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WIND POWER ASSESSMENT IN URUGUAY

Cataldo, J.[1] and Nunes, V.[2]

[1] Instituto de Mecánica de los Fluidos e Ingeniería Ambiental
[2] Instituto de Ingeniería Eléctrica

Facultad de Ingeniería, Universidad de la República, Montevideo, Uruguay.

ABSTRACT

The wind power as a large alternative energy source appear in Uruguay. A nested method to obtain the mean wind velocity time series at complex terrain sites and describe the turbulence was developed. Sites with mean velocity over 9m/s and capcity factor over 40% were found. The aerodynamic interferences loss between wind generators using a numerical model were evaluated and a numerical model was developed to design an optimal cluster wind farm. As bulk result, an installed capacity of 300MW with a cost production less than 0.065U$S/kW.h can be estimated over the all studied Region.

KEYWORDS

WIND POWER ASSESSMENT, WIND NUMERICAL MODELLING, WIND PHYSICAL MODELLING, NESTED METHODS, CLUSTER OPTIMIZATION,

INTRODUCTION

Uruguay is located in a windy region of South America where gentle hills exist (height less than 600m). The analysis of long term wind speed records from Weather Stations indicates that the wind power as a large alternative energy source appear.

The State owned Electrical Utility (UTE) has been interested since 1987 in adding renewable, non conventional energetic resources to its generation system, specially wind power. A UTE supported Wind Energy Research Programme has therefore been developed by the School of Engineering since 1988. Three stages have been accomplished, comprising the analysis of available meteorological wind records, the wind potential assesment on complex terrain using numerical and physical modelling techniques, the identification of sites for wind farms and autonomous applications and development of tools for optimization of wind farm layout and for design of autonomous systems.

WIND FIELD

Wind climate determination is the common problem in wind power assessment programs. In Uruguay, as in other places, the sites of principal interest for wind power exploitation are over complex terrain zones where measurements of wind velocity do not exist. The methodology applied to estimate the hourly wind field in Uruguay uses a combination of numerical and physical modelling.

The numerical model used to solve the mean wind velocity field up to meterological mesoscale is a mass consistent code, similar to the one presented in Sherman, 1978. This model uses as data the hourly mean wind velocity time series obtained in the weather stations located in the volume to be studied. This volume has a 500kmx500km base and its height is equal to the one of the Atmospheric Boundary-Layer (ABL). The mean velocity field is calculated as the one which makes the integral square difference minimum between a first guess and the mean velocity field and verifying the equation of continuity. The equation obtained is a Poisson equation which is solved using the finite element method. López, 1992 points out details of the methodology. The principal patterns technique (eigenvectors of the covariance matrix of the data) is used. Figure 1 shows the mean velocity field obtained at 30m over the terrain in the grid nodes with 15km mesh size. Also, the principal pattern technique was used to study the quality of the ensambles velocity data.

Fig. 1 - Numerical model out put.

The physical modelling was used to solve the wind velocity field up to the meteorological microscale. The ABL was modelled for "high wind" conditions. The method reported first in Counihan, 1969 for ABL physical simulation was used in a wind tunnel with a 1.2mx1.6mx3.6m test section. The obtained mean and turbulence velocity profiles were compared to the results reported by Harris, 1969 and E.S.D.U., 1985 and Counihan, 1975. A geometrical scale of 1/6000 was used. The measurements of velocity were made with a TSI hot-wire anemometer, which probes were positioned using a four freedom degrees robot.(see Cataldo,et.al,1992). The models were constructed following the method described in Neal, 1979 and they were located where the flow in the wind tunnel was able to be considered self-preserving. The measures were made over a set of points of the models, where the existence of a wind farm is assumed. The local speed-up and the intensity of turbulence were deduced at 30m (at the prototype scale) over each point.

Applying the speed-up factors deduced from the physical model to the wind velocity time series obtained from the numerical modelling the wind velocity time series were obtained at the sites of interest. Figure 3 shows the location of the studied sites.

1 Piria1, 2 Piria2, 3 Animas,
4 Fromento, 5 Eden, 6 Caracoles,
7 Cañas, 8 Aiguá, 9 Mariscala.

Figure 2 - Studied site locations.

The method also allow us to deduce the turbulence characteristics of the sites necessary to find out structural problems and control system operation prior of the installation. López,et.al,1992 and Catado,et.al,1995 present detailed results.

LARGE SCALE GRID INTEGRATION STUDIES

The goal of these studies was to obtain an assessment of the amount and cost of electric energy that windfarms can supply to the utility grid in the particular meteorological and topographic conditions in Uruguay.

A optimization model (Penza et. al. 1992) defines the most economical solution for: spacing between turbines, electrical configuration, voltage levels and all the electric equipments, including cables, transformers, circuit breakers and reactive power compensation.

The software tool developed minimizes the cost of the output energy delivered to the utility grid, during the expected life which is estimated in 20 years. The method takes into account the investments and aerodynamic and electric losses of the installation. The output power of each machine of the farm is calculated from the wind data of the site with an evaluation of the loss of power due to interference. The software developed also allows calculation of expected hourly electrical power output from the designed windparks, Penza et. al. 1994. Results for capacity factor and wind farm energy cost are shown in figures 3 and 4.

EVALUATION OF THE RESULTS

The results obtained from the Wind Power Evaluation for industrial scale generation are very promising. Zones with capacity factors greater than 0.35 and capabilities of power installation around 300MW were identified.

It was not possible to identify favorable zones for autonomous applications. This result is due to two reasons: zones far away from the electrical grid present very low wind speeds and the electrification coverage in Uruguay is very high (>95%).

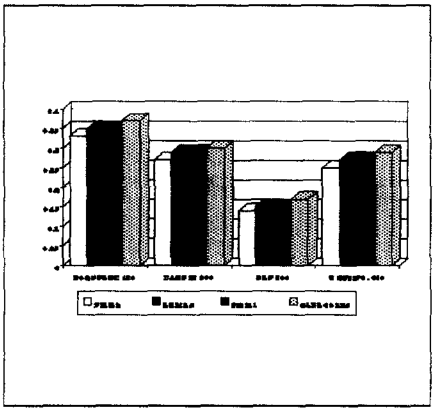

Figure 3 - Capacity factor.

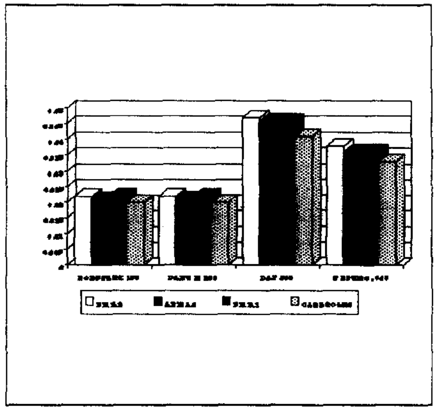

Figure 4 - Calculated energy cost.

A pilot wind farm connected to the national electrical system will be installed in "Sierra de Caracoles" site. The project comprises the installation up to three horizontal axis WECS rated 150-200 kW each and a data acquisition system for monitoring and evaluation. The results from the operation of the planned wind farm will be of great importance in determining the future and the role of wind energy in the national elecrtical system.

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