LABORATOIRE D'ELECTROTECHNIQUE ET D'ELECTRONIQUE DE PUISSANCE DE LILLE

Master Thesis Project, 2025-2026

— Hybrid Forecasting Model for PV Production with Limited Historical Data —

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L2EP – JUNIA

Funding: RACCOR-D

Context

As part of the RACCOR-D project, a photovoltaic (PV) system combined with stationary energy storage is connected to a 1500 V DC power substation. The energy management strategy of the storage, developed within the framework of an ongoing PhD thesis at L2EP, operates on two levels:

- **Day-ahead predictive management (D-1):** This involves generating a 24-hour charging/discharging profile based on forecasts of local PV production and substation consumption.
- **Real-time control:** This level adjusts the day-ahead storage setpoints based on real-time measurements and predefined constraints. A fuzzy logic controller is used for this purpose.

The forecasts required for day-ahead management are generated using AI models trained on historical datasets. For new installations, historical data is not available, making it difficult to use AI-based forecasting models from the outset. During the initial phase, a physical model of the PV system will be used to estimate production. Once sufficient data is collected, the system will transition to a more accurate AI-based model.

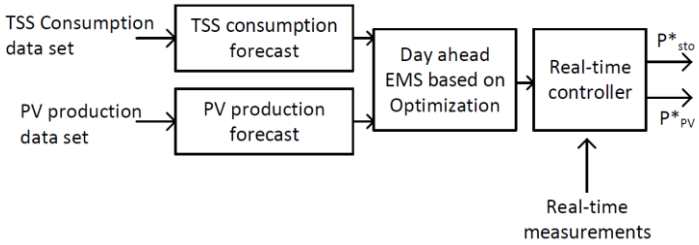

Fig 1. SCADA system diagram

Objective

This master's thesis aims to determine the optimal duration for using the physical model before transitioning to an AI-based model. It will also define the key performance indicators (KPIs)—such as prediction error, data volume, and variability—and establish threshold values that will trigger the transition. By the end of the internship, the objective is to develop a hybrid forecasting model that:

- Utilizes the physical model when no or insufficient data is available.
- Automatically switches to the AI model once enough data has been collected.

Real-world data from the Smart Grid Demonstrator at the Catholic University of Lille (UCL) will be used for model development and validation. Upon successful validation of the developed model, an industrial deployment will be carried out. With the support of our engineering team, the model will be integrated into the SCADA system.

Work steps

- Conduct a literature review on hybrid AI-physical models.
- Develop and validate a physical model for photovoltaic (PV) production based on the UCL smart grid demonstrator.
- Familiarize with the AI model used for PV production forecasting.

- Test and evaluate the performance of the existing AI model in the smart grid demonstrator as a function of data quantity
- Compare the performance of the physical and AI models.
- Define key performance indicators (KPIs) and establish rules for switching between models.
- Implement and validate the hybrid model on the UCL smart grid demonstrator.
- Transfer the developed model to an industrial setting and integrate it into the SCADA system.
- Write the final report.

Keywords

DC Railway Systems, Photovoltaic Production Forecasting, Neural Networks, Smart Grid for Railway Applications, SCADA Systems.

References

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