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OPTIMIZATION OF A HYBRID RENEWABLE ENERGY SYSTEM (HRES) IN KYTHNOS ISLAND (GREECE)

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ABSTRACT

Kythnos Island Plant consists of PV-wind-diesel hybrid system (100 kW peak/1290 m^2 PV; 200 kW diesel; 100 kW wind turbine; and 600 kWh battery storage) operates since 1983 in the Kythnos Island (Greece) was simulated and optimized by a Software Energy Manager Program (SEMP) which was developed by the author as a sizing and optimization tool. The optimum HRES was found comprise of (WG-B-DG), where of Kythnos Island Plant energy output (170 MWh/year) about 83% will be attained by WG and 17% from DG and the battery storage about 625 kWh. The PV has no any contribution in the optimum system due to the low solar energy and high costs relative to the other subsystems.

KEYWORDS: Optimization; Simulation; Solar Energy; Wind Energy; Photovoltaic; Battery; Diesel Generator; Cost

OVERVIEW

HRES is considered the best alternative energy choice according to their sustainable and positive impact on the environment. The energy cost and sustainability during the life-cycle of the HRES are the main criterions to design HRES. Numbers of papers studied different options of renewable energies, where three methods based on the available energy under worst-case conditions for (PV-Diesel, PV-only, Diesel-only) systems by using the Genetic Algorithm (GA) were optimized and compared with the method used by Hybrid Optimization Model for Electric Renewable program (HOMER) for a (PV-Diesel), this studies have shown the economical advantages of the PV-hybrid system [1]. The economic assessment of the HRES by HOMER has shown that the hybrid systems are less costly than the diesel system [2], also Khan and Iqbal found that HRES (wind-diesel generator-battery) is more economic than fuel cell at present [3].

Four modular energy systems (Diesel-only, base-case; Hybrid wind–diesel system; Wind–hydrogen storage–fuel cell–diesel; Wind–zinc storage–zinc–air fuel cell–diesel), were analyzed and compared by Clark and Isherwood where the results showed that the fuel consumption and annualized life-cycle costs can be substantially reduced by using renewable electricity generation technologies as well as energy storage devices, [4]. Celik, has found just few papers which have so far published studied the performance-cost of PV-wind hybrid energy systems, also has mentioned that the worst month scenarios lead to non-optimal system in terms of techno-economics [5].

METHODS

A HRES comprises of (WG-PV-B-DG) was simulated and optimized by testing the energy (production-consumption) balance each one of the 8760 hour. To find the optimum design and sizes (WG, PV, B, DG) the minimum of total life-cycle cost of the power system has to be found. The minimization of the total life-cycle cost of the power systems is the criterion to obtain the optimum parameters of a system.

The total life-cycle cost is taken as yearly cost, and is expressed as following:

$$Z = Cw * TWE + Cs * TSE + Cb * BE + Ca * TAE \quad (1)$$

Where-: Cw, Cs, Cb, and Ca are the energy prices of WG, PV, B and DG (SF/kWh).
TWE, TSE, TBE and TAE are the total energy per annual from WG, PV, B and DG (kWh).
Equation (1) was used to compare the triplets (TWE, TSE, BE) where for each triplet generates a value of (TAE).

RESULTS

SEMP was fed by the hourly global horizontal radiation, hourly temperature and hourly rate wind speed in Kythnos Island (Greece) of one year (8760 hour), where after a limit number of iterations the minimum costs and optimal sizes of the energy subsystems were found.
Figure 1 shows the result of the optimization in Kythnos where the optimum HRES comprises of (WG-B-DG).

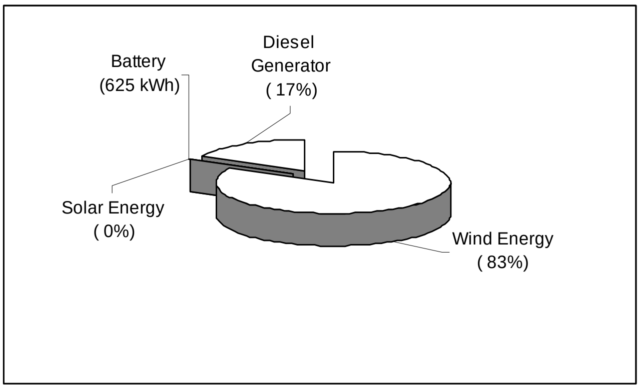

Fig. 1. Optimal HRES and contribution of each subsystem

The minimum cost of the optimum HRES was met at rotor swept area of the WG equal to 248.12 (m2)

CONCLUSION

The prices and parameters of the energy systems in addition to the environment data (solar/wind energy and temperature) formulate the optimum HRES.

REFERENCES

1. Rodolfo, D-L José Bernal-Agustín, L. (2005). Design and control strategies of PV-Electric systems using genetic algorithms. Journal Solar Energy, Vol. 79, No 1, 33-46.
2. Sami, K. Dahl, C. (2005). The economics of hybrid power systems for sustainable desert agriculture in Egypt. Journal Energy, Vol. 30, No 8, 1271-1281.
3. Khan, M. J. Iqbal, M. T. (2005). Pre-feasibility study of stand-alone hybrid energy systems for applications in Newfoundland. J Renewable Energy, Vol. 3o, No 6, 835-854.
4. Clark, W. Isherwood, W. (2004). Distributed generation: remote power systems with advanced storage technologies. J Energy Policy, Vol. 32, No 14, 1573-1589.
5. Celik, A. N. (2003). Techno-economic analysis of autonomous PV-wind hybrid energy systems using different sizing methods. Journal Energy Conversion and Management, vol. 44, No 12, 1951-1968.