CONTROL AND MONITORING OF INTEGRATED RENEWABLE SOURCES ENERGY STORAGE IN SMART GRID

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Abstract: In this paper is reflected the approach of the monitoring and control problem of the Smart Grid network, within which the energy storage is obtained from renewable resources: solar panels, wind turbines, etc. The smart grid is envisioned as a large-scale complex system that can improve the efficiency and robustness of power and energy grids. One side is forecasting API, that has been tested based on collected data from real Smart Grids mounted in Republic of Moldova. The aim is to determine if the Forecasting API can be used for such purposes and what are the best usage conditions.

Keywords: integrated renewable sources, smart grid, advanced techniques of monitoring.

1. INTRODUCTION

Two dominant technical challenges can be identified with a higher penetration of Renewable Energy generation: managing variability and uncertainty during the continuous balancing of the system, and balancing supply and demand during generation scarcity and surplus situations.

The grid infrastructure is still evolving in developing countries. The existing grid network is inadequate to accommodate the upcoming needs of clean energy and distributed generation, which may throw several challenges in design, erection, operation and maintenance. Besides focusing on Smart Grids, there is also a need to address issues of existing grid infrastructure. Usually, the several electrical parts are unevenly connected to national grid in order to optimally evacuate large wind farms or solar parks which otherwise demand for installation of entire infrastructure.

Smart Grids incorporate renewables for bulk power, as well as distributed power generation. As the power generation from renewables is not uniform i.e., intermittent and variable, they may demand storage. Battery, the most common storage device, has very short life span of 4–5 years. Other storage technologies like flywheels, thermal storage, hydrogen storage, etc. have their respective varying concerns. Pumped storage technique, which is in some regions of US, China, Japan, India and Norway, have efficiencies in the range of 70–85% [3, 4]. The problem with pumped storage techniques is that, it requires large areas as reservoirs, which are normally available in mountain side only. Research on its hybrid system with offshore wind is underway. In few regions of Germany storing compressed air in underground storage is in practice too, which can be used for electricity generation when needed. Although efficient, the complexities of storage facility become a hurdle for this technology. Flywheel is capable in absorbing energy in few seconds and delivering back quickly. Researchers found that Flywheels are very useful for supporting grid frequency for few seconds, but they are not stable for longer duration. The most common technique for electricity storage is batteries and, among them, lead-acid batteries are the most popular. Portability is their advantage, but low energy density, weight and size are the concerns for innovators to research. Further, risk of shortage of raw material for batteries is also a serious issue. Research on increasing efficiency and reducing cost of storage technologies is going on, but still battery storage technologies are expensive. Advanced Lead Acid Batteries, Flow Batteries and Lithium Ion Batteries are the options being tried in Smart Grids project for large scale storage purpose [1-2].

2. TESTING OF DATA FORECAST API

The operation of a Smart Grids depends essentially on the data collected from diverse sensors (temperature, current, voltage, generated power, etc.) in order to optimize the Smart Grids efficiency and lifetime. The control and monitoring of Smart Grids operating regimes assures better results, if speaking in terms of system costs and income.

As an objective of the project, it has been proposed to store and monitor all the data that is coming from different sensors of the Smart Grids to assure better system functionality and to determine the optimal operating regimes for higher power generation.

Forecasting the power produced by a Smart Grids would give the possibility to understand how new operating regimes would affect the Smart Grids production and also, estimate the future system costs, income and profit.

The selected forecasting API has been tested based on collected data from real Smart Grids mounted in Republic of Moldova. The aim was to determine if the Forecasting API can be used for such purposes and what are the best usage conditions. Below are presented several cases of statistical and forecasted data for different agents, time period and hours.

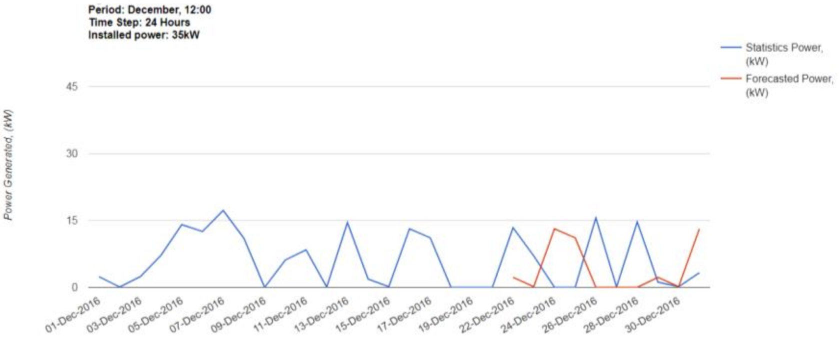

Fig. 1. Produced and Forecasted power for 10 days period. (Processed statistical period – 20 previous days. Forecasted period – 10 days).

In figure 1 it is represented the forecasted power for 10 days period. 20 previous days had been selected as the processed statistical data period (payload). It is evident form the figure that the forecasted data has a big discrepancy with the real statistical data.

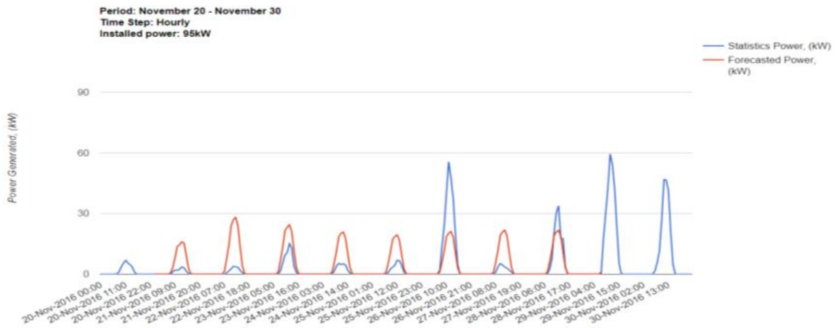

Fig. 2. Produced and Forecasted power for 10 days period (Processed statistical period – 20 previous days. Forecasted period – 10 days).

In figure 2 it is represented the forecasted power for 10 days period. 20 previous days had been selected as the processed statistical data period (payload). The forecasted data repeats the shape of the statistical data, which is a good aspect, but still shows big difference from the statistical data.

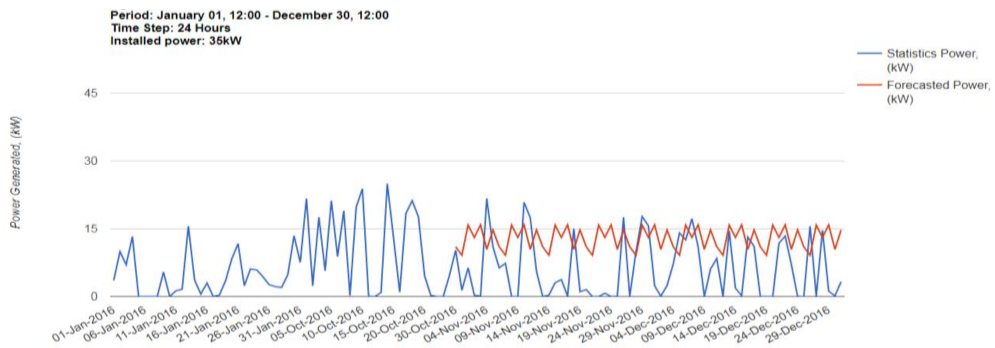

Fig. 3. Produced and Forecasted power for 2 months period (Processed statistical period – 10 previous months. Forecasted period – 2 months).

In figure 3 it is represented the forecasted power for 2 months period. The 10 previous months had been selected as the processed statistical data period (payload). It is evident form the figure, that the forecasted data values are around the real statistical data, which is a good aspect, but still shows big difference from the statistical data.

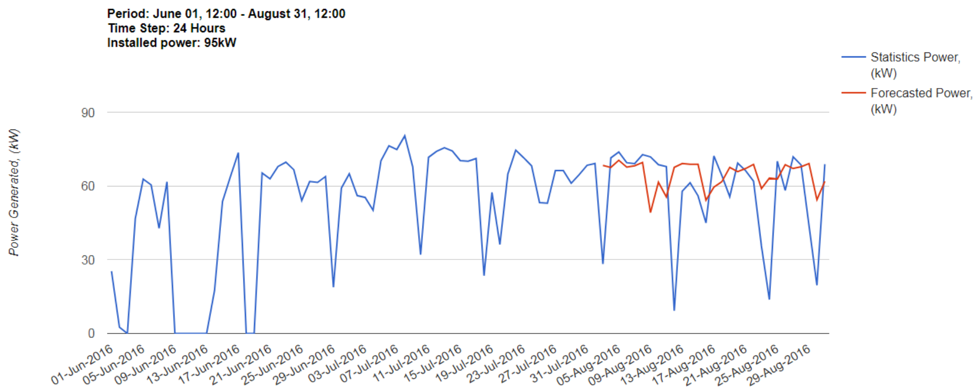

Fig. 4. Produced and Forecasted power for 1 months period (Summer). Processed statistical period – 2 previous months. Forecasted period – 1 months.

In figure 4 it is represented the forecasted power for 1 month period. 2 previous months had been selected as the processed statistical data period (payload). The forecasted data values are repeating the real statistical data and the forecasted power values are very appropriate to the statistical ones. There are still some data points that differ considerably by value from the statistical ones, which we suppose is caused by the weather conditions at that time.

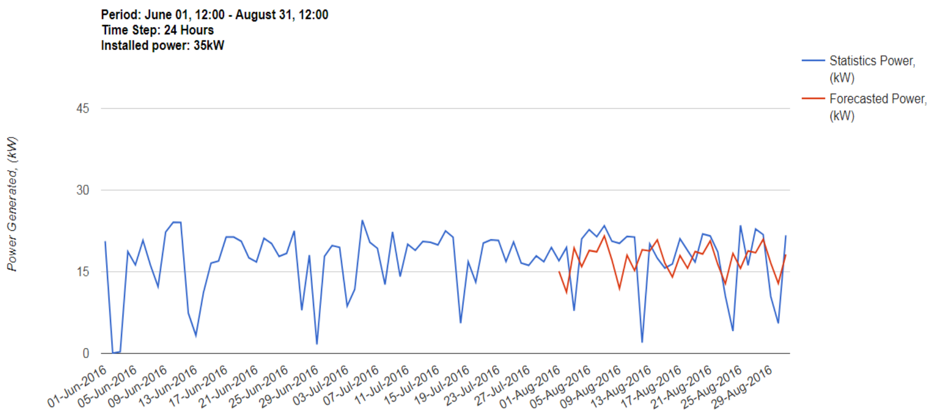

Fig. 5. Produced and Forecasted power for 1 months period (Summer). Processed statistical period – 2 previous months. Forecasted period – 1 month.

In figure 5 it is represented the forecasted power for 1 month period. 2 previous months had been selected as the processed statistical data period (payload). It is evident form the figure, that the forecasted data values are repeating the real statistical data and the forecasted power values are very appropriate to the statistical ones. More than that, the forecasted shape repeats the statistical shape for some data points. There are still some data points that differ considerably by value from the statistical ones, which can be caused by the weather conditions at the time when measurements had been made.

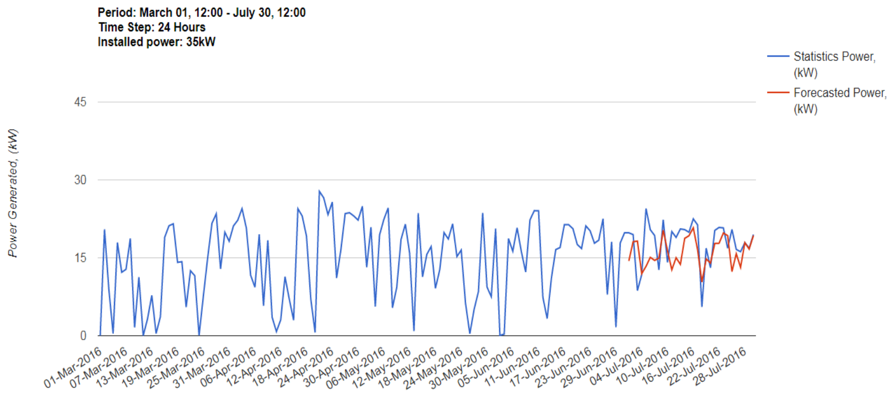

Fig. 6. Produced and Forecasted power for 1 month period (Summer). Processed statistical period – 4 previous months. Forecasted period – 1 month.

In figure 6 it is represented the forecasted power for 1 month period. 4 previous months had been selected as the processed statistical data period (payload). The forecasted data values are repeating the real statistical data and the forecasted power values are very appropriate to the statistical ones. More than that, the forecasted shape repeats the statistical shape for some data points. We consider that the forecasted result in this case is very satisfactory.

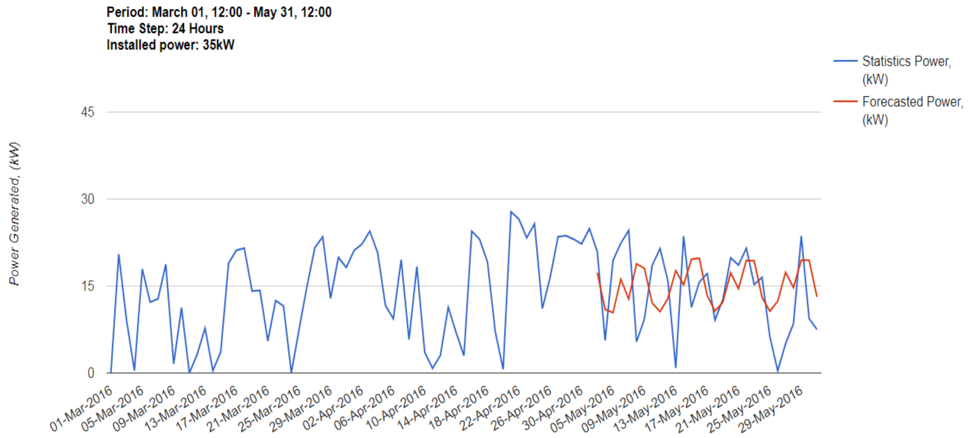

Fig. 7. Produced and Forecasted power for 1 month period (Summer). Processed statistical period – 4 previous months. Forecasted period – 1 month.

In figure 7 it is represented the forecasted power for 1 month period. 2 previous months had been selected as the processed statistical data period (payload). The forecasted data values are repeating the real statistical data and the forecasted power values are very appropriate to the statistical ones. There are still some data points that differ considerably by value from the statistical ones, which we suppose is caused by the weather at that time.

4. CONCLUSIONS

The Forecasting API results are very satisfactory for cases when the processed statistical data (payload) period is not very long. This period should not exceed 2-3 months. The usage of seasonal payload (summer, winter) gives very appropriate results to the statistical ones (fig. 4 - 7). Long or short processed statistical data periods (fig. 1-3) give worse results and the forecasting process is very time consuming. We consider that these results are conditioned by different weather conditions during the year. Another good aspect of the Forecasting API is that it determines and repeats well the periodicity of produced power (fig. 2). We consider that the tested Forecasting API can be used for forecasting purposes in our project and also Smart Grids industry.

The forecast of the amount of electricity to be produced is very important for both the producer and the distribution and system operators. According to the legal provisions of the Republic of Moldova, the electricity produced from renewable sources is to be sold in the primary market, which implies other technical requirements for the precision of the forecast.

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