Energy Demand Analysis and Management According to Availability of Renewable Energy Sources in Galapagos Islands

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ABSTRACT

This paper analyses the operation of conventional thermal power stations, in parallel with renewable energy sources in Galapagos Islands. This work includes forecast of future electric energy demands, taking into consideration external factors that may affect the demand. The availability of renewable energy sources were determined by utilising five years of wind speed records and one year for solar. Different operational scenarios of load sharing were simulated. Following these simulations the curtailment of renewable energy sources were calculated and a more convenient operation scheme and a new schedule for installation of renewable energy power plants were proposed. The resuts presented in this paper denote that the operational mode and total energy demand affect the curtailment of renewables.

Keywords: Energy demand forecast, Energy curtailment, Load sharing operation modes, Penetration of renewables energy sources.

1. INTRODUCTION

The Ecuadorian government has concentrate its efforts to reduce the uses of fossil fuels in Galapagos Islands. The Project "Zero Fossil Fuels for Galapagos" seeks for to eliminate the uses of fossil fuels in electric energy production. In order to achieve that goal is important the integration of energy demand management and the use of energy in a proper manner.

With the financial aid of international organizations and public funds, renewable energy projects have been developed in Galapagos Islands. The first of them, a wind farm in San Cristobal started operations in 2007, with an average annual penetration of 37%.

For other islands (Santa Cruz and Isabela) the Ecuadorian government has planned different projects. In Baltra island, adjacent to Santa Cruz, a wind farm of 12 MW, and for Isabela a 150kW PV system directly connected to the grid.

2. METHODOLOGY

This research was conducted in order to determine basic guidelines to the inclusion of renewable energy sources in Galapagos Island. This study was divided in four stages: (1) Electric energy demand analysis and forecast, (2) Renewable energy records analysis and determination of energy yield, (3) Simulation of parallel operation of conventional thermal power stations and renewable energy power plants and (4) Determination of guidelines to make a better use of renewable energy sources and investment.

Three set of data were obtained from historical statistical records from Galapagos Power Company, containing the following information: meteorological data, electricity demand, number of clients and tourists. To determine the incidence of external factor to electric energy demand, correlations factors were determined.

The wind farm in San Cristobal has three wind turbines of 800kW each; and the Baltra project has three turbines of 750kW, that will start operations by March 2014. In Isabela a 150kW solar farm is planned to be installed by year 2015. Based on this information and using nominal characteristics from manufacturers and the commercial software MATLAB, individual computer routines were developed for San Cristobal and Baltra to calculate the output power depending on wind speed. For the solar farm the routine calculated the output power taking into account solar irradiation, cell temperature and efficiency. With the use of these routines the load sharing between the conventional and renewable energy was calculated.

3. RESULTS AND DISCUSSION.

Energy Demand Forecast: The models were developed with data from 2001 to 2010 and it was

validated with 2011 data. The overall error is close to 1% when the model is compared with actual values from 2011.

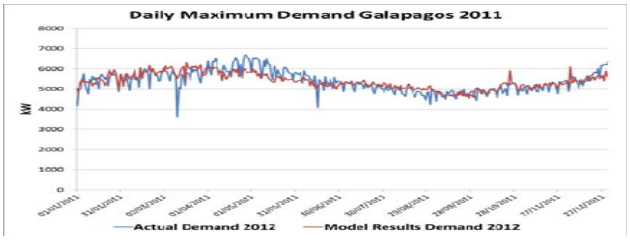

Figure 1 Maximum Daily Demand for Galapagos Islands (San Cristobal, Santa Cruz and Isabela).

Hybrid Systems Simulations: The hybrid system proposed by the Ecuadorian Government for Baltra Island will work with the same operation mode than San Cristobal system. That is taking all the renewable resource available, reducing the output power of the thermal plants (power minima) to 25% of one 650kW unit. The computer routine developed in MATLAB was able to simulate the parallel operation of each hybrid system and determine the annual energy yield for both systems, thermal and renewable.

Figure 2 Simulation of Hybrid System proposed for Santa Cruz Island.

Furthermore different modes of operation were simulated to determine the average penetration of renewable energy and the total curtailment. The simulated period was 2012 - 2032, and the operation modes: (1) 50% Thermal and 50% renewable, (2) 25% of a 650kW unit as base, (3) 25% of a 1500kW unit and 25% of two 1500% units.

4. CONCLUSIONS

- The annual increase in energy demand is determined by the increase in number of clients; on the other hand the seasonal behavior is due to the ambient temperature. Both variables need to be included in any model to predict the energy consumption of Galapagos Islands.
- Energy demand management can be a key element to increase the use of renewable energy sources and increase the reliability of the system.
- The annual penetration of renewable energy sources depend on maximum demand and operation mode. The curtailment of renewable energy sources is a major issue, due to operation mode or mismatch of demand with renewable energy availability.
- The schedule for installation of new renewable system according to Ecuadorian Government should be reconsider, and giving more support to energy saving and energy side management projects.

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