# Installed PV capacity detection on LV substations: Comparison of Data-Driven and Model-Based methods (pub. in IJEPES)

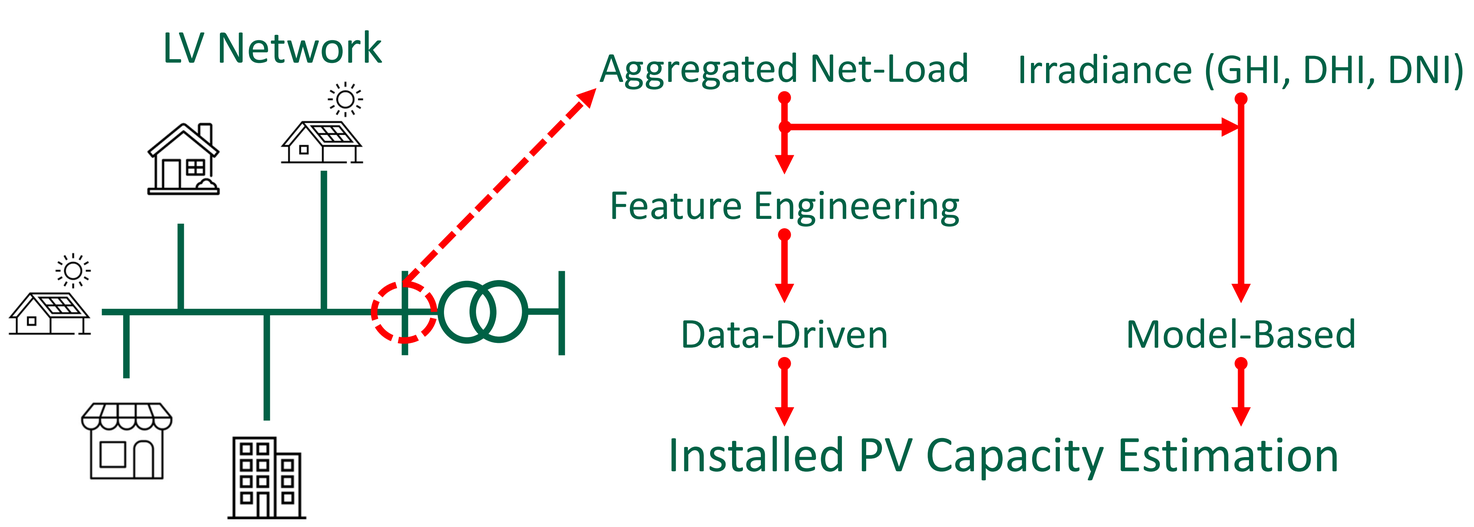
**Alexandre M. V. Gouveia**, Md Umar Hashmi, Reinhilde D'hulst, Dirk Van Hertem

This work benchmarks **Model-Based** and **Data-Driven** methods for **estimating aggregated rooftop PV capacity** at the LV substation level using data typically available to DSOs. Synthetic substations derived from real smart-meter load and irradiance data are used for evaluation. Performance is assessed through **Monte Carlo simulations**, **sensitivity analyses**, and **generalisation** tests on unseen datasets. Results show **comparable accuracy** between approaches under ideal conditions, while **Data-Driven methods demonstrate significantly higher robustness** and **achieve <5% MAPE on unseen data** under realistic assumptions.

## Problem Statement

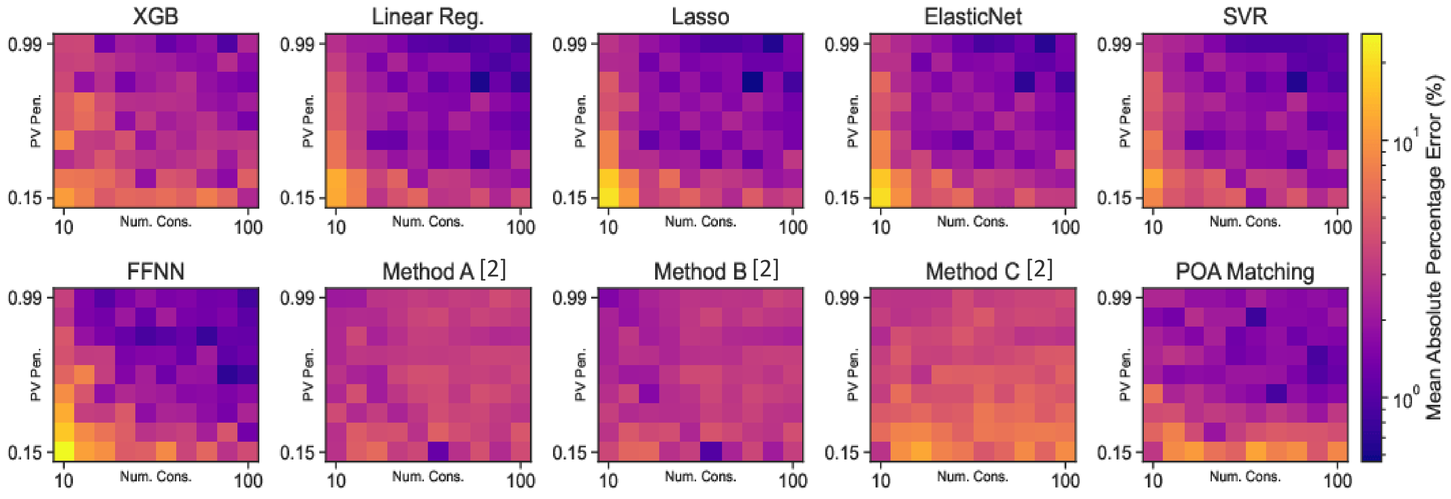
- Increasing penetration of rooftop PV
- Limited observability at LV level
- PV capacity records are error prone [1]
- Limited smart-meter data availability

**Goal:** estimate aggregated LV-substation PV capacity using net-load and imperfect irradiance measurements

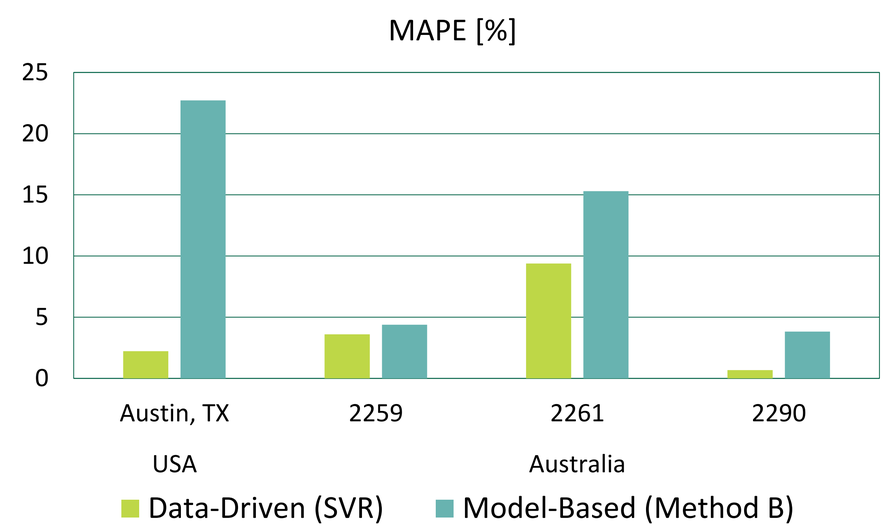



**Data-Driven PV capacity estimation matches Model-Based accuracy under ideal conditions and is far more robust under realistic data uncertainty.**
Implication for DSOs: Reliable LV PV capacity estimation is possible without high-quality irradiance or full smart-meter coverage.

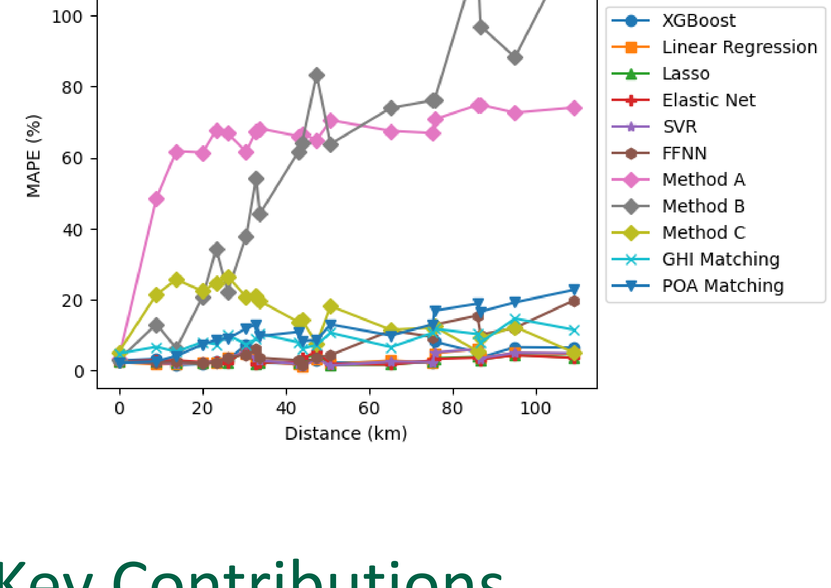
## Monte Carlo Simulations



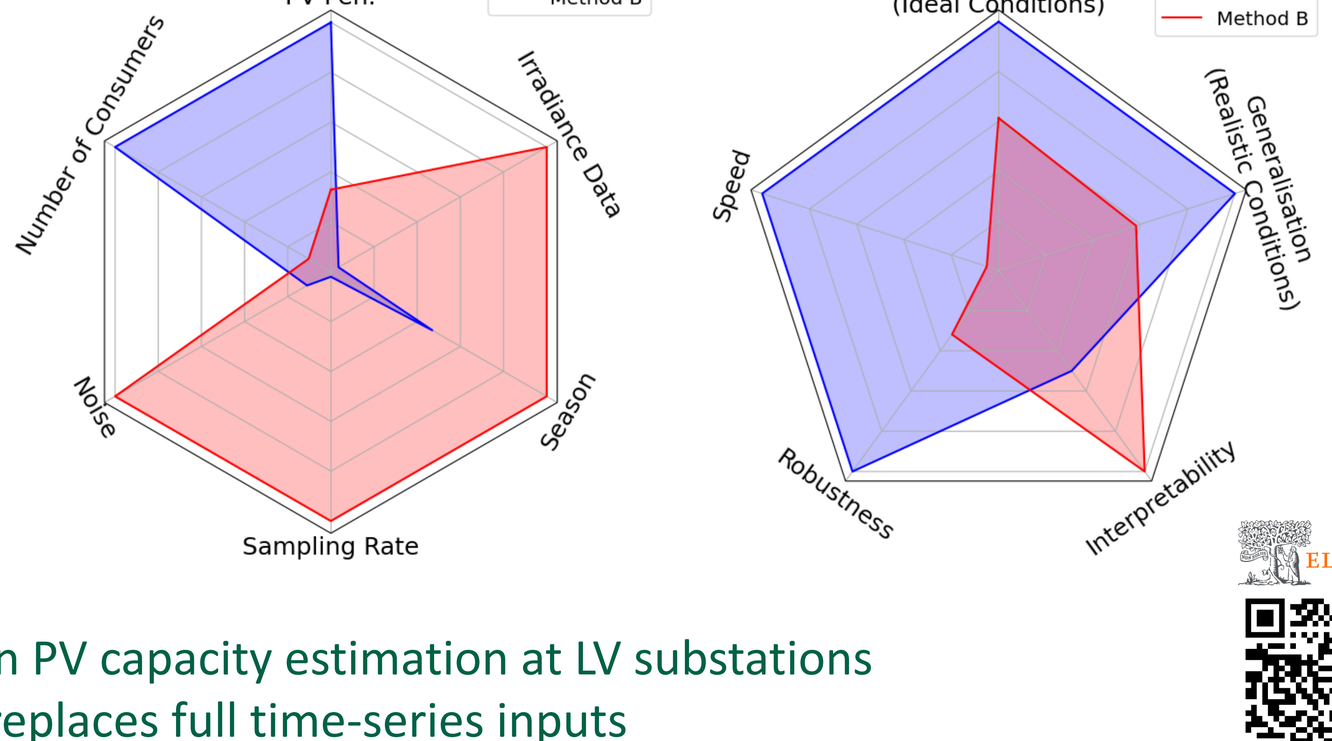

## Generalisation




## Irradiance Distance Impact




## Best of Class Comparison




## Key Contributions

- Benchmarks Model-Based vs Data-Driven PV capacity estimation at LV substations
- Relative solar-time feature engineering replaces full time-series inputs
- New linear net-load/irradiance methods added alongside state-of-the-art
- Sensitivity study: penetration, aggregation, noise, sampling, season, irradiance
- Trained on Belgian data; **generalises to USA and Australia with <5% MAPE** via regularisation

[1] Validation of Photovoltaic (PV) Connection Assessment Tool: Closedown Report, Technical Report, UK Power Networks, 2015.
[2] F. Sossan, L. Nespoli, V. Medici, M. Paolone, Unsupervised disaggregation of photovoltaic production from composite powerflow measurements of heterogeneous prosumers, IEEE Transactions on Industrial Informatics 14 (2018) 3904–3913.