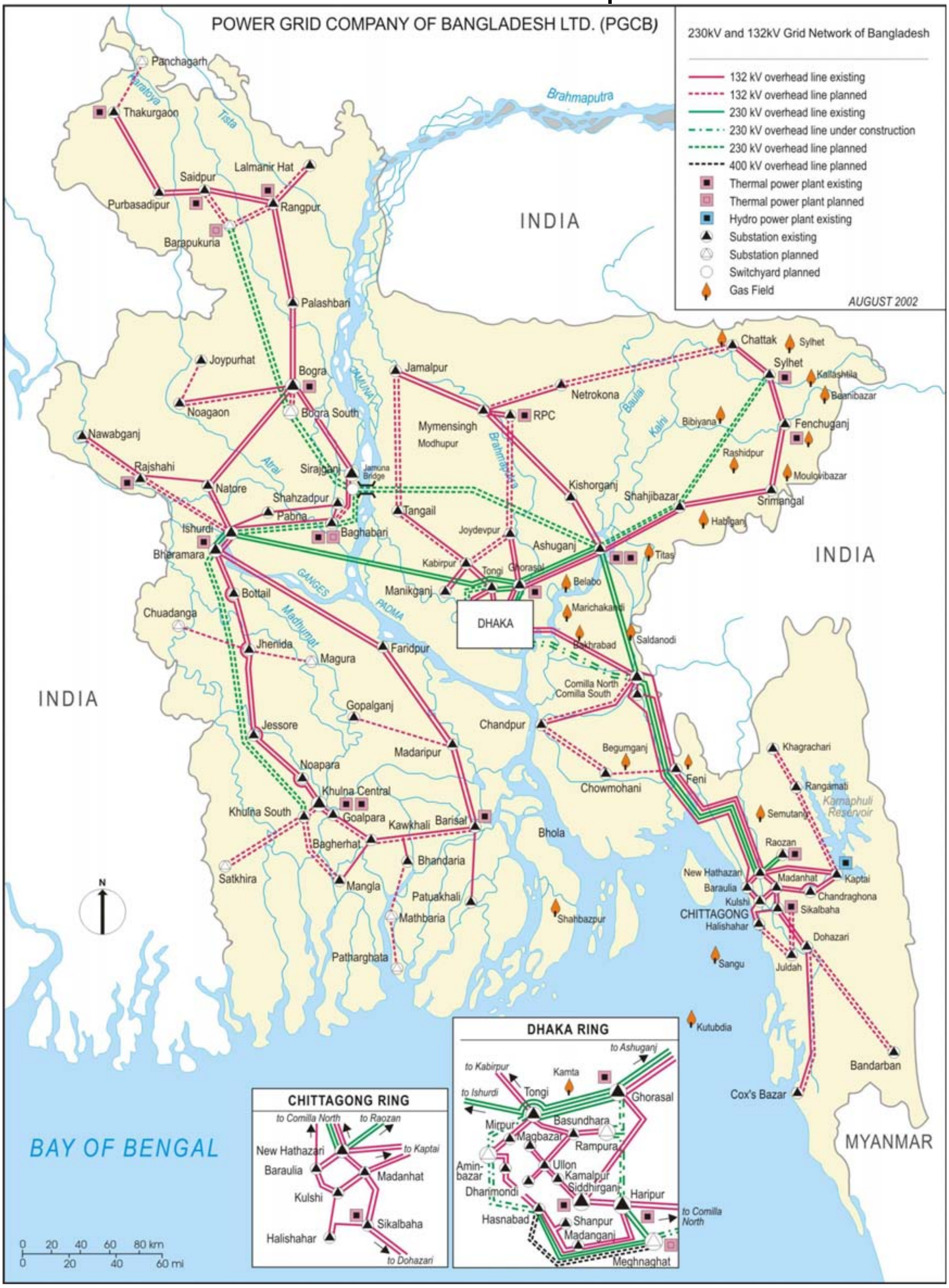
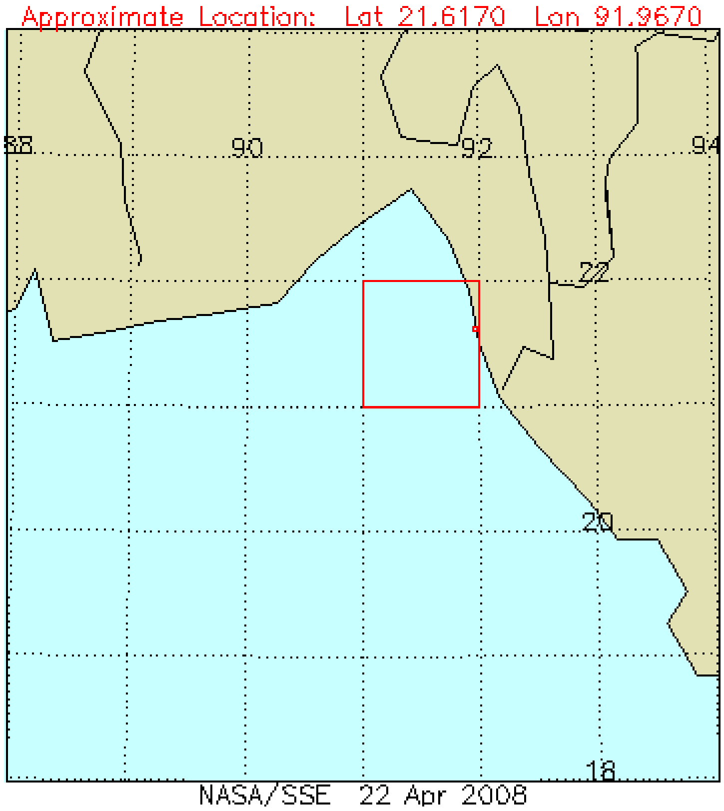
Appendix C
National Power Grid Map



Appendix D
Wind Data

NASA Surface Meteorology and Wind Energy - Tables
At Latitude **24** and Longitude **90**
BANGLADESH



Geometry Information

Average elevation: **113** meters

Northern boundary
25

Western boundary
90

Center
Latitude **24.5**
Longitude **90.5**

Eastern boundary
91

Southern boundary
24

Monthly Averaged Wind Speed At 50 m Above The Surface Of The Earth (m/s)													
Lat 24	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual

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Lon 90													Average
10-year Average	2.59	2.85	3.00	3.11	3.05	2.88	2.59	2.34	2.21	2.06	2.29	2.40	2.61

Minimum And Maximum Difference From Monthly Averaged Wind Speed At 50 m (%)

Lat 24 Lon 90	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Minimum	-9	-14	-17	-12	-10	-10	-7	-7	-7	-10	-13	-8	-10
Maximum	10	16	21	21	21	8	6	9	8	10	15	5	12

It is recommended that users of these wind data review the SSE Methodology, Section 7. The user may wish to correct for biases as well as local effects within the selected grid region.

All height measurements are from the soil, water, or ice/snow surface instead of "effective" surface, which is usually taken to be near the tops of vegetated canopies.

Parameter Definition ***Units Conversion Chart***

Monthly Averaged Percent Of Time The Wind Speed At 50 m Above The Surface Of The Earth Is Within The Indicated Range (%)

Lat 24 Lon 90	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
0 - 2 m/s	50	40	37	35	35	35	43	57	63	67	59	54	48
3 - 6 m/s	49	59	62	65	65	65	57	43	37	33	41	46	52
7 - 10 m/s	0	0	0	0	0	0	0	0	0	0	0	0	0
11 - 14 m/s	0	0	0	0	0	0	0	0	0	0	0	0	0
15 - 18 m/s	0	0	0	0	0	0	0	0	0	0	0	0	0
19 - 25 m/s	0	0	0	0	0	0	0	0	0	0	0	0	0

Parameter Definition

Monthly Averaged Wind Speed At 50 m Above The Surface Of The Earth For Indicated GMT Times (m/s)

Lat 24 Lon 90	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Average@2230	3.67	3.64	3.49	3.73	3.62	3.26	2.84	2.71	2.62	2.56	2.91	3.25	3.18
Average@0130	3.09	2.76	2.25	2.25	2.31	2.33	2.13	1.94	1.86	2.02	2.71	2.95	2.38

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Average@0430	1.35	1.49	1.71	2.00	2.40	2.70	2.46	2.17	1.96	1.44	1.36	1.28	1.86
Average@0730	1.85	2.25	2.71	2.73	2.64	2.61	2.35	1.96	1.81	1.49	1.78	1.80	2.16
Average@1030	1.86	2.50	2.99	2.97	2.68	2.42	2.24	1.90	1.81	1.53	1.67	1.74	2.18
Average@1330	2.72	3.29	3.65	3.69	3.37	2.91	2.70	2.43	2.37	2.21	2.24	2.46	2.83
Average@1630	2.91	3.42	3.63	3.83	3.79	3.44	3.06	2.85	2.66	2.64	2.82	2.81	3.15
Average@1930	3.24	3.45	3.59	3.72	3.59	3.40	2.96	2.79	2.63	2.66	2.91	2.95	3.15

Parameter Definition ***Units Conversion Chart***

Monthly Averaged Wind Direction At 50 m Above The Surface Of The Earth (degrees)

Lat 24 Lon 90	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10-year Average	113	136	157	156	153	148	146	143	142	141	137	134

Parameter Definition

Monthly Averaged Wind Direction At 50 m Above The Surface Of The Earth For Indicated GMT Times (degrees)

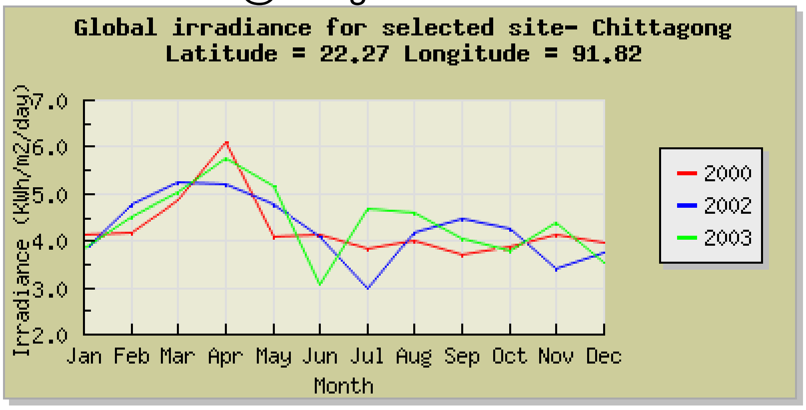
Lat 24 Lon 90	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average@2230	78	93	119	115	116	113	116	107	111	105	65	72
Average@0130	70	80	99	105	114	121	125	111	112	87	61	67
Average@0430	86	121	170	165	154	141	145	135	143	120	56	69
Average@0730	151	210	215	190	169	144	143	132	147	133	83	116
Average@1030	190	229	220	191	173	146	146	133	150	155	74	121
Average@1330	196	219	207	164	147	134	134	124	143	172	106	152
Average@1630	179	198	190	153	138	127	130	124	136	172	136	157
Average@1930	122	153	164	137	130	119	124	118	124	158	105	113

Parameter Definition

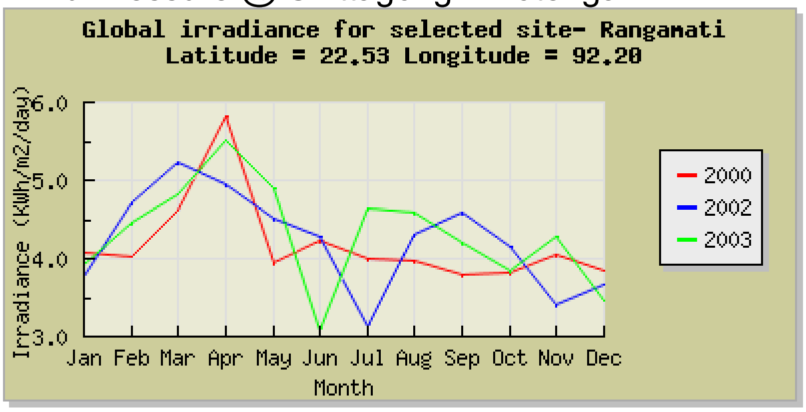
Monthly Averaged Wind Speed At 10 m Above The Surface Of The Earth For Terrain Similar To Airports (m/s)

Lat 24 Lon 90	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
10-year Average	2.04	2.25	2.37	2.46	2.41	2.27	2.04	1.85	1.75	1.64	1.82	1.90	2.06

Wind Pressure @ Rangamati



Wind Pressure @ Chittagong – Potenga



Appendix E
Wind Resource Map of South Asia

4.1. Introduction

This section presents the wind resource maps of Southeast Asia. The maps depict the mean wind speed and wind power density at 65 m, the mean speed at 30 m (a height suitable for small wind turbines), and the seasonal wind resource. We use the following wind speed and

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wind power density classification schemes for the maps. The wind power density is quoted only at the height of large wind turbines, as it is not often used to predict the performance of small turbines.

Table 4.1 Wind Resource Classifications

Map Color	Speed at 65 m (m/s)	Power Density at 65m (watt/m2)	Suitability for Large Turbine	Speed at 30m (m/s)	Suitability for Large Turbine	
Green	<5.5	<200	Poor	<4.0	Poor	
	5.5 - 6.0	200-250	Poor	4.0-4.5	Fair	
	6.0 - 6.5	250-320	Fair	4.5 - 5.0	Fair	
	6.5 - 7.0	320-400	Fair	5.0 - 5.5	Good	
Yellow	7.0 - 7.5	400-500	Good	5.5 - 6.0	Good	
	7.5 - 8.0	500-600	Good	6.0 - 6.5	Very Good	
	8.0 - 8.5	600-720	Very Good	6.5 - 7.0	Very Good	
	8.5 - 9.0	720-850	Very Good	7.0 - 7.8	Excellent	
	9.0 - 9.5	850-1000	Excellent	7.5 - 8.0	Excellent	
Red	>9.5	>1000	Excellent	>8.0	Excellent	

As the table suggests, small wind turbines are able to function at lower wind speeds than large turbines. A resource area that is of only “fair” suitability for utility-scale wind power plants may be “good” for village power. Furthermore, it is important to note that a particular location may not be assigned the same color at different heights. That is because the wind shear (the rate of change of wind speed with height above ground) varies considerably depending on the surrounding land cover and other factors. Thus it is necessary to present the results at 30 m and 65 m on separate maps. The wind power density is also not a fixed function of the wind speed because of variations in the frequency distribution and air density (the latter mainly due to elevation). However, such variations are typically small, so we present both wind power and wind speed on the same map.[8]

4.2. Wind Speed and Power at 65 m

Map 4.1 shows the predicted mean wind speed and power density at 65 m for the Southeast Asia atlas region. Good to excellent wind resource areas are concentrated in two areas: (a) mountains and mountain passes of moderate to high elevation in the southern half of the region (south of latitude 19°N); and (b) coastal areas of southern Vietnam. In both cases, the driving force is the monsoon cycle. The mountains of central and southern

Vietnam lie in an especially favorable position since they form a nearly continuous barrier that is perpendicular to the monsoon winds, which come from the northeast from around October to May and from the southwest from June to September. The mountain chains of western Thailand and the Malay Peninsula experience strong winds from time to time, but the mean speeds are significantly lower than in Vietnam and Laos. Aside from the acceleration due to the compression of the wind flow over the mountains, the wind may be enhanced in certain areas

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by mountain waves – the “bouncing” of a thermally stable air mass after it is displaced upward by a mountain range – and by temperature-driven downslope flows.
The northeast monsoon winds are not only driven over the mountains but also around the end of the Southeast Asia peninsula, where they converge with the offshore wind and accelerate. This accounts for the good to excellent wind resource found along the southern and southeastern coast of Vietnam. Small peninsulas sticking out from the coast are likely to experience especially strong winds.
In contrast, the coastal and inland plains of Thailand and Cambodia, as well as the northern mountainous region of Southeast Asia, appear to present few or no opportunities for large-scale wind power. The winds aloft are generally weak, and thus there is little momentum to be brought near the surface. Unstable moist convection causes strong winds in localized areas for short periods of time, but at most other times the wind speeds are relatively low.

4.3. Wind Speed at 30 m

The wind resource map at 30 m height above ground (Map 4.2) gives an indication of potential opportunities for village power using small wind turbines. Small turbines are sensitive to a lower range of wind speeds, and sites not suitable for utility-scale wind power generation may nonetheless be attractive for village power applications. Areas classed as “fair” or better for small wind turbines include large sections of southern and central Vietnam, both coastal and mountainous, as well as central Laos and central and southern
Thailand, and coastal areas around the Bay of Bangkok and possibly, right at the shore, on the Malay Peninsula. However most of the northern half of Southeast Asia (except along the Vietnam coast and near the China border) appears unsuitable, as does much of central and northern Cambodia away from the coast.

4.4. Seasonal Wind Maps and Wind Rose Charts

Maps 4.3-4.6 depict the wind resource at 65 m in four seasonal periods.[9] Since the color scale is the same in each case, it is easy to see differences from one period to the next. The greatest contrast is between December-February and June-August, which correspond roughly to the peak of the northeast (winter) and southwest (summer) monsoons, respectively. The other two seasons are transitional periods.
High winds occur in both December-February and June-August but in very different areas. It is striking that in December-February, when the prevailing wind is mainly from the northeast, strong winds occur in the plains to the *west* of the Giai Truong Son (Central mountains, or Chaine Annamitique) in central Vietnam and Laos. This reflects the fact that the warm and moist air coming off the oPower Celln is cooled as it rises over the mountains and loses its moisture, which causes it to become heavier and to flow rapidly down the western slopes into the lowlands below.

The northeast monsoon also brings strong winds to southern Vietnam. This may occur near the coast because the northeasterly wind creates a low-pressure zone to the south and west of the terminus of the Truong Song mountains. The low pressure reinforces the sea breeze and also pulls in offshore winds coming around the peninsula. On the other hand, the area of strong wind at around 14 degrees latitude in central Vietnam represents a channeling of the northeasterly winds through a broad gap in the mountains.

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In June-August, southwest winds on the mountains of western Thailand are quite strong, whereas
in Vietnam windy areas are found to the east of the mountains, an echo of the downslope winds seen in December-February on the opposite side of the range. It is also possible that along the coast of Vietnam the low-pressure area created in the lee of the mountains reinforces the land-sea breeze that occurs because of the especially strong summer heating of the land surface. These general patterns can be seen in the wind rose charts for nine selected points shown in Map 4.7.[10] The nine points are numbered starting from the southwest and going clockwise around the region. At points 1 and 2, the winds are mainly westerly because the summer monsoon produces the strongest winds in this part of the region. There is an indication of a moderate sea breeze from the south at site 2. Moving northeastward, the easterly and northeasterly winds of the winter monsoon become more important. Point 4 in the eastern plains of Thailand is especially interesting, as the wind here is entirely from the northeast, thanks to the winter flow down the western slope of the mountains. The reverse occurs in summer at point 7, resulting in a significant westerly component to the wind there. At point 8 on the southeastern coast of Vietnam, the wind is almost entirely from the northeast and parallel to the coast.

4.5. Adjustments for Local Conditions

It must always be kept in mind that the mean wind speed or power at a particular location may differ substantially from the predicted values because of variations in elevation, exposure, surface roughness, and other factors. The following guidelines should be followed when interpreting the maps.

4.5.1. Obstacles

This atlas assumes that all locations to be considered for wind energy are free of obstacles that could disrupt or impede the wind flow at the height of the wind turbine. “Obstacle” does not apply to trees if they are common to the landscape, since their effects are already accounted for in the predicted speed (however note the discussion of displacement height below). However a large outcropping of rock would pose an obstacle for a wind turbine, as would a nearby shelter belt of trees or a building in an otherwise open landscape. As a rule of thumb, the effect of such obstacles extends to a height of about twice the obstacle height and to a distance downwind of 10-20 times the obstacle height.

4.5.2. Variations in Elevation

Generally speaking, points that lie above the average elevation within a 1x1 km square will be somewhat windier than points that lie below it. A rule of thumb appropriate for Southeast Asia is that every 100 m increase in elevation above the average will result in an increase in the mean wind speed of 0.25 m/s, or

$$\Delta v \approx 0.0025 . \Delta z$$

This formula is most applicable to small, isolated hills or ridges in otherwise flat terrain. It should be used with caution, if at all, in mountains where it is difficult to determine what the “average” elevation is, and where wind flows in any event can be very complex.

4.5.3. Variations in Roughness

The roughness of the land surface – which is determined mainly by the height and type of

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vegetation and buildings – has an important impact on the mean wind speed at heights of interest for wind turbines. The MesoMap system assumes a certain roughness for each type of land cover in the land cover data base. As noted in section 3, the land cover assignments may be wrong in some places, and even if correct, the land cover and roughness may vary within a grid cell.

The following table provides approximate factors that can be used – with caution – to adjust the wind speed estimate at a particular location for different values of surface roughness.

Table 4.2 Wind Speed Adjustment Factors

Land Cover	Roughness	Height Above Ground	
		65m	30m
Lake or OPower Celln	0.2	1.05	0.95
Low Grass or Corps	2	1.02	0.89
High Grass or Corps	5	1	0.86
Low, spares trees	13	0.98	0.82
Wood/Sparse Forest	40	0.94	0.76
Towns	75	0.91	0.71
High, Dense Forest	120	0.89	0.68
High, Dense Forest (15m displacement)	120	0.83	0.56

These factors may be used when the local surface roughness differs substantially from that indicated in the land cover map. (The CD-ROM that accompanies this atlas provides the elevation and surface roughness assumed by the model at each point in the map.) The corrected speed is the map speed multiplied by the factor from the table for the correct land cover, divided by the factor for the land cover assumed by the model. For instance, suppose the predicted wind speed is 6.5 m/s for a tropical forest land cover, whereas the actual land cover is low, sparse trees. The corrected wind speed estimate would then be 6.5.0.98/ 0.89 = 7.1m/s. The factors in Table 4.2 were calculated on the assumption that the wind is in equilibrium with the surface roughness. When the wind encounters an abrupt change in surface roughness – for example, when it exits a forest to enter an open field – the wind profile will not fully reflect the smoother surface of the field for a distance of up to several hundred meters downwind of the change. For this reason the correction method described here should not be used for a clearing that is smaller than about 1000 m across. When in doubt, a meteorologist should be consulted.

4.5.4. Displacement Height

An additional factor to consider is that the heights of the wind maps and in Table 4.2 may not always be the height above ground. Where the vegetation is very dense, the "effective ground level" is not the ground but the middle of the vegetation canopy because the wind flow is displaced upward. The level of zero wind, called the *displacement height*, is typically about 2/3 the height of the top of the vegetation.

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In dense tropical forests the height above ground at which the predicted wind speed actually occurs *may be as much as 15-20 m higher than indicated on the maps*. Or, using the factors from the last row of Table 4.2, the speed at 65 m may be about 7% (1-0.83/0.89) lower than indicated on the map, while the speed at 30 m it may be 18% (1.0-0.56/0.68) lower.

Map 4.1

South Asia (Thailand, Vietnam, Combodia, Myanmmar)

Map 4.3: Win Speed at 65m elevation

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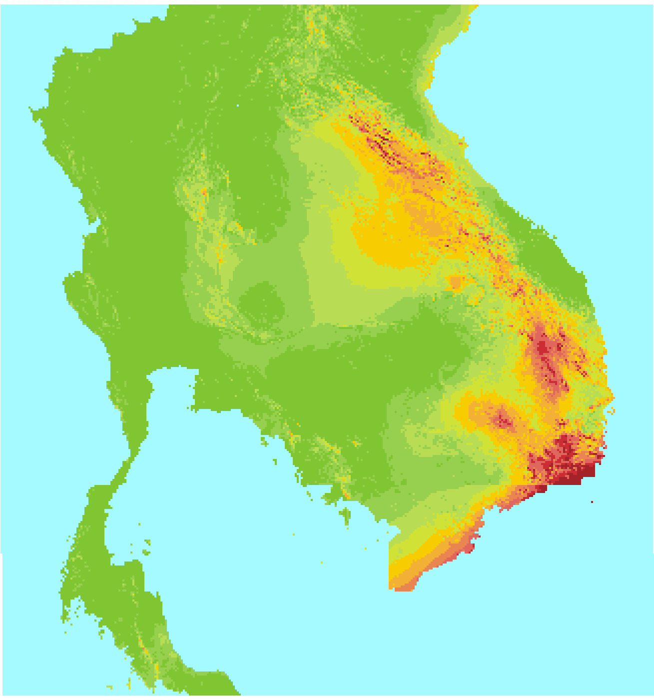

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Appendix F
RET Analysis

Technology		Wind turbine
Analysis type		Method 1 (selected) / Method 2 / Method 3
Wind turbine		
Power capacity	kW	10,000
Manufacturer		Suzlon
Model		S.82/1,500 - 80m
Capacity factor	%	35.0%
Electricity exported to grid	MWh	36,500
Electricity export rate	BDT/MWh	4,000.00

Emission Analysis

Base case electricity system (Baseline)		GHG emission factor (excl. T&D)
Country - region	**Fuel type**	**tCO2/MWh**
Bangladesh	All types	0.611

Electricity exported to grid	MWh	68,328
GHG emission		
Base case	tCO2	41,748
Proposed case	tCO2	4,175
Gross annual GHG emission reduction	tCO2	37,573
GHG credits transaction fee	%	0.0%
Net annual GHG emission reduction	tCO2	37,573
GHG reduction income		
GHG reduction credit rate	BDT/tCO2	1200.00
GHG reduction credit duration	yr	10
GHG reduction credit escalation rate	%	10.0%

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Financial Analysis

Financial parameters		
Inflation rate	%	5.0%
Project life	yr	20
Debt ratio	%	80%
Debt interest rate	%	10.00%
Debt term	yr	5
Initial costs		
Power system	BDT	500,000,000
Other	BDT	10,000,000
Total initial costs	BDT	510,000,000
Incentives and grants	BDT	5,000,000
Annual costs and debt payments		
O&M (savings) costs	BDT	10,000,000
Fuel cost - proposed case	BDT	0
Debt payments - 5 yrs	BDT	107,629,372
	BDT	
Total annual costs	BDT	117,629,372
Annual savings and income		
Fuel cost - base case	BDT	0
Electricity export income	BDT	122,640,000
GHG reduction income - 10 yrs	BDT	20,231,921
	BDT	
Total annual savings and income	BDT	142,871,921
Financial viability		
Pre-tax IRR - equity	%	65.0%
Pre-tax IRR - assets	%	22.6%
Simple payback	yr	3.6
Equity payback	yr	2.1

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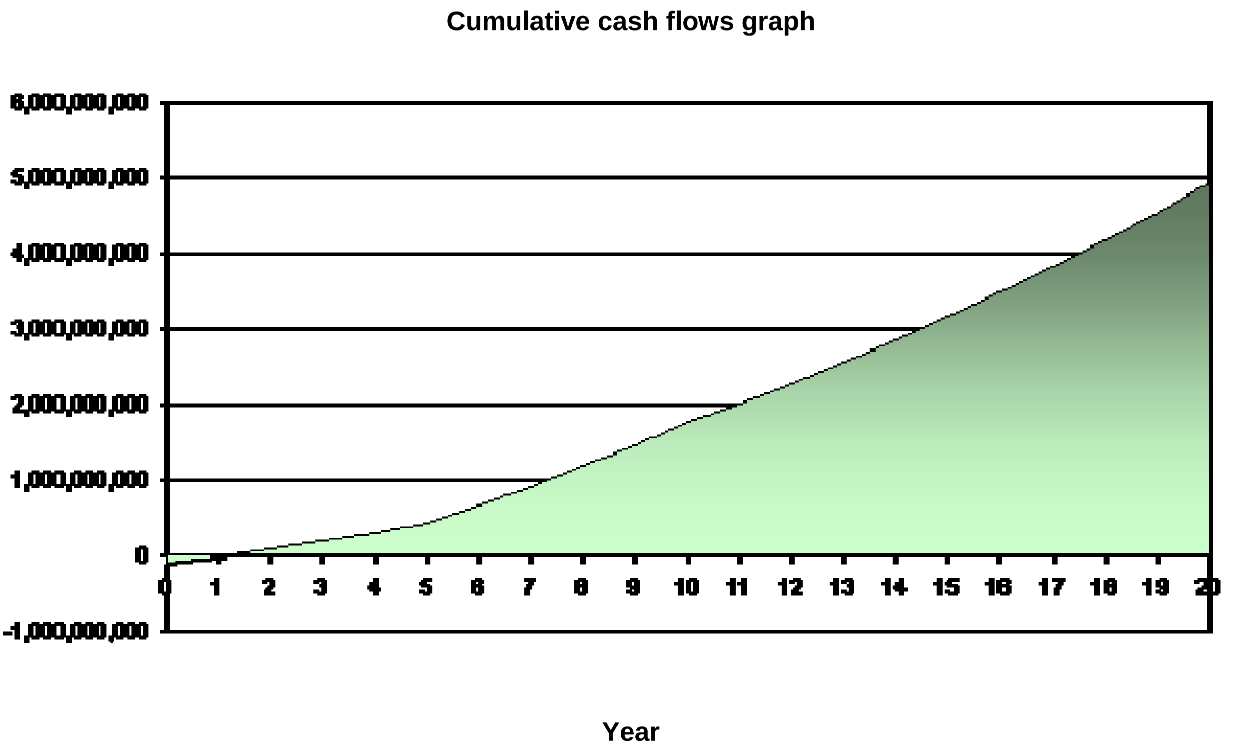
Return of Investment



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