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Improving the wind speed estimation algorithms using results obtained in the field

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Abstract: The production of green energy from wind power is a topic of great importance nowadays and of wide interest throughout the world. The system described in this paper allows an in-depth evaluation of the energetic efficiency of the green power solution proposed to power a measuring station located in a remote location, for which we have available estimated values for the wind speed. Our goal is to study the difference between the values proposed with the aid of theoretical algorithms for energy production estimation and the field data. By studying this differences new solutions can be proposed to optimize the algorithms.

Keywords: *energetic efficiency, green power, SCADA systems*

1. INTRODUCTION

The production of green energy from wind is a topic of great importance nowadays and of wide interest throughout the world. The hybrid system (solar and wind power) in Floresti (figure 1) is composed of a 1 kW wind turbine, two 240W each solar panels, batteries, inverter, 2,3 kW pump, RTU (Remote Terminal Unit) and SCADA(Supervisory Control and Data Acquisition) system. The system described in this paper allows an in-depth evaluation of the energetic efficiency of the green power solution proposed to power a measuring station located in a remote location, for which we have available estimated values for the wind speed. To achieve this goal the system has an Algodue power meter, a hybrid controller, a PLC (Programmable Logic Controller) to control the power production, to process the parameters and transmit them via a GPRS connection to the dispatcher, and a Siemens WinCC (Windows Control Center) application that takes the data from the OPC (OLE for process control) server, and archives and displays them on the screen.

Fig. 1. Hybrid system in Floresti

The software that supports this operations is comprised of a MicroWin application on the PLC, responsible for reading the parameters of the system from the power meter and the hybrid controller, controlling the power production, and for sending the important parameters to the dispatcher through a GPRS connection. This paper will focus on the WinCC application present on the dispatcher computer or on the local computer. The difference between the dispatcher and the local version is that the last one uses PC Access to connect to the PLC.

A. SCADA SYSTEM

A SCADA (Supervisory Control and Data Acquisition) system is an industrial system for measurements and control, composed of a central computational equipment, named "master" and one or many units located on the technological installation for acquisition and regulation and a software package used in the monitoring, control, command and remote regulation.[1]

The main components of a SCADA system are described below:

- Ø A Human-Machine-Interface or HMI which is the apparatus which presents process data to a human operator, and through this, the human operator monitors and controls the process.
- Ø A supervisory (computer) system, gathering (acquiring) data on the process and sending commands (control) to the process.
- Ø Remote-Terminal-Unit(RTUs) connecting to sensors in the process, converting sensor signals to digital data and sending digital data to the supervisory system.
- Ø Programmable Logic Controller (PLCs) used as field devices because they are more economical, versatile, flexible, and configurable than special-purpose RTUs.
- Ø Communication infrastructure connecting the supervisory system to the Remote Terminal Units

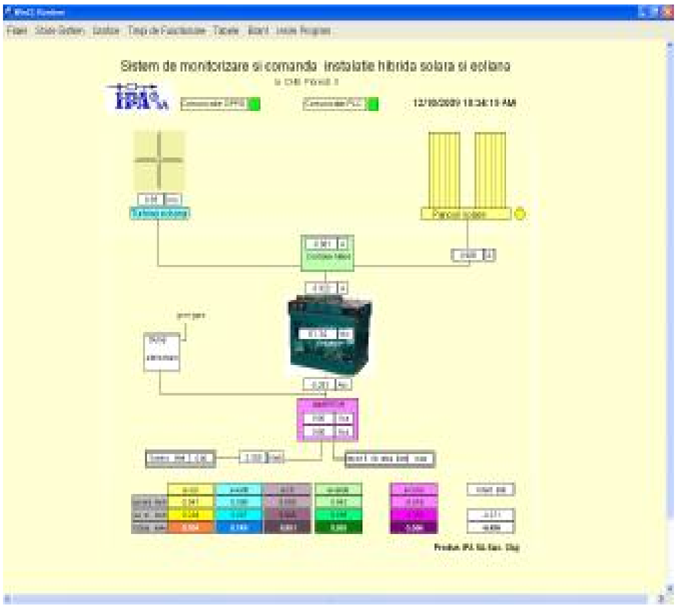

Fig. 2. The main window of the WinCC application

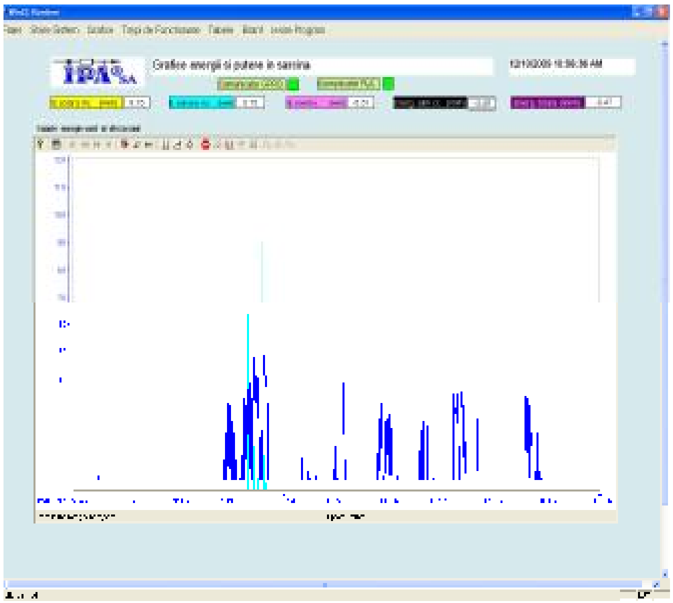

Fig. 3. Chart representing the correlation between wind and speed wind energy production

B. DESCRIPTION OF THE WINCC APPLICATION

The WinCC(Windows Control Center) program has the following functionalities:

- full graphics display
- alarm display, alarm archiving and alarm logging
- measured value acquisition (archiving functions, data compression, minimum and maximum values)
- Report Designer for documenting machine sequences and process sequences with individual reporting
- Process communication to various PLC systems
- Standard interfaces for database and data processing
- Programming interfaces (API) are available in all WinCC application modules and allow access to data and functions
- Complex visualization tasks can be solved with the ANSI-C programming language and/or Visual Basic Script[2]

The WinCC application gets the hybrid's system parameters from the dedicated OPC server in real time, and processes them. The most important parameters are:

- battery voltage[V],
- total energy in the battery[kWh],
- wind speed[m/s],
- controller current[A],
- wind power[W],
- wind energy[kWh],
- inverter current[A],
- inverter power[W],
- inverter energy[kWh],
- solar current[A],
- solar power[W],
- solar energy[kWh],
- apparent power[W],
- active power[W],
- reactive power[W]
- time[3]

The real time parameters are displayed on the graphical interface (figure 2) and then are archived at an archiving rate of 5 minutes using the Tag Logging. The main panel is displayed in figure 2 and as a whole is a schematic representation of the system. The way of navigating from one panel to another is through the menu seen at the very top of the figure. The panels are structured in sub-menus: fisier, stare baterie, grafice, timpi de functionare, tabele, bilant, iesire program. The energy producers(wind turbine and solar panels) are represented in the top section of the panel with their most important parameter attached (wind speed and the current produced in the solar panels). The hybrid controller, the battery, the inverter are depicted in the middle section of the panel, while the load components are at the bottom with the most important energy parameters.

Having previous values from this archive, charts can be constructed that describe the evolution in time of the parameters. Certain parameters are grouped together on the same chart to illustrate the correlation between them. For example in figure 3 the wind speed and the energy produced from wind power can be seen on the same chart. By interpreting this chart an evaluation of the wind measurements accuracy is made. This chart is important because the wind speed is never constant, it varies very quickly making a correct reading very difficult. The technique used to record the wind speed was to read to number of impulses given by the anemometer in a period of one minute. In contrast the energy produced from wind power is recorded in real time. By comparing the two on the chart in figure 3 we can detect if the measurement of wind speed is made correctly.

The raw data gathered in the tag logging database is processes to create new and more meaningful values.

By using the ANSI C functions available in WinCC, monthly and yearly balanced sheets are calculated for the most important values. These sheets are very important because they allow the evaluation of the performance of the energy production system and the comparison between the wind and the solar component.

2. DATA INTERPRETATION

Other processing of data include determining the wind speed average, which is a key parameter for any location. The data for the wind speed that was available before installing the system was comprised of wind speed values estimated for the location by the two major specialized applications in the field: RetScreen and Homer, but also bought satellite data from a company in Austria. RetScreen and Homer are applications that aid in the construction of hybrid energy farms, and the wind speed data used by them is public, usually provided by NASA. This raw data is processed with algorithms to produce better estimations for a particular location. Comparing the value obtained from the field data with the one given by Homer and RetScreen a big difference between the two was observed. This was caused by the fact that the data used by the simulators is considered on a wide area of 5x5 km and then to produce better data for the location algorithms are applied. To improve this estimations better formulas for the algorithms can be used that take into account terrain rugosity, obstacles,… The optimal solution would be to carry on measurements for at least a year before using the results to create new parameters for the formulas.

Another way of interpreting the distribution of wind speeds is the Weibull distribution screen, in which the percentages of measured data for every wind speed interval is displayed. The intervals are from 0-1, 1-2, 2-3, 3-4, 4-5, … (m/s). By selecting the start date and the finishing date various interpretation of the wind speed variation can be made. By selecting as start date the installation date of the system and as finishing date the current day the evaluation will be very accurate, because it will include the longest possible time interval. By selecting only months and comparing the differences between them a pattern can be created for the interval of a year.

The difference between the simulated and field data can be seen in figure 4 and 5. The currently used algorithms for wind speed estimations are clearly not very good. A decision to construct a wind farm in the location made based only on the data available before the field data gathering would have been a very costly mistake, because the dimensioning of the components would have been wrong. A decision regarding a location cannot be currently taken without making field data gathering. This fact can change if better formulas can be made available. As for wind speed average the difference is also quite substantial, because of the limitations of the estimation algorithms.

A new way to easily understand and interpret data is by using charts made in a very easy way to understand, like figure 6 and 7. In figure 6 by using accumulating values for the energies (consumed, produced, green) the most important parameters of the system can be easily interpreted and the performance of the system can also be evaluated. The battery voltage and current are similarly portrayed in figure 7. This new visual way to represent the most important values of a system are innovative because the behavior of the hybrid system in one moment in time can be understood only by looking at this graphs.

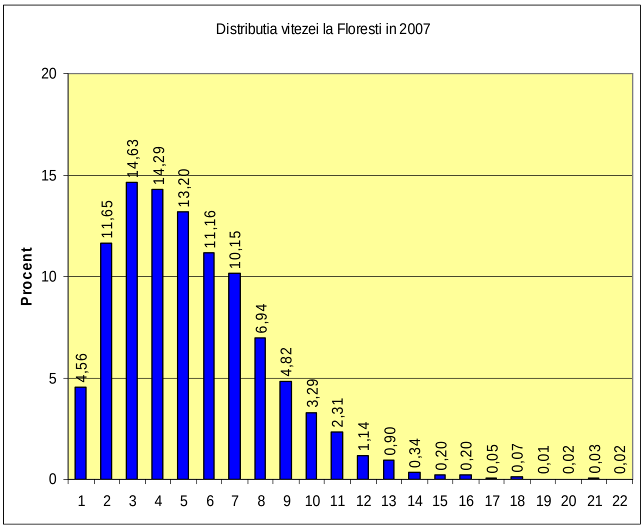

Fig. 4. Wind distribution calculated for an area of 5x5 km

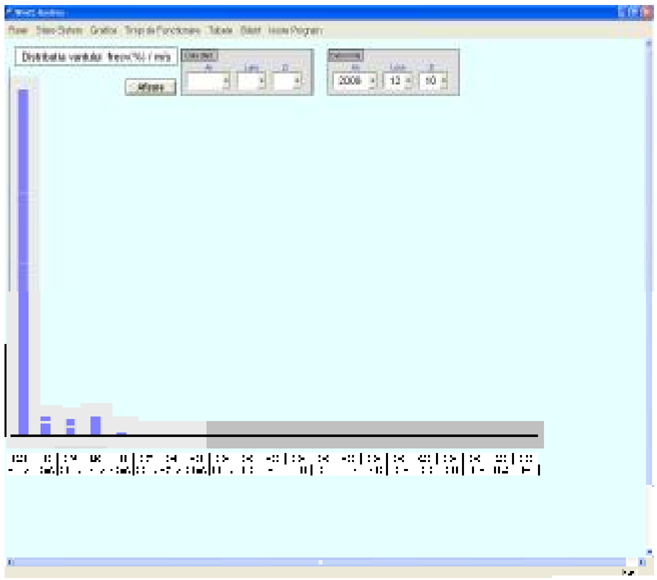

Fig. 5. Wind distribution according to field data

To achieve a high performance of the hybrid system it‘s very important to dimension correctly the system components.

The first step for this task is to establish the load needed in that location. After this the system components can be chosen accordingly. The Homer and RetScreen simulators do a good job in this purpose, but field data also shows some discrepancies.

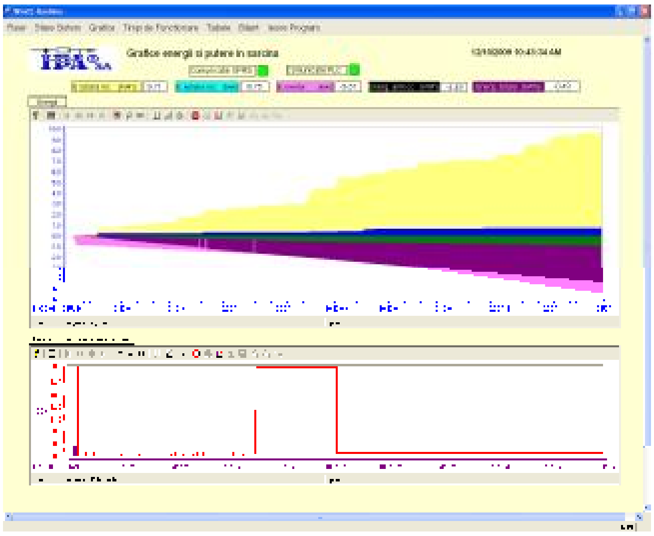

Fig. 6. Chart representing the active power

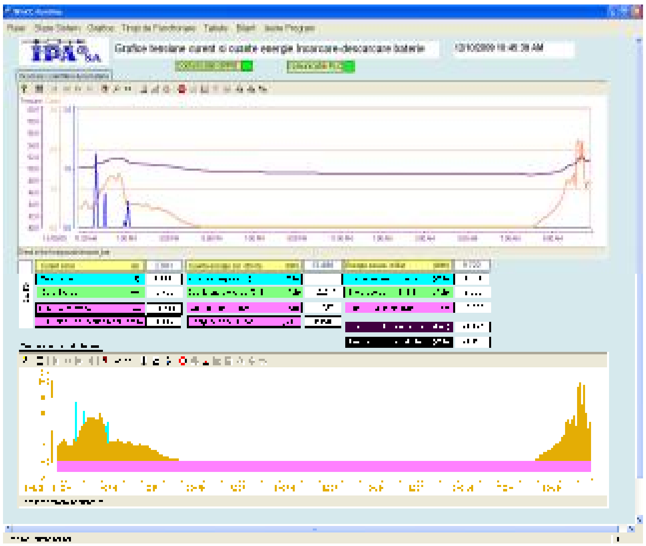

Fig. 7. Chart representing battery voltage and current

3. DIMENSIONING THE SYSTEM

At this time it seems that the efficiency considered by Homer for the solar panels is double compared to the field data. This can be caused by the fact that the simulators don't consider the loss of performance of the solar panels in real life temperature, and give estimations only in optimal situations. Also the wind speed estimated for the location is based on the data given for an area of 5X5 km without the possibility of applying a correct algorithm to take into account the different features of the location. Thus the values given can be used only as very rough estimations of the wind energy potential in that area. To make a better estimation of the difference between estimations and the field data, a time of at least one year is necessary for data gathering.

After this goal is achieved, and the database is completed with values for at least one year, the future step will be to create a new algorithm that takes into account the field data values and the dimensioning issues studied in this paper.

4. EXPORTING THE DATABASE

A very important part in the application is the export module (figure 8), which allows different tags to be exported as csv (comma separated values) files. The csv files can be easily imported in other programs like, Excel, MatLab, where other data processing can be applied. This feature is important because the main goal of the project was the creation of a database that contains the most important parameters of the hybrid system. The ability to export the database and to use the data available in other applications greatly increases the flexibility and the portability of the project.

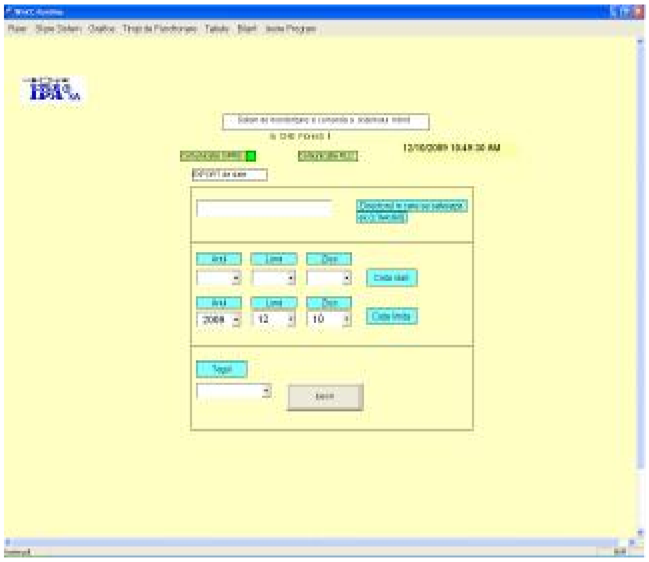

Fig. 8. Panel displaying the export options

The system proposed for this project is a very flexible system, with the possibility of adding more RTUs to gather data from different locations and has proved to be a good tool for gathering of data needed to create a better algorithm for wind speed estimation in a location.

5. CONCLUSIONS

Analyzing the values gathered in the database we have come to these conclusions:

- based on data gathered from about half a year, the conclusion is that the field data and the values given by programs like Homer and RetScreen differ quite substantially.
- studying the charts that describe the evolution in time of the battery voltage, the wind speed and wind power we came to the conclusion that in some situations even if the wind speed was different the loading current was the same. For example if the voltage is close to the maximum allowed of 52V and the wind speed is close to 5 m/s the loading current is equal to the situation where the battery is close to the minimum of 46V and the wind speed is at 2 m/s. This situation can be explained only by the fact that the controller's performance wasn't very good.

- another important observation is that the performance of an hybrid system in an isolated location is greatly influenced by the initial dimensioning of the system. In our case the performance would've been much better if the inverter would've been much smaller than 4kW. By being so large compared to the rest of the systems components (1,5 kW wind turbine and 0,5kW solar panels) it turned into a consumer of energy.
- better formulas and algorithms are needed to insure a correct estimation of wind power in a locatio;

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