An Optimal Cost System Configuration Design for Mini Wind Power Plants: A Comparative Case Analysis

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ABSTRACT

Winds are essentially caused by the solar heating of the atmosphere, causing unequal expansion and caused by the solar heating of the air of various region. This in turn result in convection currents and other movements of large masses of air. In general during the day the air above the land mass tends to heat up more rapidly than the air which over water, at night the process is reversed. The speed of wind increases with height. They have been measured at standard height of ten meters where they are 20-25% greater than close to the surface. At a height of 60 m they may be 30-60% higher. In the optimization process, HOMER software selects one system configuration out of all configurations generated in the simulation process that satisfies all technical constraints and has the lowest life cycle cost.

I Introduction:

Wind carries enormous quantity of energy. Wind power has been used for centuries to sail vessels, pump water, grinding grain. Before the development of electric power on large scale, wind power has served many countries as source of power on early days and was called as wind mills. Today, windmills modern equivalent a wind turbine can use the wind energy to generate electricity. The total wind potential available on earth during an entire year is approximately equal to twice the world energy consumption from conventional resources.

(a) 4.2 MW Wind Power Plant at Harshnath Sikar Rajasthan: The project is in Harshnath Village of Sikar District Rajasthan India.. The generated electricity is wheeled to the nearest grid sub-station through a 33 kV supply line and fed into the grid after stepping up to 132 kV. The purpose is development, design, engineering, procurement, finance, construction, operation and maintenance of wind power project of 4.2 MW in the Indian state of Rajasthan to provide reliable, renewable power to the Rajasthan state electricity grid. The project considered has used the barren land at Harsh & Antri villages, in Sikar district in the state of Rajasthan. The project is helping in bridging the gap between demand and supply of by using wind as a source of generating electrical energy utility. The various data collected for Wind Power Plant as per requirement of software Homer (2.81 version) for cost optimization has been introduced or incorporated in the software for simulation.

(b) 1.2 MW Wind Power Plant Gorera Village Dist. Jaisalmer Rajasthan: Wind electricity generation project is located in Gorera Village Jaisalmer, Rajasthan, India .Purpose of the project activity is to generate electrical energy through sustainable means using wind power resources, to utilize the generated output for selling it to the State Electricity Board for meeting the energy shortages in the state and to contribute to climate change mitigation efforts. The various data collected for Wind Power Plant as per requirement of software Homer (2.81 version) for cost optimization has been introduced or incorporated in the software for simulation.

(c) 2.5 MW Wind power Plant at Baramsar Village Dist. Jaisalmer: The project activity is an initiative by the Transport Corporation of India Limited towards clean energy generation by means of installation of 2 state-of-art Wind Electricity Generators of individual capacities 1.25 MW each at village Baramsar District Jaisalmer in the State of Rajasthan aggregated to a total installed capacity of 2.5MW. The generated electricity from the aforesaid wind farm is evacuated to the RVPN grid

under a power purchase agreement and subsequently all the electricity generated is sold to the state electricity utility. The various data collected for Wind Power Plant as per requirement of software Homer (2.81 version) for cost optimization has been introduced or incorporated in the software for simulation. Hw

## II Optimization & Analysis Results of different Mini Wind Power Plants:

(i) Gorera Village Jaisalmer 1.2 MW Wind Power:
For Gorera Village Jaisalmer, various combinations have been obtained of wind systems with wind turbines, generator, battery, converter and grid from the HOMER Optimization simulation. Optimal system configuration is shown in figure 1.1

Figure 1.1 Optimization Result Details

HOMER uses the total NPC as its main selection tool. All the possible wind system configurations are listed in ascending order of their total NPC in the figure shown above. Costs taken in optimization table are in Indian rupees and the technical and economical details of all the configurations of the wind systems from the optimization process are shown in detail in figure 1.1, where the best possible combination of Wind and grid is highlighted in blue and the next best possible combination is marked with a red coloured box. As per the optimization results, the optimal combination of renewable energy technology system components are a 1200 KW wind, and 400 KW grid with a dispatch strategy of cycle charging. The total NPC, Capital cost and cost of energy for such a wind system are Rs.30,765,630, Rs.24,740,000 and Rs.0.707/KWh, respectively.
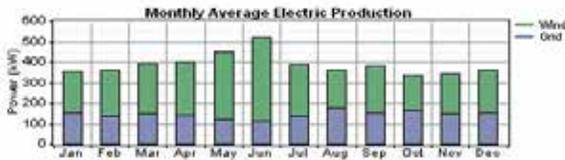
Figure 1.2: Monthly Average Electricity Production from the Considered Renewable Components

Figure 1.2 shows the monthly production of the electricity produced in KW by wind plant. Replacements occur majorly in the 15th year of the system, mostly for changing batteries and maintaining turbine and generator. In 25th year salvage cost is maximum for replacement turbine and generator. All these cash flow calculations do not consider any discounts, government funding or subsidies.

(B) Baramser Village, Jaisalmer 2.5 MW Wind Power Plant: For Baramser Village, Jaisalmer various combinations have been obtained of wind systems with wind turbines, generator, batteries, grid and convertors from the HOMER Optimization simulation. The best optimal system is shown in figure 1.3.

Figure 1.3: Optimization Result Details

HOMER uses the total NPC as its main selection tool. All the possible wind system configurations are listed in ascending order of their total NPC in the figure shown above. Costs taken in optimization table are in Indian rupees and the technical and economical details of all the configurations of the wind systems from the optimization process are shown in detail in figure 1.3, where the best possible combination of wind and grid is highlighted in blue and the next best possible combination is marked with a red coloured box. As per the optimization results an optimal combination of renewable energy technology system components are a 2500KW wind, and 1000KW grid. Details of this configuration are shown in figure 1.3. The total NPC, Capital cost and cost of energy for such a wind system are Rs.62, 515,812, Rs.49, 380,000 .766/KWh, respectively. Replacements occur majorly in the 15th year of the system, mostly for changing batteries and maintaining turbine and generator. All these cash flow calculations do not consider any discounts, government funding or subsidies.

(c) Harshnath Sikar 4.2 MW Wind Power:
For Harshnath, Sikar, various combinations have been obtained of wind systems with wind turbines, generator, batteries, grid and convertors from the HOMER Optimization simulation. The best optimal system is shown in figure 1.5.

Figure 1.5: Optimization Result Details

HOMER uses the total NPC as its main selection tool. All the possible wind system configurations are listed in ascending order of their total NPC in the figure shown above. The technical and economical details of all the configurations of the wind systems from the optimization process are shown in detail in figure 1.5, where the best possible combination of Wind, DG and grid is highlighted in blue and the next best possible combination is marked with a red coloured box. As per the optimization results an optimal combination of renewable energy technology system components are a 4200KW wind, 4200KW DG, and a 400KW grid. The total NPC, Capital cost and cost of energy for such a wind system are Rs.90,522,784, Rs.84,380,000 and Rs.0.308/KWh, respectively. Replacements occur majorly in the 11th and 22th year of the system, mostly for changing batteries and maintaining generator. Salvage cost is higher in 25th year of service as replacement of items is due. All these cash flow calculations do not consider any discounts, government funding or subsidies.

III Summary and conclusion:
Individual analysis of mini wind power plants is done using software and optimal cost system is designed for a specific location .For Off-Grid rural electrification, since the last decade with the help of renewable energy sources (RES) has become a cost-effective and convenient option for areas where grid connection is neither available nor feasible in the near future. The various results obtained for different projects for designing an optimal system configuration are:

(i) Gorera Village Jaisalmer 1.2 MW Wind Power Plant: As per the optimization results, the optimal combination of renewable energy technology system components are a 1200 KW wind, and 400 KW grid. The total NPC, Capital cost and cost of energy for such a wind system are Rs.30,765,630, Rs.24,740,000 and Rs.0.707/KWh, respectively.

(ii) Baramser Village, Jaisalmer 2.5 MW Wind Power Plant: As per the optimization results an optimal combination of renewable energy technology system components are a 2500KW wind, and 1000KW grid. The total NPC, Capital cost and cost of energy for such a wind system are Rs.62,515,812, Rs.49,380,000 and Rs.0.766/KWh, respectively.

(iii) Harshnath Sikar 4.2 MW Wind Power Plant: As per the optimization results an optimal combination of renewable energy technology system components are a 4200KW wind, 4200KW DG, and a 400KW grid. The total NPC, Capital cost and cost of energy for such a wind system are Rs.90,522,784, Rs.84,380,000 and Rs.0.308/KWh, respectively.

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