Assessment of power flow variability in a PV-enabled nanogrid

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INTRODUCTION

Microgrids, particularly, promote local usage of renewable energy and develop the efficiency of distributed power. Emerging power systems with high share of decentralized, volatile, random, uncontrollable and intermittent RES-based generation have lower inertia due to the static converters mediated energy transfer. In this situation, the energy transfer is affected by voltage and frequency deviation, voltage waveform distortion and three-phase voltage unbalance and other power quality problems for microgrids. Therefore, to achieve an optimal energy control, the needs is for real time information on both use- and generation power profiles. The impact of high variability of prosumers' power profiles can be anticipated from the microgrids' control, especially in off-grid operation.

FRAMEWORK

- Grid implementation:
  - **PV-enabled prosumer – as a nanogrid,** with regulatory constraints
  - **TyphoonHIL for simulation and Matlab** for variability assessments
- Framework for power flow variability assessments:
  - The coefficient of variation of **RMSE - CV(RMSE)** normalizes the of root mean squared error value using the mean estimated value.

$$CV(RMSE) = \frac{1}{\bar{y}}\sqrt{\frac{\sum_{i=1}^{N_w}(x_i - y_i)^2}{N_w}}$$

  - The coefficient of determination R^2 is a metric used to assess the predictive or evaluative capability of a linear regression model. It indicates the normalized measure of how well the model fits the data.

$$R^2 = 1 - \frac{\sum_{i=1}^{N_w}(x_i - y_i)^2}{\sum_{i=1}^{N_w}(y_i - \tilde{y}_i)^2}$$

- Objectives
  - To identify the variability in the net power flow for a PV-enabled prosumer – acting as a nanogrid with regulatory constraints.
  - Propose a procedure to categorize microgrids based on the variability in their energy transfer.

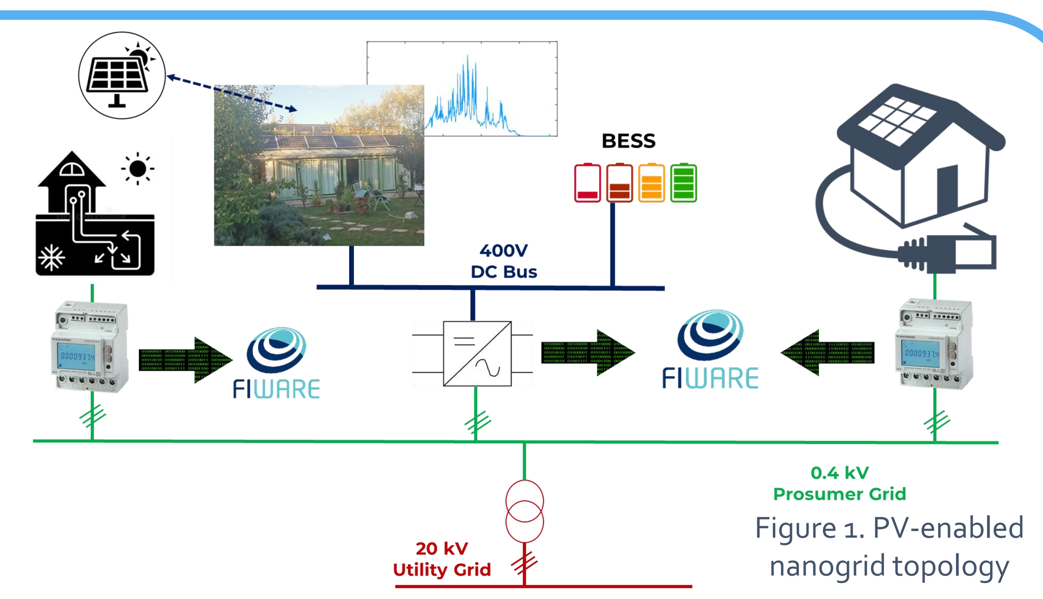


Figure 1. PV-enabled nanogrid topology

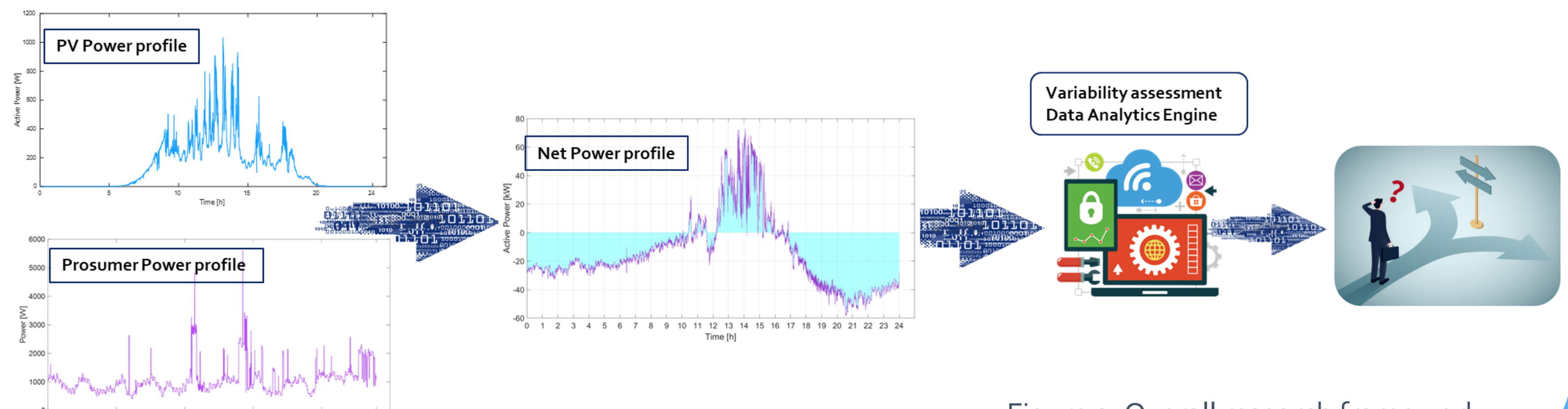
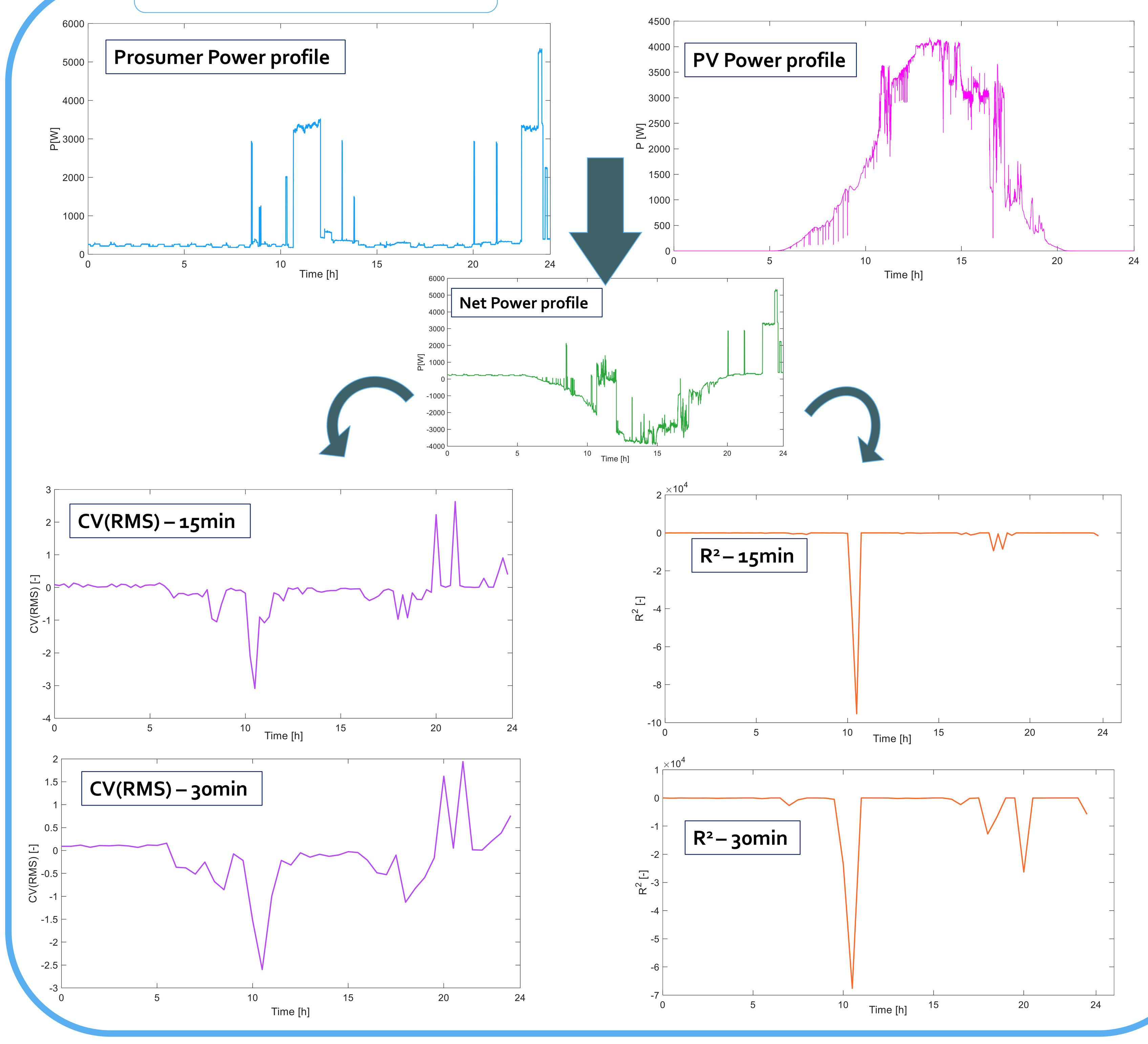


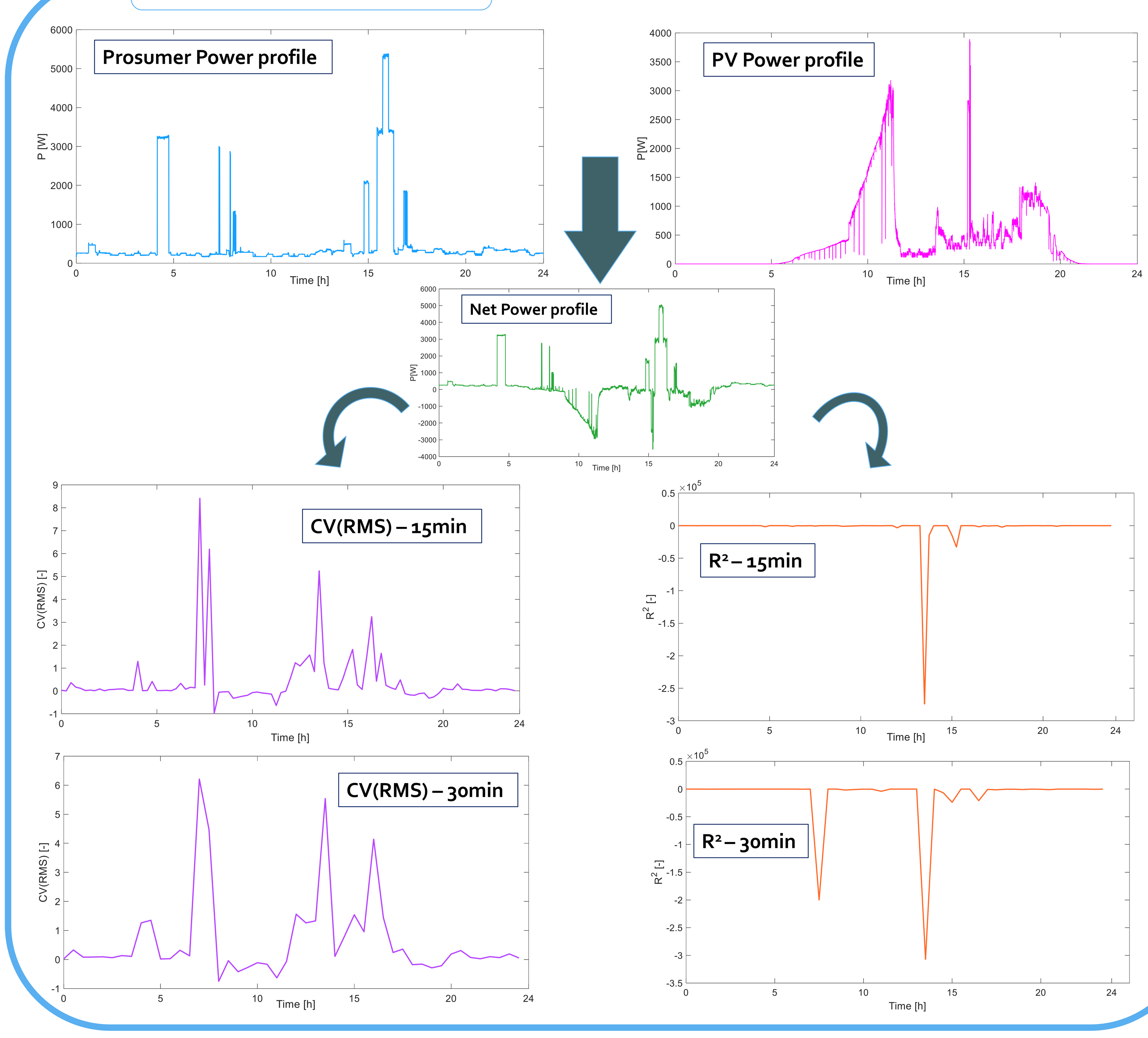
Figure 2. Overall research framework

Using net power profile to assess and categorize the variability of the energy transfer in nanogrids

Results – 05 June



Results – 09 June



HINTS FOR FUTURE WORK

- Investigate optimal sizing, placement, and control strategies for ESS within microgrids.
- Machine learning and data analytics techniques to be associated used to enhance prediction accuracy.
- Explore real-time monitoring and control solutions that can dynamically adapt to changing conditions.
- Study market mechanisms and pricing strategies within microgrids that can incentivize flexibility in power use and generation.
- Explore user-centric approaches to load management and control that align with consumer needs and habits.

Acknowledgment

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