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DETAILED ANALYSIS OF NETWORK LOSSES IN A MILLION CUSTOMER DISTRIBUTION GRID WITH HIGH PENETRATION OF DISTRIBUTED GENERATION

Fraunhofer IWES

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Wolfram Heckmann, Heike Barth, Johannes Dasenbrock, Chenjie Ma,
Thorsten Reimann, Alexander Scheidler (Fraunhofer IWES)
Lucas Hamann (E.ON Hanse AG)
Martin Braun (Fraunhofer IWES & University of Kassel)

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Agenda

- Efficiency and regulation
- The investigated distribution grid
- Combined method for determination of grid losses
- Results
  - Losses per grid level
  - Influence of distributed generation (DG)
  - Influence of reactive power provision

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Efficiency and Regulation

- main part of losses occurs on distribution level
- ranging from 2.3% to 11.8% in European countries
- definition of losses is not harmonized

- actual losses considered for yardstick regulation
  - "in the long run" controllable costs
  - definition based on energy input or output?
  - considering DG penetration and coverage?

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Distribution Grid in North of Germany

- 1.4 million residents
- about 130 HV/MV substations
- about 14000 MV/LV substations
- line length MV: 17500 km
- line length LV: 32800 km
- peak power: 4100 MW

- Installed DG in 2011
  - 2500 MW wind
  - 700 MW PV
  - 300 MW biomass

- expected in 2020
  - 7000 MW wind

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Combined Method for Determination of Grid Losses - Challenges

- Loss calculation based on technical data only
  - Consumption, generation, grid structure
- Load flow calculations bottom-up
  - from LV to HV to fully account for reverse power flow
  - 1 year, 15 min intervals
- Dealing with restrictions in availability of digitalized data (mainly on LV level)
  - LV grids modeled as categorized building blocks

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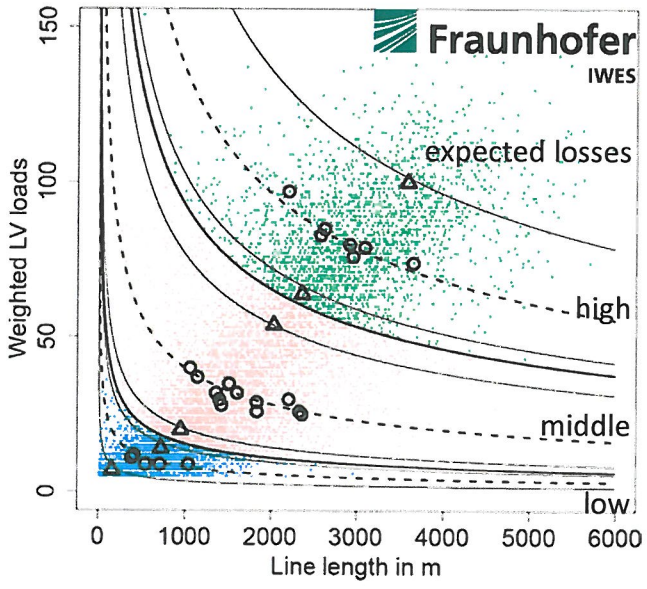
Combined Method for Determination of Grid Losses – LV Model

- Categorized building blocks
  - Statistical analysis of GIS and metering data
  - Different load and DG generation patterns
  - Building blocks representing classes of grids with similar
    - impedance
    - DG penetration
    - load profile



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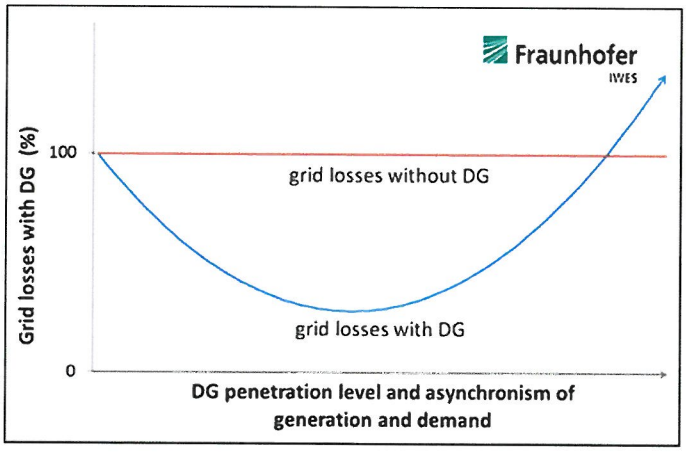
General influence of DG

- in the beginning DG reduces grid losses
- with high DG penetration this effect can be reversed
- local synchronism of generation and demand is important



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Losses per Grid Level

Grid levels	northern Germany	France [ERDF CIRED 2009]
HV/MV substations	10%	17%
MV grid level	34%	28%
MV/LV substations	14%	36%
LV grid level	42%	14%
others		5%

- The differences emphasize the importance of individual analysis.
- Details of losses in transformer stations
  - HV/MV: 58% iron losses
  - MV/LV: 79% iron losses

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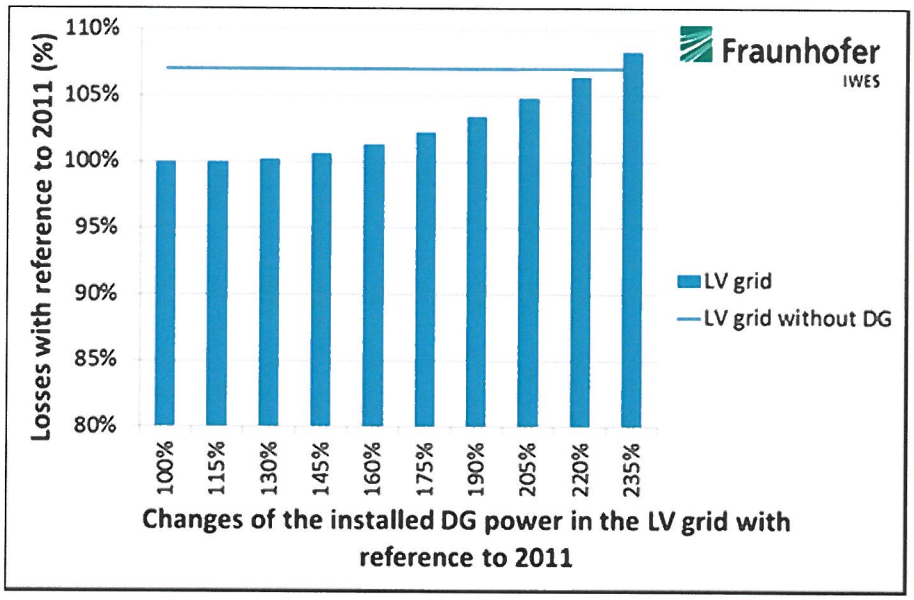
Grid Losses and DG Penetration – LV level



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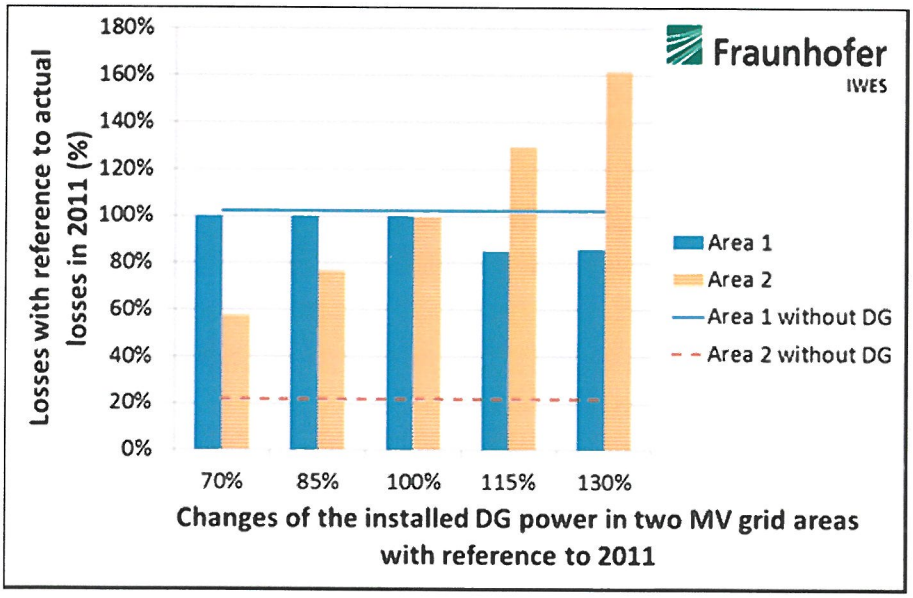
Grid Losses and DG Penetration – 2 MV Examples



Grid Losses and Reactive Power Provision

Reactive power provision concept	Area 1	Area 2
cosφ = const.	100%	100%
cosφ (P)	85%	103%

- The influence of the power provision concept is visible.
- The loss optimized concept depends on the grid and generation structure.

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Conclusions

- Losses have to be determined per grid level for regulation and the allocation of efficiency efforts.
- Harmonized definitions of losses and benchmarks considering DG are needed.
- Introduction of a combined method of modeling and power flow calculation from LV to HV level.
- Grid losses per voltage level are determined with increased preciseness.
- Enables a good understanding about future developments.
- DG penetration and reactive power provision play a major part.

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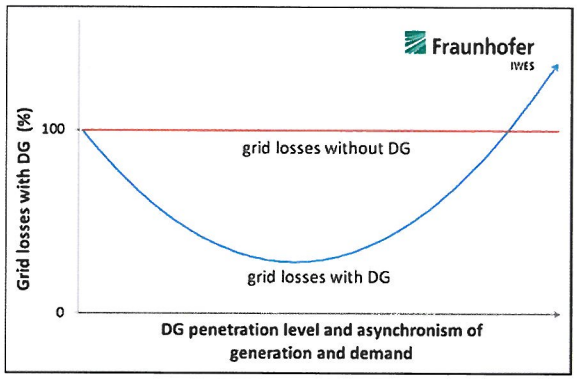
Detailed analysis of network losses with high penetration of distributed generation



Fraunhofer
IWES

Wolfram Heckmann

wolfram.heckmann@iwes.fraunhofer.de

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