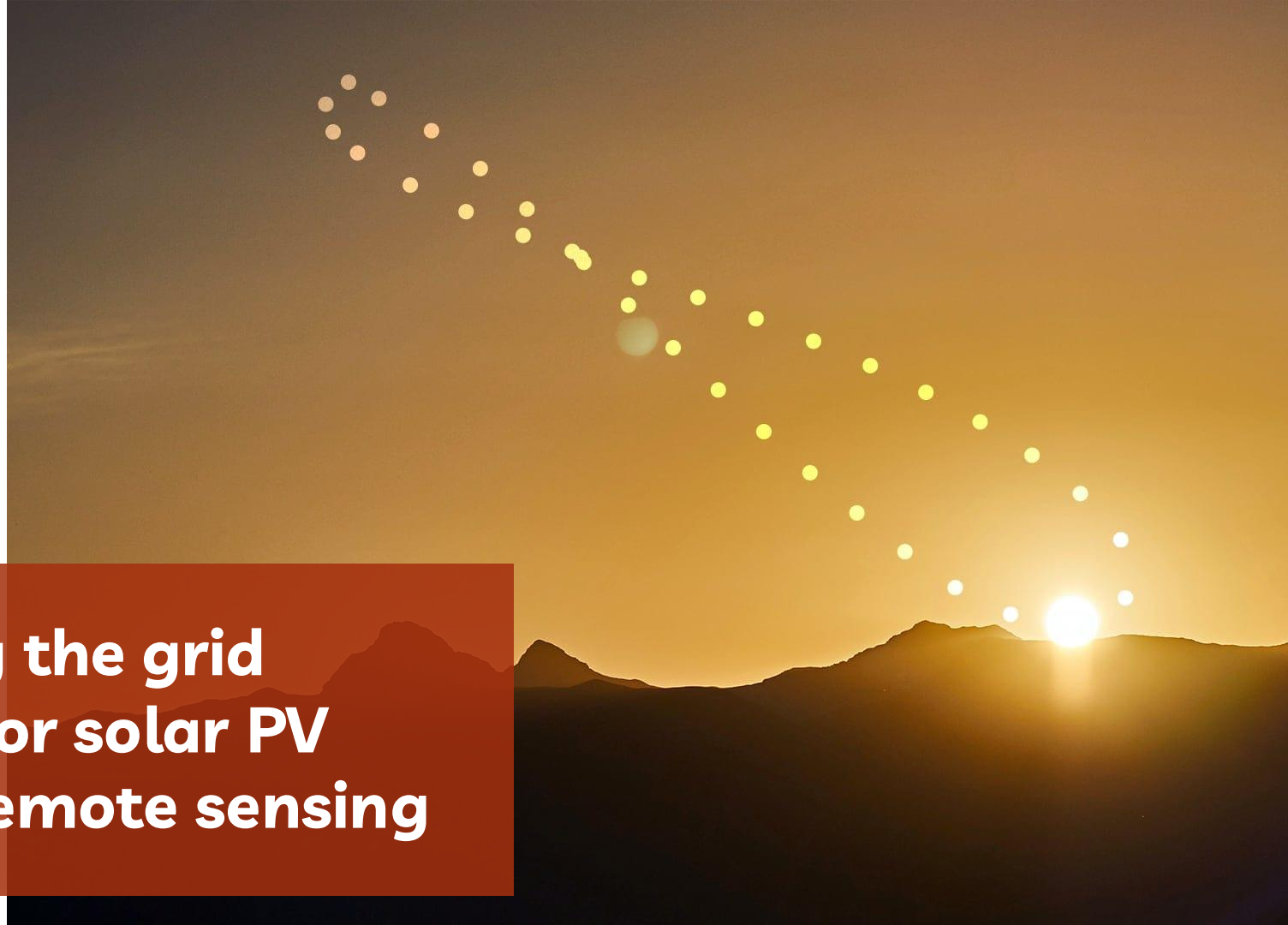
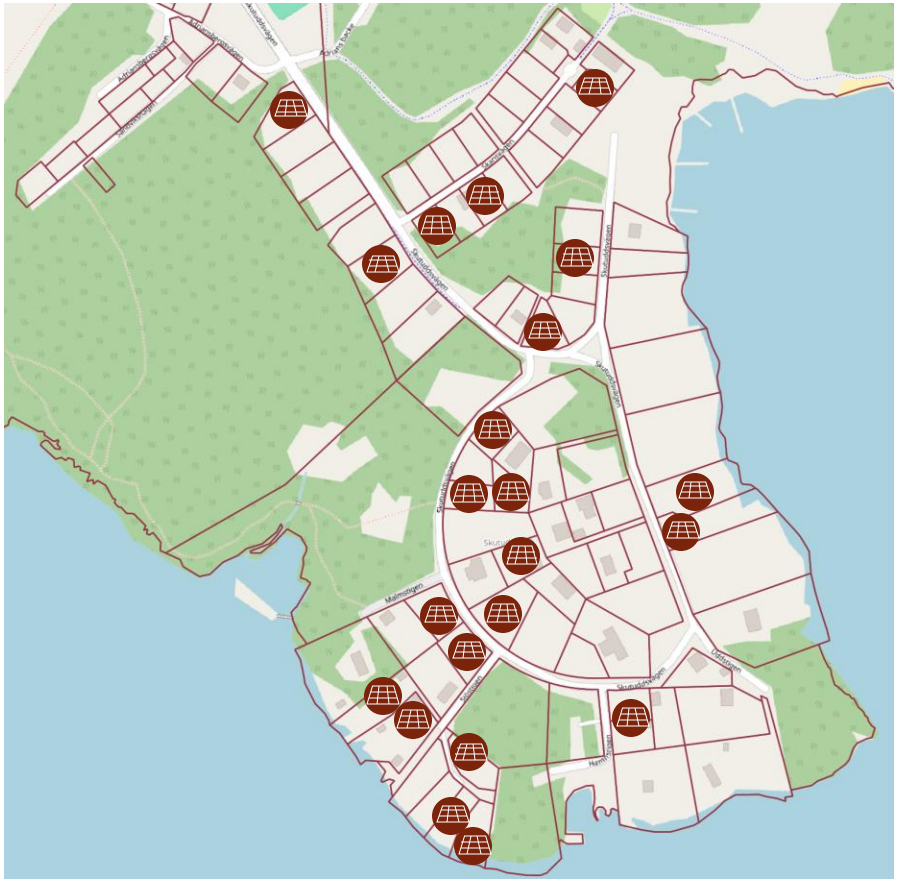


Increasing the grid capacity for solar PV through remote sensing

Background: The grid operator information gap



The grid operator generally collects the following information about each PV installation through the pre-notification and final registration processes:

- The connection point (real property designation)
- The DC capacity of the modules
- The AC capacity of the inverter

What they know since before:

- Cable dimensions and length

What they need to fulfil:

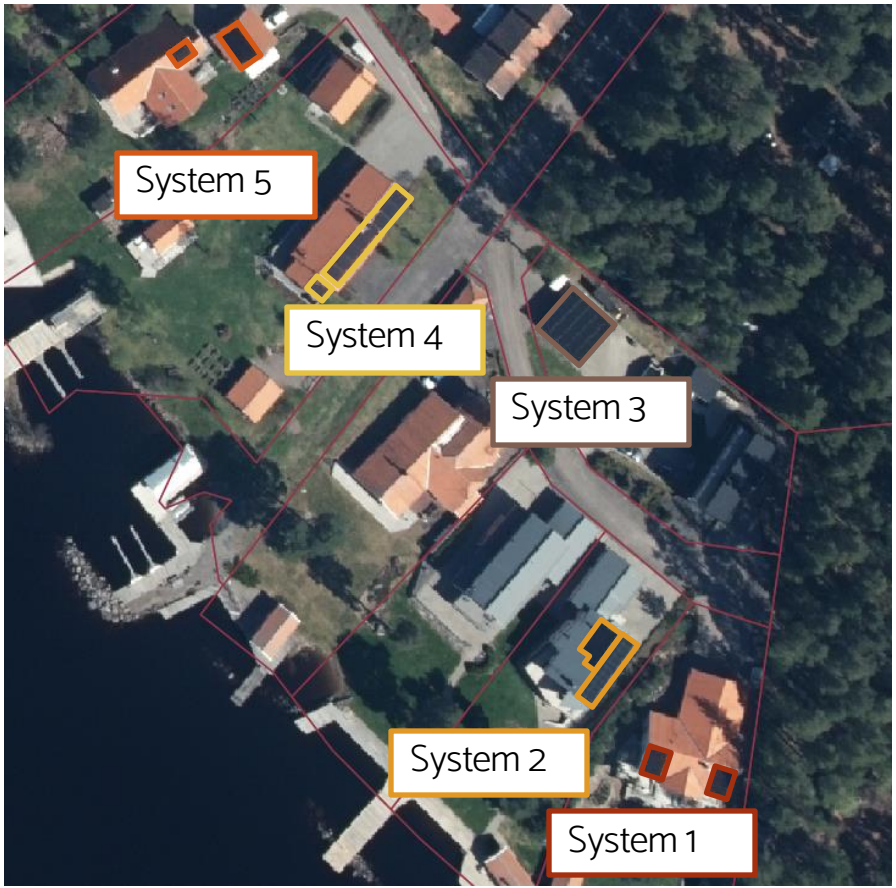
- Keep the voltage and frequency variations within ±10%

What they lack:

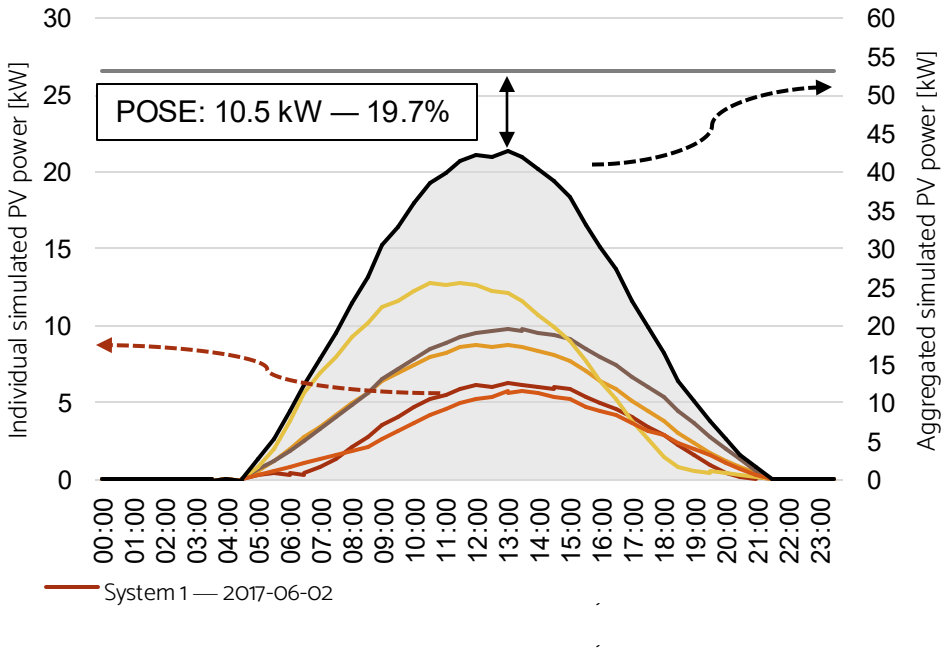
- The orientation PV systems

What they do:
Make a worst-case scenario assumption which is that all systems can produce at their maximum capacity at any given time.

The PV orientation smoothing effect — “POSE”



The five systems have a combined installed AC capacity of 53.2 kW. Simulations of all half-hours between 2017-05-01 and 2025-08-10 (145 102 points) revealed an aggregated maximum peak of 42.7 kW.



J. Lindahl, et al. (2025), *Assessing the economic value for grid operators of quantified smoothing effects from PV systems with varying orientations*

The Alfrödull remote sensing steps

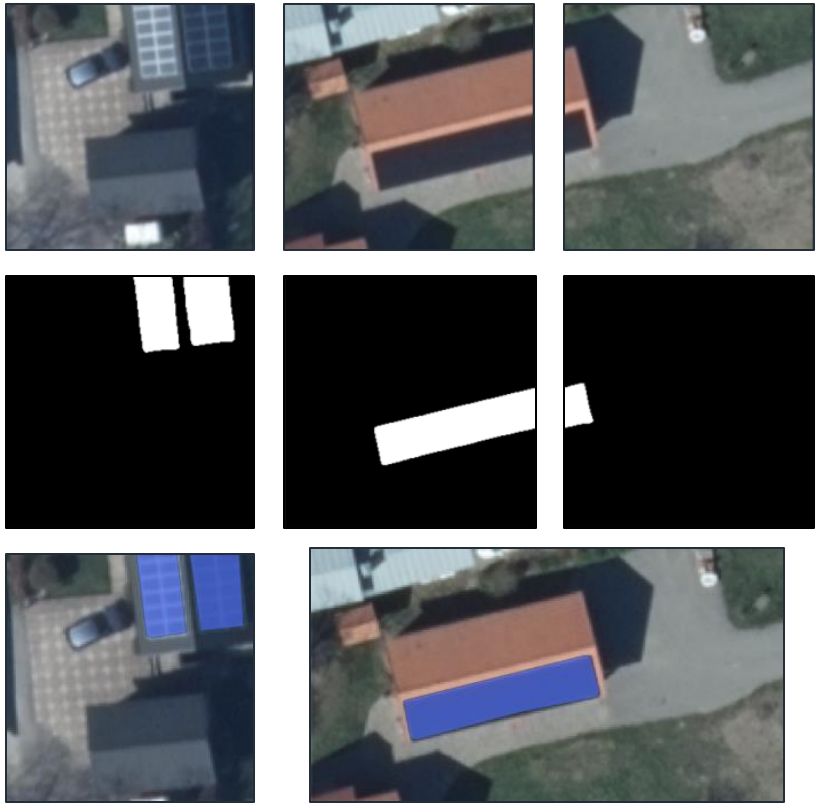
Aerial orthophotos taken every second year

Current accuracy: >95% of all systems identified, F1-score of 0.89



A U-net segmentation machine learning algorithm

Current accuracy: A Mean Intersection over Union (mIoU) of 0.94



Â Erdahl et al. (2023). *Mapping of rooftop solar systems in aerial images using deep learning.*

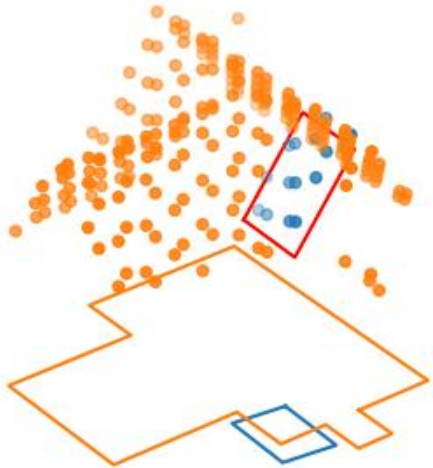
A. Erdahl et al. (2023). *Mapping of rooftop solar systems in aerial images using deep learning.*

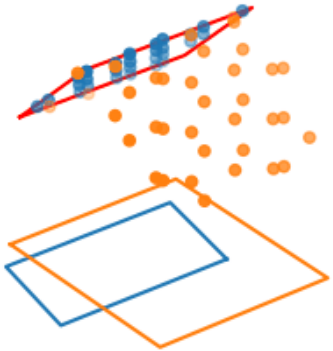
The Alfrödull orientation calculations

Light Detection and Ranging (LiDAR) data is downloaded and processed through geometrical calculations

Current accuracy: >95% of PV systems get the right orientation





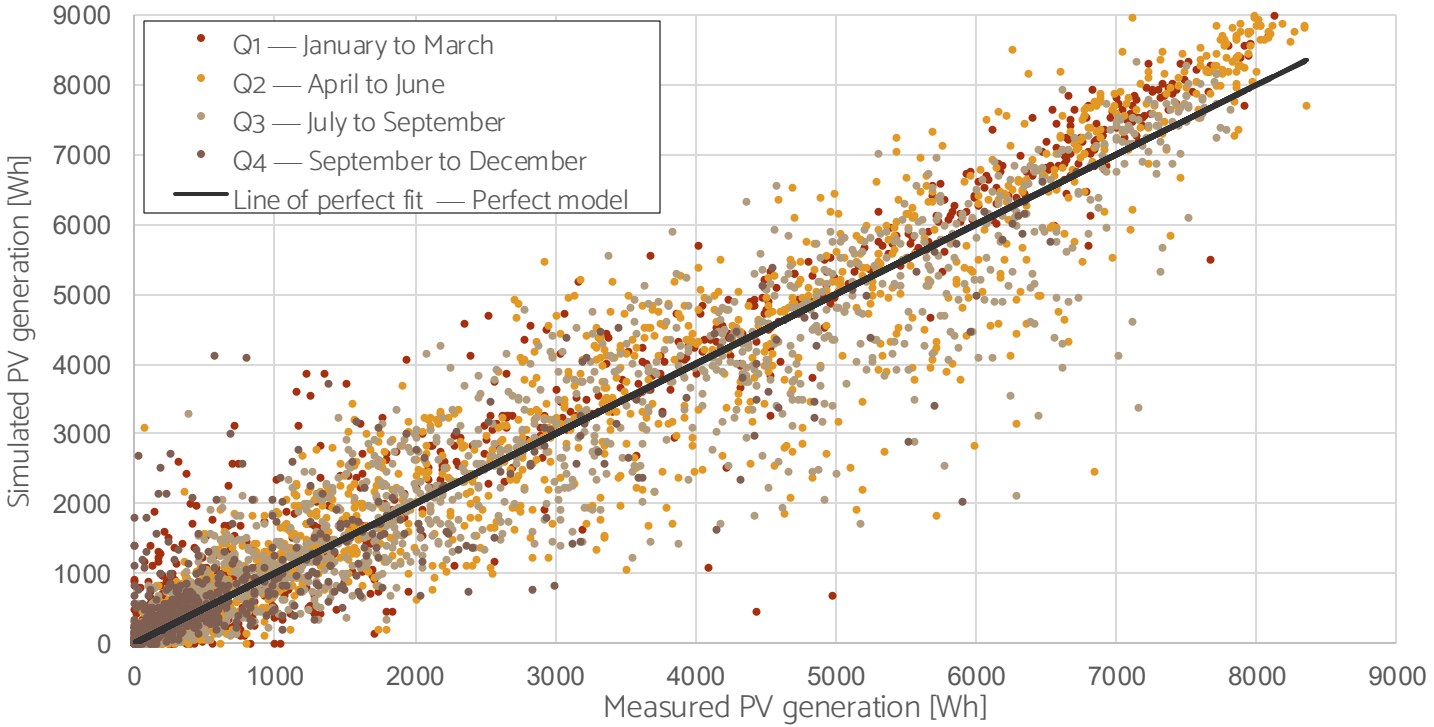


D. Lingfors, et al. (2025), *Deriving the orientation of existing solar energy systems from LiDAR data at scale*

The Alfrödull PV power simulations

A physical PV power simulation model

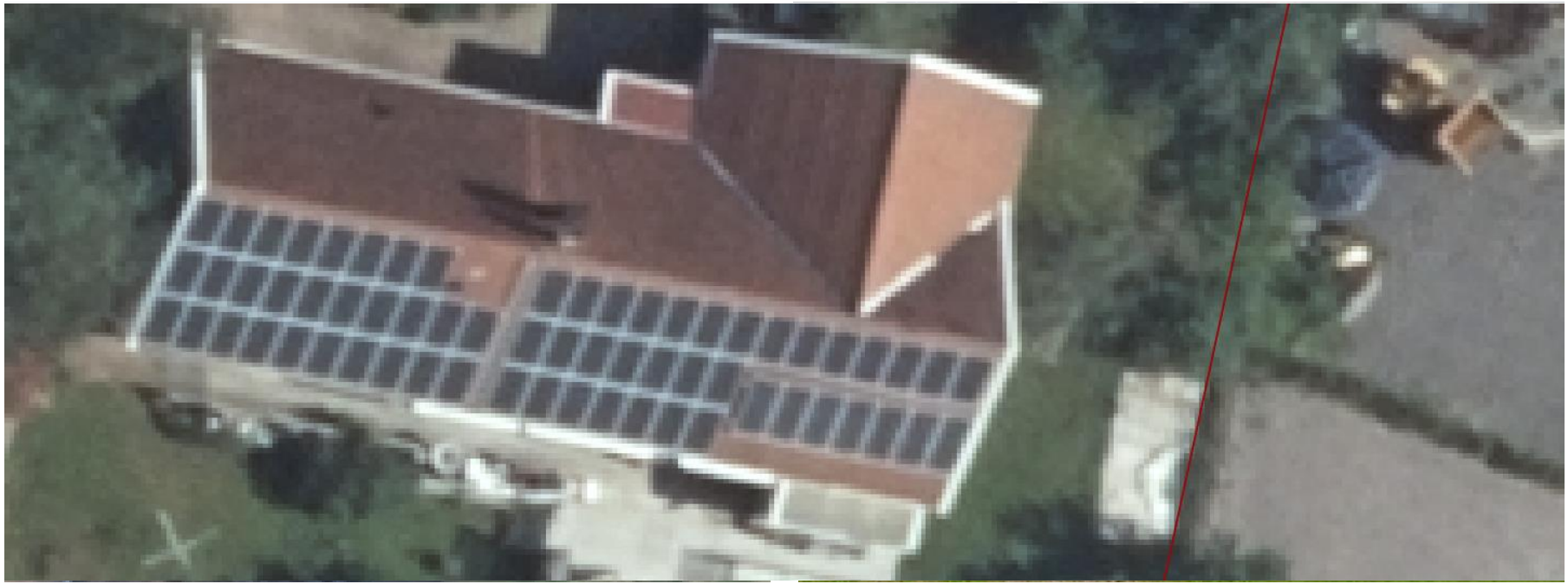
Current accuracy: A coefficient of determination (R^2) value of 0.83–0.96 for 40 reference systems



G. Öhgren, et.al. (2025), *Remote sensing compatible snow loss modelling for PV power simulations*

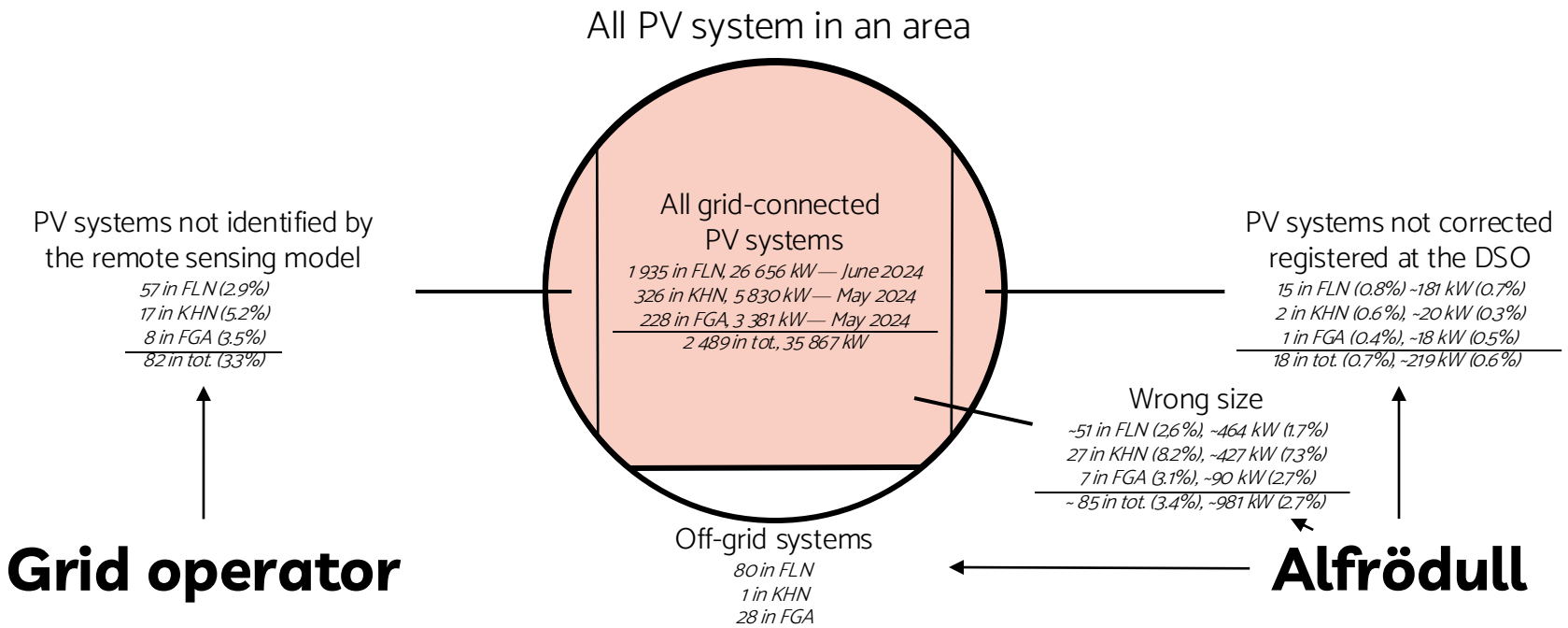
The Alfrödull as an inventory tool

All PV system in an area



PV system ≤ 20 kW registered 2014,
with expansion since then.

Alfrödull as an inventory tool

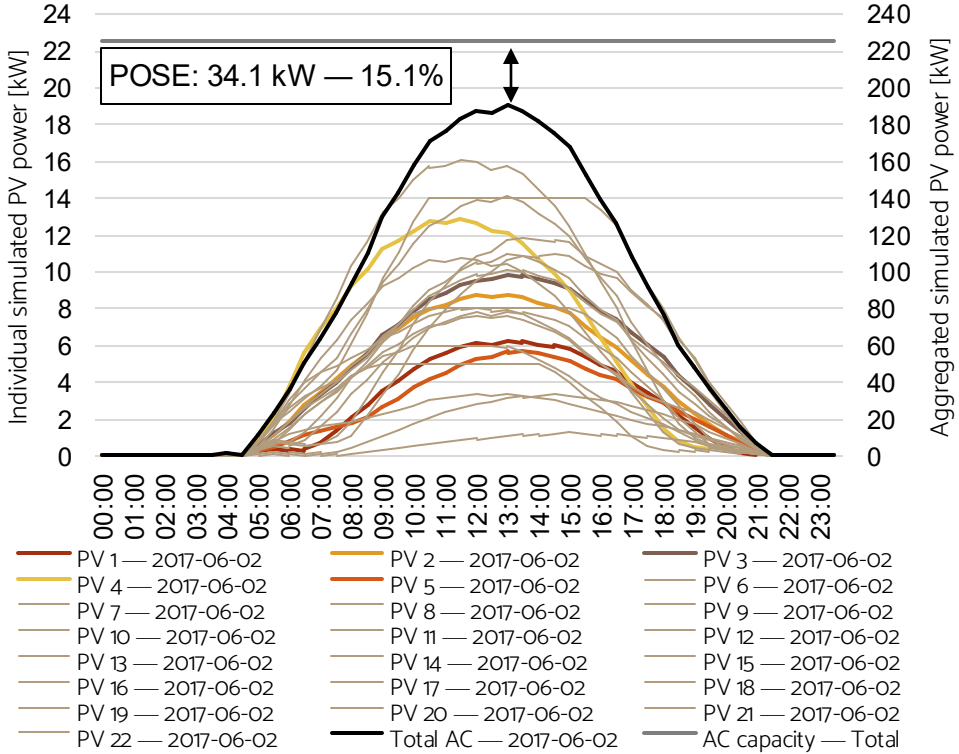


J. Lindahl, et al. (2025), *Assessing the economic value for grid operators of quantified smoothing effects from PV systems with varying orientations*

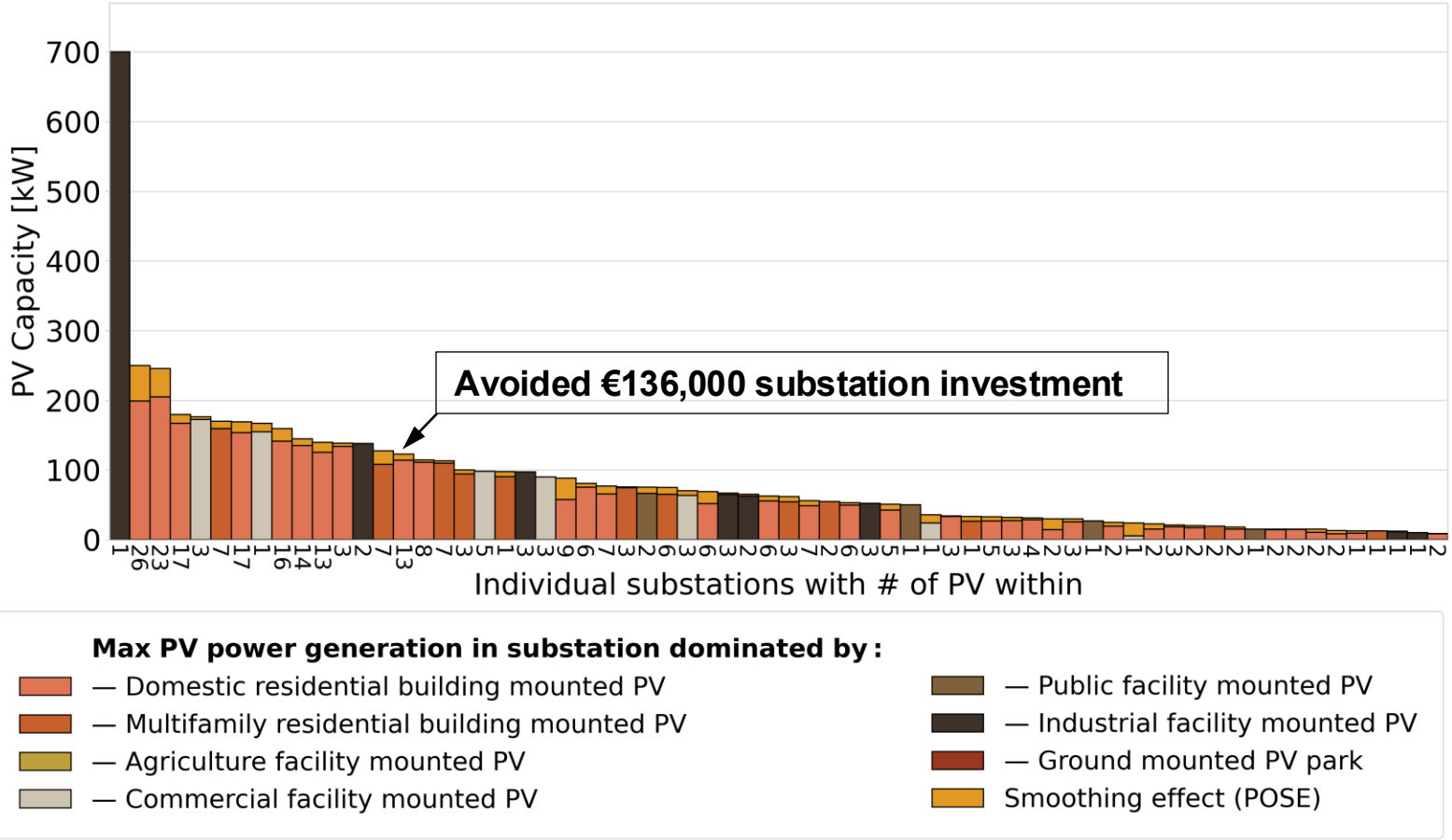
The “POSE” for one substation



The systems have a combined installed AC capacity of 225.3 kW. Simulations of all half-hours between 2017-05-01 and 2025-08-10 (145 102 points) revealed an aggregated maximum peak of 191.2 kW.

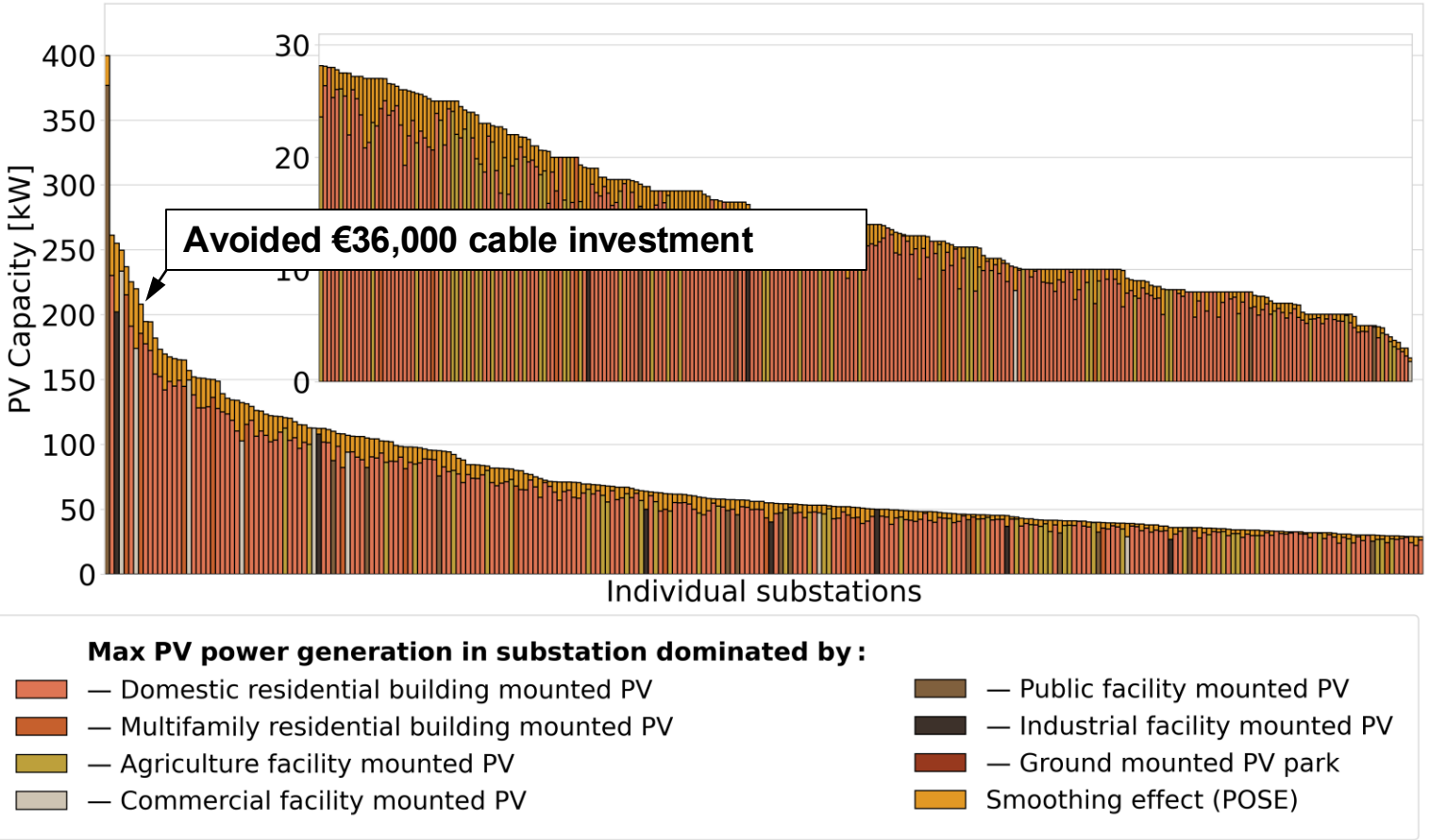


POSE in Karlshamns Elnät (KHN)



J. Lindahl, et al. (2025), *Assessing the economic value for grid operators of quantified smoothing effects from PV systems with varying orientations*

POSE in Falu Elnät (FLN)



J. Lindahl, et al. (2025), *Assessing the economic value for grid operators of quantified smoothing effects from PV systems with varying orientations*

Conclusions

Semi-structured interviews with two Swedish DSOs demonstrated that remote sensing combined with high-resolution PV simulations offers a scalable and cost-effective approach to distribution grid management. The analysis by the remote sensing approach generated substantial value for the DSOs through:

- **Accurate PV mapping:** Enables precise identification of installed PV systems which can be used to detect registry discrepancies.
- **Improved capacity estimates:** DSOs were found to under current praxis overestimate the PV power that can be injected by distributed PV systems into low-voltage grids by **8–12%**.
- **Unlocking existing capacity:** By accounting for smoothing effects, the method reduces the need for costly grid reinforcements, with avoided investments of approximately **€36k and €136k** at the two DSOs so far.
- **DSO benefits:** Delivers economic gains and operational insights, supporting data-driven planning, prioritization of grid interventions, and faster customer connections.



Thank you for your attention!

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