On the economic value of electricity distribution networks

- A case study for Germany -

Marius Stankoweit

Nordic Conference on Climate Change Adaptation, Bergen

30 August, 2016

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

GERICS
Climate Service Center Germany

Contextualization

Evaluate climate-change induced risks on the electricity grid:

- What is the actual economic impact of a grid interruption?
- What are the relevant climatic risks? How are they projected to change?

© Fotolia/ Sebastian Seemann

→ Identify grid domains of high economic importance and significant climate-change-induced risks

Research question

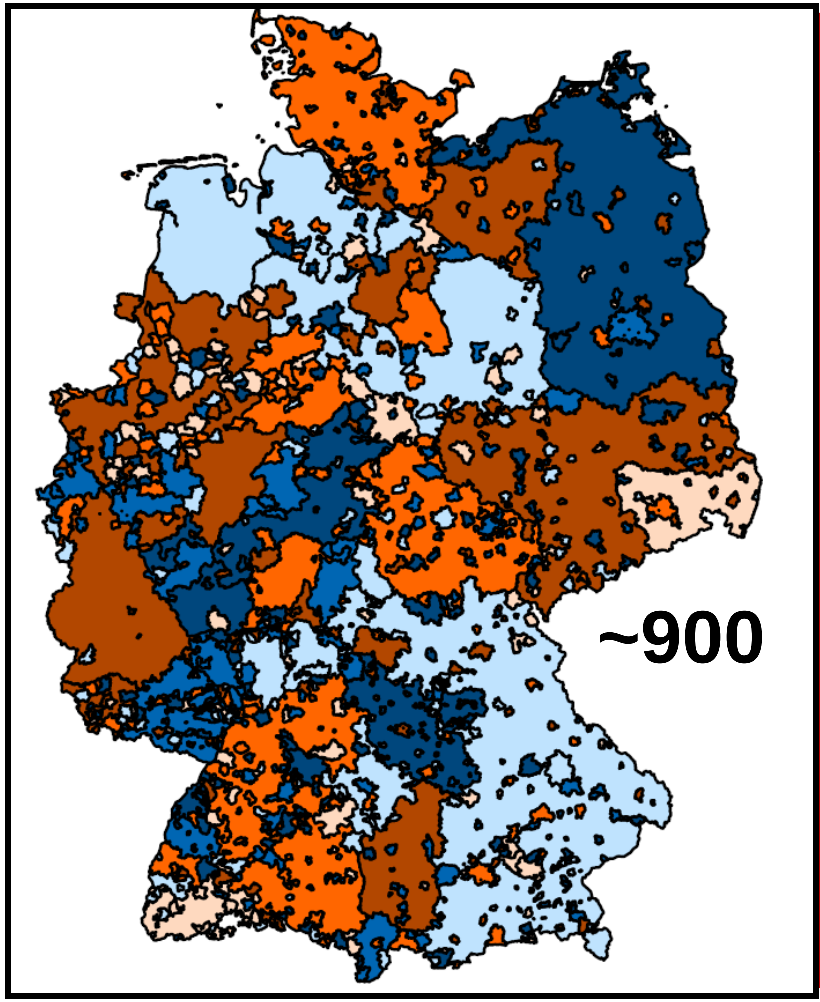
- Important for e.g.:
- water & food supply
- health services
- economic activity

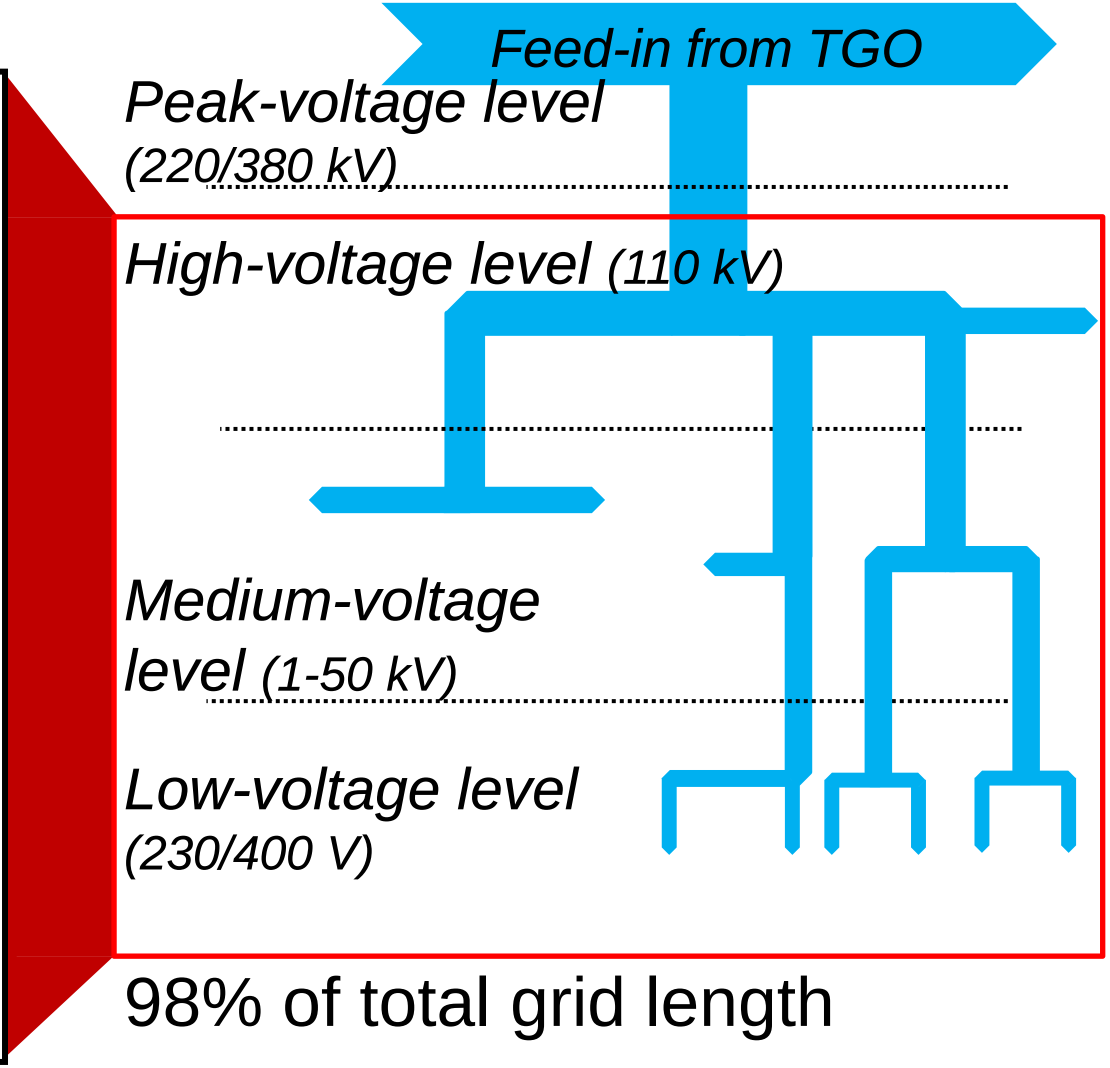
© Fotolia/ Sebastian Seemann

→ **What are the economic costs of an interruption of the electricity grid?**

Electricity grid structure

Distribution Grid Operators (DGO)





98% of total grid length

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

GERICS Climate Service Center Germany

Methodology: Value of Lost Load (VoLL)

Step 1:

- **Value of Lost Load:** Economic costs resulting from a non-delivered kWh of electricity.
- **Methodology**: [Piaszeck et al., 2014]
  → Infer costs from macroeconomic data (indirect approaches)
    - Linear relationship between gross value added (GVA) & electricity consumed (EC):

$$\boldsymbol{VoLL(s,r)} := \frac{\boldsymbol{GVA(s,r)}}{\boldsymbol{EC(s,r)}}$$; sector s, region r

    - Dimension: $[VoLL(s,r)] = \text{€}/kWh$

- **Economic costs from a grid interruption depend on:**
  - voltage level of interruption, since e.g. $VoLL(LV) \neq VoLL(MV)$
  - amount of electricity consumption interrupted

Methodology: Value of Lost Grid (VoLG)

Step 2:

- **Ideally: from €/kWh→ €/interruption**
  → Requires detailed knowledge on actual structure of grid and electricity flow data (not avail.)
- **Proxies to quantify impact of an interruption on consumption:**
  → Annual electricity consumed from a voltage level: $EC(VL)$
  → Length of grid needed to provide that consumption: $L(VL)$

- **Value of Lost Grid (VoLG):**

$$VoLG(VL, DGO) = VoLL(VL, DGO) \cdot \frac{EC(VL, DGO)}{L(VL, DGO)}$$

DGO: Distribution grid operator, VL: voltage level

- **Dimension (VoLG):**

$$[VoLG] = \frac{€}{kWh} \cdot \frac{kWh}{km} = \frac{€}{km}$$

Data

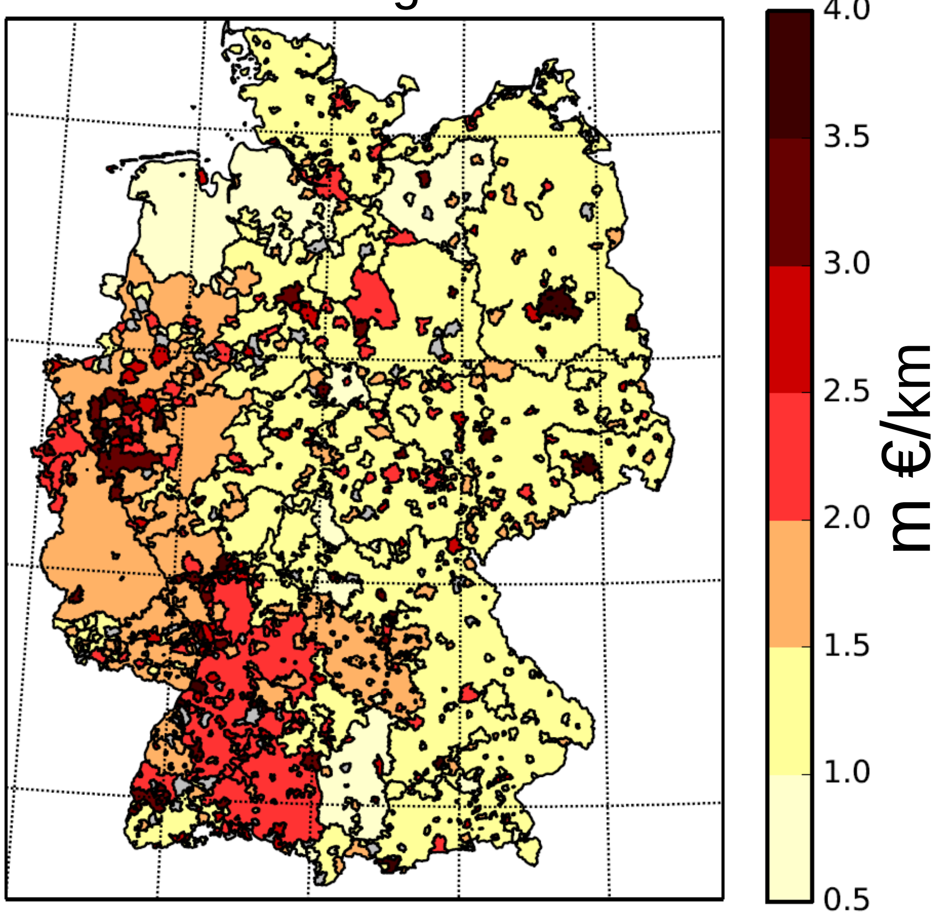
- Federal statistical offices
  - Macroeconomic data (electricity consumption, gross value added)
  - Population data on county on municipal level

- German employment agency
  - Employment data on economic sectors

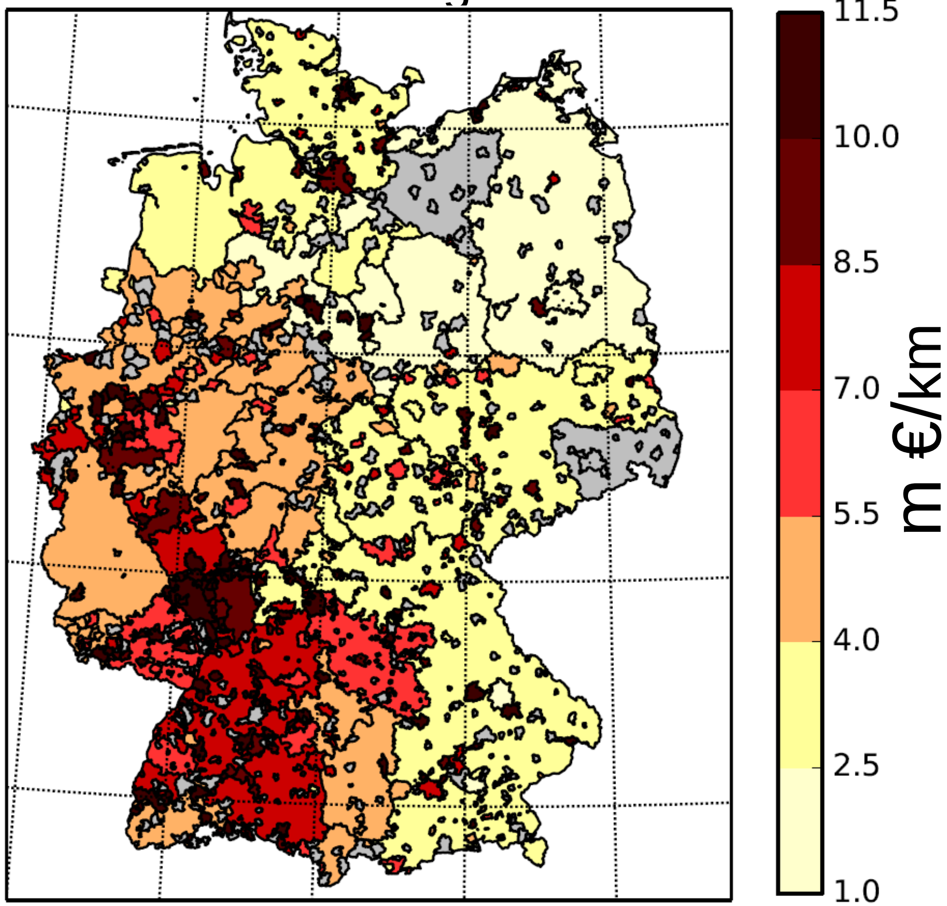
- Distribution grid operators reporting obligations
  - Structural data of grid (electricty consumption from grid levels, grid length)

Results: Value of Lost Grid

Low-voltage level



Medium-voltage level



Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

GERICS Climate Service Center Germany

Results: Value of Lost Grid

- High VoLG-regions similar in both levels: South-West & West

- $|VoLG(LV)| = 3.19 \frac{m\,€}{km}$ $<$ $|VoLG(MV)| = 7.41 \frac{m\,€}{km}$

  → Uninterrupted functioning of medium voltage-level is economically (on average) much more important than low-voltage level

- $\sigma_{rel.}(LV) = 48\ \%$ $\approx$ $\sigma_{rel.}(MV) = 46\ \%$

  → Within one voltage-level: Uninterrupted functioning of grid in certain domains is economically more important than in others

Conclusions

- **Value of Lost Load (VoLL)** concept has little informative power to quantify economic consequences of a grid interruption
  → Proposed methodological advancement (**Value of Lost Grid**):
    - account for difference in VoLLs between different voltage levels
    - account for structural data of grid (annual electricity consumption, grid length)

- **Benefits:**
  - Estimate average economic importance of individual voltage levels of individual distribution grid operators
  - Identify domains whose uninterrupted functioning is economically much more important than in other domains
    → e.g high VoLG-regions in South-West & West of Germany
    → Regional variation in economic importance is probably not a unique characteristic of the German grid

Conclusions

- **Limitations:**
  - Rather simplifying economic assumptions
  - Neglection of complex grid structures

- **Outlook:**
  - Identify relevant climate/weather risks
  - Analyze: Does current capacity of resistance of grid (e.g. share of overhead lines) mirror economic importance and climate/weather risks?

- Thank you! -

Questions?

contact: marius.stankoweit@hzg.de