Sizing and Optimization for Hybrid Central in South Algeria Based on Three Different Generators

C. AMMARI  
chocho.mah@gmail.com  
LDDI Laboratory, University Ahmed Draya-Adrar

M. HAMOUDA  
jhamouda@yahoo.fr  
LDDI Laboratory, University Ahmed Draya-Adrar

S. MAKHLOUFI  
makhlofi.s@yahoo.fr  
LEES Laboratory, University Ahmed Draya-Adrar

Abstract—In this paper, we present a study of the size for the hybrid central containing a three different generators, two on renewable energy (solar and wind power) adding a diesel generator for feeding the village when renewable source is insufficient. Acquaintance of daily consumption for the city is the key to size hybrid central, for this reason, we made a full study, economically and sociological in this village. The hybrid central will distribute energy to rural village in southwest of Algeria called “Timiaouine”, the program used for simulation is Hybrid Optimization Model for Electric Renewable (HOMER), this program will simulate the central and choose the optimum configuration economic and ecologic.

The hybrid central size for secure the energetic continuity of the village with minimum cost.

Keywords—hybrid central, HOMER PRO, renewable energy, solar energy, wind energy, diesel generator.

1. INTRODUCTION

The energy demand grows exponentially every day due to the increase in industry and population, for this reason the world bank and international energy agency estimate doubling in installing capacity of energy over the 4 following decades [1]. Renewable energy sources are powerless to meet energy demand because some sources richness with season like solar and wind energy, or depend on the location like hydroelectric. However the drawbacks of renewable energy sources can be limited by using solar energy in a hybrid system [2].

The electric energy system made up of one renewable source and another conventional sources named Hybrid Renewable Energy Systems (HRES) [3], that system can work in off-grid (standalone) or grid connected mode. The hybrid energy systems composed essentially from renewable energy generators (AC/DC sources), nonrenewable generators (AC/DC sources), power conditioning unit, storage, load (AC/DC) and sometimes may include grid. [4]

HRES can use one or both of the renewable sources (solar photovoltaic and wind turbine) in combination with storage system like fuel cell, batteries or ultra-capacitor. This back up energy devices (or named also secondary sources) are introduced into the system to supply the shortage power and to cover the peak consumption. [5]

In some cases, the system can be 100% on renewables source by eliminating the diesel generators and replace via large storage capacity, but this has a strong impact on overall system cost. [6]

There are many combinations for hybrid energy systems such as solar, wind, hydroelectric, or geothermal with conventional sources like diesel generator and storage device (battery or fuel cell). [7]

We can classify HRES by capacity installed, these systems vary from few kW to hundreds of kW, with a capacity less than 5 kW can be treated as the small systems, this kind of systems is generally used to serve the loads of a remotely located home or a telecommunication relay system. Then the systems with the capacity more than 5 kW and less than 100 kW can be treated as the medium systems, these are used to power remotely located community which contains several homes another required amenities. The medium systems in most cases work in stand-alone mode and sometimes may be connected to utility grid, if it is nearby. The other type of the system is able to cover the energy of a region, with the capacity of more than 100 kW can be called as the large system. These systems are generally connected to grid, to enable the power exchange between the grid and the system in case of surplus or deficiency [8].

In order to find the optimal sizing and operational strategy for a hybrid renewable energy system, HOMER PRO software is one of the best program work in hybrid system. This software based on three principal tasks which are simulation, optimization and sensitivity analysis. [9]

The future of HRES is to combine two or more renewable power generation technologies to make best use of energy available in the site to obtain the greatest efficiencies that could be found from a single power source.

2. System Description

The hybrid central is composed of:
- Solar photovoltaic.
- Wind turbine.
- Diesel generator.

The connection of hybrid system is illustrated in the bellow figure:
2 Hybrid central sizing:

For size a hybrid central in HOMER PRO, we should follow these steps:

2.1 Load consumption:

The load profile is an important step to find whether the energy produced by the central is matching the load demand [8]. Arabali and al. [10] propose a method for the hourly load variation by using Gaussian distribution with specific limits. The statistical methods are also generally used for the estimation of the residential energy consumption [11-13].

The HOMER PRO program filed loads according to their type (home, commercial, industrial or city) and proposed model for each type.

In our case, the load is consumption of Timiaouine city. We will describe in this part just the consumption for houses and schools, because it presents 98% from global consumption of Timiaouine city.

2.1.1 Housing consumption:

We classified the consumption in two seasons; a season when consumption is low (winter), and a season when consumption is high (summer).

In winter season, we noticed that most consumption of houses is in the refrigerator and light (45%), the other consumption divided between the rest devices, the consumption rest low and equal 16.17 kWh/day.

In the high season consumption, the air-conditioner presents more than 60% from the global house load, the daily consumption is 46.9 kWh.

2.1.2 Primary and secondary school:

The Figure 2 represents the consumption of primary school with 400 students, the school is composed of:

- 20 classrooms
- 1 staffroom
- 2 offices
- 1 bathroom

The capacity of secondary school is over 900 students; it is composed of:

- 30 classes
- 1 staffroom
- 4 offices
- 2 bathrooms
- 2 laboratories
- computer lab.

Fig 2: The consumption of primary and secondary schools in two seasons
2.1.3 Global village consumption:
Timiaouine town consumes 7,52 MWh every day in winter and 23 MWh/day in summer, the household presents 93% from global consumption (fig 3), the second most consumption is the schools by 5% (secondary and primary).

2.2 Generator sizing:
2.2.1 Solar photovoltaic:
The initial capital cost is 1100€/kWh, the cost of maintenance it takes 10€, the lifetime of panel is 25 years. Photovoltaic generator is size with 2500 kW, because the strategy of program HOMER PRO is the choice of a capacity equal or less than the peak load.

2.2.2 Wind turbine:
In our system, we use two wind turbines mark GAMESA, type G52 with 850 kW power output, the cost of this type is 1,8 million euro and is the same for replacement, the maintenance costed at 18333€, the figure 4 describes the yearly production of renewable energy (solar and wind turbine).

2.2.3 Diesel generator:
Generator diesel is used like support in peak load or absence of the renewable generators production (solar or wind). The initial cost is 500 €/kWh, this price is the same price for replacement, the maintenance cost is 0.03 € with 15000 hours for the lifetime. Finally, HOMER PRO size the generator capacity to 1400 kW. Figure 5 illustrates the daily production of diesel generator.
Fig 5: diesel generator daily profile

Fig 6: Global solar monthly average

Fig 7: Wind speed monthly average
The diesel engine is used as emergency protection but the usage of batteries and more green energy can reduce the emissions of this generator.

2.3 Weather data:

The climatic conditions play a major role as the entire power generation is dependent on this. For every different location the weather conditions will be different. So, for a feasibility study or for optimal sizing of the hybrid systems, weather data is a very important tool for analyzing the climatic conditions thoroughly before setting up a plant. Such data is mostly available at the local meteorological stations, for some potential sites the space research agencies like national aeronautics and space administration (NASA) have made the data available through the web resources [8], the figures 6 and 7 characterize the weather data for Timiaouine city.

3. RESULTS:

The global investment for this central is 22 million euro with 0.336 €/kWh and that’s what shown in the economic report (Fig. 8), the central produces 10.63 GWh every year, 72% of this energy from renewable energy (fig9).

The minimum percentage for renewable energy is a condition we can add to the ecologic strategy for limiting the usage of hydrocarbons; in our case we chose 60%. To secure the energy system of Timiaouine town we add another condition in sizing strategy of the central, this parameter is named ‘increase in load profile’ and we opted for 10%.
4. CONCLUSION

In this study, we were sizing and simulating a hybrid central based on three different generators, this central was simulated by software HOMER PRO. This central uses all renewable resources available in the urban village.

The optimum configuration proposed by HOMER PRO is hybrid central produce 10.63 GWh every year, most of this energy is produced from renewable source (72%), this result is better than Rohit and Subhes [14] when use hybrid central base on solar PV, bio diesel, hydropower and batteries with 0.442 €/kWh.

5. REFERENCES