HEDNO

Energy Forecasting at the Secondary Substation Level for DSO Participation in Residential Local Flexibility Markets

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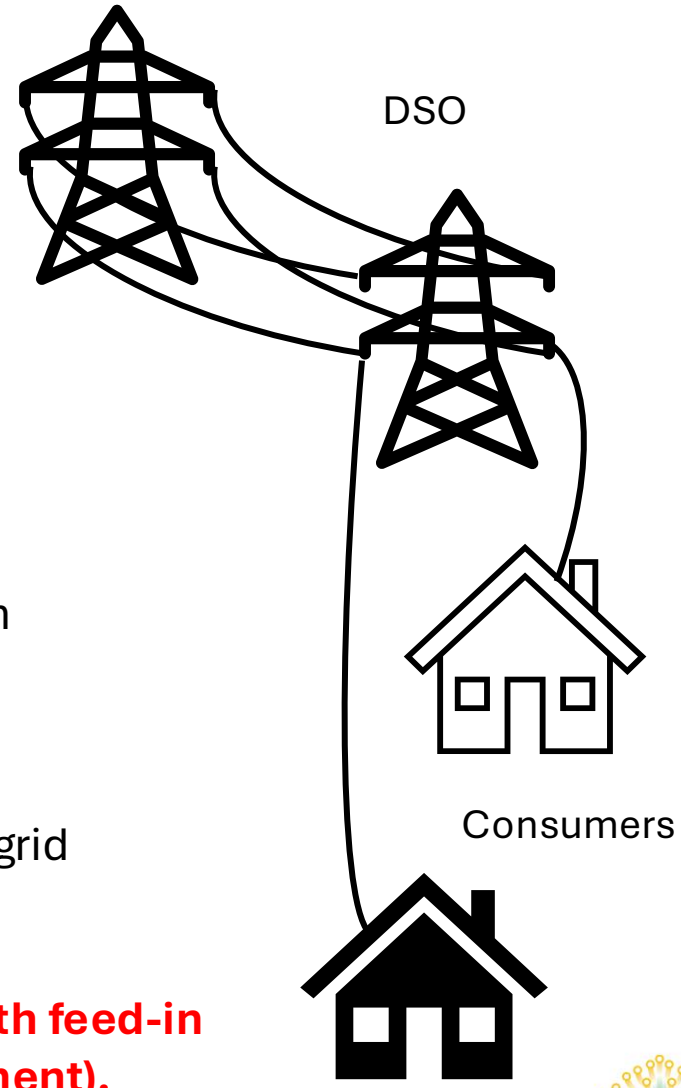
This project has received funding from the European Union's Horizon programme under the Grant Agreement No. 101136216

Local flexibility market

Decarbonization

Distributed Energy Resources (DERs) & Renewable Energy Systems (RESs)

Power distribution



Issue for Distribution System Operators (DSOs):

- Congestion
- Voltage violations
- Increased "stress" to the grid
- Power cuts

DSO address the issues with feed-in management (RES curtailment).

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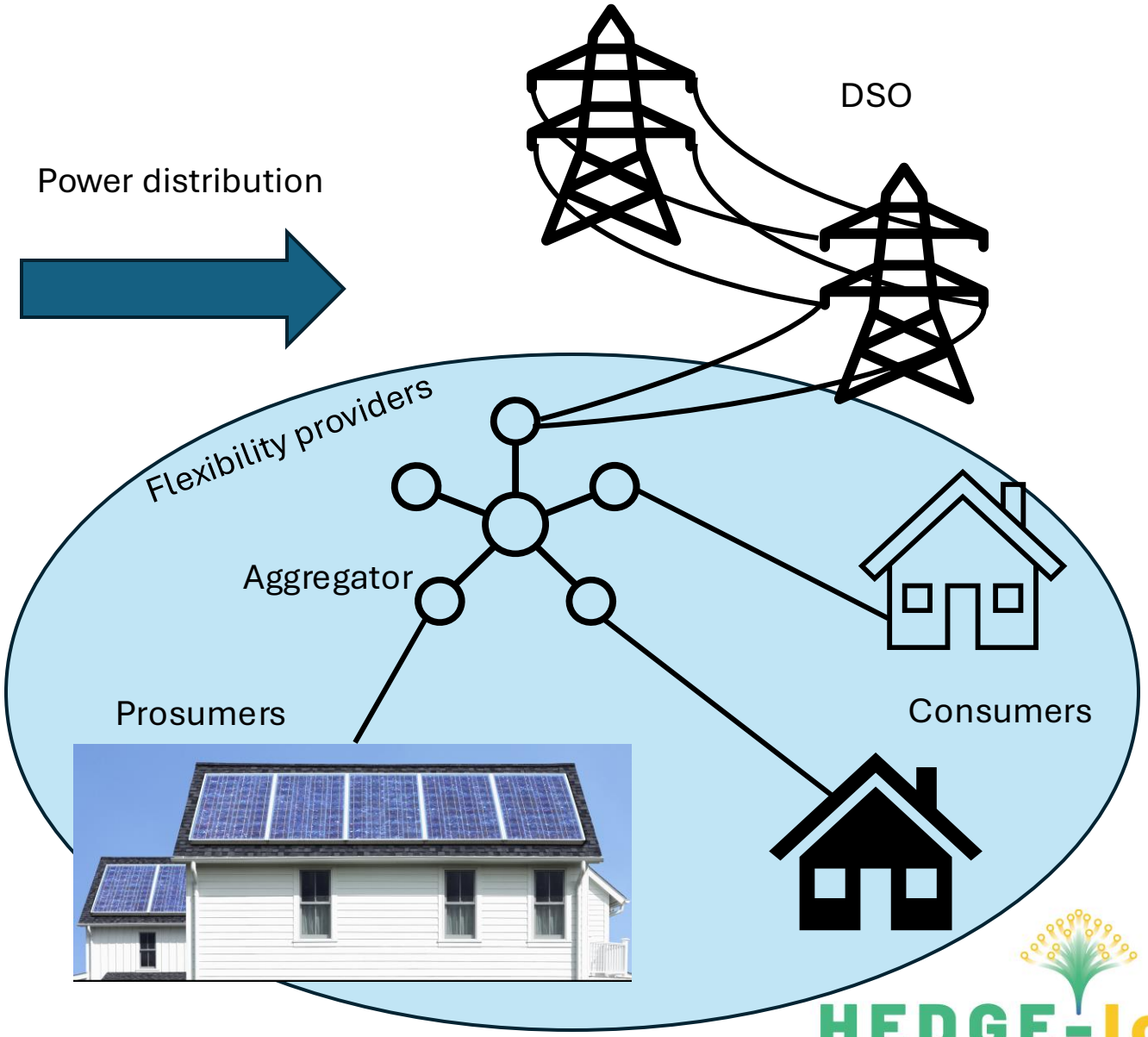

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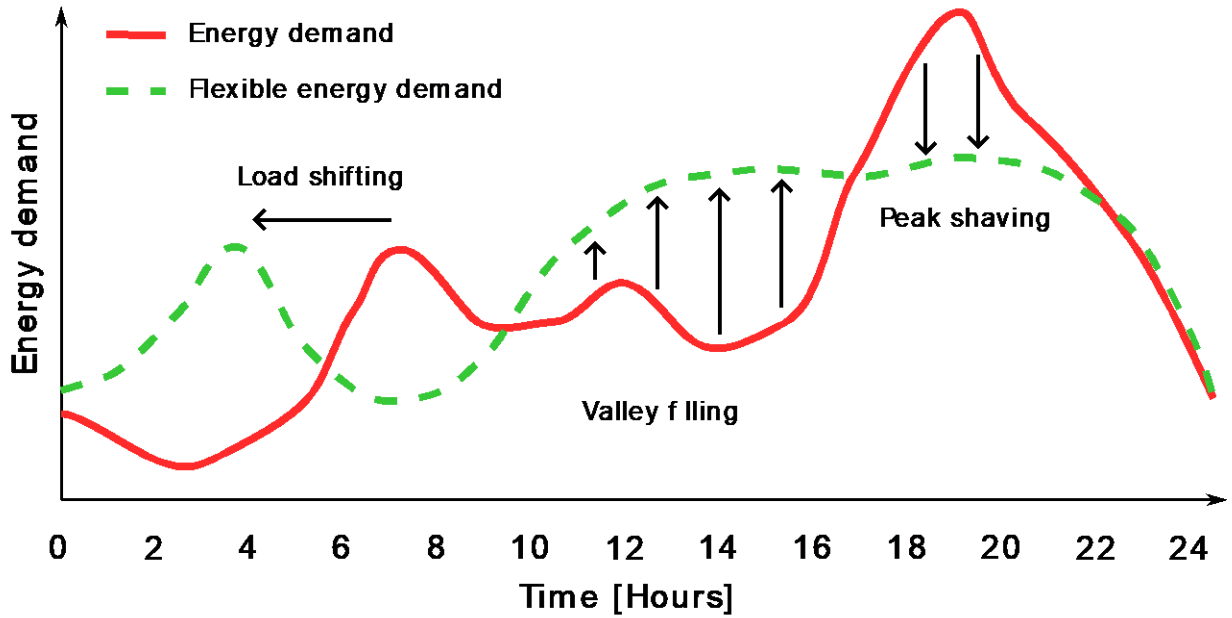
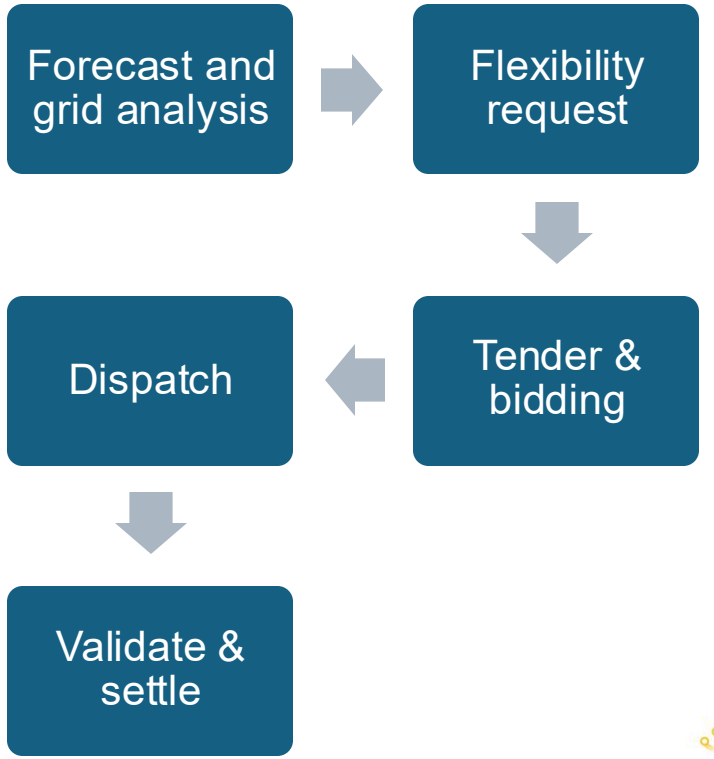
Explicit flexibility

Proactive commitment to modify energy consumption or generation.



Simplified LFM (DSO side)



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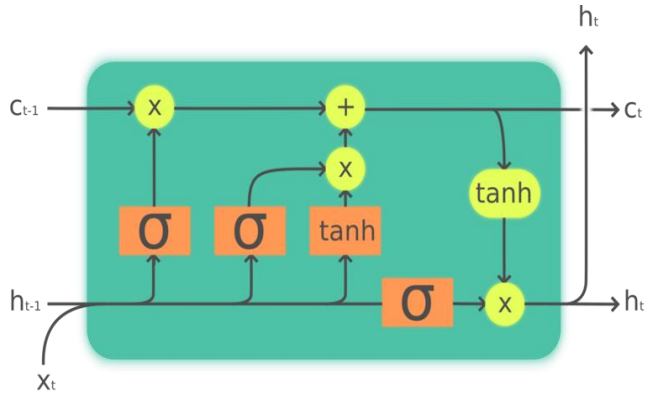
Forecasting

- Forecasting individual households is challenging, due to its stochastic nature.
- Forecasting at substation level using Long Short-Term Memory model (LSTM).



LSTM is a recurrent neural network made of the shown unit cell.

Process for forming flexibility requests

Demand forecast → Power flow analysis → Load reduction/increase → Flexibility request

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Data and LSTM training

Real world data from secondary substation of the Greek DSO:

- Energy consumption at low voltage level
- Power quality at low voltage level
- Temporal granularity 15 mins
- Metering device (Meazon, Greece)

Weather data from the open meteo platform

Market operating with Market Time Unit (MTU) of 15 mins

Training set 8 weeks of data to predict the 6th MTU

Forecasting results evaluated using $MAPE = \frac{1}{n} \sum_{i=1}^{n} \left| \frac{Y_i - \hat{Y}_i}{Y_i} \right|$

predicted value

actual value

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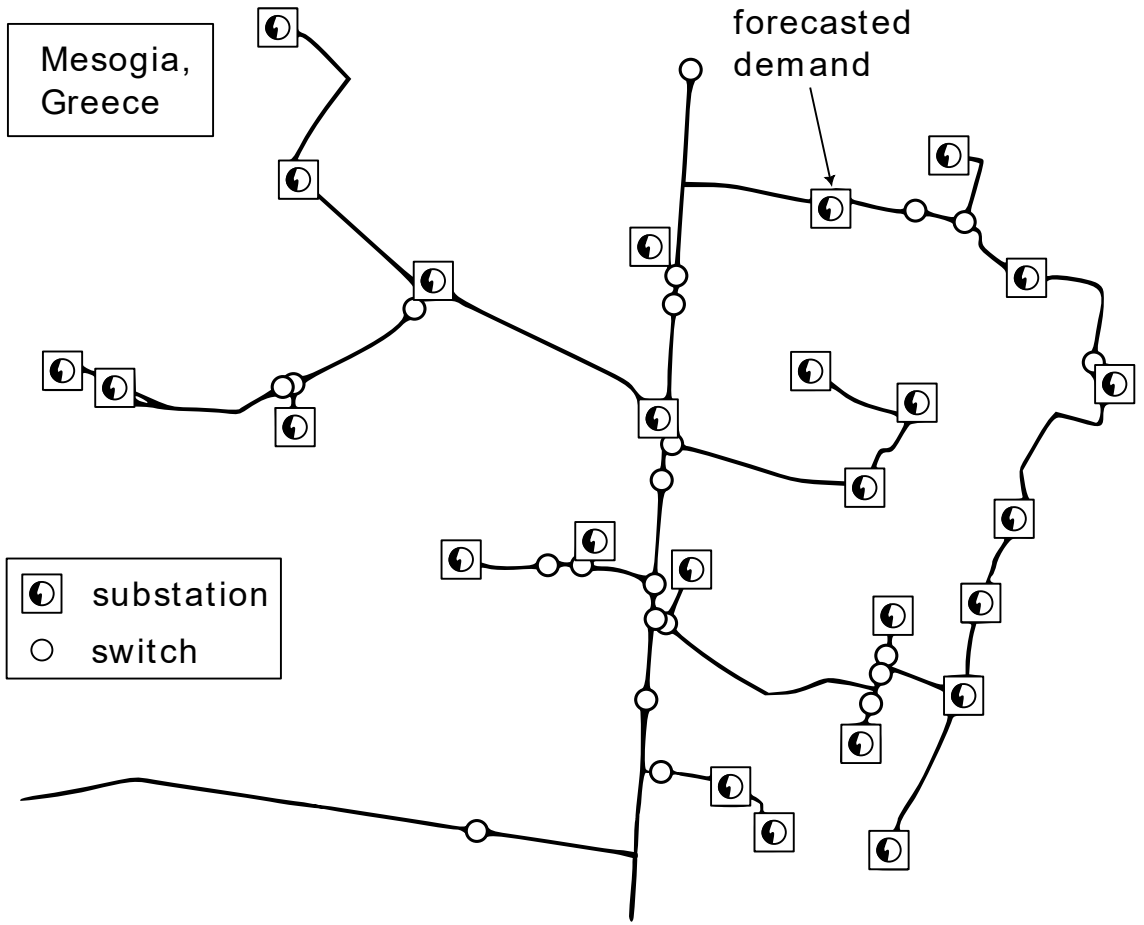
Power flow analysis

- Forecasted energy converted to active power
- Powerfactory software (ver SP5, DIgSILENT GmbH, Germany)
- Power factor set to 0.95
- Load factor for remaining urban substations set to 0.80



Network topology used for power flow analysis.

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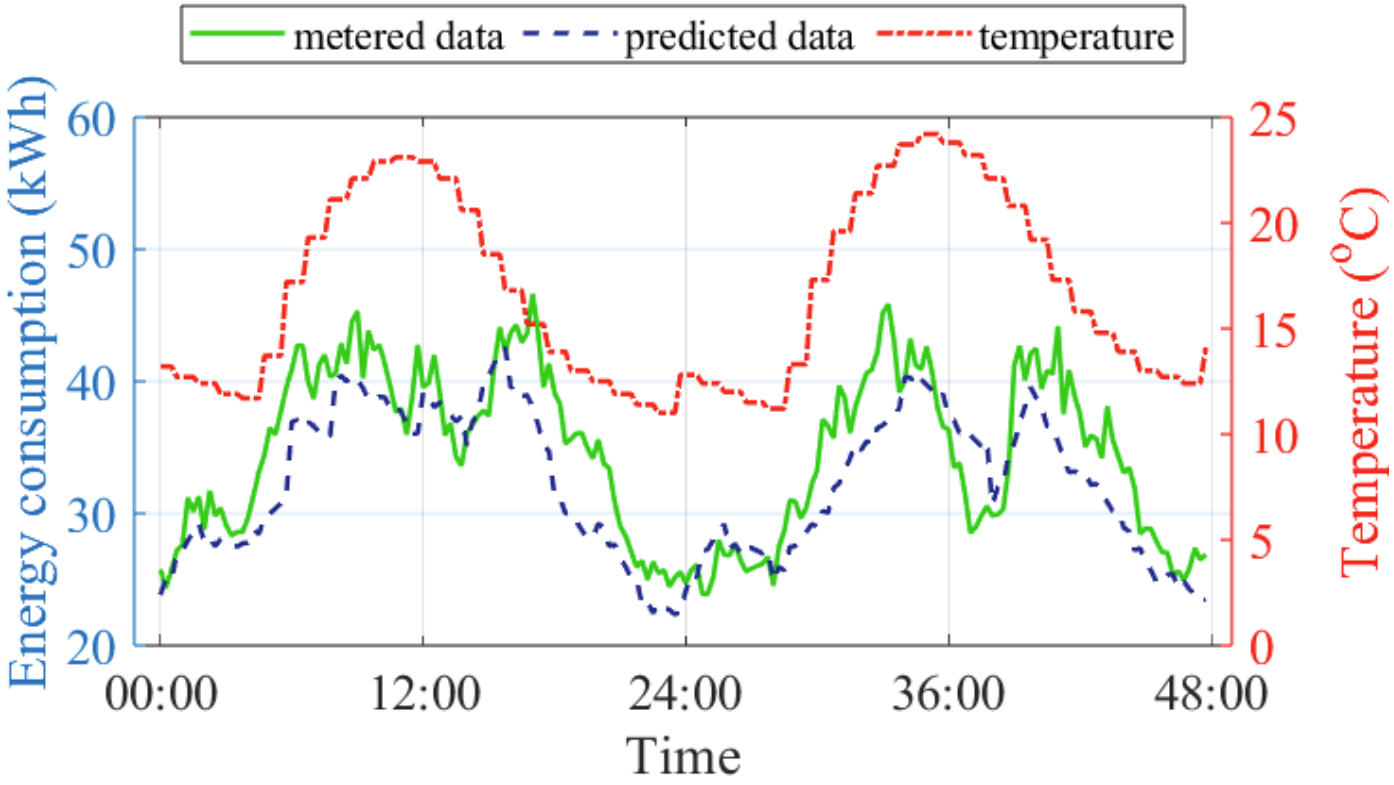
Forecasting results

LSTM prediction achieved a mean absolute percentage error of 0.085.

Forecasted energy consumption at substation level:

- Predicted time series at 6th MTU
- Prediction of voltage violations
- Validation of dispatched flexibility



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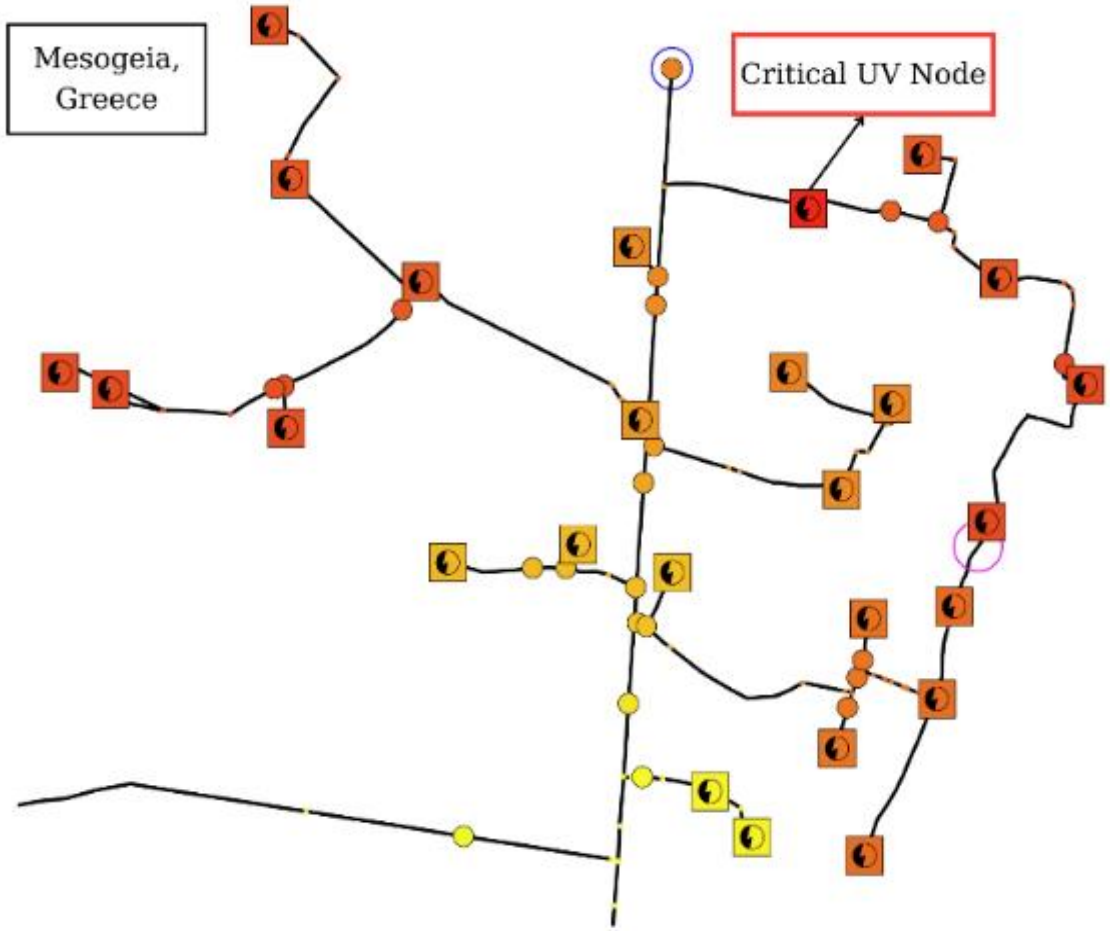
Grid analysis results

Grid analysis:

- Identification of undervoltage event
- Effect of event on the wider grid
- Required flexibility of 84kW to maintain grid stability

Flexibility from residential consumers.



Undervoltage issue identified in power flow analysis.

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Conclusions

The study explored:

- AI-driven load forecasting
- Power flow analysis to form flexibility requests

DSO related benefits:

- Proactively identify and address stress conditions
- Dynamic procurement of flexibility requests
- Baseline for validating demand-response event

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Next steps

- Improve the LSTM algorithm to further reduce the error by adding features (i.e. weekdays/weekends)
- Apply the forecasting algorithms to aggregated consumers (flexibility portfolios) to calculate their baseline within a flexibility market
- Test the proposed methodology in a Demo Flexibility Market within the framework of the HEDGE-IoT project

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Thank you for your attention

HEDGE-IoT Partners

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