Locate a Pumped Storage Power Plant in Gran Canaria Island. Simulation by software Homer the electric system in 2015

A. Pulido, G.Winter, B.Galvan, J.Romero, C. Roca
Electrical Engineering Department, University of Las Palmas de Gran Canaria. (*Spain*)
apulido@die.ulpgc.es

***Abstract*--Gran Canaria is one of the seven Canary Islands, located near Morocco Shore, this position offers a significant renewable energy potential to supply local and tourist population with clean energy. The island is rich in wind and solar resources; it has some wind farms with more of 4000 hours equivalent per year. It has an Energy Plan that provides for increased electricity generation from renewable energies. We think that a pumped storage is good for this isolated power system. We look for potential sites and try to analyze some beneficial effects with homer software.**

***Index Terms*--insolated power system, renewable energies, pumped storage, simulation**

I. Introduction

The present work aims to analyze the effect it would have to install a Pumped Storage Power Plant on the island of Gran Canaria. In order to make better use of renewable generation, even increasing it penetration (1). The software has been used homer (6) for study of isolated power systems.

This is an isolated power system that aims to increase renewable generation strongly; the Canarian Government has set a target of 2015, which will be our year of study.

On the other hand try to determine the optimal location for the facility.

As the pumping power would be required to useful 99% of the energy produced by renewable energy.

II. THE ISLAND OF GRAN CANARIA IN NUMBERS

It has an official population of 829,597 and an area of 1,560 km2, 42,76 % of the territory is protected. It has 59 large dams, is the isle in the world with greater water storage capacity.

The island is isolated electrical systems, and today the generation park is 981,3 MW, being composed as it is shown: 7,8% renewable, 22,7% Combined Cycle, 9,3% Diesels, 17,7% Gas Turbine, 42,5% Steam Turbine.

The annual electrical energy produced (MWh) is the following: 3.571.329 Thermal Power Plants, 207.981 Wind and 549 Photovoltaics.

Disaggregating the coverage of energy demand for each technology: Steam Turbine 50,8%, Diesel 8,7%, Gas Turbine 3,7%, Combined Cycle 31,1%, Cogeneration 0,1% and Renewable 5,5%.

The fuels used for generation are the fuel oil (69%) and Diesel (31%). The external dependency is extreme and the contribution of renewable energy is minimal, PECAN Islands Energy Plan 2006 aims to change this. So, today wind power is 76,3 MW and 0,948 MWp photovoltaic currently installed, the aim in 2015 will be 411 MW and 46 MWp, respectively.

III. PENETRATION OF RENEWABLE GENERATION

A great amount of the electricity generated by renewable energy-based generation units is often rejected as a result of network restrictions and technical reasons related with the safe operation of the electrical systems. Some static and dynamic considerations listed below.

There are some statics issues:

- Limited current contribution especially in low hours, causing it to be disconnected at that moment renewable generation, losing a free and clean energy.
- Wastage a part of the clean generation, because it does not coincide with consumption. In the next picture we can see the wind seasonality.
- All the time it´s necessary shutting down and starting up the generators, with the economic and maintenance effects that goes with it. With a storage device is possible smoothing the load curve.(2)

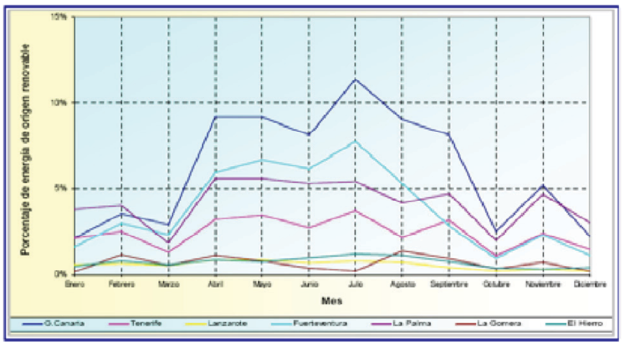

Fig. 1. Annual variation of wind generation in Canary Islands

When we use unmanaged energy, it makes more difficult with the dynamic behaviour, Because the power system must be operated within tight margins of frequency and voltage.(3)(4)

- Conduct off Voltage dips
- Solutions to the wind mass disconnections
- Contributions to the short circuit currents
- Margins allowable frequency
- Inertia and damping of system oscillations
- Additional Services for Primary Regulating Power-frequency control.

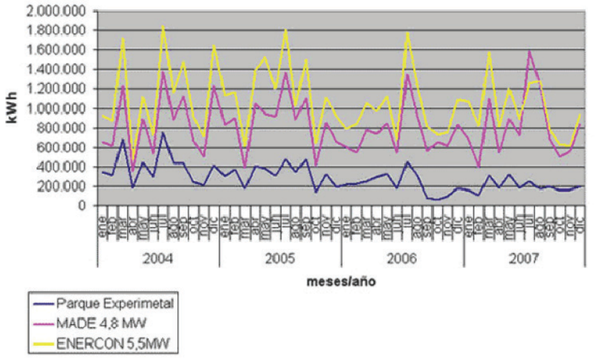

Fig. 2. Abrupt oscillations in wind power generation

To adjust the generation and demand and provide capacity to regulate the system, we study a reversible hydroelectric with pumps and turbines, so that at least one turbine is always running, dark blue in the graphic.(5).

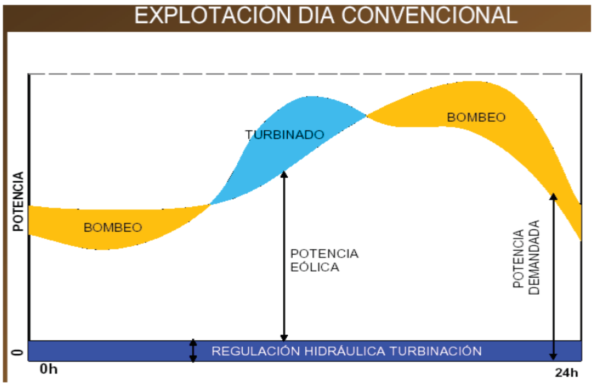

Fig. 3. Daily operation a windy day normal

IV. CRITERIA TO LOCATION THE OPTIMUN FOR THE PUMPED STORAGE

It thus dismissed those deposits too small, or inaccessible. Finally he drew up a list of ten proposals. A priori we would try to exploit existing dams, at least one of them, in order to minimize investment and environmental impact.

- Difference in elevation between dams
- The lower dam near the sea, so it’s possible provide the installation of a desalination plant
- Near the location of areas of high wind potential
- Invade environmental protection zones
- Energy stored
- Possibility of power evacuation

With these criteria has found the optimal solution, using two existing dams: *Soria* and *Las Niñas*.

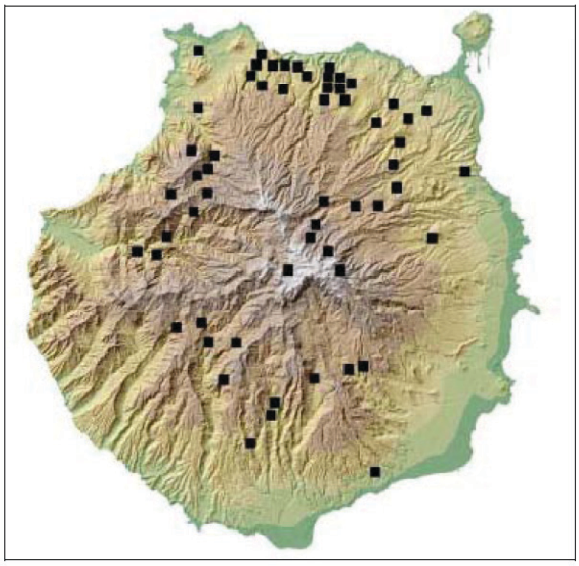

Fig. 4. Big dams in Gran Canaria Island

V. SIMULATION BY HOMER

We did the model of the electric system in 2015.

A. Modelling elements

1) Pumped Storage Power Plan.

It has been divided in three elements, first, Turbine running continuously for regulation, with a power of approximately 10% of the average power demand, second, load loadable with annual consumption which reflects the pumping set which gives the energy plus the losses annually consumed by the regulation turbine and at the end, the rest of power plant is modelled as a battery, the capacity is modelled approximately 5.200.000 kWh. It was considered that the nominal output voltage will be 66 KV. Besides the above, has set the system's efficiency by 70% and the minimum load condition, which is considered 30%.

2) Demand Insular.

This tag represents the primary charge. In the case, meaning the energy demand of the Island of Gran Canaria. Like the rest of the elements, it was decided to scale because the values was out of range. Specifically with forecasts for 2015 that offers PECAN (Energy Plan of Canary Islands). In these, it is estimated that demand in the Island of Gran Canaria increase by 28% based on 2006 data. We have the hourly consumption of 2006. All the values have been increased on the same percentage, and that are the values input in the model.

3) Wind turbines and wind resource

We analyzed the all wind power as a single park, thus adding capacity across the island. At present, the sum of all wind power on the island gives a value of about 76 MW installed. Similarly, output in 2006 was 197.030.364 kWh.

The power scheduled for 2015 will be of 411 MW, from which we will work in the simulation.

To correctly define the characteristics model is taken as a wind turbine of 2 MW ENERCON company, namely the E- 82. Because it will be the more installed over this island.

The goal is to work with an installed capacity of 411 MW, and each brings 2MW wind turbine, so that in the simulation is considering the installation of 206 devices.

To define the wind resource is the monthly average has the resource and to seasonality in production wind resource was adjusted so that annual production in 2015 keep the current ratio of the whole island park MWh/MW for each months.

4) A set of conventional generation as two diesel Groups

The design of this element is once again made reference to the reports of the PECAN 2006. At the events, provides an estimate of the increased demand in the period 2005/2015. The estimated installed capacity was based on analysis of annual peak demand recorded in the park service generator at each island as the electrical power needed to be calculated to meet the most extreme situations that may occur, regardless repetition frequency of such peak demands within a given year.

The consumption of the groups were determined by the current ratio of T Fuel / kWh and T diesel / kWh.

An added advantage to the pumping station is the smooth load curve avoiding sudden changes in service and frequent starts and stops.(2)

5) Photovoltaic Park

It has introduced the use of solar radiation on average in the island and the power of 46 MWp expected by 2006 PECAN

By simulating the pumped storage as a battery, so it includes a DC/AC converter the numbers exited of rank the magnitudes have been working at scale.

B. Simulation results and parameter settings

Once all the elements was adjusted battery power and stored energy capacity in order to match the use of renewable production by 95-99%.

There is a contribution of 49% of the demand corresponds to conventional thermal generation, photovoltaic 2,4%, the rest is wind energy.

VI. CONCLUSIONS

Eliminating the storage device is increased over 30% of untapped renewable energy, for excess generation unmanaged 50% of demand at the moment, the maximun to keep control of the system variables.

The study of optimal place to pumped storage is concluded that of the ten options, the best is *Las Niñas - Soria*, in all criteria was the highest score, except for the difference in elevation between dams is 397m, there is an option with a difference of elevation of 750m, but the rest were the best: energy stored 5196MWh, horizontal distance between dams 0,93 km, distance from the low dam to the shore 1,65 km, altitude 44 m, is 4km from the nearest desalination plant, the dam of *Las Niñas* is smaller than *Soria*, so the determinant of the ability, being 5,18 hm^3, *Soria* dam place has no environmental protection, or protected by Natura 2000 European network, So the impact of pumps building and turbines building shall not very important.

Fig. 5. Soria dam. Gran Canaria

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[6] https://analysis.nrel.gov/homer/