AIsland

Artificial Intelligent Islanding Detection using Decentralized Grid-Forming Inverter

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Unintentional islanding - already an acute problem in today's power grid

- Unintentional islanding in the power grid in case of:
  1. Partial system split in the event of a fault and
  2. Balance between consumed and generated power.

$$S_{con} \approx S_{gen}$$

- VDE-AR-N 4105: Unintentional islanding must be locally detected and destabilized through generation units.

In future power grids

- Steady expansion of renewable energies (energy transition) favors the undesirable formation of island grids (see Figure 1).
- Impending conflict of goals: Decentralization of grid-forming properties (grid-forming battery converters) vs. unintended islanding.

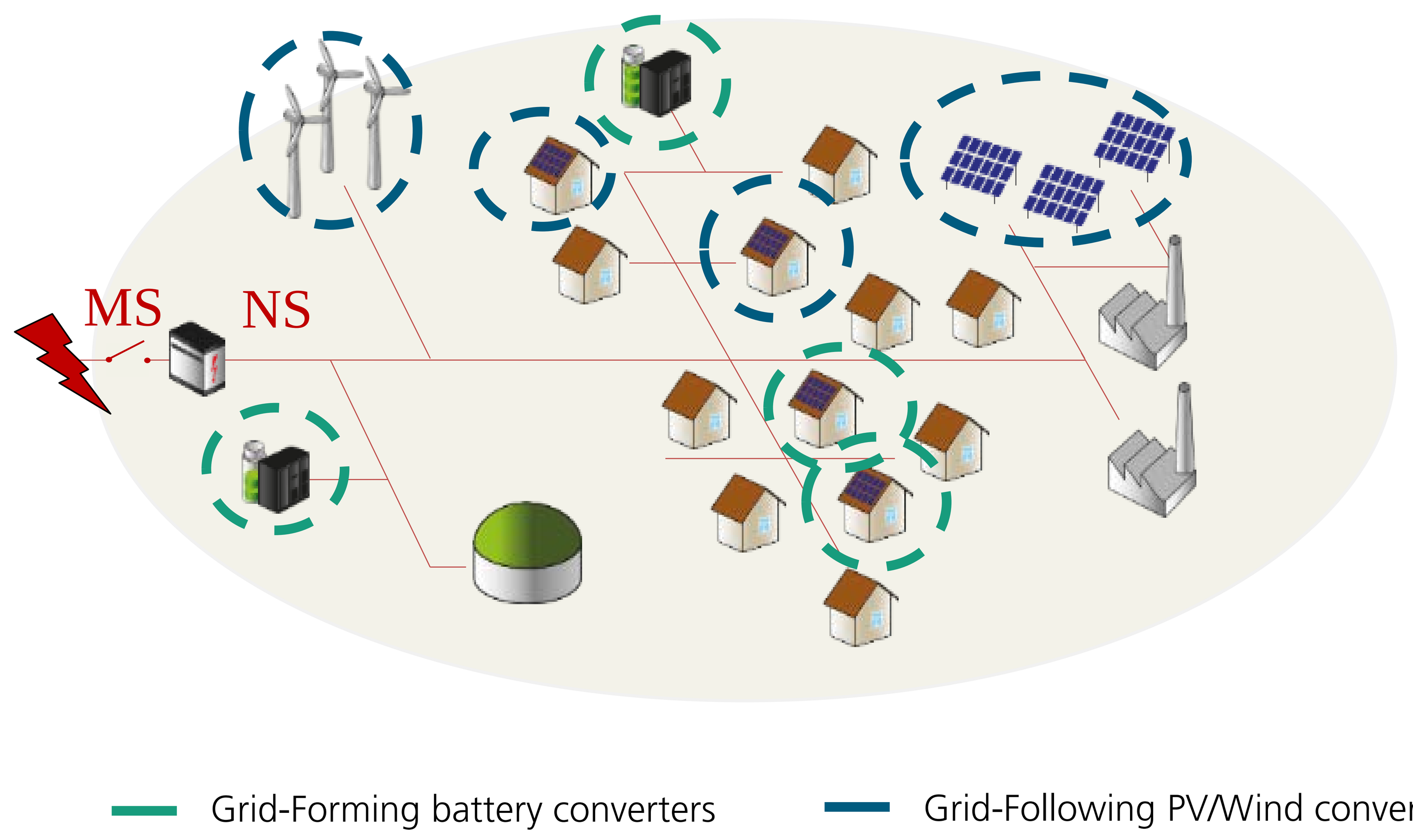


Figure 1: Future microgrid in islanding operation (disconnected from power grid), characterized by state of the art converter coupled PV and wind generators as well as novel grid-forming battery converters.

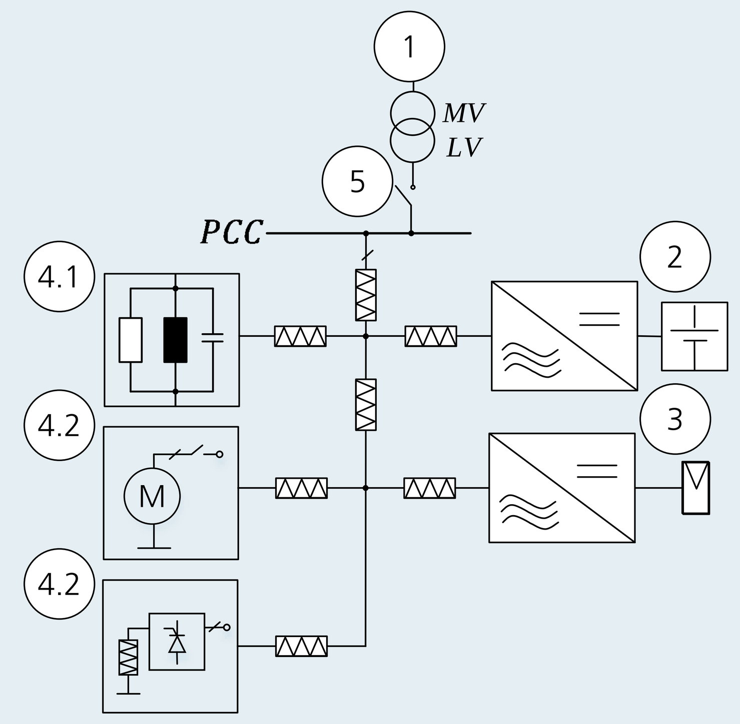
AIsland project goals

- Development of a ML-based islanding detection method (minimally invasive) for grid-forming power converters.
- Based on already included measurements, without the need for additional hardware requirements.
- Enabling detection of unintended islanding in microgrids with a significant amount of distributed grid-forming capabilities.
- Creation of a simulation-based dataset for islanded microgrids with decentralized distributed grid-forming power converters.

Simulation model and ML results

Figure 2: Microgrid simulation model[1] (simplified illustration)

1. Medium voltage grid model
2. Grid-forming converter models
3. Grid-following converter models
4. Load models
   (4.1 linear, 4.2 non linear)
5. PCC switch (for islanding)



Considered machine learning methods and results:

- LSTM (Long short-term memory) – Accuracy 99.59%.
- XGBoost (eXtreme gradient boosting) – Accuracy 99.54%.

Detailed analysis of LSTM performance

- False cases: grid tied operation (PCC switch closed).
  - Additional difficulty due to dynamic system events based on the components 1 – 4.
- True cases: islanding operation (PCC switch opened).
  - Dynamic islanding through opening of PCC switch.

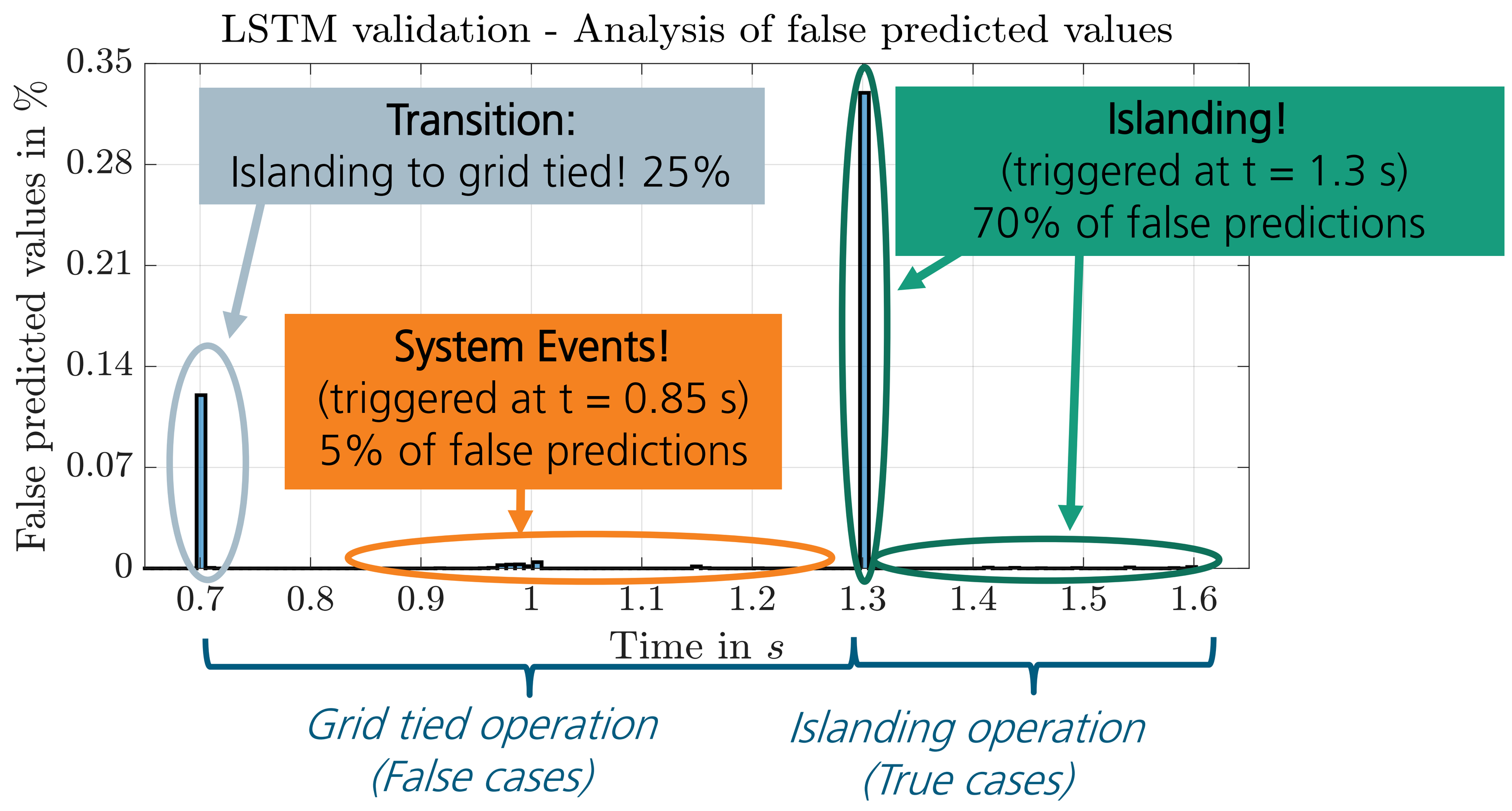


Figure 3: Analysis of false predicted values using LSTM for islanding detection for 1640 randomly initialized simulations with a total data set size of 103.377.400 time values. Dynamic system events at t = 0.85 s based on the components 1 – 4, Islanding at t = 1.3 s (closing of PCC switch).

- Very high accuracy (99.59%) in time-based correct prediction of grid tied/ islanding operation
- Very fast islanding detection (~6 ms)[2]
- Small system size of 5 MB, compared to XGBoost with a system size of 1 GB

1. S. Papathanassiou, N. Hatziargyriou, K. Strunz, "A Benchmark Low Voltage Microgrid Network," Proceedings of the CIGRE Symposium: Power Systems with Dispersed Generation, Apr. 2005

2. Compared to the maximum required islanding detection time of up to 2 s in German grid standards VDE-AR-N 4105 and VDE-AR-N 4110.

Supported by:

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Hessisches Ministerium für Wissenschaft und Kunst

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