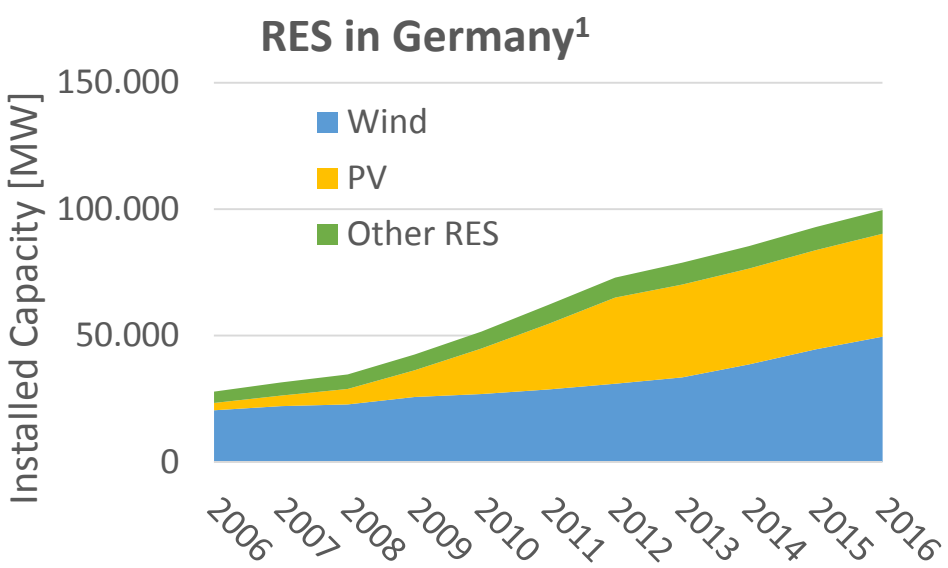
DER INTEGRATION STUDY FOR THE GERMAN STATE OF HESSE

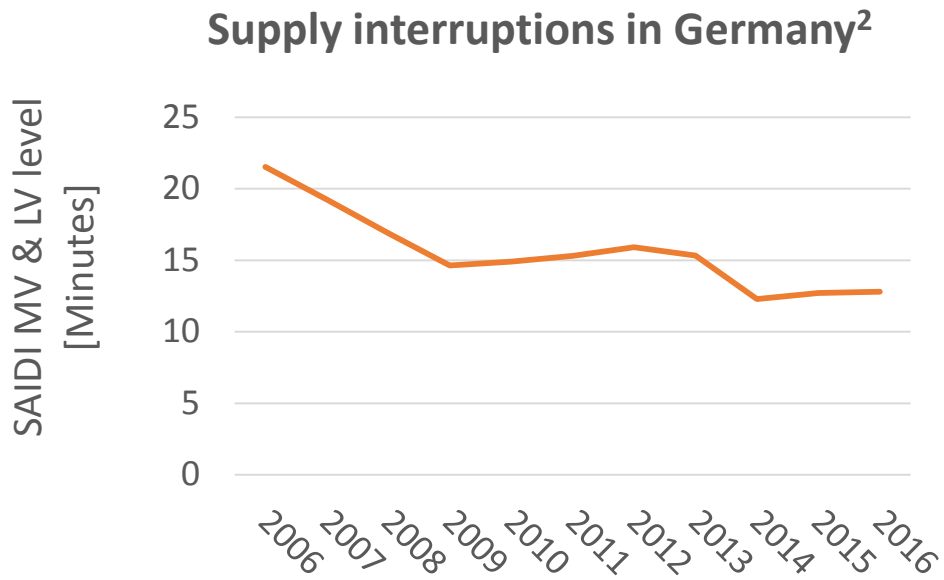
M. Kraiczy, A. Scheidler, J. Ulffers, M. Braun

Wind and PV integration in Germany

Challenges and Status

- Variable and distributed renewables (Wind and PV) are the key elements of the German energy transition → ~88% of Wind and 100% of PV capacity are connected to the distribution level[1]*
- Energy transition torwards renewables does not seem to have a negative impact on the quality of supply in Germany





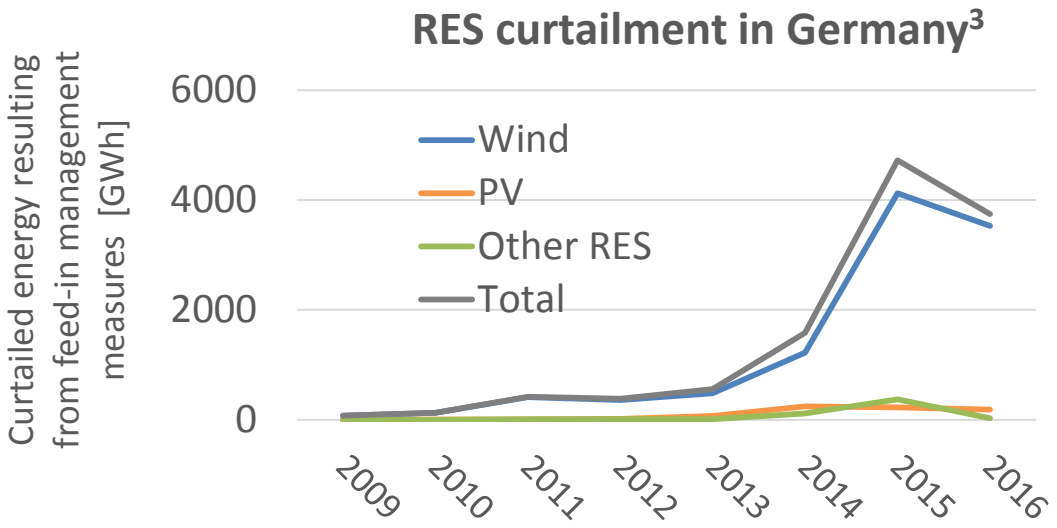
[1] RES capacity entitled to payments under the EEG (Renewable source act). Data source Bundesnetzagentur: EEG in Zahlen 2016
[2] Supply interuption under section 52 Energy Industry act. Data source: Bundesnetzagentur: Monitoringbericht 2017
* In Germany, also the HV level is mainly considered as part of the distribution level.

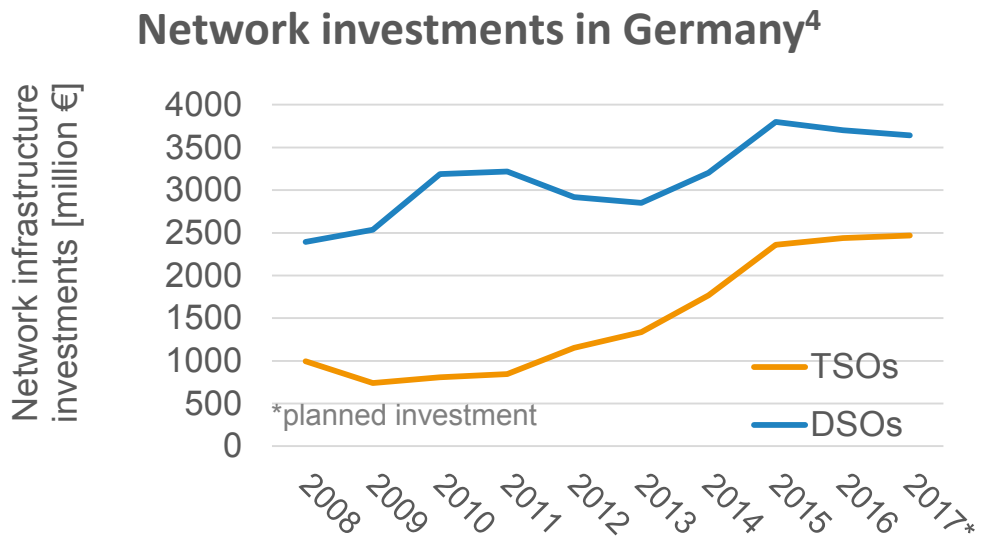
Fraunhofer IEE

Wind and PV integration in Germany

Challenges and Status

- Increased need for RES curtailment to resolve tense network situations
- Expansion of power transfer capacities (i.e. stronger north-south corridor interconnection) require additional investments at the transmission level
- Prospectively, higher investments at the distribution level expected, to achieve higher DER penetration (i.e. Wind and PV) and integrate new consumers (i.e. EV)





[3] Curtailed energy resulting from feed-in management measures. Data source Bundesnetzagentur: EEG in Zahlen 2016
[4] Data source: Bundesnetzagentur: Monitoringbericht 2017

Fraunhofer IEE

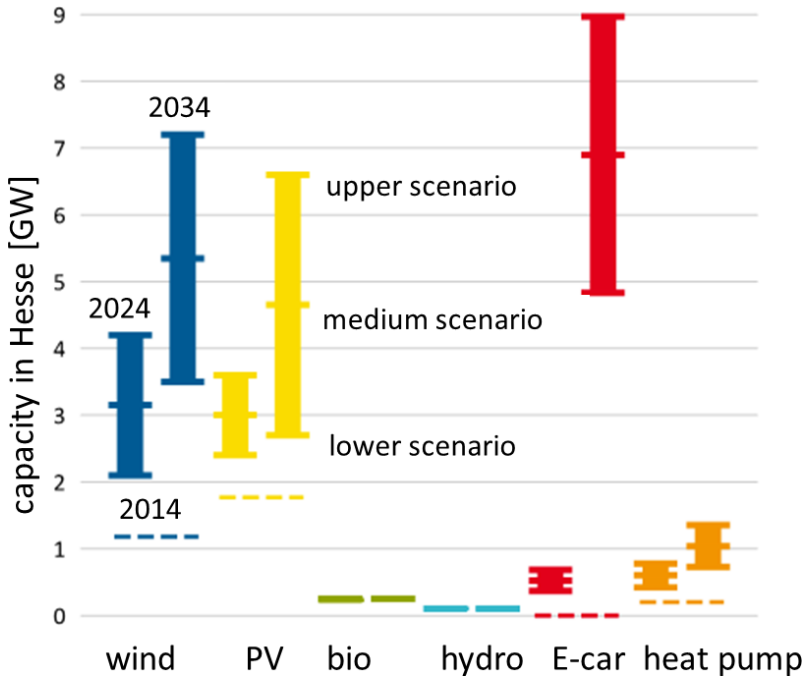
Wind and PV integration in Germany

Grid integration studies

- High importance of grid integration studies due to dynamic future development of DER and new consumers

- Key goals of integration studies:
  - Design of likely scenarios for future DER and consumer development
  - Assessment of investment cost for necessary grid reinforcement and expansion measures
  - Identification of key technologies that can contribute to lower investment cost
  - Technical, political and regulatory recommendations

Scenarios of the Hessian grid integrations study[5]



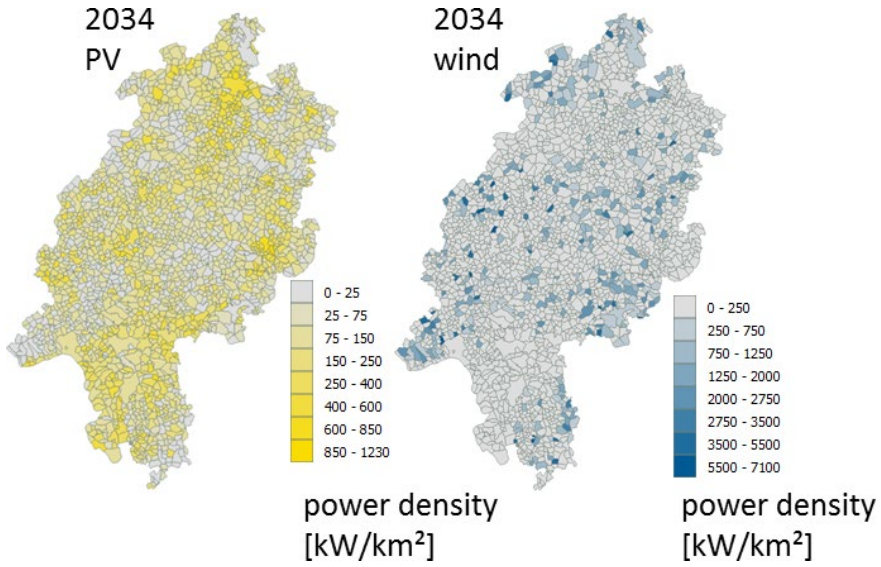
[5] reprinted [translated] from: Verteilnetzstudie Hessen 2024 - 2034

Wind and PV integration in Germany

DER** integration study for the German state of Hesse

- German state of Hesse: 6% of Germany‘s area and 7% of Germany‘s population
- The study investigates reinforcement and expansion cost of Hessian distribution grids* until 2034
- Innovation highlights:
  - High spatial resolution for future scenarios
  - Analysis and calculation of only real grids in large numbers (>700) at all voltage levels
  - Probabilistic grid calculations for a large number of possible grid configurations
  - Spatial extrapolation by regression models
  - Comparability of conventional and innovative measures established by detailed cost models
  - High generalizability of results through harmonized planning premises and assessment procedures at the distribution level

Power density distribution of PV and wind plants in Hesse[6]



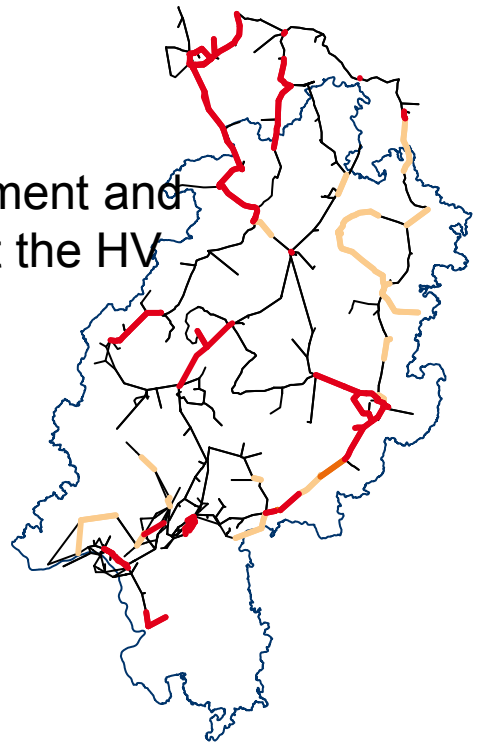
* In Germany, also the HV level is mainly considered as part of the distribution level.
** The term DER is used for electric energy resources and controllable loads connected to the distribution level.
[6] reprinted [translated] from: Verteilnetzstudie Hessen 2024 - 2034

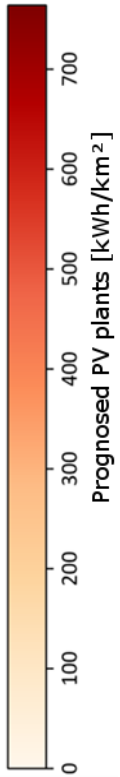
Fraunhofer IEE

Wind and PV integration in Germany

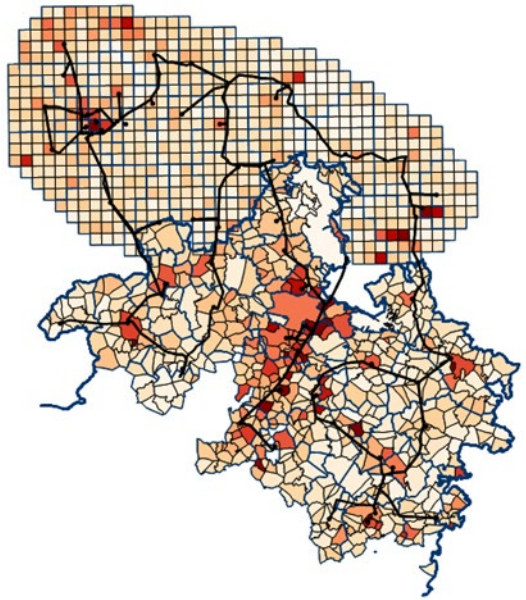
DER integration study for the German state of Hesse – HV results

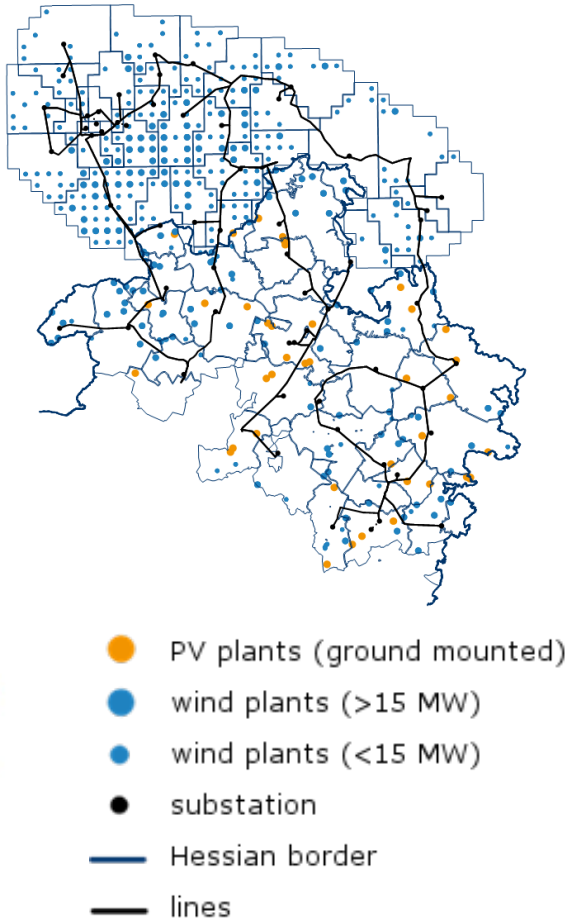
- A high penetration of PV and wind plants in northern Hesse contributes to voltage violations and line overloadings
- This requires reinforcement and expansion measures at the HV level until 2034





Prognosed PV and wind plants in northern Hesse[7]





[7] reprinted [translated] from: Verteilnetzstudie Hessen 2024 - 2034

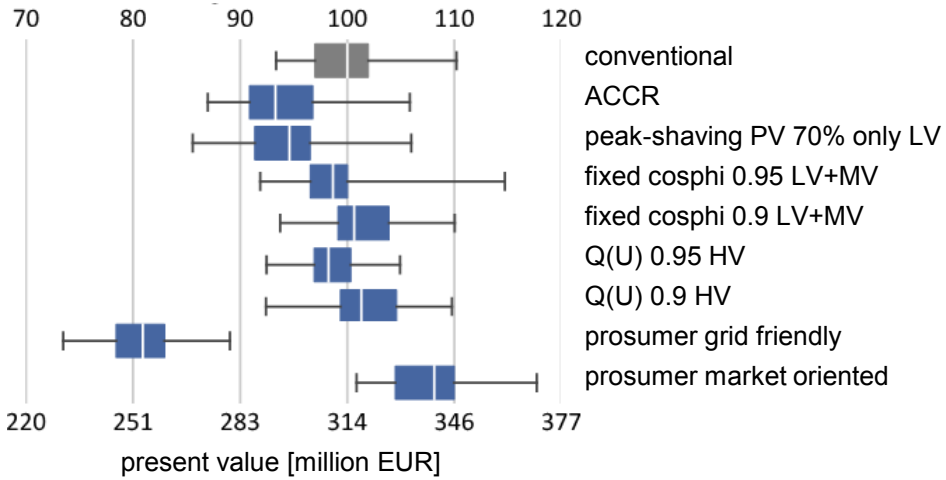
Fraunhofer IEE

Wind and PV integration in Germany

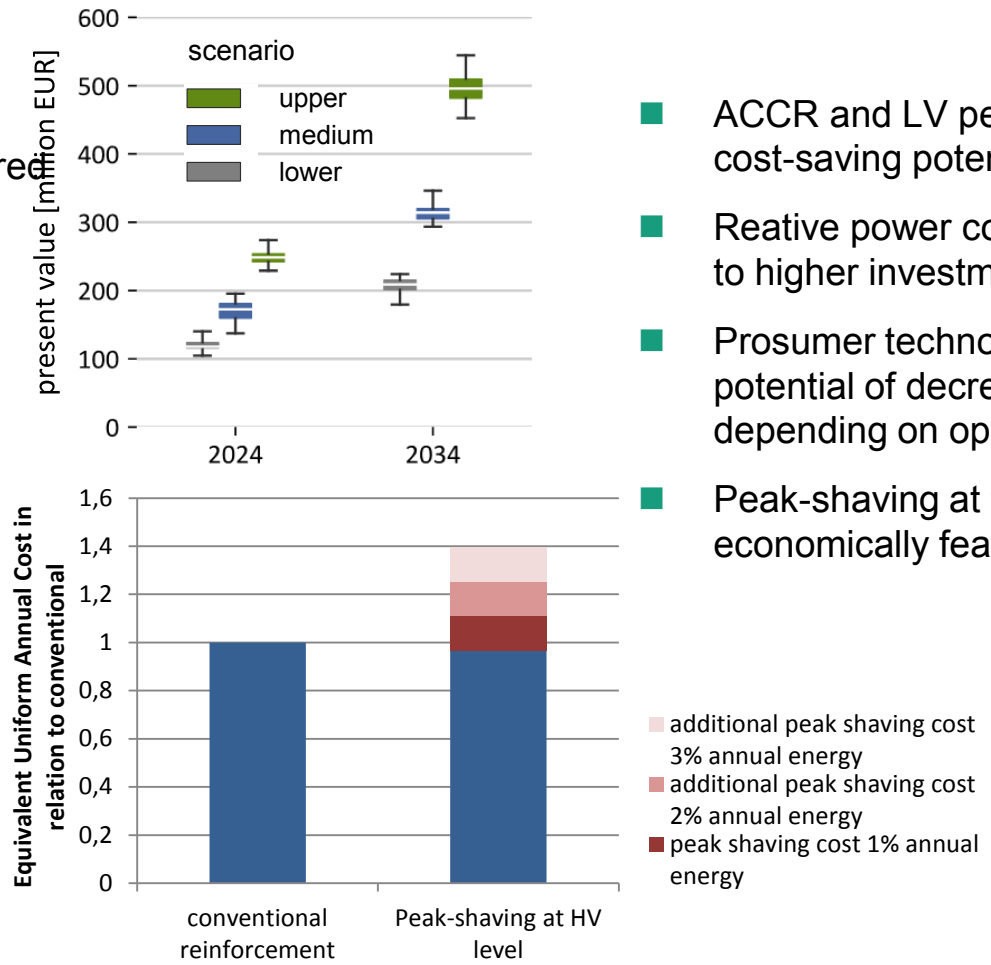
DER integration study for the German state of Hesse – HV results

- The investment cost at the HV level amount to 170 million EUR (2024) resp. 314 million EUR (2034) for the medium scenario
- 2034 the spread between the scenarios increases compared to 2024

Effects of innovative technologies at the HV level[9]



Reinforcement/expansion cost at the HV level[10]



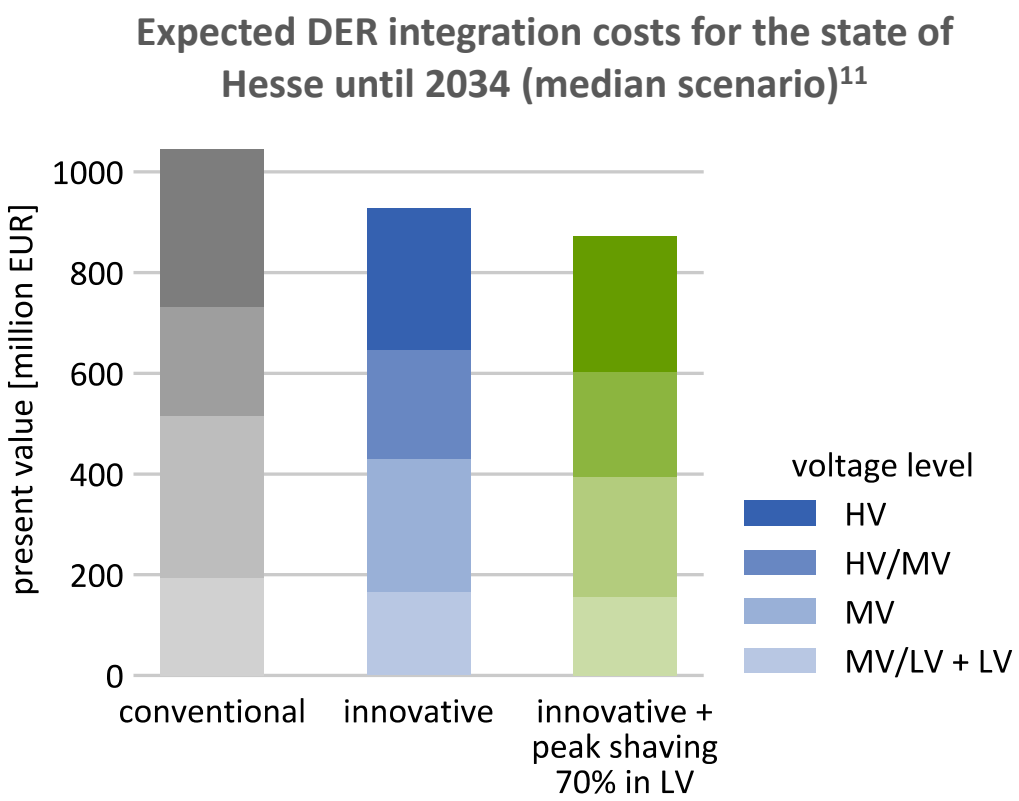
- ACCR and LV peak-shaving show highest cost-saving potential
- Reative power control methods can lead to higher investment cost
- Prosumer technologies have high potential of decreasing/increasing cost depending on operational behaviour
- Peak-shaving at the HV level is not economically feasible

[9,10] reprinted [translated] from: Verteilnetzstudie Hessen 2024 - 2034

Fraunhofer IEE

Wind and PV integration in Germany

DER integration study for the German state of Hesse – summary of results



- Until 2034 grid expansion cost of around **1 billion EUR** are expected in total LV, MV and HV level if grid expansion is limited to **conventional** technologies and planning approaches
- **Innovative technologies**, i.e. smart LV transformers, DER volt-var control, advanced HV/MV transformer tap control and high-temperature conductors, can **decrease grid investment costs by around 11%** until 2034
- **PV peak power limitation** in the LV level can reduce the grid investments costs cumulative for the LV, MV and HV level **additionally by 6%.**
- **High risks and cost saving potentials of prosumer technologies** highlights the importance of **coordination** between local, regional and system-wide needs for flexibilities and ancillary services by DER, which requires an **advanced cooperation between Transmission and Distribution grid operation.**

[11] reprinted [translated] from: Verteilnetzstudie Hessen 2024 - 2034