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# Simulation and economic evaluation of a hybrid system for off-network renewable power plant at village, border post and farm

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**Abstract**

Energy consumption has grown dramatically in the recent years. One of the major sources of energy is fossil fuel, which has limited resources and also pollutes the air. Over the past decades, researchers have looked for a reliable alternative to fossil fuels. One of the most appropriate solutions is the use of renewable energy sources. The main objective of this research is to evaluate the economic of three hybrid power plant sites named as a village, a border checkpoint and a farm, by Homer software. The final cost of an off-network renewable power plant for the village, border post and farm site is $ 23,288, $ 56,000, and $ 7795438, respectively, while the final cost of the on-network power plant for each of the three sites is $ 4531, $ 172125 and $ 3491431, respectively. The results indicate that the three off-network hybrid power plants are not economically feasible.

**Keywords:** Hybrid power plant, Wind turbine, Renewable energy, Homer

## 1. INTRODUCTION

The use of power plants with consumption of fossil fuel are known as the main approach of production electricity in the world. Many studies have been done about the energy and exergy analysis of power plants [1] and pollutant dispersion [2, 3] from them. The increasing consumption of fossil fuels as a limited source of energy and its impact on the environment is one of the most serious problems in the last decades. There are various ways to reduce fossil fuel consumption, which are generally divided into two different categories. The first category involves increasing the efficiency of equipment. Power plant equipment is often concerned with the heat transfer, so comprehensive studies on the heat transfer have been carried out by researchers [4-11]. The second way involves the use of renewable energies, which is a good alternative to the fossil fuels. Many authors investigated various aspects of the renewable energies such as solar energy [12] and wind energy [13].

Generated electricity by fossil fuel and renewable energy is transferred to the main electricity network. In some cases, some areas are significantly far from the main transmission line of electricity, so it may be advisable to generate electricity separately in that area instead of the using of the electricity from the main transmission line. Therefore, one of the important applications of separate generation of electricity is to supply electricity to off-network areas. In the past years, the separate generation of electricity was usually done by diesel generators. But renewable energy technologies such as wind turbines, fuel cells and solar panels are nowadays widely used. Several technologies called hybrid systems are used to reduce shutdown rates. Many comprehensive studies were done on the hybrid systems [14, 15].

Renewable energies are preferred over other types of energy because of their many benefits. The concern about continued supply of energy to human societies is important. The global industrial development and the increasing demand for energy along with the limitation of fossil energy resources make the need for renewable energy more and more evident. Feasibility and economic study of constructing of a hybrid power plant to supply the required power to several off-network sites such as Alam Abad village in Khuzestan province, border checkpoint in Ardebil province and a farm in Alborz province are performed in this study.

## 2. RESEARCH METHOD

At first, the demand of energy in different stated areas should be explained completely which can be found in table. 1.

Table 1 Demand of energy at different cases

| Case | Energy consumption (Wh/day) |
|---|---|
| Alam Abad village | 127990 |
| border checkpoint in Ardebil province | 59022 |
| farm in Alborz province | 851000 |

In order to study the conditions of these areas for the use of solar and wind energy, it is necessary to determine wind velocity and radiation values in these areas. Information is provided in the Fig.1, Fig. 2 and Fig. 3 which are input of Homer software

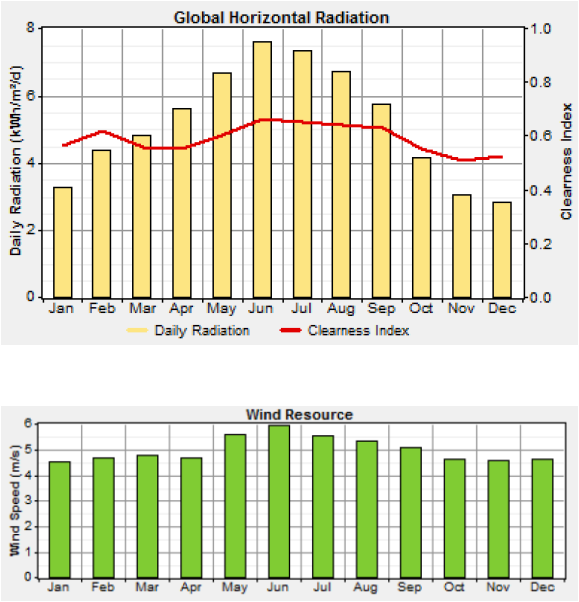


Figure 1 Daily radiation profile for a village in Khuzestan province (left), Average monthly wind speed profiles for a village in Khuzestan province (right)

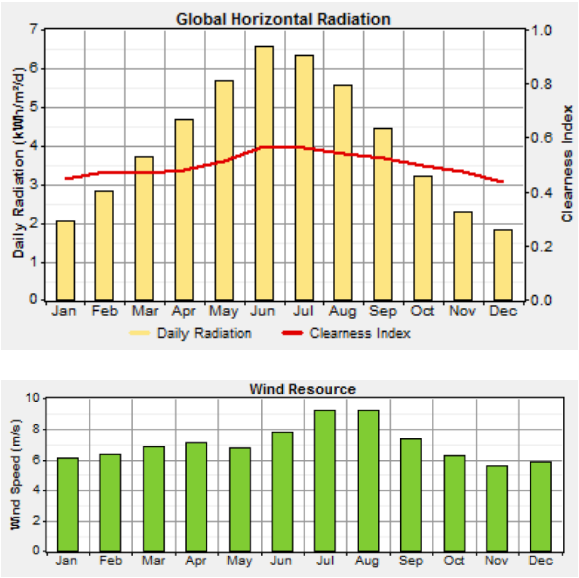


Figure 3 Daily radiation profile for a farm in Alborz province (left), Average monthly wind speed profiles for a farm in Alborz province (right)

The designs of the hybrid power plant for the three sites are shown in Fig. 4 which are obtained after importing weather and radiation data as well as load consumption profiles to the Homer software. The values in Fig. 4 indicate that the load and energy profiles of farm is higher than those of the other two sites.

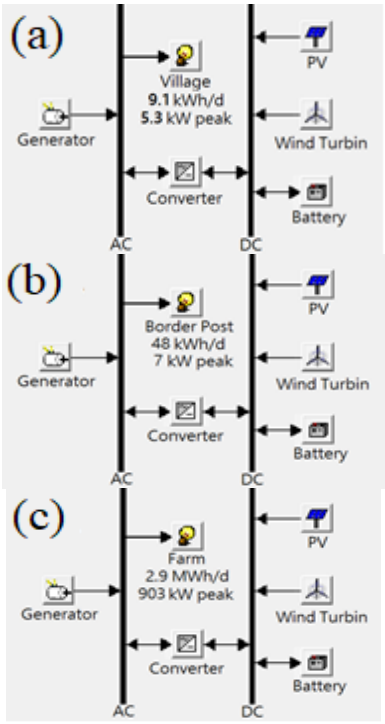


Figure 4 Schematic of the sites under study: (a) the village, (b) the border post, (c) the farm

One of the limiting parameters is the cost of the equipment. The cost of the equipment is considered as a function of the power output. The following figures show how the initial and maintenance cost of each equipment changes with the variation of the output power.

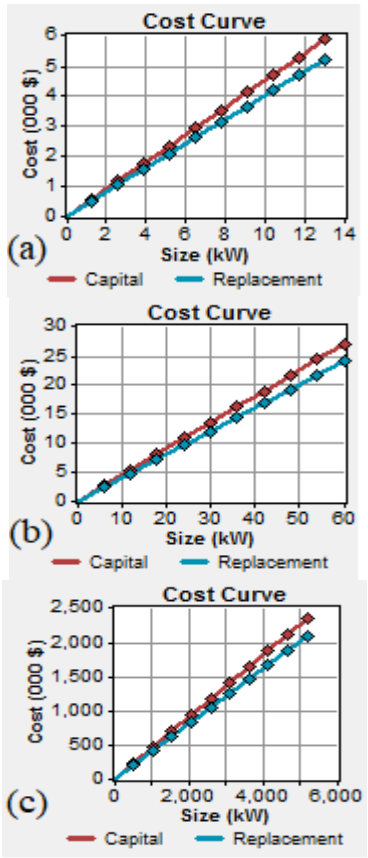


Figure 5 Diesel generator cost: (a) the village, (b) the border post, (c) the farm

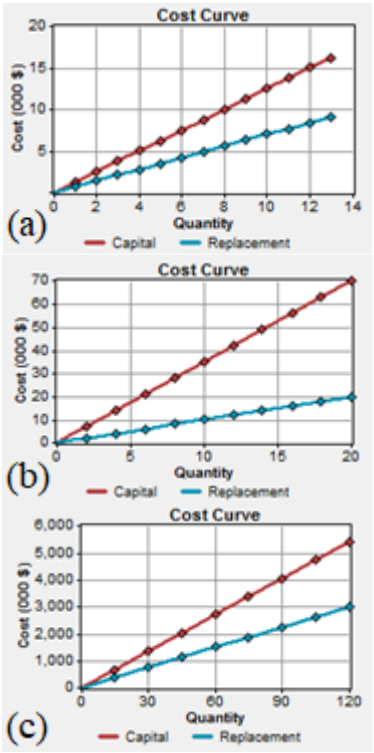


Figure 6 Wind turbine cost: (a) the village, (b) the border post, (c) the farm

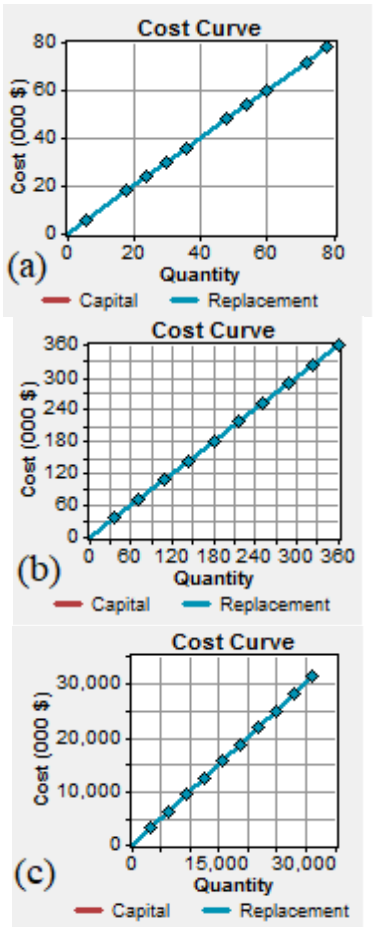


Figure 7 Battery cost: (a) the village, (b) the border post, (c) the farm

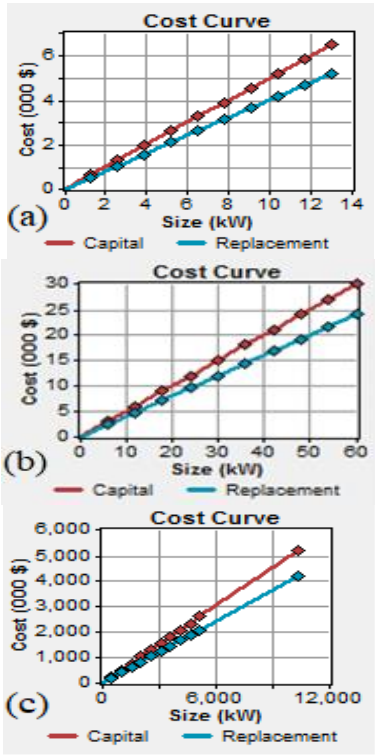


Figure 8 Heat exchanger cost: (a) the village, (b) the border post, (c) the farm

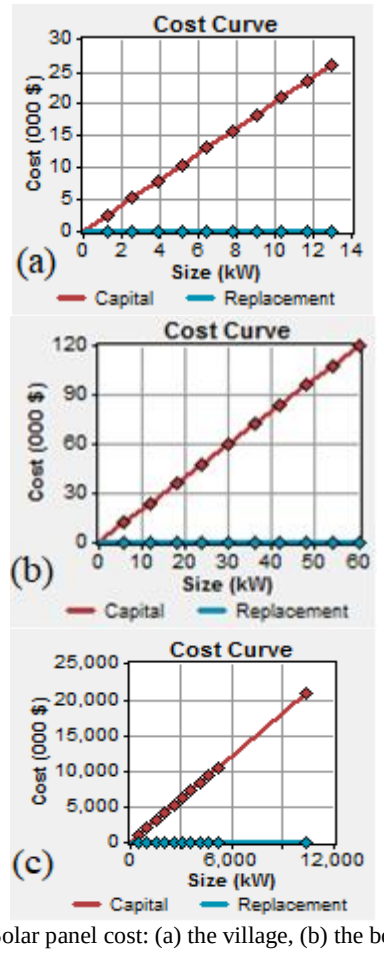


Figure 9 Solar panel cost: (a) the village, (b) the border post, (c) the farm

## 3. RESULTS AND DISCUSSION

Wind turbines, photovoltaic modules and diesel generators are used to generate power for all three hybrid sites. Finally, the software proposes the best-case scenario in terms of optimal economic conditions. The detail of the best scenario is investigated comprehensively. In the software all prices are entered. The optimal economic case is selected from all the results presented by the software and the diesel generator is not used in the hybrid power plant site of the village. Fig. 10 illustrates the generation capacity of the photovoltaic panel and the wind turbine at different months of the year. As can be seen, a large part of the power output is generated by solar panel due to the region's high radiation and low wind. The amount of energy generated from the solar panel for the site is 7208 kWh and for the wind turbine is 1537 kWh. It means that 82% and 18% of the total production capacity of 8744 kWh is produced by radiation and wind, respectively.

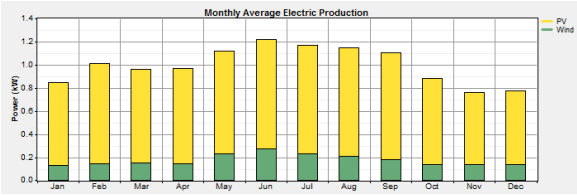


Figure 10 Production capacity in different months of the year for the village

The Homer software does not utilize the solar panel and diesel generator system for border power plant, and all the power generated by the wind turbines. Fig. 11 shows the averaged generation power over the different months of the year. According to the results of Homer, the only source of power generation as mentioned is the wind turbine with 52921 kWh.

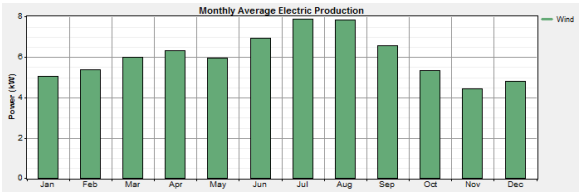


Figure 10 Production capacity in different months of the year for the outpost border

In the farm modeling, the software avoids the choice of diesel generators in the most economical way, preferring to use more batteries. Fig. 11 shows the solar panel and wind turbine generation capacity at the farm site. At the hybrid power plant, the solar panel produces 20% and wind turbines produces 80% of the power, which is 935868 kWh and 3663127 kWh, respectively.

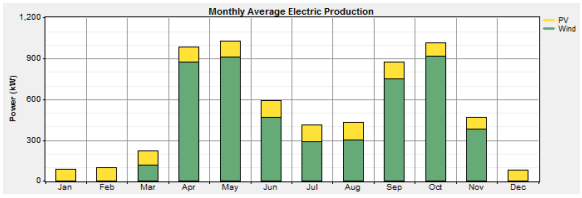


Figure 11 Production capacity in different months of the year for the farm

## 4. CONCLUSION

In this paper, three different areas are considered which are named as village, outpost border and farm. The energy consumption of these areas is investigated in detail. The economic analysis is performed for all cases. It is tried to use a hybrid system to generate power. The hybrid system uses fossil fuel, radiation and wind energy to generate power. The current results are summarized as follows.

- For the village: A combination of solar and wind energies with a higher share of solar energy is suitable.
- For the border region: A system that uses wind energy is better.
- For the farm: A combination of wind and solar power with a higher share of wind is suitable.

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