DISTRIBUTION GRID OPERATIONS MANAGEMENT
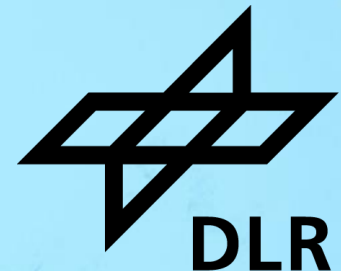
Moiz Ahmed

German Aerospace Center (DLR) - Institute of Networked Energy Systems

Oldenburg, Germany

DLR - a national network of institutes and facilities
Institute of Networked Energy Systems

6 Research Areas:

- Aeronautics
- Space Research
- **Energy**
- Transport
- Defence and Security
- Digitalization

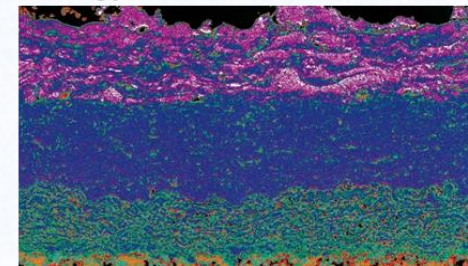**Institutes and facilities across Germany**
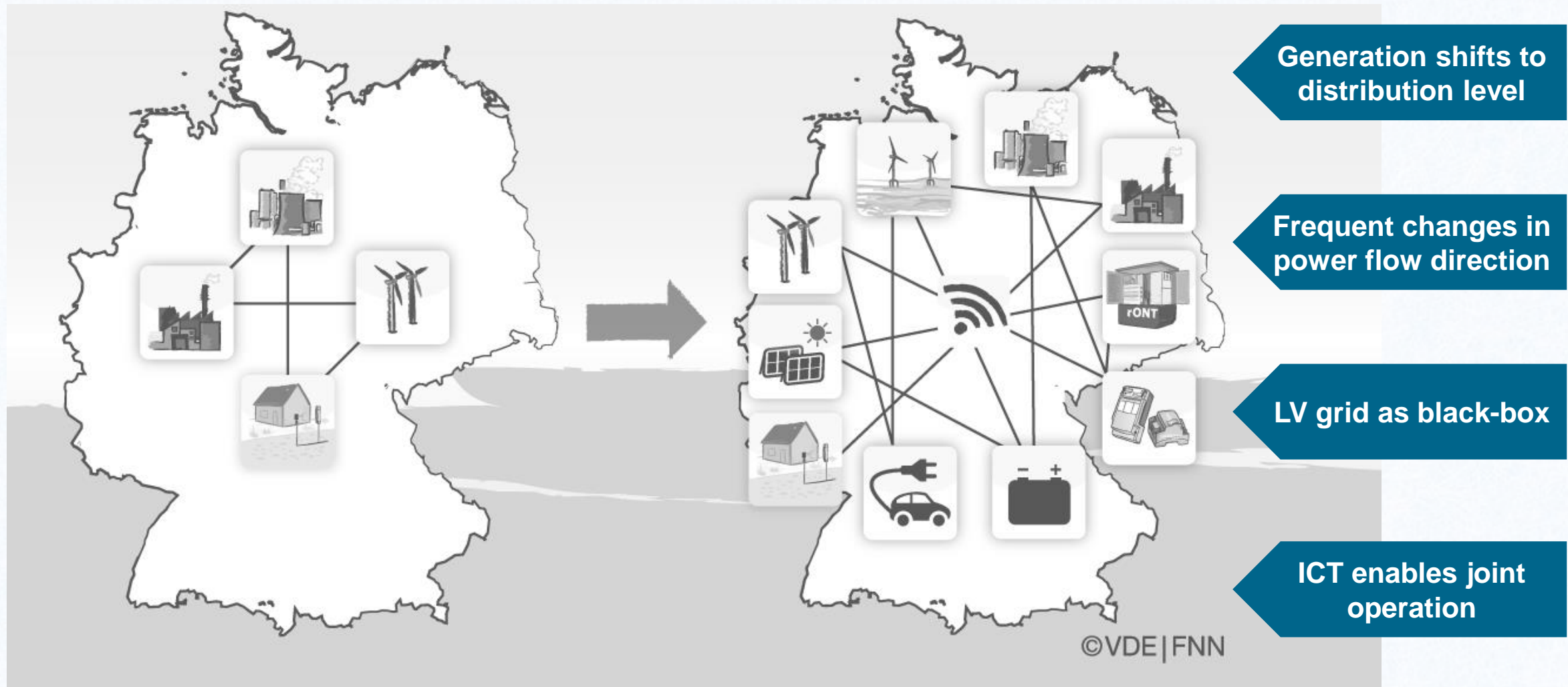
Solar Energy

Energy Converters

Energy Storage

Energy Systems Analysis

Wind Energy

Energy System Technologies

Managing the Complexity of Energy Systems

Generation shifts to distribution level

Frequent changes in power flow direction

LV grid as black-box

ICT enables joint operation

©VDE|FNN

Image source: VDE-FNN

Framework

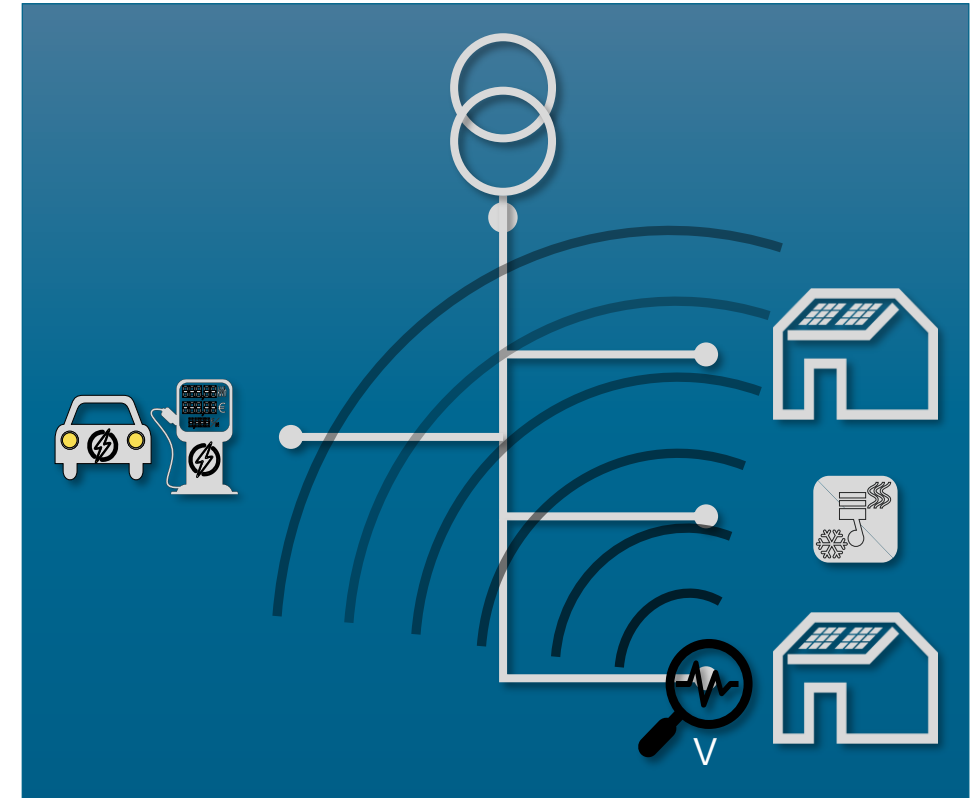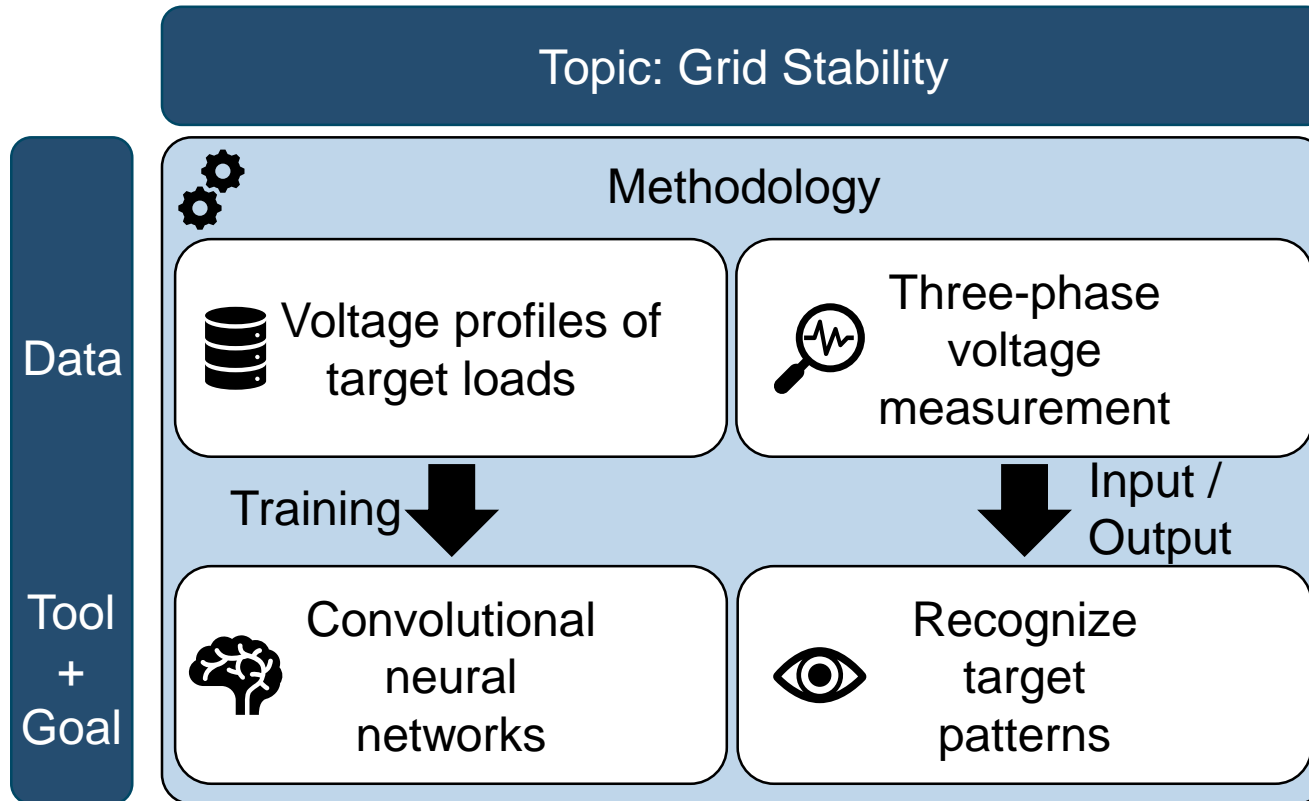| Recognition of grid participants in distribution grid	Short-term power prediction for PV systems	In-house smart grid control center

- Gain more insights into local distribution grids
- Importance of short-term prediction of solar output for grid operations
- Overarching ICT-platform enabling data-exchange to optimally utilize network capacities
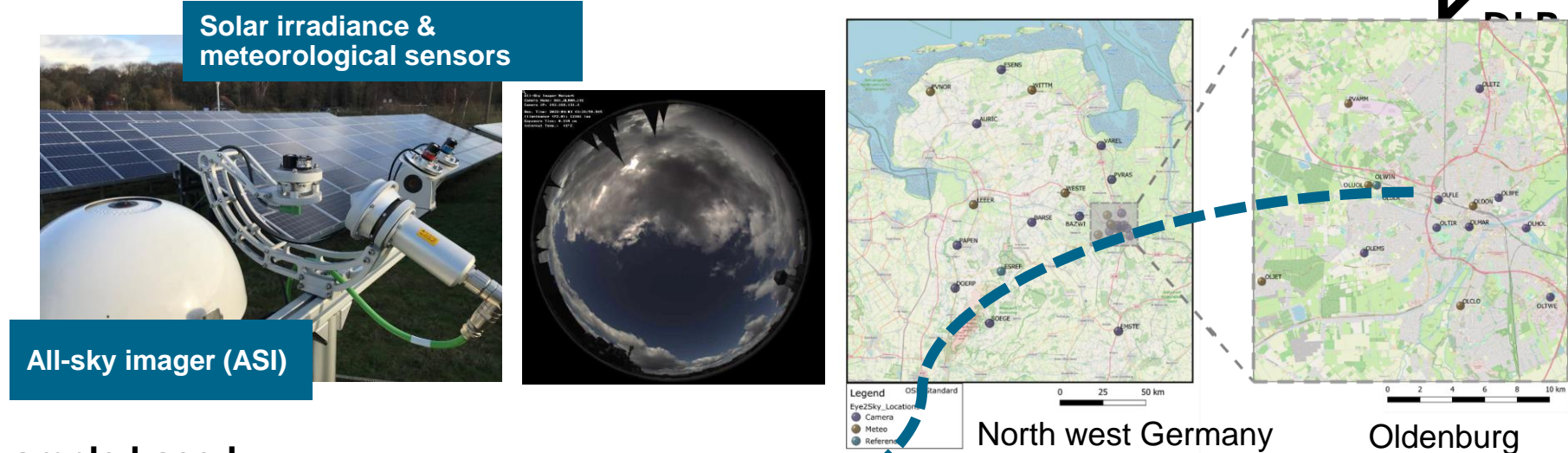
Voltage-Based Recognition of Active Grid Participants in Distribution Grid

Topic: Grid Stability

Methodology

Voltage profiles of target loads	Three-phase voltage measurement

Training →   Input / Output

Convolutional neural networks	Recognize target patterns

Data

Tool + Goal

- Machine learning application to gain knowledge about the local grid for stabilizaton of LV grids
- Use new information to adapt decentralized control strategies at the individual point of coupling

[2] Schlachter et al., 2022 [3] Bokker et al., 2023 [4] Schlachter et al., 2022
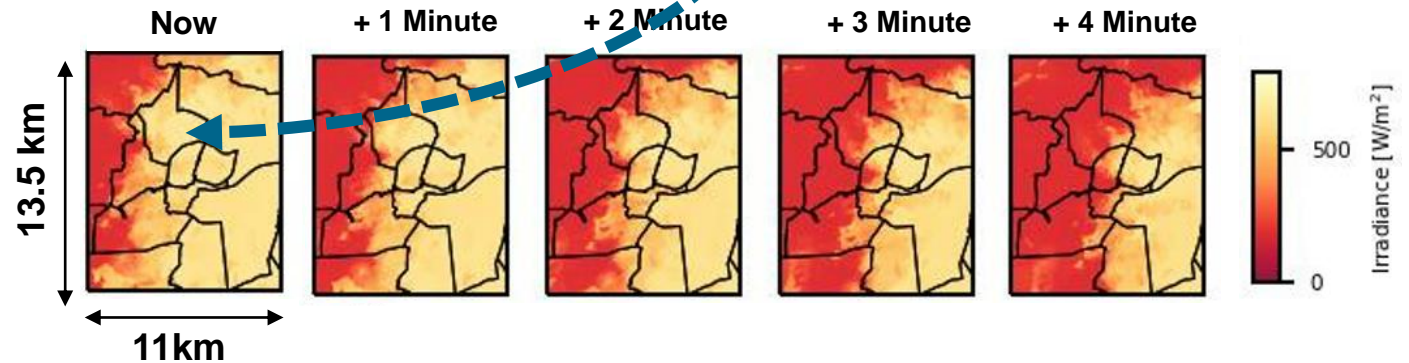
Eye2Sky – Probabilistic Solar Nowcasting

- Total 30 measurement stations

- Covering ~110km x 100km area in north-western Germany
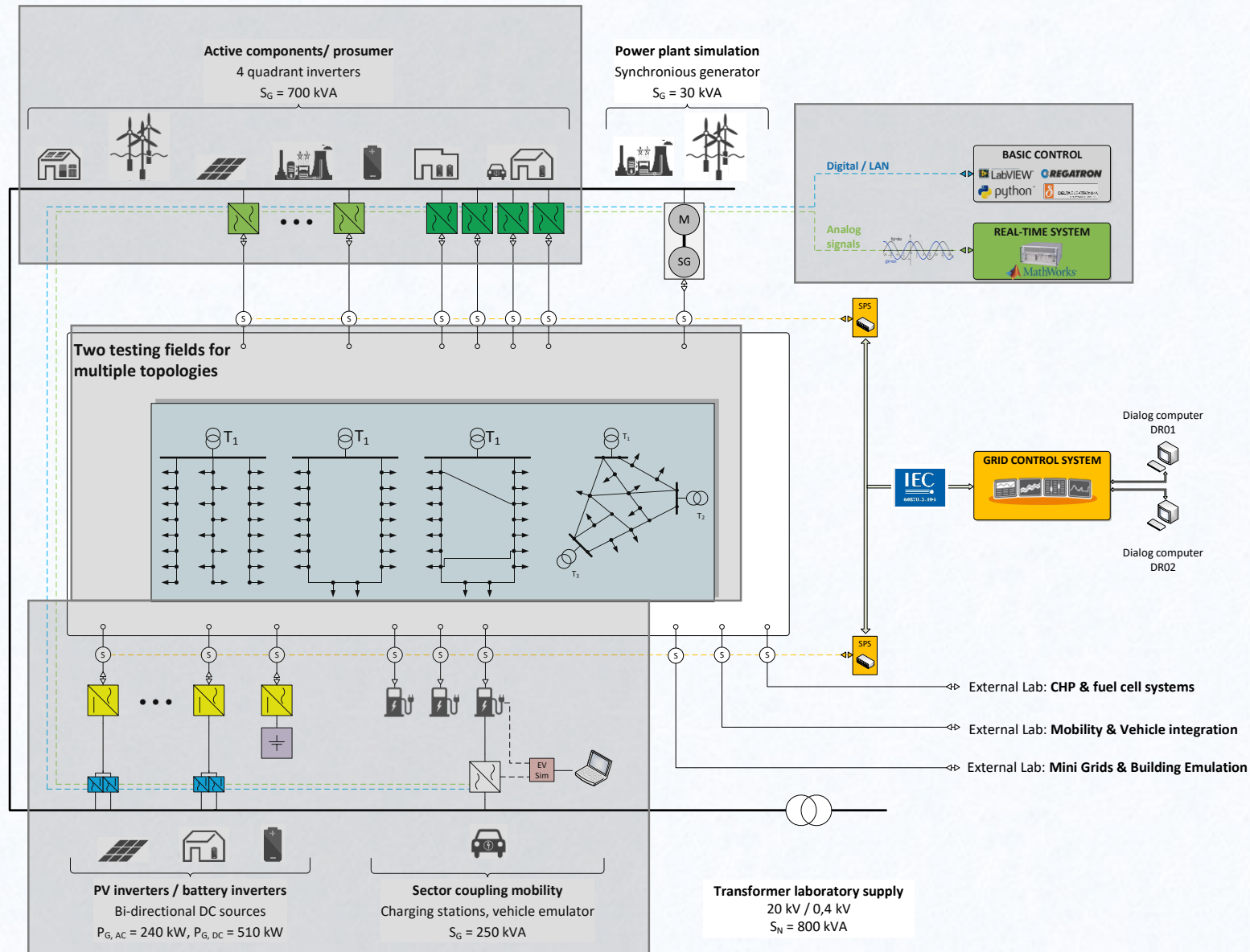
- High-density network Oldenburg

Solar irradiance nowcast example based on network of 13 cameras in Oldenburg

- 4 minute ahead forecast (up to 30 minutes possible)

- **Spatial:** 50 meters

- **Temporal:** 1 minute

Solar irradiance & meteorological sensors

All-sky imager (ASI)

North west Germany

Oldenburg

Now   + 1 Minute   + 2 Minute   + 3 Minute   + 4 Minute

13.5 km

11km

Irradiance [W/m²]

500

0

- Eye2Sky: Regional and urban all-sky imager and solar irradiance measurement network
- Developed for very accurate high-resolution and very short-term solar irradiance forecasts

Networked Energy Systems Emulation Center (NESTEC)

Smart grid operator as an innovative control center for intelligent distribution networks

* This slide has been removed due to confidential material. If there is interest in the topic, pleas contact the presenter. Details on last slide.

References

[1] DLR – VE, Institute of Networked Energy Systems: https://www.dlr.de/ve/en

[2] Schlachter, H.; Geißendörfer, S.; von Maydell, K.; Agert, C. Voltage-Based Heat Pump Recognition in Low Voltage Distribution Grids with Convolutional Neural Networks," *2022 IEEE PES Innovative Smart Grid Technologies Conference Europe (ISGT-Europe)*, Novi Sad, Serbia, 2022, pp. 1-6, https://doi.org/10.1109/ISGT-Europe54678.2022.9960641

[3] Bokker, O.; Schlachter, H.; Beutel, V.; Geißendörfer, S.; von Maydell, K. Reactive Power Control of a Converter in a Hardware-Based Environment Using Deep Reinforcement Learning. *Energies* **2023**, *16*, 78. https://doi.org/10.3390/en16010078

[4] Schlachter, H.; Geißendörfer, S.; von Maydell, K.; Agert, C. Voltage-Based Load Recognition in Low Voltage Distribution Grids with Deep Learning. *Energies* **2022**, *15*, 104. https://doi.org/10.3390/en15010104

[5] **Infrastructure Video:** Eye2Sky: One-of-a-kind System for short-term Forecasts of Solar Power feed-in Eye2Sky in 5min video

[6] Schmidt, Thomas und Stührenberg, Jonas und Blum, Niklas und Lezaca Galeano, Jorge Enrique und Hammer, Annette und Vogt, Thomas (2022): A network of all sky imagers (ASI) enabling accurate and high-resolution very short-term forecasts of solar irradiance. In: Wind & Solar Integration Workshop. IET Digital Library. 21st Wind & Solar Integration Workshop, 12.14. Oct. 2022, The Hague, Netherlands, https://digital-library.theiet.org/content/conferences/10.1049/icp.2022.2778

[7] von Maydell et al., 2022. The Networked Energy Systems Emulation Center at the German Aerospace Center DLR – bridging the gap between digital simulation and real operation of energy grids. at - Automatisierungstechnik, 70(12), 1072-1083. https://doi.org/10.1515/auto-2022-0019

[8] **Infrastructure Video:** NESTEC - Unique Hardware System Emulator that links Living Labs with Modelling/Simulation NESTEC in 5 min video

Thankyou

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Image source: DLR