Presented at the European Wind Energy Conference; Coopenhagen; 2-9 July, 2001

SCOPE AND PROSPECTS OF RE-ENGINEERING AND RETROFITTING WINDFARMS IN INDIA

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ABSTRACT: The paper starts with a brief analysis of the characteristics of the Indian wind energy programmes while enumerating the developments that have taken place so far. In view of the large scope for renewable energy based power genereation and in order to boost the present uprise of the wind farm development, the authors investigate the possibilities that lay in re-engineering of existing wind farms. Existing wind farm entrepreneurs are showing interest to improve the performance of their wind farms. New initiatives are suggested addressing the involved technical and commercial concerns of both the state-run utility (the principal customer of wind generated electricity) and wind farm entrepreneur to spur development of economically competitive wind-power plants In addition, inferences are drawn from a recently conducted detailed case study at a 5 year old large wind farm in Muppandal area. The study involved conducting detailed WAsP based analysis based on remote land use & land cover details interfacing with GIS. In addition, detailed site investigations were conducted to assess the health of the machines and the adequacy of the power evacuation facility together with the analysis of the machine down times. The paper highlights the benefits that can be expected from such undertakings for several parties both in India and in EU. The paper finally outlines the possible business opportunities and economic benefits that exist for retrofitting and re-engineering in the country, which has over 700 individually designed wind farms.
Keywords: wind farm development, re-engineeering of windfarms, India, emission trading

1 WHY IS IT NECESSARY?

The Ministry of Non-conventional Energy Sources (MNES) [previously Department of Non-conventional Energy Sources (DNES)], Government of India (GOI), gave impetus to grid quality power generation by wind turbine technology in the 7th National Five-Year Plan (NFYP) (1985—90). Since then, wind-power generation has gained good response from industries, entrepreneurs and businessmen. By the start of the 8th NFYP (1992—97) period, grid quality wind-power generation became the thrust area of the MNES. India, with 1339 MW of installed capacity (March 2001), stands fifth in the world wind energy installation ranking list—with around 97% contribution being made by the private sector. Most of the wind-power developments have essentially taken place in terms of total installed capacity in the States of Tamil Nadu (61%), Gujarat (14%), Maharashtra (12%) and Andhra Pradesh (7%), where the State-run utilities and State nodal agencies, operating under the aegis of both the State energy departments and the MNES, provided active support.

The primary driving force the India to promote wind energy has been the acute (& growing) demand-supply gap and energy security. Rise fall and rise in terms of capacity additions since 1991 with year wise capacity additions is shown in figure 1.

The following reasons can be attributed to the slowdown:.

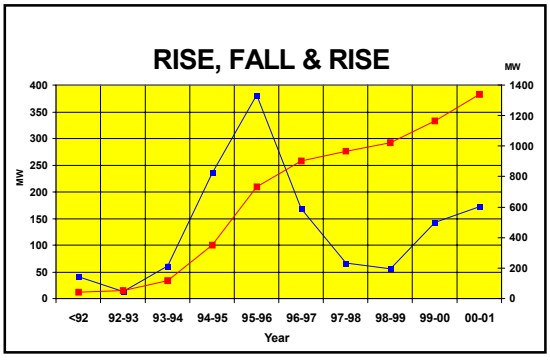
- Attractiveness of investment in wind-power plants as a means for tax saving decreased by nearly half in the financial year 1996-97

- Performance of wind farms was much below the expectation raised in feasibility studies, because of inadequate wind resource assessment, improper wind-power plant design and siting. This is due to either lack of appropriate tools to estimate winds in time and space in complex terrains or to the fact that the wind analysis packages used were largely appropriate for only flat terrains (whereas the sites in India are highly complex in nature)

- Nearly all the the wind turbines installed in India are of European design where there has been little or no effort to adapt wind for operation in weak Indian grids, and as a consequence performance of wind-power plants has been considerably affected.

Lately under the aegis of globalization and liberalization phenomena , the private sector has been driven to be competitive, and under this new environment it has realized the economic utility of the fixed life cycle cost of wind generated electricity (against the market price based conventional fossil based electricity). As a result there is resurgence among the earlier investors in wind farms to improve their wind power plant performance.

Figure 1. Evolution of wind power capacity addition in India since 1991.



Morover, the operation time of wind turbines is seriously affected because of lack of spares (largely) and proper O&M measures. In this regard it may be noted that there are nearly 55 different types of wind turbines form nearly 30 different wind turbine manufacturers. Many of those

WT manufacturers have either disappeared or have stopped manufacturing anymore the earlier WT products. Of the nearly 55 different WT makes & types nearly 23 types of wind turbines are rated below 250 kW and 11 are below 100 kW rating.

2 WHAT DOES IT INVOLVE?

Before commencing on impleting ad-hoc measures to improve the performance of WTs (& so the WF in India) it is necessary to have an comprehensive technical investigations and then to evaluate the cost-benefit ratios of each of the issues considered. The economic spin-off oppurtunities under the emission trading frameworks under AIJ/JI frameworks or under probable framework of CDM under Koyoto protocal presents a very good win-win situation for EU entities and wind farms in India. A five stage process is required to undertake such an activity as described below.

Step 1: Investigations

- Assess adequacy of siting and wind resources, which includes (a) Re-location of wind turbines on account of bad siting & wake losses, (b) Increasing hub height of the wind turbines and (c) Increasing rotor swept area
- Assess adequacy of machine power curve which includes (a) Dirty blades, (b) Pitch angle settings for stall regulated machines, (c) Yaw misalignment & (d) High wind hysterisis
- Evaluate adequacy of electrical networking which includes (a) T&D losses & (b) Reactive power compensation
- Assess machine down time in term of (a) O&M practises: Schedule, MTBF (logistics) & (b) Availability and reliability of spares

Step 2: Configuration / design

- Improved WF layout
- Optimal Turbine design modifications
- Seeking design certifications

Step 3: Financial closure

- Preparation of bankable project documents
- Seeking finances (loans) from financial institutions/Utilities/Corporates

Step 4: Implementation

- Project scheduling: Low wind period & other site specific conditions
- Contracting

Step 5: Verification

- Third party inspection for Emission trading

3 KEY FINDINGS OF A CASE STUDY

A detailed study was undertaken on the request from the wind farm owner of 13 MW wind plant in the Southern State of Tamil Nadu. The wind farm comprises of 52 no. of 250 kW class wind turbines with a 30m hub height operating at an 13% CUF. It may though be noted that the improvement that one can achieve in an operating wind farm in India is very case specific (underlining the very need for the initial investigations as stated under section 2 above). It was observed that 10 wind turbines were poorly generating on account of bad siting as investigated following detailed wind analysis & wake loss estimation after normalizing the performance of each wind turbines against losses due to down time and grid abnormalities. Percentage increase in generation as investigated is given below.
The investigations resulted in an overall potential for increase in generation of at least 50%. The distribution of this increase over the factors affecting the energy generation is as follows:

- Siting	37%
- Power curve	3% (Pitch angle setting changes & yaw alignment)
- Electrical losses	7% (power evacuation & reactive power compensation system)
- Machine down time	3% (Timely & with reduced logistical wait time)

A detailed cost-benefit analysis has been worked out for only the 10 identified badly sited wind turbines for three differtent options.

Table 1: The three different options investigated,

Option 1	Considered increasing the hub height of the wind turbines at the same location from 30m to 40m, 45m & 50m
Option 2	Considered relocating the wind turbines with the same hub height to new locations
Option 3	Considered relocating the wind turbines to new location with also increase in hub heights to 40m, 45m & 50M.

The findings of the case study are described with respect to effects on the economics and on the increase of power generation. The main results are given in terms of costs per MW installed to enable comparison with similar cases.

The results are as presented below in the tables. As may be obvious, the most attractive option for this case study wind farm (& for the 10 badly sited wind turbines) was to only relocate to other better locations in the wind farm area.

Table 2: The incremental cost in USD

	Increase to 40m	Increase to 45m	Increase to 50m
Option 1	35,245	41,775	49,881
Option 2	17,548		
Option 3	36,020	42,550	50,657

Table 3: % increase in generation

	Increase to 40m	Increase to 45m	Increase to 50m
Option 1	22%	32%	40%
Option 2	37%		
Option 3	55%	62%	& 69%

Table 4: Pay back period

	Increase to 40m	Increase to 45m	Increase to 50m
Option 1	14.2 yrs	11.6 yrs	10.7 yrs
Option 2	4 yrs		
Option 3	5 .1 yrs	5.3 yrs	5.7 yrs

The main results are summarised in table 5. The financial results are given in terms of costs per MW installed to enable comparison with similar cases.

Table 5: Key findings of the case study.

Cost for relocation per MW	72,736 USD
Cost of investigation per MW (typically 4 nos. of 250 kW machines)	1,272 USD
Cost of relocation per MW (typically 4 nos. of 250 kW machines)	71,463 USD
Increase of generation by siting alone (CUF 18%)	37%
With a balance of 10 years life time, cost of incremental generation per kWh	0.02 USD/kWh
Cost of mitigating one Emission Reduction Unit (1000 kg CO2 equivalent or ERU) over the balance of the life time	USD 15/ERU
Pay-back	4 years

4 WHO BENEFITS FROM IT?

The above described approach of re-engineering and retrofitting of wind farms has several beneficial effects. In the first place it helps to restore the investor confidence in India. Enable utilising effectively the large onshore potential (>10,000 MW). In this respect also India can serve as example of success story for wind in a Developing world.

Secondly it contributes to creation of employment and to capacity building both in EU & India.

Thirdly it engages India (developing country) towards mitigating climate change efforts

Finally it provides increased opportunities for trading emission credits.

5 WHAT ARE THE BARRIERS?

This chapter discusses the barriers that have to be considered when developing a strategy for retrofitting wind farms in India.

- Lack of awareness: This relates to lack of knowledge of the prospects for improvement of wind farm performance among both the Indian wind community and European wind energy industry.

- Uncertainty & lack of proven projects (uphill battle): There is considerable scepticism among the Indian private investors. Infact, the very confidence in wind turbine technology as a means of economically producing electricity is damaged for manufacturers have not been able provides solutions and more importantly keep to the promises (expectations raised). In this context, there is need for having demonstration projects.

- Finance to seed the initial investigation: In the context that the wind farm owners have lost confidence in wind turbine technology, it is difficult to make them invest again for improvement that they are not sure of.

- Capacity building: There is considerable need to build the skills, knowledge and expertise locally

among Indians to be able to undertake similar technical investigations, and also among the small scale industry to initiate repair/development/construction of wind turbine components (as may be suited for the Indian grid & site conditions).

- Many WT original equipment suppliers have disappeared, with consequences on the following:

  - access to machine drawings & specs.

  - longer time and greater effort required to effect the design modifications.

6 CONCLUSIONS

The findings of the case study in lieu of the new emission trading opportunities that exist now, clearly demonstrate that it is surely a win-win situation for all the involved stakeholders. Moreover, with more than 10,000 MW of additional wind farm potential capacity for utilization, it is imporatnt ot regain the confidence of the private sector. It may also be noted that replacement of old smaller machine with larger current technology machine is just as attractive as this case study concluded in term of payback period, but has greater potential for GHG gases abatement. However, this is limited till the economic utility value of the existing smaller WTs (with a remaining life time of 8-10 years) is found. In this regard probably market development for wind-diesel systems for rural electrification could be a possible solution.

Finally, the following strategy is recommended by the authors.

- Constitute & formalize a framework to oversee these activities
- Initiate/undertake re-powering wind farm projects in India under the exisiting AIJ/JI frameworks
- Assist GoI in bringing Policy changes to bring about production based incentives (rather than current investment based incentives) for this encourages economically competittive operation of wind farms in India
- Enable technical capacity enhancement locally so that appropriate design modications can be udertaken
  - suiting local grid (e.g. power evacuation systems, gear box design modifications)
  - better wind modelling for complex terrains
  - power curve testing and correction
  - design/load calculations for optimal WT component designs

REFERENCES

1. Rajsekhar B and Van Hulle, F; Assessment of grid integrational problems of wind farm. ECN publications: ECN-C-97-045. Netherlands Energy Research Foundation, The Netherlands, August 1997

2. Rajsekhar B, Van Hulle, F & Jansen, J C; Indian wind energy programme: performance and future directions; Energy Policy 27 (1999); 669-678