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Policy, Planning and Implementation of Wind Energy Technology, Wind Farms: Case Study

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Abstract: *The study focuses on the science and technology of wind farms or on providing an evaluation of technology-push and demand-pull public policies* [4]. *This study concludes with strong policy recommendations towards the enhancement, the exploitation and the acceptance of wind energy in India. At present wind turbine generators require a land use planning in the case of a wind farm development in accordance with the policies* [1]. *Development of wind power in Karnataka state is interesting fields of conflict between national goals for technological development and local spatial planning and governance of land use* [3]. *They were used in the study of byadagi, 16.8 MW and banjagondanahalli, 18.9 MW wind farms. It was developed between 2010 and 2012. The study is based on which includes the legal wind farm design as well as wind assessment in the regional areas and a study of byadagi, 16.8 MW and Banjagondanahalli, 18.9 MW wind farms involves estimation of annual energy yield, capacity factor, machine availability factor. Which is important for power generation and economic feasibility of wind farms. Finally obtained results for byadagi, 16.8 MW and banjagondanahalli, 18.9 MW wind farms compared and results are discussed.*

Keywords: *Energy yield, cash flow, Break even period, feasibility*

1. INTRODUCTION

Nearly two decades ago the Indian economy was snatched back from the brink of a composite economic crisis. The Indian government undertook some hard-hitting liberalization measures that would have been unthinkable in a business as usual political landscape. Largely as a result of those actions, today India is in a position to be counted as one of the’ emerging economies’. Successive governments have looked towards locking in an average economic growth rate of at least 6-8%, up from 3.5% from the 1950s through the 1980s. This was revised to 8.1% last year by the Planning Commission. Given the plans for rapid economic growth, the requirement for energy services [23] and supporting infrastructure is simultaneously escalating. Electricity demand has continuously outstripped production, and a peak energy shortage of around 12.7% prevailed in 2009. To meet this shortfall as well as the National Electricity Policy target of ‘Electricity for All by 2012, the cleanest options available to India are Renewable Energy Technologies (RETs). For the government to seriously consider meeting its promise of electricity for all by 2012, renewable energy options including wind power will have to play a crucial role in India’s emerging energy mix. Not only are they environmentally sound but also their project gestation periods are significantly shorter than those for thermal or nuclear power plants. According to the Ministry of New and Renewable Energy (MNRE), today the share of renewable based capacity is 10.9% (excluding large hydro) of the total installed capacity of 170 GW in the country, up from 2% at the start of the 10th Plan Period (2002-2007). This includes 13,065 MW of wind 2,939 MW of small hydro power, 1,562 MW of (biogases based) cogeneration, 997 MW of biomass, 73 MW of ‘waste to power’ and 17 MW of solar PV for grid connected renewables at the end of 2010. The originally stated cumulative target for the current plan period was to add 92 GW of new capacity of which about 14 GW was to come from renewable sources. Given the right mix of regulatory and institutional support, renewable sources met the proposed capacity addition of 14 GW from renewable energy before the end of the 11th five year plan-period (2007-2012).

This would bring the total share of renewable energy sources up to 15% of the new installed capacity in the 11th plan-period [4]. Over the next decade, India will have to invest in options that not only provide energy security but also provide cost-effective tools for eradicating energy poverty across the board. India is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and has as part of its obligations released a National Action Plan on Climate Change (released in June 2008) by Prime Minister which has laid out his government's vision for a sustainable and green future for India's economy. India's developmental needs will be challenged by climate change impacts. This requires a timely pre-emptive shift towards achieving an energy efficient and green economy [16]. Over the next couple of decades renewable energy will play a major role in delivering that shift.

2. OUTCOMES OF LITERATURE

The study focuses on the science and technology of wind farms [12] or on providing an evaluation of technology-push and demand-pull public policies. Drawing on a thorough review of Indian governmental documents, the international wind energy literature, press reports, and recent empirical research undertaken in over worldwide. Clearly, this should be of concern to both the Indian, central Government and Karnataka state Government, Executive and drawing on international experience from other countries, we conclude with strong policy recommendations towards the enhancement, the exploitation and the acceptance of wind energy in the India. An examination was conducted of the various academic materials that addressed the topic of the wind power projects [6], which was followed by an assessment of policies and governmental studies on renewable energy. This review highlighted policy issues rounding the area of renewable energy and wind energy in particular. In addition to identifying the principal strands of the international energy literature introduced in this study, and this review also enabled us to identify the principal developments and drivers in the international wind. There view of national and regional journals. Study in sight in to the India, in particular Karnataka Government's wind power planning [7] and implementation as they related to wind power projects and understand further the views and the status of various steps in implement wind power taking upcoming wind farm projects and steps involved in the estimation of power generation also economic feasibility of wind farms [24] for case study in the regional area and lot of constraints involved in wind power projects.

3. WIND FARMS: CASE STUDY

In this study, we have taken two different geographical location for Estimation of Energy Yield, Capacity Factor[13] and Cash Flow[14].The proposed site of wind farm is a complex hilly area near village Banjagonahalli , Holalakere taluk, Chitradurga District, Karnataka State and another site is near at village Sidenur, Byadagi taluk of District Haveri in Karnataka State. Wind turbine generator (WTG) manufacturer offer wind turbines with two or three different rotor diameters corresponding to low (large rotor), medium (standard rotor) and high or offshore (small rotor) wind velocity data. At a first screening the outer dimensions of the available terrain are of importance. Wind turbines require a mutual spacing of atleast four to fiverotordiameters, corresponding to approximately 300 to 500 meters. A flat and undisturbed area is required because buildings, trees and other obstacles lead to a lowering of the wind velocity [17]. Annual average wind velocity at given site is 7.45 m/s, study reveal that 2.1 MW WTGs is suitable for these sites.

4. RESULTS AND DISCUSSION

4.1. Introduction wind Farm Energy Yield Calculation

The annual energy yield [12] is calculated by multiplying the wind turbine power curve with the wind distribution function at site [18]:

$$E_y = \left(\sum_{i=1}^{i=n} f_{w_i} P_{w_i} \right) \quad \text{kWh}$$

Where:

E_y is annual energy yield in kWh

W is the wind speed in m/s

N is the number of data bins covering the wind speed range of the turbine (0.5or1m/s intervals)

f_{wi} *is* the number of hours per year for which wind speed is *w*m/s[10]

p_{wi} is the power resulting from a wind speed of *w*m/s in kW

4.2. Cash Flow Calculation for 16.8 Mw wind Farm

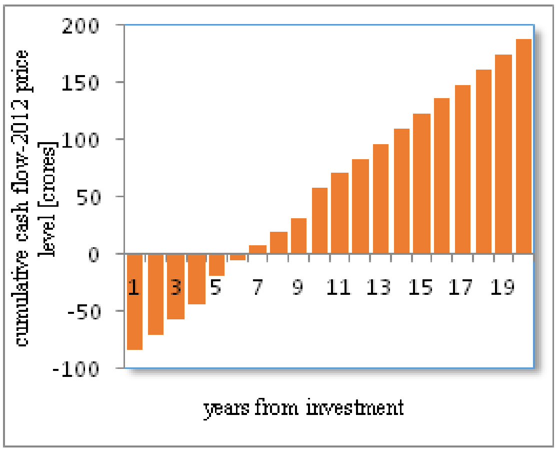

Fig1. *Cash flow for 16.8 MW wind farm at 3.7Rs/kWh*

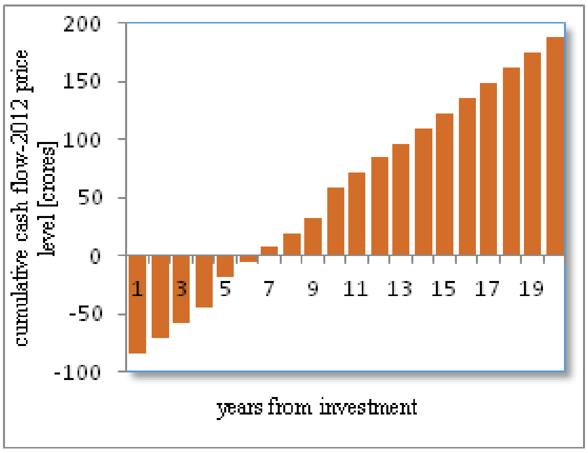

Fig2. *Cash flow for 16.8 MW wind farm at 4 Rs/kWh*

Table1. *Summary of cash flow for 16.8 MW wind farm (2012 level)* [9]

Feed in tariff	3.7	4.2	Rs/kWh
Investment cost (1st year)	96.6	96.6	Crores[Rs]
Refurbishment cost (For 10 year)	11.76	11.76	crores[Rs]
Yearly wind farm production in MWh	43638.4	43638.4	MWh
Gross income from production	16.15	19.2	crores[Rs]
Yearly recurring costs	12.9	16.47	crores[Rs]
Break even period	7	6	Years
Internal rate of return(IRR)	14	16	%

A cash flow calculations for two different feed-in tariffs over an anticipated life span of 20 years; the results are summarized in table 1. Financing costs are taken into account and all expenses and incomes are based on 2012 price levels so the influence of inflation is implicitly included [18].

The calculations show that, at a feed-in tariff of 3.7Rs/kWh, the rate of return of 14% is just enough to cover the cost of financing the project and profit is generated. At a tariff of4.2Rs/kWh the project generates a16% return gross.

Cash flow at 3.7Rs/kWh and 4.2Rs/kWh for 16.8 MW wind farm is shown in figure 1 and figure 2 respectively.

4.3. Cash Flow Calculation For 18.9 Mw wind Farm

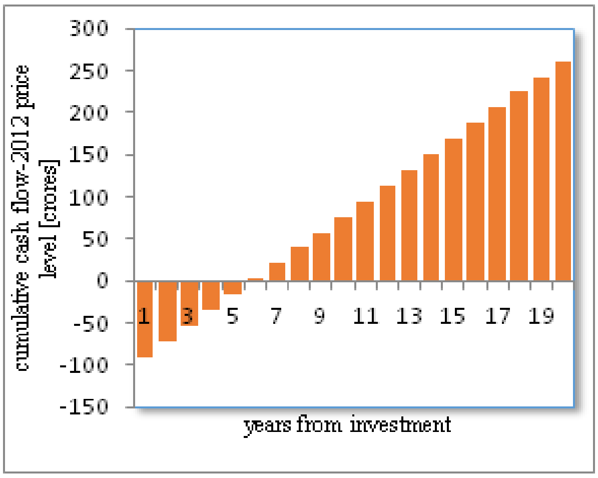

Fig3. *Cash flow for 18.9 MW wind farm at 3.7 Rs/kWh*

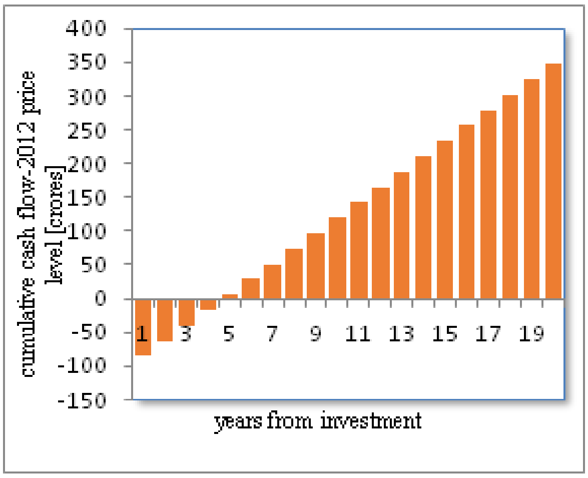

Fig4. *Cash flow for 18.9 MW wind farm at 4 Rs/kWh*

Table2. *Summary of cash flow for 18.9 MW wind farm (2012 level)*

Feed in tariff	3.7	4.2	Rs/kWh
Investment cost (1st year)	108.6	120.6	crores[Rs]
Refurbishment cost (For 10 year)	13.2	13.2	crores[Rs]
Yearly wind farm production in MWh	61265.7	61265.7	MWh
Gross income from production	22.6	26.9	crores[Rs]
Yearly recurring costs	21.09	22.8	crores[Rs]
Break even period	6	5	Years
Internal rate of return(IRR)	18	25	%

A cash flow calculations for two different feed-in tariffs over an anticipated life span of 20 years; the results are summarized in table 2. Financing costs are taken into account tand all expenses and incomes are based on 2012 price levels so the influence of inflation is implicitly included.

The calculations show that, at a feed-in tariff of3.7Rs/kWh, the rate of return of18% is just enough to cover the cost of financing the project and profit is generated. At a tariff of 4.2Rs/kWh the project generates a 25% return gross [18]. Cash flow at 3.7Rs/kWh and 4.2 Rs/kWh for 18.9 MW wind farm is shown in figure 3 and figure 4 respectively.

Table 3. *Comparison of Two wind Farms for Feasibility*

	Byadagi 16.8 MW wind farm	Banjagondanahalli 18.9MW wind farm
Feed in tariff	3.7 Rs/kWh	3.7 Rs/kWh
Avg annual wind velocity	7.45 m/s	8.01 m/s
WTG capacity	2.1 MW	2.1 MW
Annual full load hrs	6002 hrs	6051 hrs
Gross energy yield	43638.4 MWh	61265.7 MWh
Capacity factor	31%	37%
Break even period	7	6
Internal rate of return	14%	18%

For feed in tariff of Karnataka state is 3.7 Rs/kWh for 10 year from date of wind farm operation. The power rating of the wind turbine 2.1 MW can be found from the suzlon manufacturers of wind energy systems. Annual wind velocity at wind farm is 7.45 m/s and 8.01 m/s. Capacity factors of wind farm varies from 20% to 40%, two wind farms have capacity factor of 31 % and 37%. This is good for power generation and wind farm feasibility point of view.Users or owners of this feasibility calculation should understand that tariff effects can have a substantial impact on cash flows and rates of return, both wind farm “Project Economically viable” [16]. This indicates, in the most likely scenario, that the savings accrued from installing a wind energy system is weighed by the overall energy yield and costs of the system. Once a result is obtained for the Internal rate of return (IRR), the user or investor must make a decision whether the IRR obtained is reasonable for continuing with the process of developing a wind energy system.

5. CONCLUSION

Obviously, the entire world needs energy and the energy demand is constantly growing. Non renewable energy looks to be slowly but surely getting its dominance and some innovative policy and planning methods have really helped boosting wind energy sources. Wind farms of Byadagi, 16.8 MW and Banjagondanahalli, 18.9 MW are sufficient enough to provide energy for household operations as well as commercial in regional areas. This study reveal that capacity factor of Banjagondanahalli, 18.9 MW wind farm is good. Because of the wind availability is more. A wind power project using a 2.1 MW turbine is likely to be economically feasible at the two wind farms. Karnataka is bestowed with good wind energy potential in the country, 7161 MW wind energy potential have been assessed for Karnataka by Karnataka renewable energy development limited and cumulative installed capacity of 1715 MW. By adopting effective policy and planning methods, it’s possible to reach 7161 MW capacity. Many people see in wind power system energy solution that doesn't harm our environment, and this is the reason why they go for it. Of course the low costs are quite helpful too. Wind energy project once built require little maintenance, and wind turbines do not interfere with electrical or transmission signals. There are really lots of ways in order to save money by using wind energy system at remote areas. It is up to us to make the right decision. Wind energy sources have an impact on the environment. Concerns about the greenhouse effect and global warming, air pollution, and energy security have led to increasing interest and more development in wind power. It is most promising and efficient energy source. But we'll need to continue to non-renewable energy until new, cleaner technologies can replace them. Until then, the future is ours, but we need energy to get there.

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