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COST AND FEASIBILITY OF REPOWERING WIND FARMS IN KANIYAKUMARI DISTRICT OF MUPPANDAL AREA OF TAMIL NADU

Dr. P.S.J SUDAN
Assistant Professor, P.G and Research Department of Economics,
V.O.Chidambaram College, Thoothukudi ,
Affiliated to Manonmaniam Sundaranar University Abishekkapatti, Tirunelveli, Tamil Nadu India.

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Abstract

The aim of this paper is to determine the main cost and feasibility of repowering wind farms. The Muppandal area wind farms have first generation WTGs which have completed an age of 15 – 20 years. In Muppandal wind farm efficiency of production function has negative impact because the wind resources are underutilised by old wind farm turbines. The investigator has chosen the sample units from a total of 225 first generation (WTGs). At the Muppandal wind farm there are 71 farms operating these 225 wind turbines. The calculation indication the costs, the Net Present Value (NPV), the Internal Rate of Return (IRR), and the Pay-Back Period of these alternatives. The main costs in a repowered wind farm involve civil works, wind turbines, electrical network and safety and health. Results shows that the total cost of repowering a wind farm of 1 MW is nearly 160,000,000. Further garret ranking techniques was used by identifying the challenges of repowering project in the study area. The options of reducing carbon emission and enriching the renewable energy investment, repowering the wind turbine technology has highly economically potential

10.48047/jocaaa.2024.33.08.599

1. Introduction

Environmental problems in the current era are a cross border issue. Industrialisation and growth of population increases the usage of energy. It automatically increases carbon emission; climate change ultimately leads to health problems and life thread to the present to future generations. In the world each year an estimated 6.5 million deaths are linked to air pollution with the number set to increase significantly in coming decades unless the energy sector takes greater action to curb emissions. In China, recent signs of energy emissions have declined. But energy emissions generally rise in India. (IEA 2016). Coal is the backbone of the Indian power sector, accounting for over 44 percentages in 2013 (IEA 2015). The use of fossil fuel-based energy, carbon dioxide (co2) emissions has increased to 1.591 trillion metric tons per capita in 2013 (IBRD 2013). The level of economic growth and development in India is dependent on a number of factors, to encourage a high rate of growth, different economic mechanisms have been developed based on India's characteristics and potential and available natural resources.

The renewable energy development option is only an environmental problem (Reddy AKN 1992). A perennial issue in evaluating the economic prospects of renewable energy is the relative role of markets and government. Those renewable sources are entitled to at least a measure of public support to offset policies favoring fossil and nuclear energy (Joel Darmstadter 2002). Many of the firms invest in recycling and re-use of its materials, environmentally friendly technologies, and internal training in green economy. The insufficiency of bank loans, high level of bureaucracy and inadequate funds, leads to less investment in renewable energy (Nor Aznin Abu Bakar et al 2017). In case of Costa Rica derives significant percentage of the total electricity supply from a variety of clean renewable sources. The countries success with sustainable electricity production is surprising considering that the construction of renewable source plants is relatively capital and technology-intensive with limited resources and a highly centralised energy sector. Finally the country in successful with sustainable sources of energy concern over diminishing fossil-fuel reserves and global climate change (Joseph wild Ramsing & Brian potter 2008).

10.48047/jocaaa.2024.33.08.599

2. Cost and Feasibility of repowering wind farms

The climate change impacts on the near – term stability of the wind energy resource in the United States. The wind energy resource is naturally a function of the climate system because the fuel is the wind speed and thus is determined by the atmospheric circulation (Pryor & Barthelmie 2011). The financial and electrical aspects of repowering the Jamgodarani wind farm the calculation shows that the repowering cost can be recovered within 8 years and 7 months (Manoj Verma et al. 2018). The economic aspects of the repowering process significant reduction in the number of wind generators there are strong indications that repowering is a profitable endeavor, whose costs can be recovered in five years. This is mainly due to the sharp increase in the production of each generator (Castro et al. 2011). The replacement of older wind turbines with new, high performance turbines repowering can also be used to reorganise wind power locations in order to better integrate them into the planning of residential areas in municipalities. This information contains basic information regarding the details of wind power and repowering (Manoj et al. 2015). The financial feasibility of repowering wind farm projects are the most relevant technical variable is the increase in production efficiency and the most relevant economic variable is the capital expenditures in new equipment. The repowering project would not be feasible in the absence of government support (Anxo Calvo et al 2013). A techno-economic analysis of a real wind farm repowering experience at the Malpica wind farm, explores the annual energy production of the repowered Wind farm increases up to twofold than that of the old wind farm with the same rated power (Villena Ruiz et al 2018).

The repowering potential and its benefits which offer an attractive opportunity to improve the quality of power generation and efficiency of the wind sites. The right policy framework and incentives could significantly change the landscape of ageing wind farms in India (Neeraj Sen et al. 2012). In India important is given to concentrate on development of new, technically advanced, state of art wind turbines which are cost effective and reduce per unit cost of wind power. With a high-quality wind resource assessment, efficiency of wind farm can be increased which can subsequently reduced per unit cost of generation. Further, starting offshore wind energy installation, repowering of old turbines with new higher

10.48047/jocaaa.2024.33.08.599

capacity wind turbines, increasing research and development budget in wind energy technology and enhancing regulatory and tariff regime to bring wind energy into national power system (Deepak Sangroya & Jogendra Kumar Nayak 2015). Techno economic approach of repowering a wind farm, by repowering one of the old Indian wind farms located at a potential wind site. Various options of repowering have been suggested and compared based on annual energy production and levelised cost of generation. The partial repowering could be economically more attractive than total repowering, whereas total repowering of old wind farms located at potential sites would be essential to meet renewable energy targets of nations like India (Prabu et al. 2015).

Tamil Nadu holds second rank in wind power among the states of India. Tamil Nadu is having an onshore wind potential of 95 GW at 150 meter height. With the total installed wind capacity of 9,015.09 MW in State Transmission Utility, around 13,000 MU of wind power is generated every year which contributes to 9.91% of State consumption. The all-time high power generation peak of Wind Energy has been recorded on 10.09.2023 as 5,838 MW. Tamil Nadu is the first State in country towards implementing re-powering of old wind mills owned by private wind power generators and so far 96 old wind mills with 26.20 MW has been Repowered. Repowering is an economically feasible solution in Tamil Nadu but cost benefit of current situation and government wind power subsidy in wind power price determined the repowering works. Repowering the wind farm is the right move to save energy as well as to generate a higher profit from the existing wind potential (Anand John et al 2015). Repowering assessment of an old wind farm located at Gudimangalam near Coimbatore in Tamil Nadu which is a good wind potential site. Accordingly the option of repowering proves to be a feasible option in terms of both technical as well as economic aspects. The wind farm investors must therefore promote repowering based on its technical and economic feasibility along with the utilisation of the new policy frameworks for repowering (Anish Paul and Prabu 2016). The repowering, the first-generation wind turbines can be replaced with modern multi-megawatt wind turbines. The production of wind energy increased to 24 percentages and energy yield was more than 4 times and the capacity of the wind farm became double in Kayatharu Tamil Nadu (Nivedh et al. 2013)

10.48047/jocaaa.2024.33.08.599

3. Objectives and Methodology

Based on the issues and the research problem the researcher has raised some valuable questions to arrive at the objectives. Why wind power is not fully utilised? What are the challenges in the repowering project? Based on this research questions objective is framed (i) To analyse the economic feasibility of repowering wind power. (ii) To find out the challenges of repowering wind power. and (iii), To examine the repowering policy satisfaction of wind energy investors. The calculation indication the costs, the Net Present Value (NPV), the Internal Rate of Return (IRR), and the Pay-Back Period of these alternatives. Further garret ranking techniques was used by identifying the challenges of repowering project in the study area.

4. Selections of Wind Energy farms

To give well tested findings the researcher has selected primary data from the wind farm other energy producing sources. Muppandal wind farm is for selecting this region. By measuring the geographical condition, Western Ghats have a Pass in between Arabian Sea and Bay of Bengal. Means, Western Ghats and Srilanka. Due to this geographical reason, wind blow is common in all the seasons. It proves its importance for the production of wind Energy. So the researcher selected Muppandhal to study the issue. The farm has first generation WTGs which have completed an age of 15 – 20 years. The investigator has chosen the sample units from a total of 225 first generation (WTGs). At the Muppandal wind farm there are 71 farms operating these 225 wind turbines. Data is collected through a well – constructed questionnaire to achieve the objectives formed.

10.48047/jocaaa.2024.33.08.599

Figure 1

Muppandal Wind Farm Aerial View

Figure 2

Wind flow Pass of Kaniyakumari District map

Table.1

Number of Old Wind Farms and Turbine Established During Each Year at the Muppandal Wind Farm

SI. NO	Year of Establishment	Number of Wind Farms	Percentage	No. of Windmills	Percentage
1	1992	1	1.41	3	1.32
2	1993	5	7.05	13	5.77
3	1994	24	33.80	86	38.23
4	1995	20	28.17	82	36.45
5	1996	9	12.68	14	6.22
6	1997	3	4.22	8	3.56
7	1999	6	8.45	15	6.67

10.48047/jocaaa.2024.33.08.599

8	2000	3	4.22	4	1.78
	Total	**71**	**100**	**225**	**100**

Source: Office record of Muppandal Wind Farm

It is seen that out of 24 farms, surveyed (33.80 percent) farms have established their windmills in between 1994. These 24 farms have installed 86 (38.23 percent) windmills. The old turbines have old model turbines established during this year's availability of technology which is insufficient. Moreover, the percentage of windmills turbine significantly reduced after the year 1996.

5. Results

The factor of production in economics determines Land, Labour, Capital, and Organisation. In Muppandal wind farm efficiency of production function has negative impact because the wind resources are underutilised by old wind farm turbines. The allocative efficiency is improved when technology advances in new product which leads to optimal distribution of goods and service. The technological advancement needs capital investment which is a significant instrument that leads to the research and development of efficiency production. There is a need for technological advancement of repowering the wind farm for efficiency of renewable energy production.

6. Cost and Feasibility of repowering Wind farms

The main costs in a repowered wind farm involve civil works, wind turbines, electrical network, safety and health, and others. Civil works includes the costs of demolition of all the old installation, new roads to access the repowered wind farm, foundation of new wind turbines, and construction of new ditches for the electrical cables. Regarding the steps which have been considered, the value of different costs of a repowering wind farm, taking in to account the particulars for 10,000,000 for civil works, 50,000,000 for wind turbines, for electrical networks, 60,000,000 for Safety and health 10,000,000, and for others including tax 30,000,000. So, the total cost of repowering a wind farm of 1 MW is nearly 160,000,000. To identify the economic viability and financial profitability of an individual windmill, all calculations in this study are made by using the Tamil Nadu Electricity Board (TNEB)

10.48047/jocaaa.2024.33.08.599

buying rate. The profitability is decided by the unit cost of electricity and the price at which the TNEB bought the electricity from the windmill owners.

The Table 2 discusses cash inflow of the repowering project and the net present value of the project for fifteen years. The 1 MW of repowering production of wind energy in Muppandal area is 25,028, 571.4 units that is sold by (TNEB) at 2.75 tariff rate.

Table 2

Cash Inflow and Net Present Value of Repowering Wind Energy in Muppandal Wind Farm

Year	Cash Inflow in Rupees	Net Present Value
0	160,000,000	160,000,000
1	68828571	62565171
2	58504286	48324540.2
3	47388471	35588741.7
4	37436892	25569397.2
5	28826407	17872372.3
6	21619805	12193570
7	15782458	8096400.95
8	11205545	5221783.97
9	7731826.1	3278294.27
10	5180323.5	1994424.55
11	3367210.3	1178523.6
12	2121342.5	674586.915
13	1294018.9	373971.462
14	763471.16	200792.915
15	435178.56	104007.676
	Total	**223, 236, 578.708**

Source: Computed data in excel office

10.48047/jocaaa.2024.33.08.599

The table 2 clearly explains the investors taking a positive decision for repowering wind energy. Because the repowering is economically viable at 10 percentages of interest and the net present value is assigned positive sign that means the investors get 223,236,578.708 this amount is greater than the investment amount of 160,000,000. So, the investors get a net profit of 63236579. This repowering project in Muppandal area is economically viable. Further Internal Rate of return is the efficient variable for investment decision making in repowering wind farm that is clearly explained in table 3.

The table 3 shows the IRR rate between discount rate of 10 percentages to 25 percentages. Based on the calculation, IRR the rate of return for repowering wind power is 8.86 percent that means the IRR is less than the cost of capital and reject the project. The return given by the repowering wind energy is less than the expected return by the investors at 2.75 tariff rate. So, the repowering of wind energy is not economically feasibility at 2.75 tariff rate. Investors are not ready to reduce their cost of capital investment and the expected return value. Further the table 4 explains the discounted payback period of the repowering wind energy.

The table 4 explores the discounted payback period of the farms present value of cash flow up to year three as 146478453. Further total investment amount of repowering wind farm is 160000000. After the fourth year the recovered amount from repowering wind farm is 13521547 but present value of cash flow in fourth year is 172047850. So after the discounted payback period of the project of three years and less than 1 month the investment amount is recovered by the repowering wind energy.

10.48047/jocaaa.2024.33.08.599

Table 3

Internal Rate of Return in Repowering Wind Power in Muppandal Wind Farm

Year	Cash Inflow	NPV Discount rate at 10 percentages	NPV Discount rate at 25 percentages
0	160,000,000	160,000,000	160,000,000
1	68828571	62565171	55062856.8
2	58504286	48324540.2	37442743
3	47388471	35588741.7	24262897.2
4	37436892	25569397.2	15311688.8
5	28826407	17872372.3	9426235.09
6	21619805	12193570	5664388.91
7	15782458	8096400.95	3298533.72
8	11205545	5221783.97	1871326.02
9	7731826.1	3278294.27	1036064.7
10	5180323.5	1994424.55	554294.614
11	3367210.3	1,178523.6	286212.876
12	2121342.5	674586.915	144251.29
13	1294018.9	373971.462	71171.0395
14	763471.16	200792.915	33592.731
15	435178.56	104007.676	15231.2496
	Total	**223, 236, 579**	**-154481488**

Source: Computed data in excel office

10.48047/jocaaa.2024.33.08.599

Table 4

Discounted Pay Back Period of Repowering Wind Energy in Muppandal Wind Farm

Year	Cash Inflow Rupees	Discounted Rate at 10 Percentage	Cumulative Present Value
1	68828571	62565171	62565171
2	58504286	48324540.2	110889711
3	47388471	35588741.7	146478453
4	37436892	25569397.2	172047850
5	28826407	17872372.3	189920222
6	21619805	12193570	202113792
7	15782458	8096400.95	210210193
8	11205545	5221783.97	215431977
9	7731826.1	3278294.27	218710272
10	5180323.5	1994424.55	220704696
11	3367210.3	1,178523.6	221883220
12	2121342.5	674586.915	222557807
13	1294018.9	373971.462	222931778
14	763471.16	200792.915	223132571
15	435178.56	104007.676	223236579

Source: Computed data in excel office

5. Challenges of Repowering Wind Farm in Muppandal Area

In this section the researcher briefly analysis the challenges of repowering project in Muppandal Area. The past studies explore the different challenges of the repowering project during their atmospheric and political issues. Here also respondents are express the various challenges for repowering project in Muppandal area. Hence the researcher used garret ranking techniques.

10.48047/jocaaa.2024.33.08.599

Table 5

Challenges of Repowering Projects in Muppandal Wind Farm

SI. NO	Factors	Calculated Garret value	Garret Average Score	Ranks
F1	Power Purchase Agreement	9854.22	98.54	1
F2`	Disposal of wind turbine	8063.11	80.63	2
F3	Competition of other renewable energy	7564.00	75.64	3
F4	Incentives	7102.22	71.02	4
F5	Policy Package	6935.11	69.35	5
F6	Grid Augmentation	6851.56	68.52	6
F7	Niwe Certification	6768.00	67.68	7
F8	Finance	6248.89	62.49	8
F9	Political Issues	3448.89	34.49	9
F10	Project ownership	276.35	2.76	10

Source: Primary data

Table 5 explores the challenges of repowering project faced by the Muppandal wind farm. The highest garret value and average score is found for the factor as power purchase agreement rate and financial viability of the project. The second challenging factor is disposing of old wind turbine which is not economic and environmental viable. Further there are significant challenges from competition of other renewable energy. Solar energy highly competitive with wind energy electricity production. Respondents feel solar energy is economically viable because of low

10.48047/jocaaa.2024.33.08.599

space need and small number of labour. While incentive and policy package also have significant challenges of repowering project. In order to compensate for the additional cost of repowering appropriate incentives are needed. Further the policy package must encourage the state government to provide additional tariffs rate for repowering project. Furthermore the factors like grid augmentation, NIWE certification, finance, Political issues also considered serious challenges of repowering project.

6. Conclusion

1 MW of repowering wind farm reduces 2600 tons of carbon according to the report of national renewable energy laborites. This leads to achieve the sustainable development of repowering wind mills. Concerning the cost of repowering the wind energy project is economically viable than construction of a new wind turbine. More over other cost of repowering project especially disposing old wind turbine is a serious threat of repowering wind energy. As for environment is concerned the carbon emission and number of wind turbines also reduced from 225 to 50, so the visual effect and sound is consequently reduced. The changed from vestas 500 kw average plant load factory is 19.60 percent and 750-kw average plant load factory is 27.60 percent which increases the energy efficiency of the location increases and the business profitability

10.48047/jocaaa.2024.33.08.599

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