Institute for Advanced Sustainability Studies
IASS in Potsdam

Integration of distributed energy resources into the grid
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Results from an interview series with German distribution grid operators

Coimbra, November 2016

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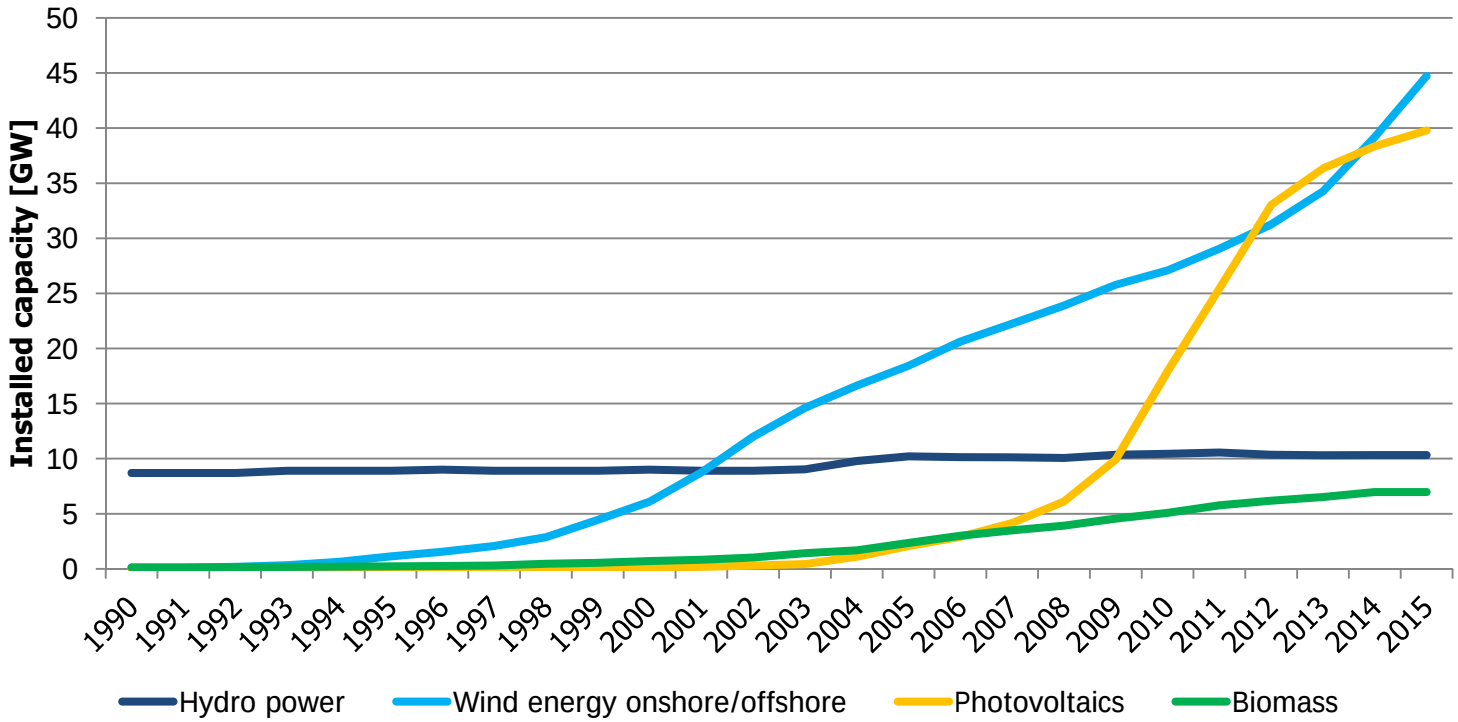
Content

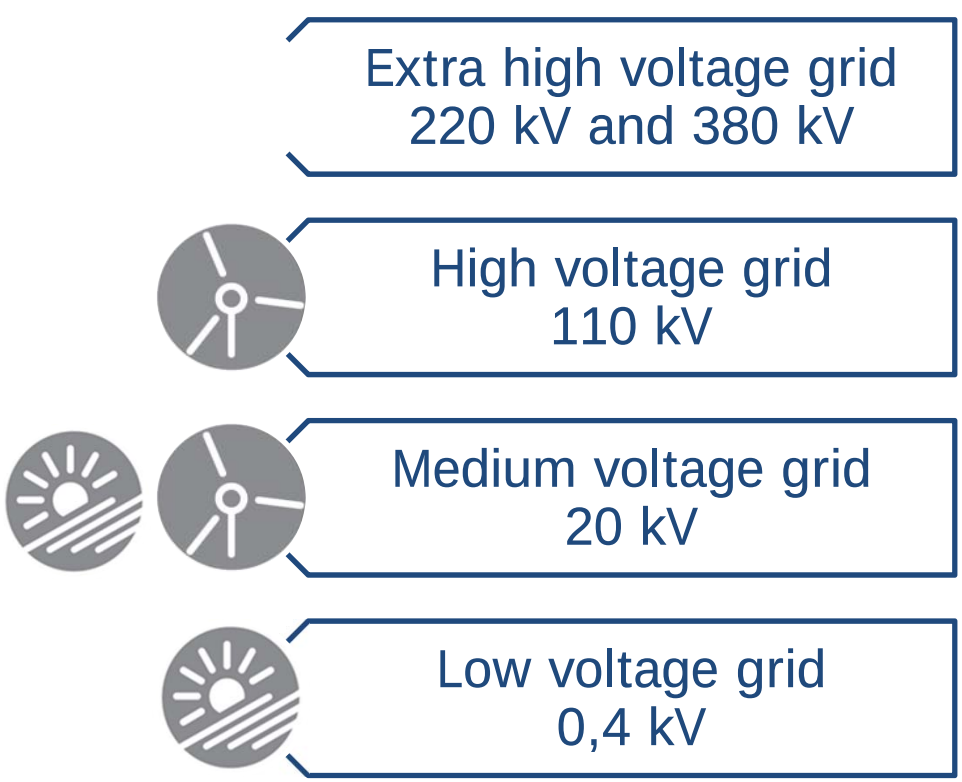
1. Basic information on renewables in Germany
2. Integration of photovoltaics in the low voltage grid
3. Regulatory framework for distribution grid operators

Basic information on renewables in Germany

Development of renewable energies in Germany

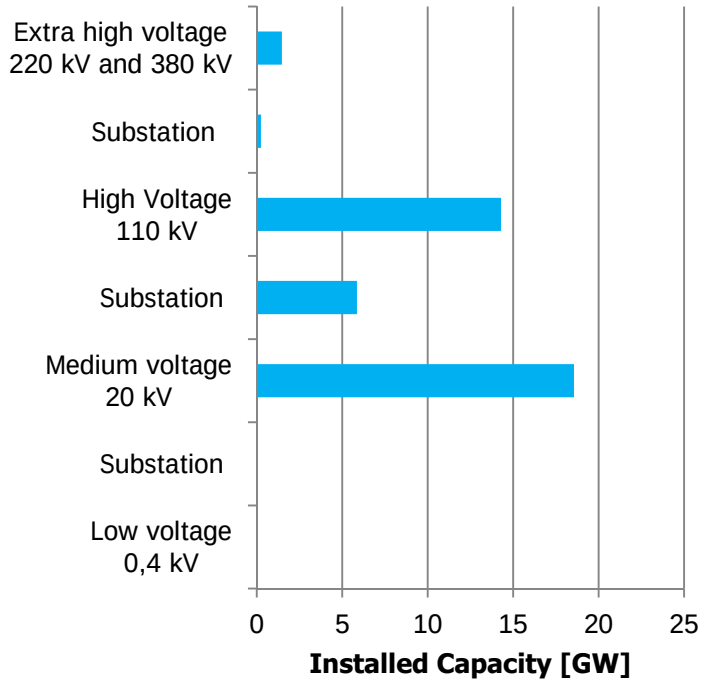


Structure of the electric grid

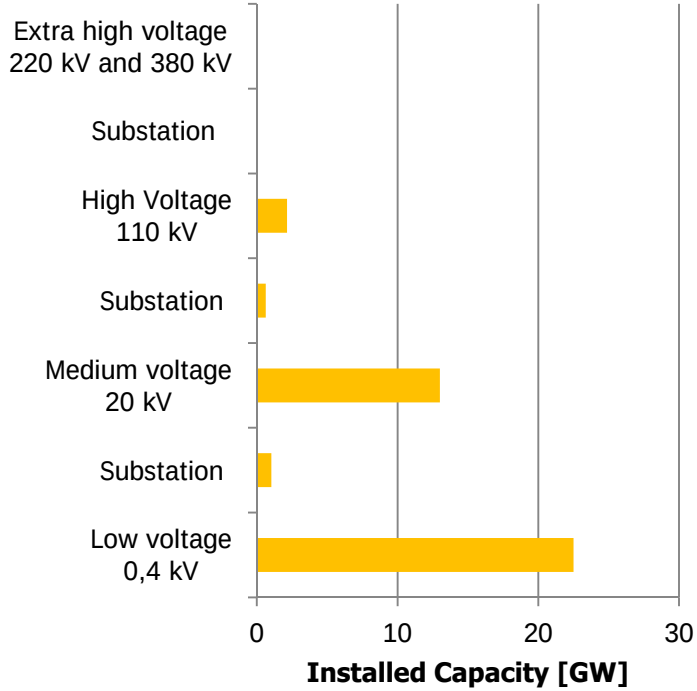


Grid connection of wind energy and photovoltaics

Wind energy

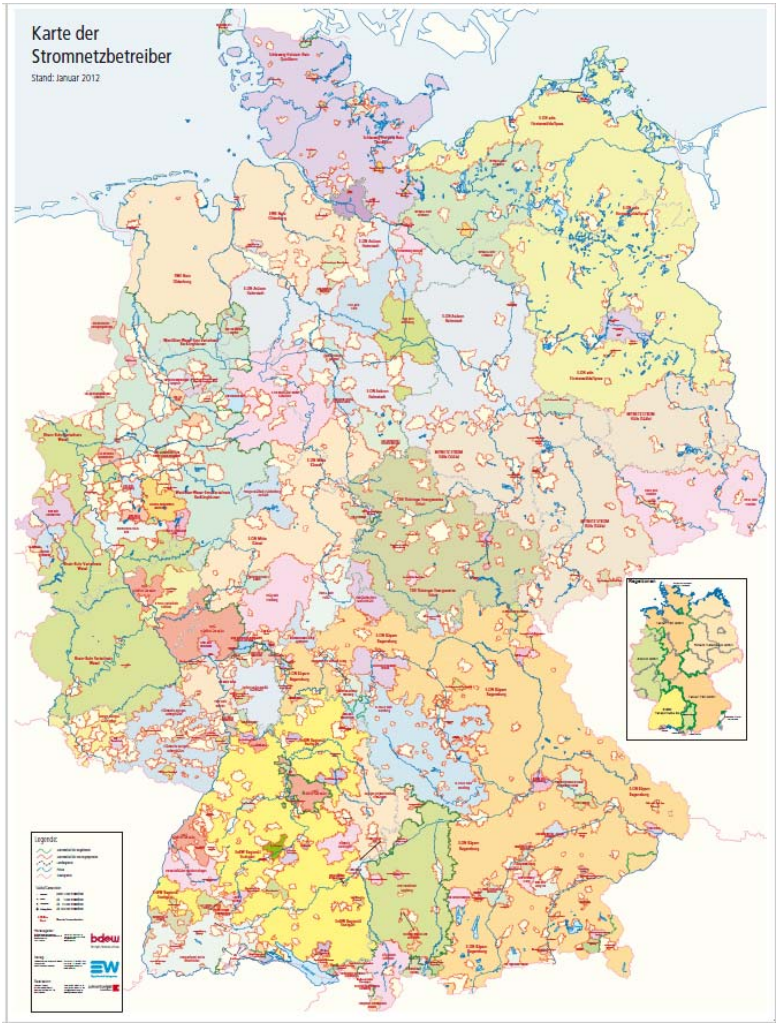


Photovoltaics



Distribution system operators

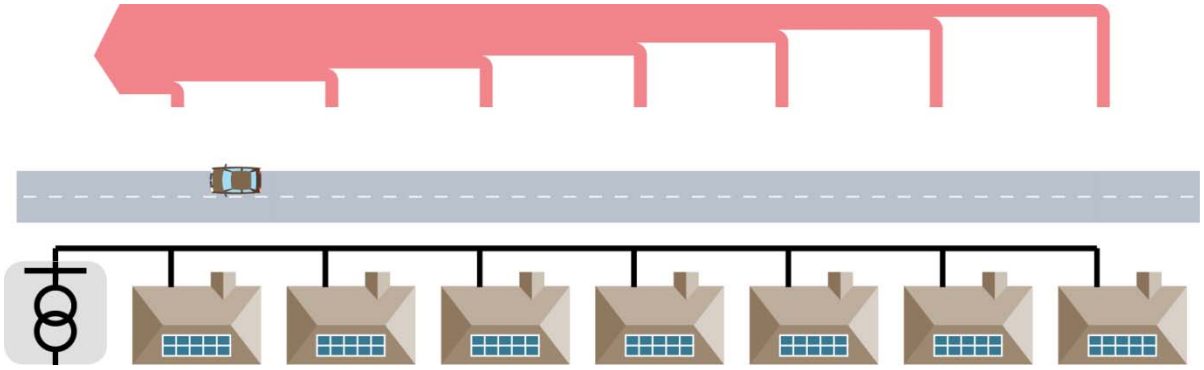
- 881 DSOs operate the low, medium and high voltage grid
- We conducted 10 interviews with the largest DSOs



Integration of photovoltaics into the low voltage grid

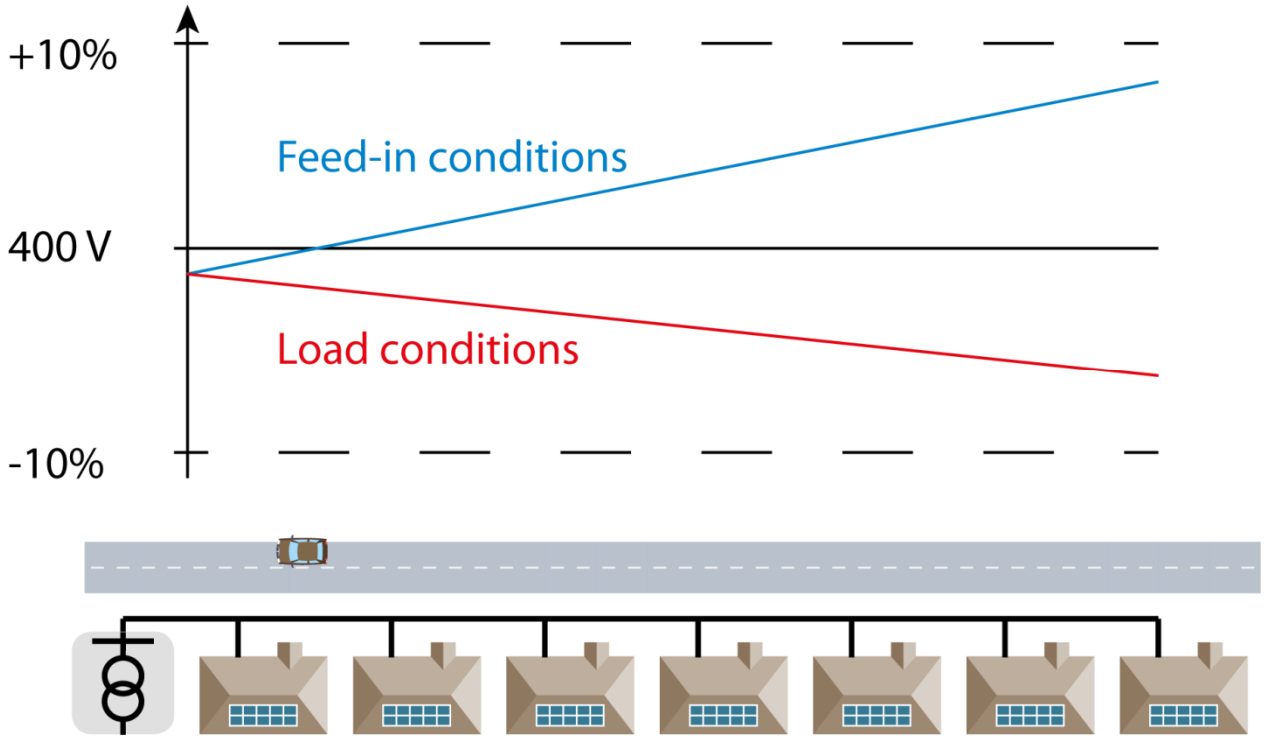
Impact of PV systems on amperage

- Reverse flow may exceed power rating of transformers and cables



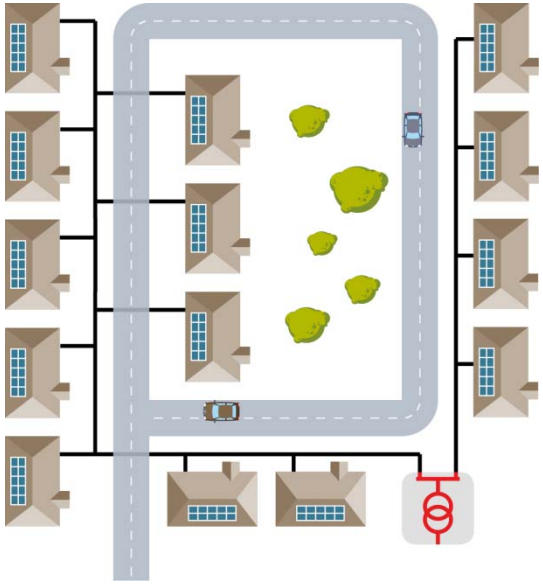
Impact of PV systems on voltage

- Voltage may exceed the upper 10% limit

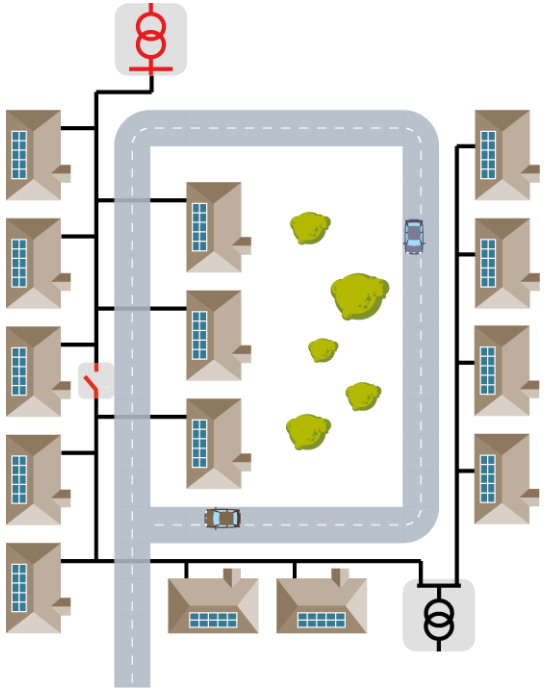


Classic solutions

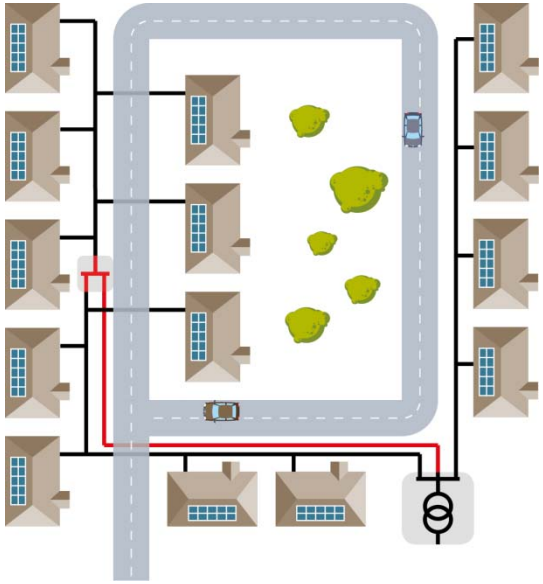
Replace transformer



Install additional transformer(s)

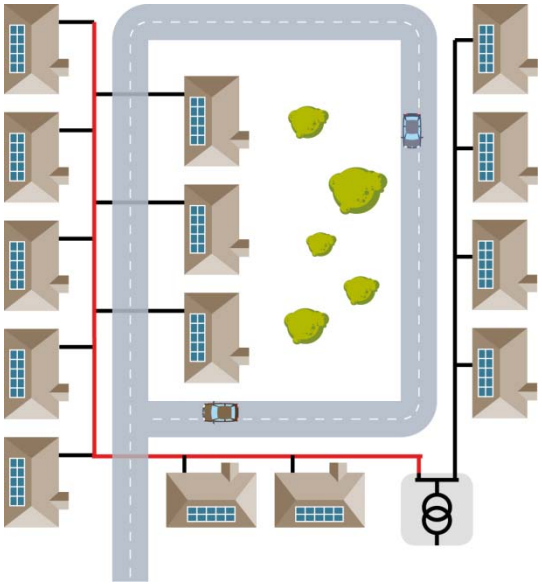


Lay parallel cable(s)

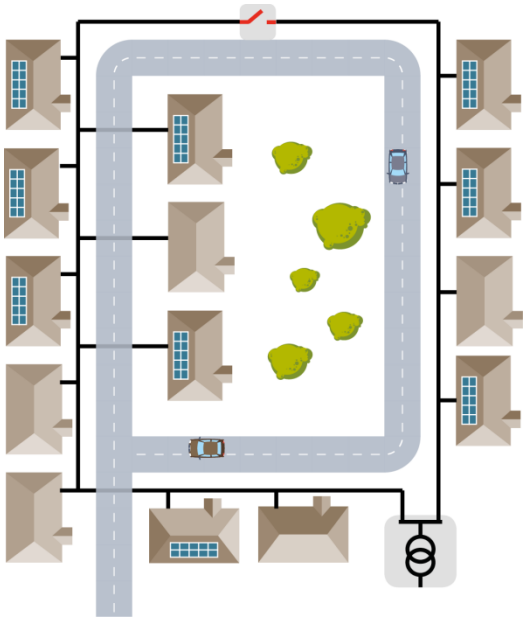


Classic solutions

Replace cable(s)



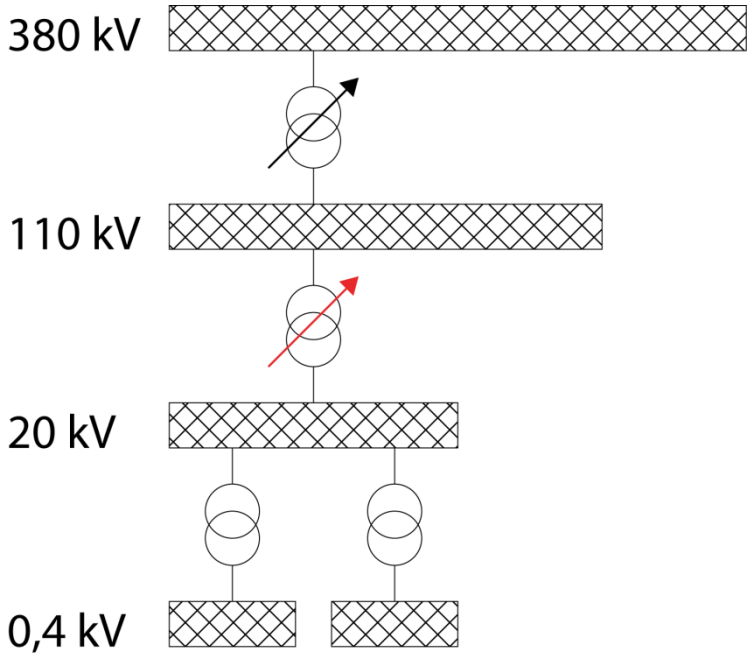
Change grid topology



Innovative solutions

Wide area control

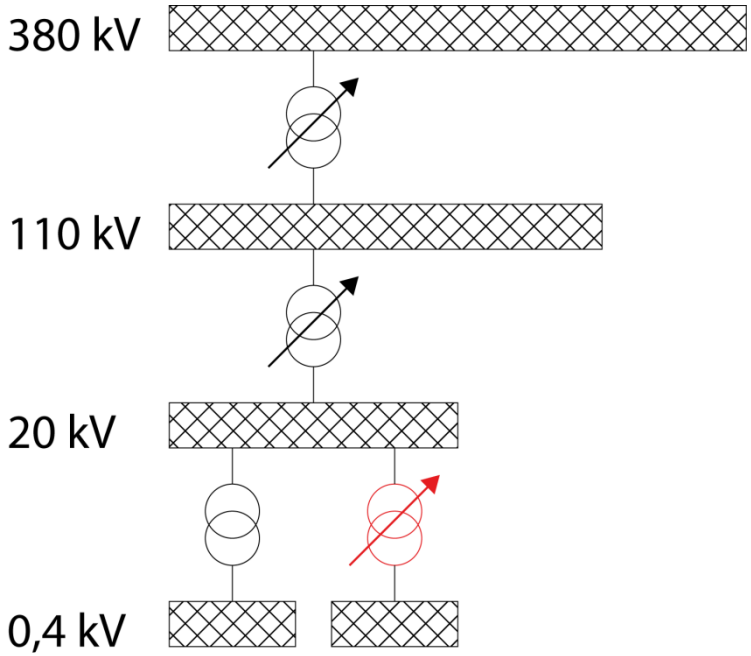
- Actively control the voltage at the 20/100 kV substation
- Control algorithms also includes current generation from distributed energy resources



Innovative solutions

Variable distribution transformers

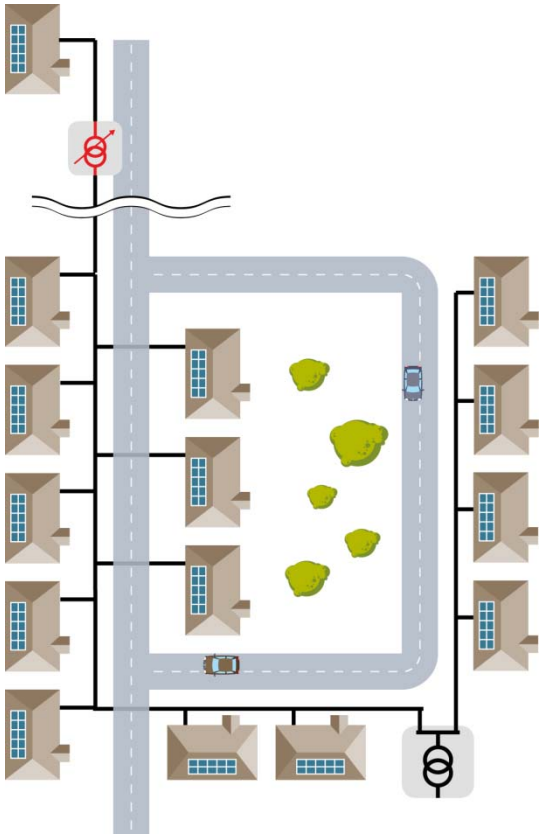
- Substitute classic transformers with variable transformers
- Voltage of low voltage grid can be controlled individually



Innovative solutions

Booster

- Variable transformer that can increase/reduce voltage
- So far only pilot projects implemented in Germany
- Boosters may be an efficient solution for long distribution lines



Innovative solutions

Reactive power feeding

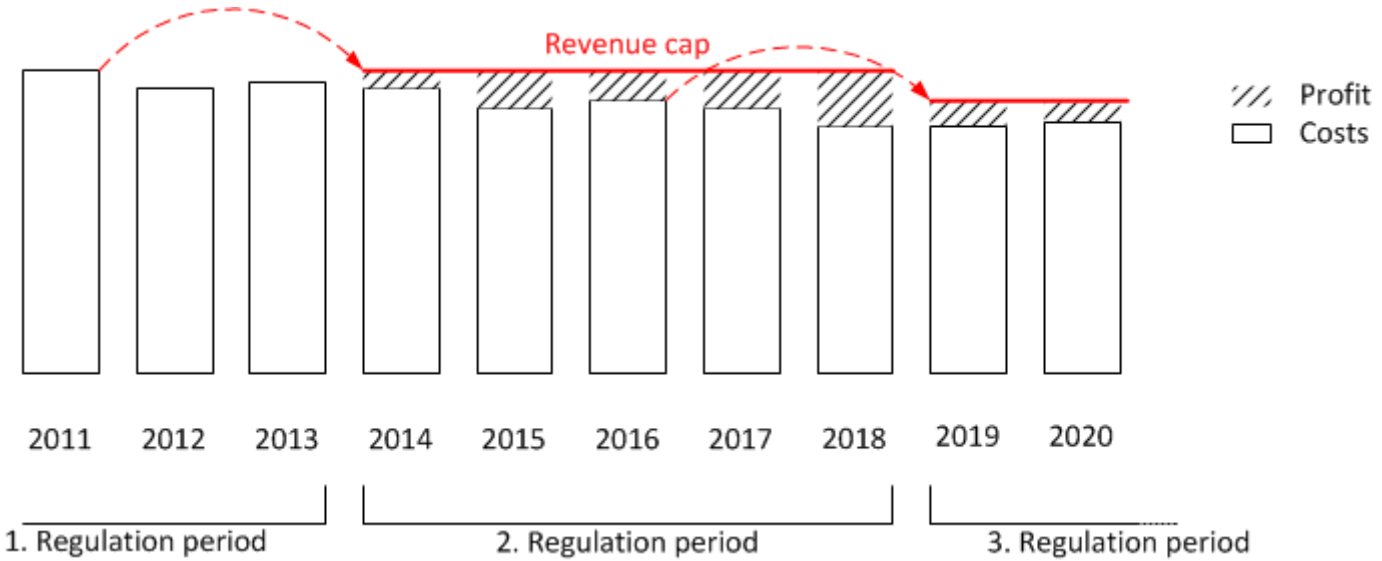
- Reactive power can reduce voltage
- PV inverters are required to generate a certain amount of reactive power

Germany’s incentive-based regulation

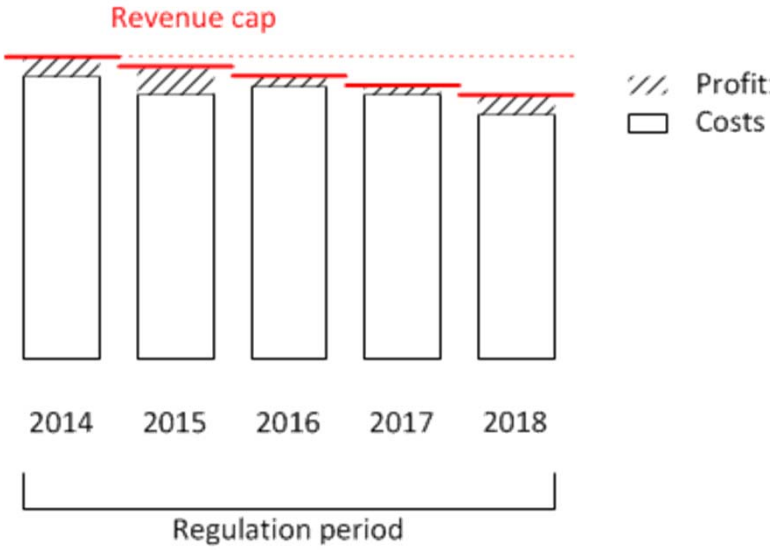
Germany’s incentive-based regulation

- Germany’s regulator determines a revenue cap (budget) for each operator.
- This revenue cap is primarily based on past costs of grid operators.
- Grid operators calculate the grid fees according to the revenue cap.
- The regulator established two inventive mechanisms to keep costs low.

Incentives through budget approach



Incentives through efficiency comparison



Incentives for innovative solutions?

- Germany's incentive-based regulation is technology neutral.
- Grid operators could implement the desired solutions in the past.
- There are no restrictions regarding the use of new technologies.
- Strong incentive for capital intensive solutions as there's an grid operators receive an return on equity of 9%.

Summary and conclusions

- Grid integration of distributed energy is a challenge but there are several technical solutions available.
- Conventional grid extensions were in most cases the most efficient solution.
- In economic terms, grid operators in Germany are not affected negatively by the development of distributed energy resources.

Obrigado pela atenção!

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