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## Topic 5: PV Systems and Storage – Modelling, Design, Operation and Performance

### Subtopic 3: Operation, Performance and Maintenance of PV Systems

#### *Using analogs ensembles and genetic algorithm to handle uncertainty in a microgrid*

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#### Abstract

**In this work, a novel approach to deal with the PV forecast uncertainty during the energy management of a microgrid is presented. A novel adaptation of an analogs ensembles method allows to obtain a Sharpness indicator that is correlated with the PV forecast uncertainty. This indicator can be used to dynamically restrict the usable battery capacity when doing the day-ahead optimal scheduling using a genetic algorithm. This permits to deal with the PV uncertainty internally within the microgrid. This gives a total certainty to the grid operator about the power needs of the microgrid one day in advance. In this way, in a big scale, the uncertainty caused by a higher penetration of renewable energy sources in the national grid could be highly reduced. The main results of a real study-case are presented and the limitations of the method for its implementation are also discussed.**

**Keywords:** uncertainty, analogs ensemble, microgrids, energy management system, genetic algorithm, battery management.

**Remarks:** We chose subtopic 3 as the study touches the operation and **energy management** of a microgrid with **storage**.

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## Aim of the work

In this paper, a novel approach to take into account uncertainty of deterministic forecasts of photovoltaic production into the energy management system of a microgrid is presented. The idea is to be able to perform a day-ahead planning of the microgrid (MG) energy requirements from the grid, and being able to follow the forecast power profile despite of the forecasting errors. By doing this internal management of the uncertainty, the grid operators are not affected by the renewable (solar) uncertainty, which would allow a higher penetration of renewables into the national grid.

## Approach

The estimation of uncertainty has been obtained using the analogs ensemble method, via the Sharpness indicator. Simulations are performed over real data of production and consumption of a tertiary building. Day-ahead is selected as the planning-and-scheduling time horizon due to its pertinence in current energy markets. Deterministic forecasts of solar irradiance from MeteoFrance are used as the base for the uncertainty estimation. The estimation of the uncertainty of the deterministic forecasts is performed using an adaptation of the analogs ensembles method. This method is selected due to its versatility as a data post-processing method [1]. The scheduling of the battery is performed using a genetic algorithm. The cost function for the optimization includes the cost of the energy bought to the grid, and the battery usage. The aging of the battery is taken into account using a model that accounts for the depth-of-discharge and the average state-of-charge of every cycle of charge-discharge of the battery. The rainfall count algorithm [2] is used to identify the charging cycles in the battery profile.

The solar irradiance forecasts used are for the site of Ecole Polytechnique (Palaiseau, France) and are provided from ARPEGE NWP model from MeteoFrance, while ground measurements are obtained from the SIRTA atmospheric observatory [3] (<http://ipsl.sirta.fr>) for the years 2016 to 2018.

## Scientific Innovation and Relevance

Situations as the one presented in Fig.1 can be avoided by dynamically assigning a battery usable capacity to the EMS every time the day-ahead scheduling is performed. In this manner, the grid operator can have total certainty of the power requirements from the MG, as the uncertainty is managed internally with the available storage capacity.

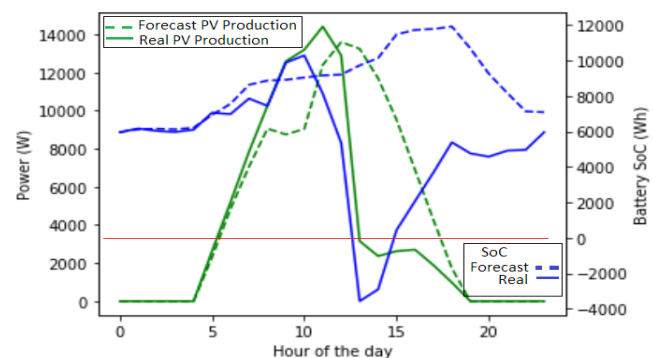


Figure 1. Violations to SoC profile due to forecasting errors

Preliminary results show effectively a reduction in the deviation between forecasted and real grid power profiles when the dynamic sizing is performed.

## Preliminary Results

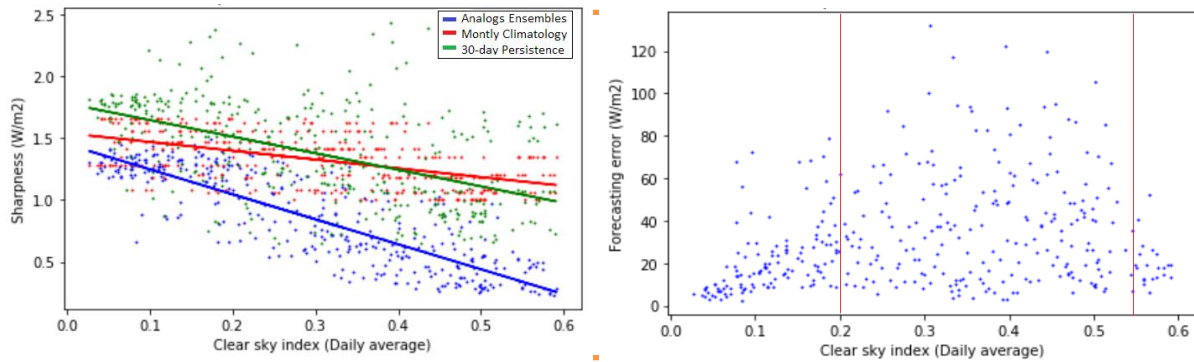


Figure 2. (a) Correlation between Sharpness and CSI (b) Correlation between CSI and Forecast Error

An important contribution of this work is the adaptation of the analogs ensembles method to obtain a deterministic indicator of the uncertainty of a (deterministic) solar-irradiance forecast. This indicator is called Sharpness. As seen in Fig. 2(a) the Sharpness is able to differentiate between days with different values of clear sky index (CSI) in a better way than reference methods such as Monthly Climatology or a 30-day Persistence. Since CSI and forecasting errors are correlated (as seen in Fig. 2(b)), the Sharpness can give us an idea of the uncertainty of a given forecast, and due to its deterministic nature, can easily be implemented in an energy management system.

## Conclusions

The sharpness parameter obtained from the adapted analogs ensembles method, appears to have a good correlation with the uncertainty of the deterministic forecasts used in this study. This deterministic parameter, allows to have, in advance, an estimation of how accurate a deterministic solar irradiance forecast is; which is a useful tool that can be included in an energy management system.

The method of restricting the usable battery capacity appears promising in order to deal with PV production uncertainty. Preliminary estimations show that this technique allows to deal with forecasting errors internally within the microgrid, avoiding to hand them over the grid.

Besides, genetic algorithm shows to be an interesting option to do almost-optimal battery scheduling while dealing with its non-linear aging cost.

## Ongoing Work

The incorporation of the rainfall count algorithm to estimate the Dod and average SoC of the battery is being developed. After this is done, the average aging of the battery can be included in the computation of its cost. The test over a period of one year with real data of solar production and consumption are also being performed.

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