



Model-free Detection of Solar Generation in Distribution Grids Based on Minimal Exogenous Information

Speaker:

Petrusev Aleksandr

Supervisors:

Vincent Debusschere, G2ELab, Université Grenoble Alpes

Rémy Rigo-Mariani, G2ELab, Université Grenoble Alpes

Patrick Reignier, LIG, Université Grenoble Alpes

19 May 2022, Nancy

Context of the problem

Information about PV generation is crucial for distribution system operations:

- status estimation
- reconfiguration
- voltage management

“Hidden” generation may incur additional uncertainty into the net charge by impacting the net load profile.



Simulated network

Objective:

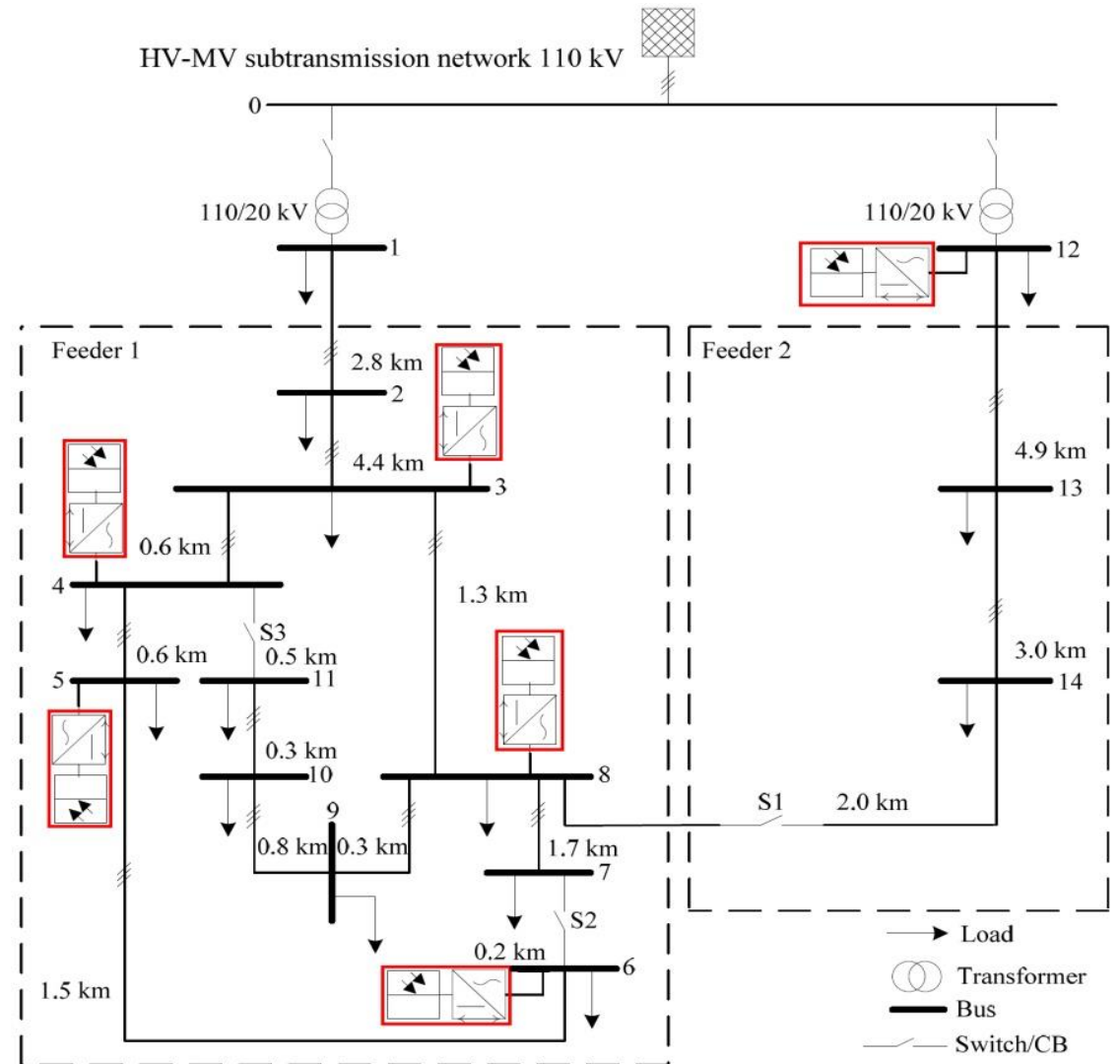
- Discriminate the nodes with and without solar generation

Problem:

- Currently available tools typically require data that is difficult to access

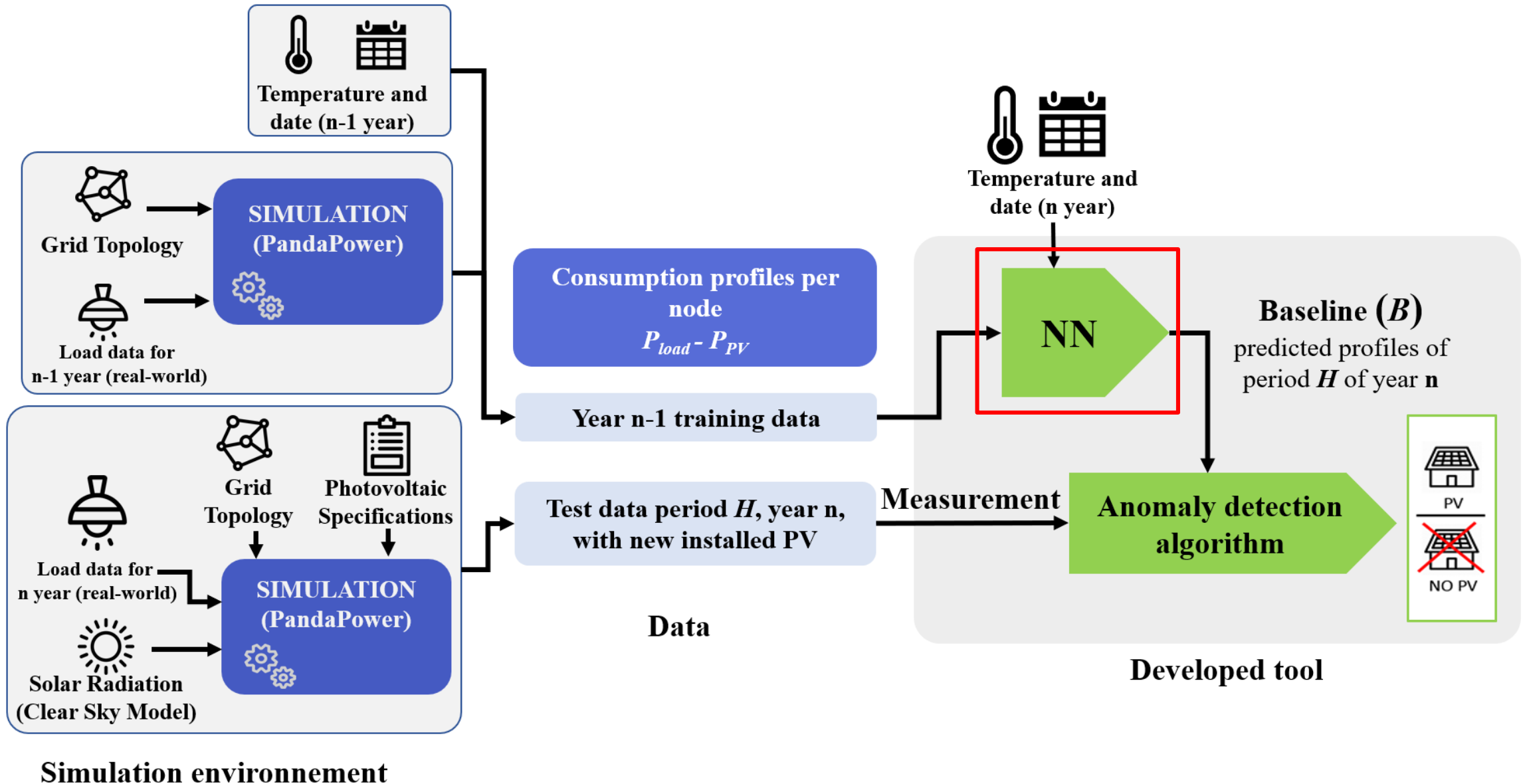
Tasks:

- To reach the highest precision of detection
- Rely only on smart meter and temperature data



Network simulated for the year 2010 (with PV in red)

Algorithm implementation

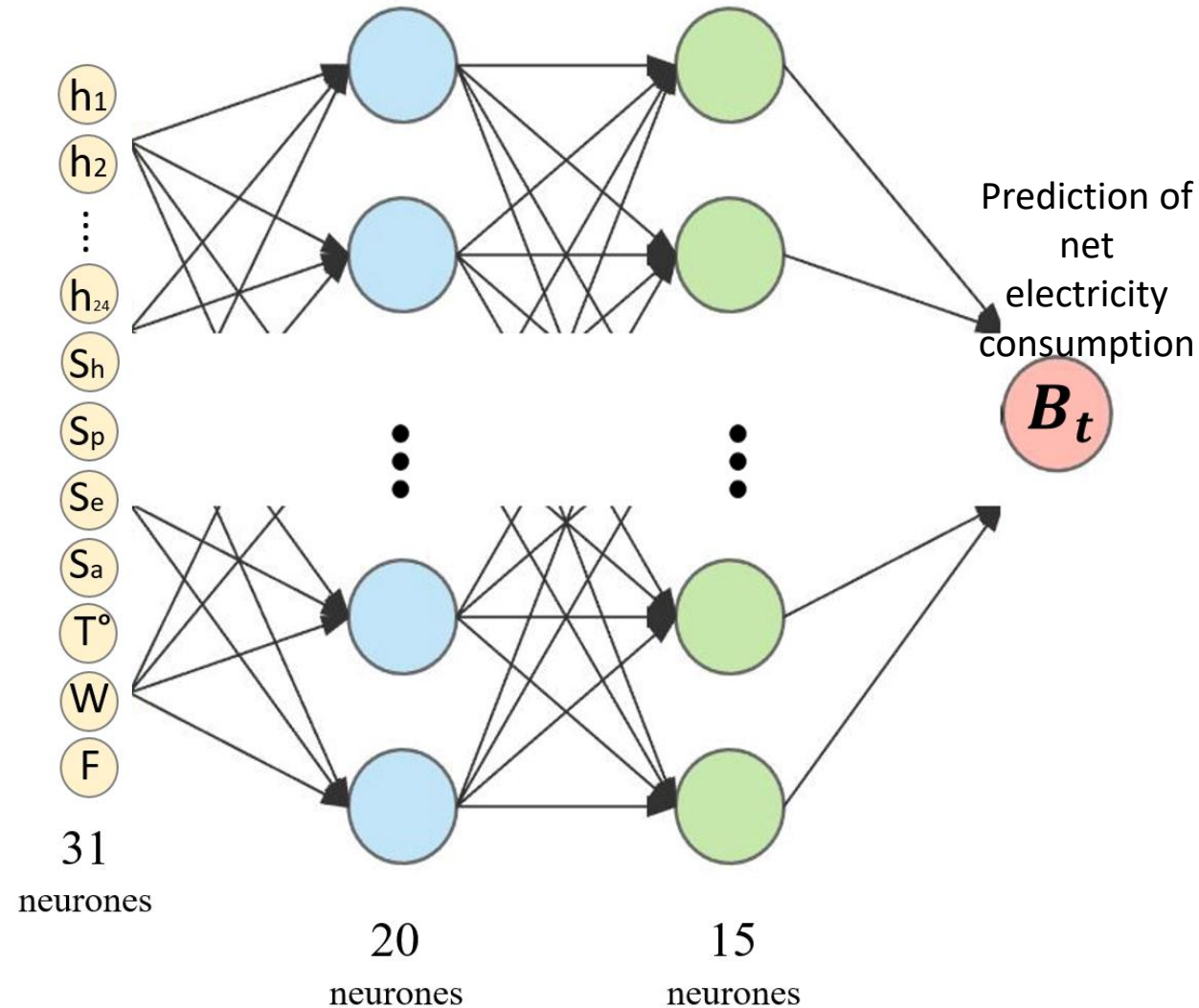


Neural network

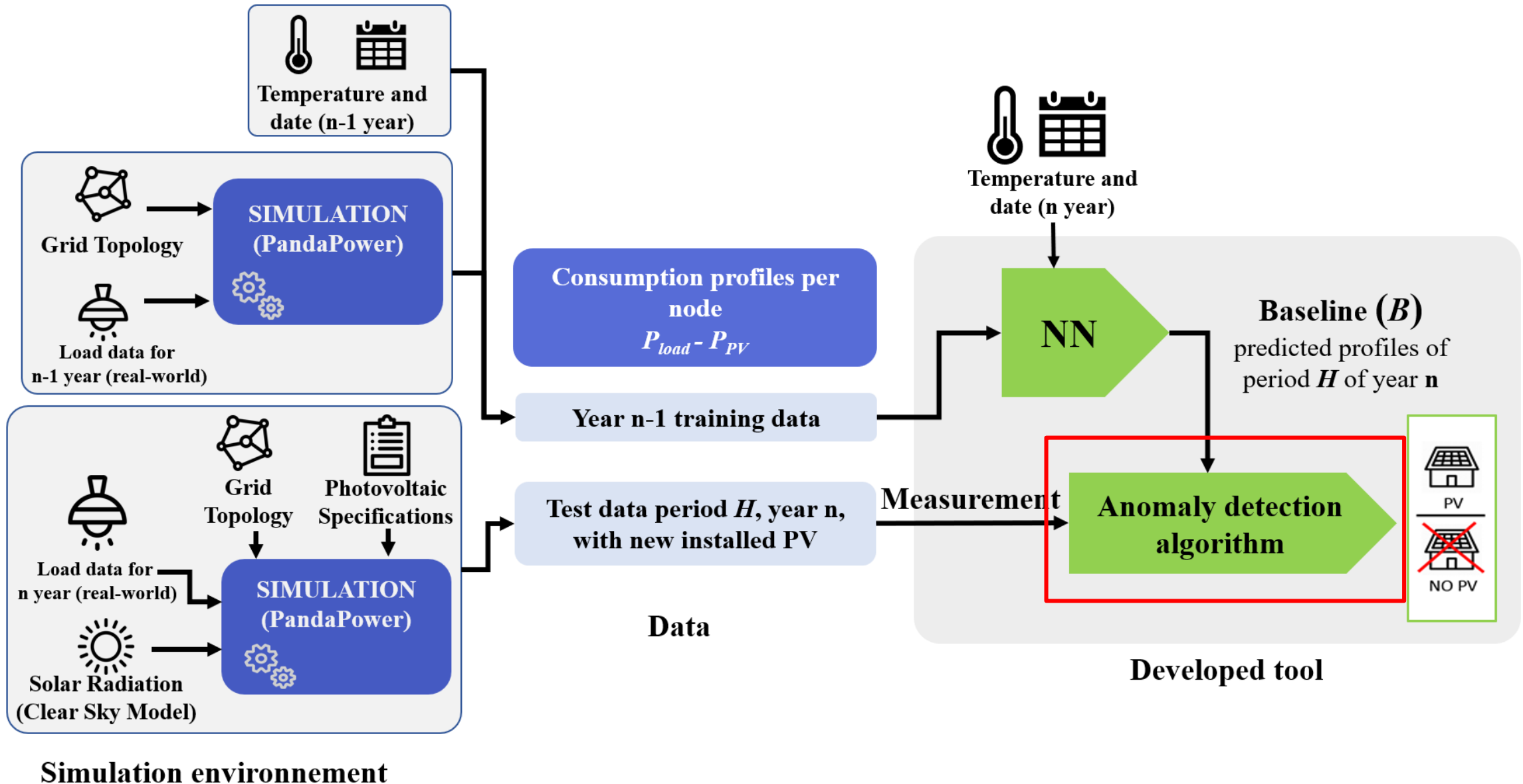
- **24 features** to determine at what hour of the day the simulation will be performed – h_i , $i = 1 \dots 24$;
- **4 features** to indicate the season – S_h (winter), S_p (spring), S_e (summer), S_a (autumn);
- **3 features** : temperature (t°), weekend (W) and holiday (F).

$$\left. \begin{array}{l} h_i \\ S_h \\ S_p \\ S_e \\ S_a \\ W \\ F \end{array} \right\} = (0,1)$$

$$T^\circ \in (-\infty; +\infty)$$



Algorithm implementation



Anomaly detection algorithm

B – baseline

P – measurement

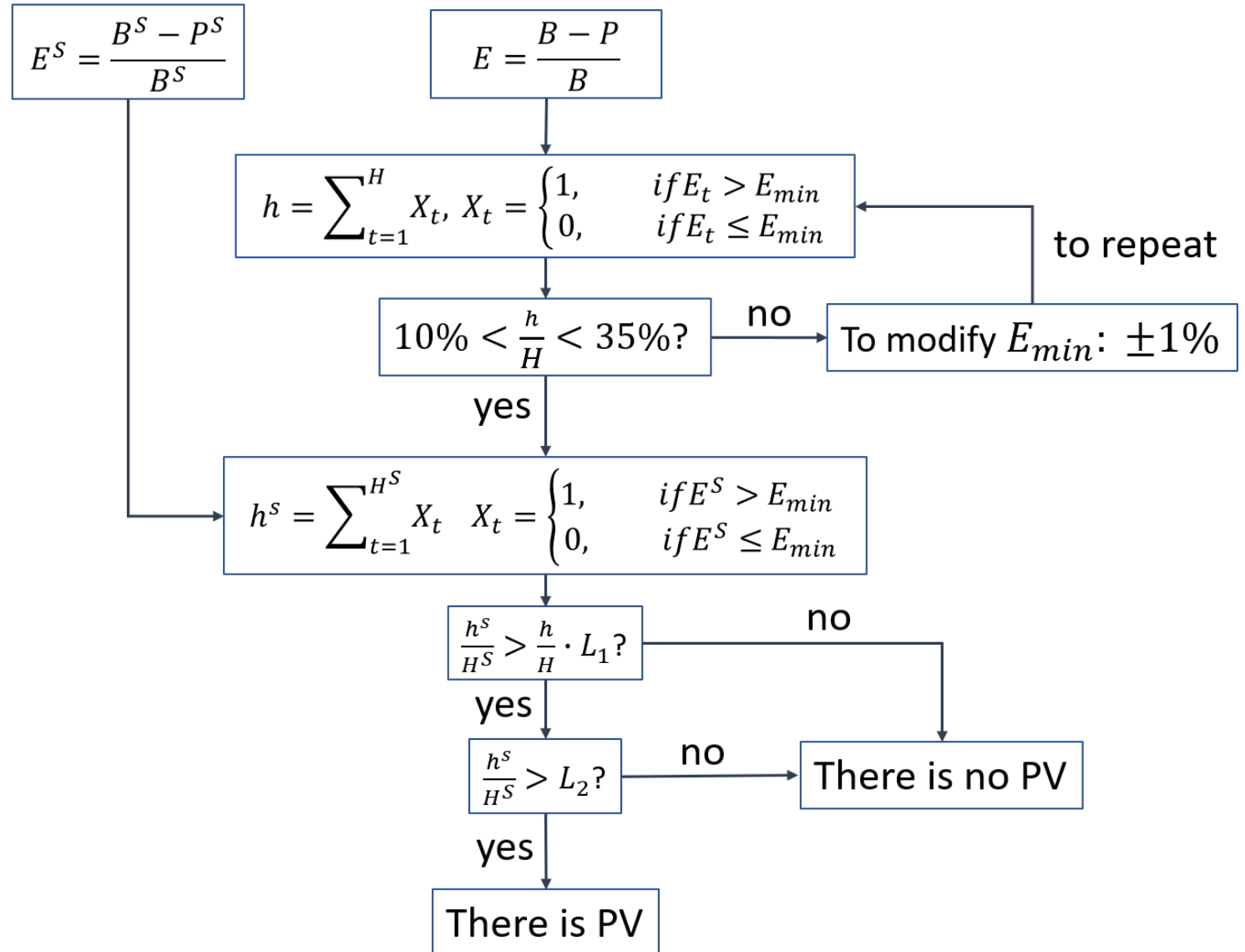
H - time horizon

H^S - sunshine hours (9 a.m. - 4 p.m.)

B^S – baseline for “sunshine hours”

P^S – measurement for “sunshine hours”

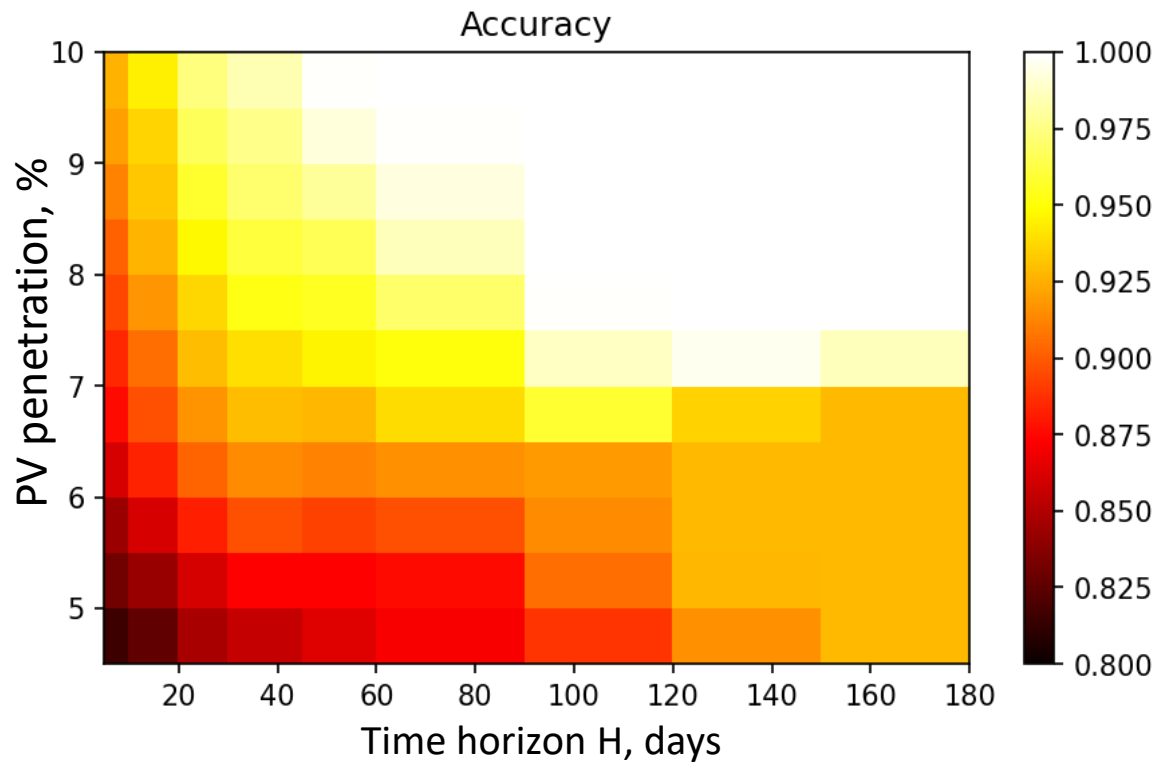
E_{min}, L_1, L_2 - thresholds



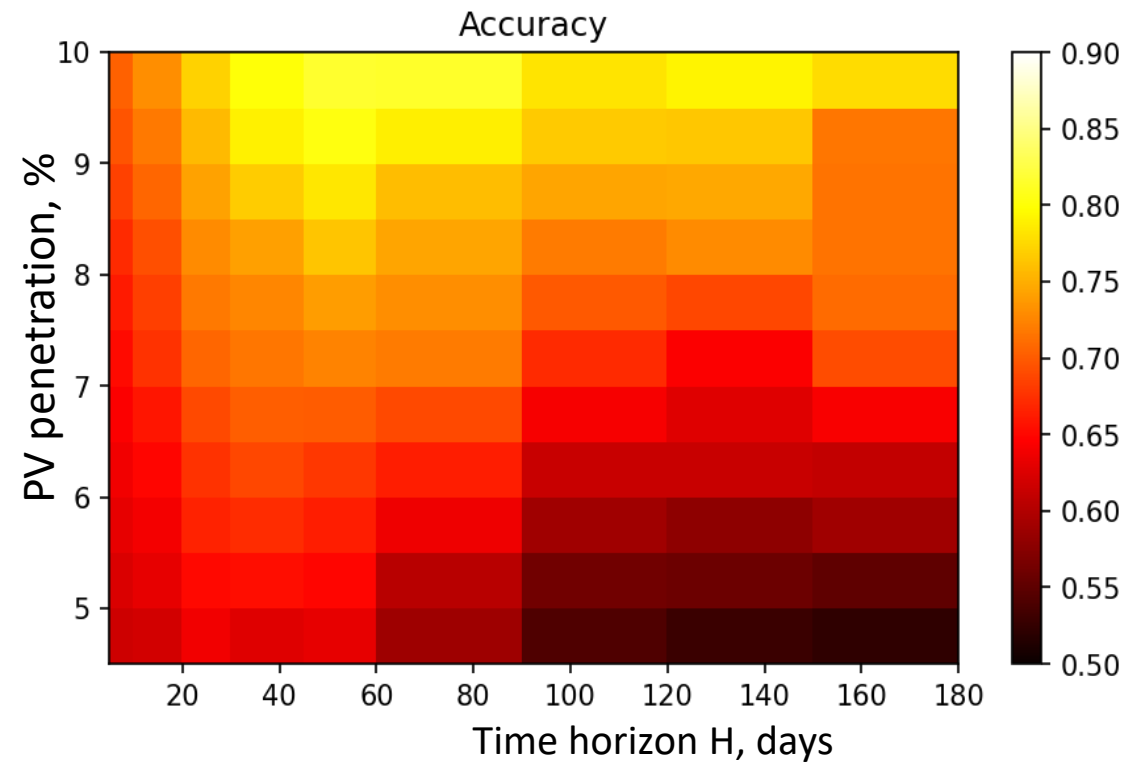
Results

The implemented solution, was tested across all the nodes of the simulated electrical grid and its sensitivity was analyzed with regard to the level of PV penetration (PV_{nom}/P_{cons}) and time horizon H .

Metric	Variables
$Accuracy = \frac{\text{Number of correct detection results}}{\text{Number of all results}}$	<ul style="list-style-type: none"> PV_{nom} is the nominal PV capacity, [kW] P_{cons} is the maximum consumption power of the node, [kW]



Average accuracy dependence from April to September



Average accuracy dependence from October to March

Conclusion

- Proposed method uses only the temperature and consumption data
- Neural network are very compact models that can be trained offline within minutes and can then analyse any time period within seconds.
- A next step may consist in not only detecting PV installations, but also in disaggregating the load and generation values for net load measurements

*Thank you for your
attention!*

Aleksandr.petrusev@grenoble-inp.fr

References

1. REFIT: Electrical Load Measurements (Cleaned)

URL: <https://pureportal.strath.ac.uk/en/datasets/refit-electrical-load-measurements-cleaned>

2. Iowa Distribution Test Systems

URL: <http://wzy.ece.iastate.edu/Testsystem.html>

3. Smart meters in London

URL: <https://www.kaggle.com/jeanmidev/smart-meters-in-london/>

4. Dark Sky API

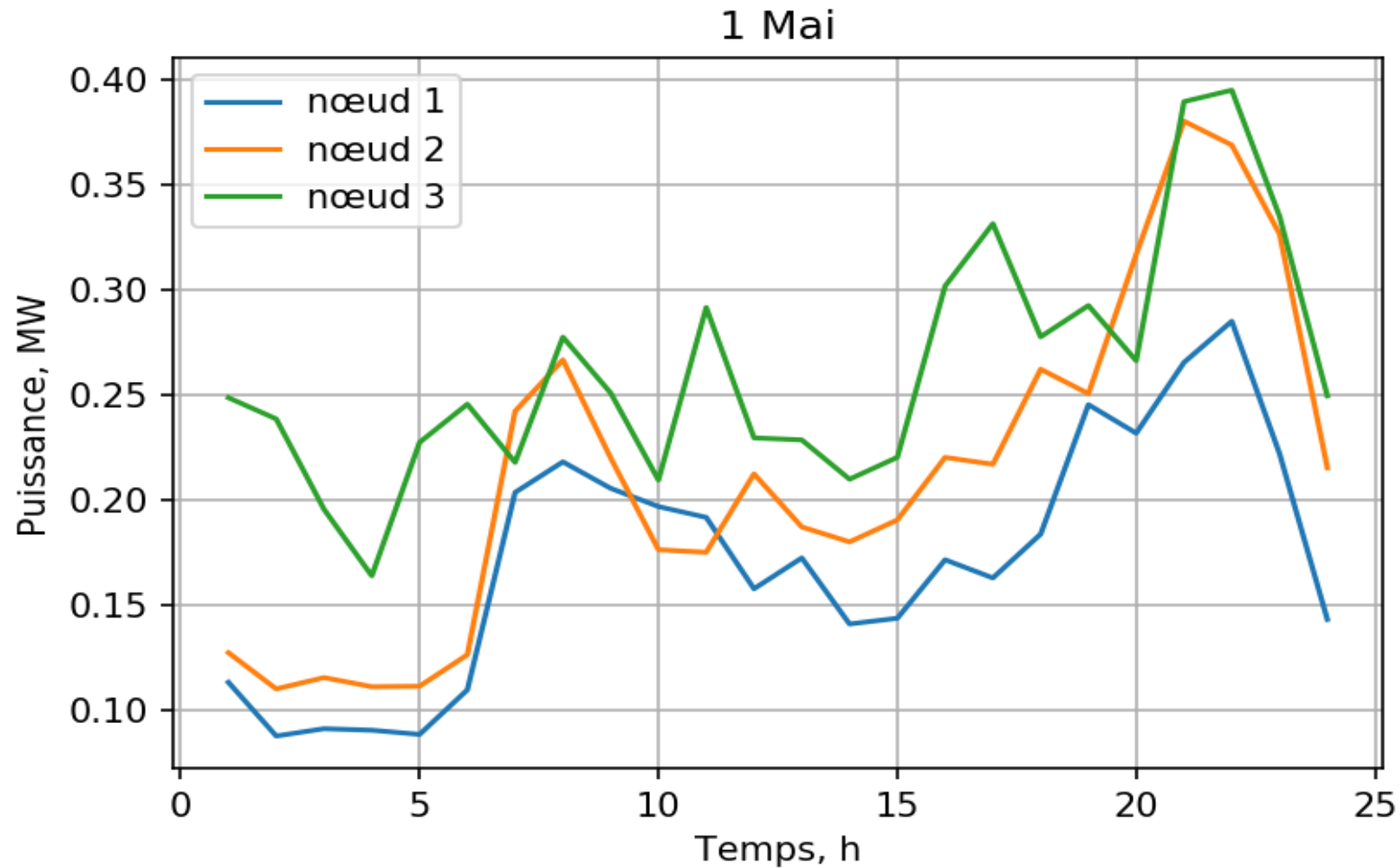
URL: <https://darksky.net/dev>

5. PVWatts Calculator

URL: <https://pvwatts.nrel.gov/index.php>

6. Michaelangelo Tabone, Sila Kiliccote, and Emre Can Kara. “Disaggregating solar generation behind individual meters in real time”. *In Proceedings of the 5th Conference on Systems for Built Environments*. ACM, 43–52, 2018.

Database



**Consumption (May 1, 2013) of
«Smart meters in London»**