

Climate Change Influence on Critical Infrastructure

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Topic
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Scientific Evaluation

Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research

January 24, 2018

■ Critical Energy Infrastructure

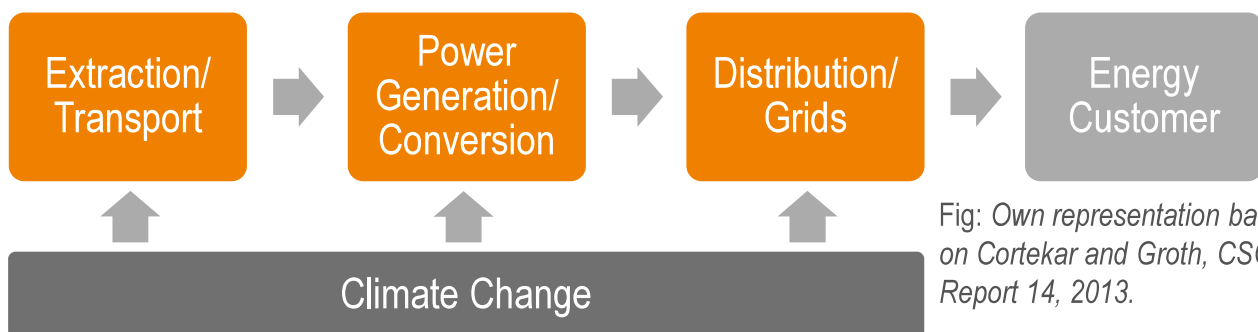
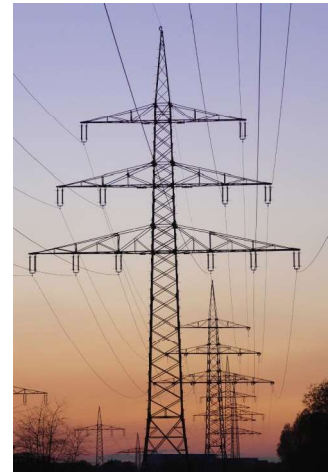


Fig: Own representation based on Cortekar and Groth, CSC Report 14, 2013.

Project Outline

- **Research Question:** What are the risks related to climate change impacts on the electricity grid infrastructure in Germany?
- **Hypothesis:** Risks are locally very different.
- **Tasks:**
 - Weather-induced reasons for grid interruption
 - Vulnerability of grid
 - Economic impacts of grid interruptions
 - Probability changes of potentially hazardous events under climate change



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Weather-induced Reasons for Grid Interruption

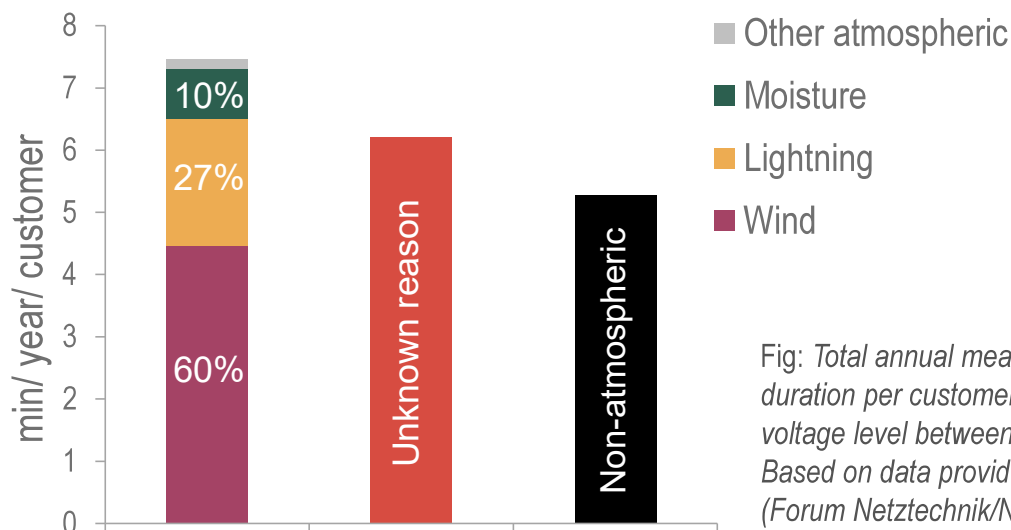


Fig: Total annual mean outage duration per customer in the medium voltage level between 2004-2015; Based on data provided by FNN (Forum Netztechnik/Netzbetrieb)

- Commonly wind does not directly damage the grid, but causes trees to fall on the grid infrastructure [e.g. Ward, D., Climatic Change, 2013]

Vulnerable Part of Grid: Overhead Lines

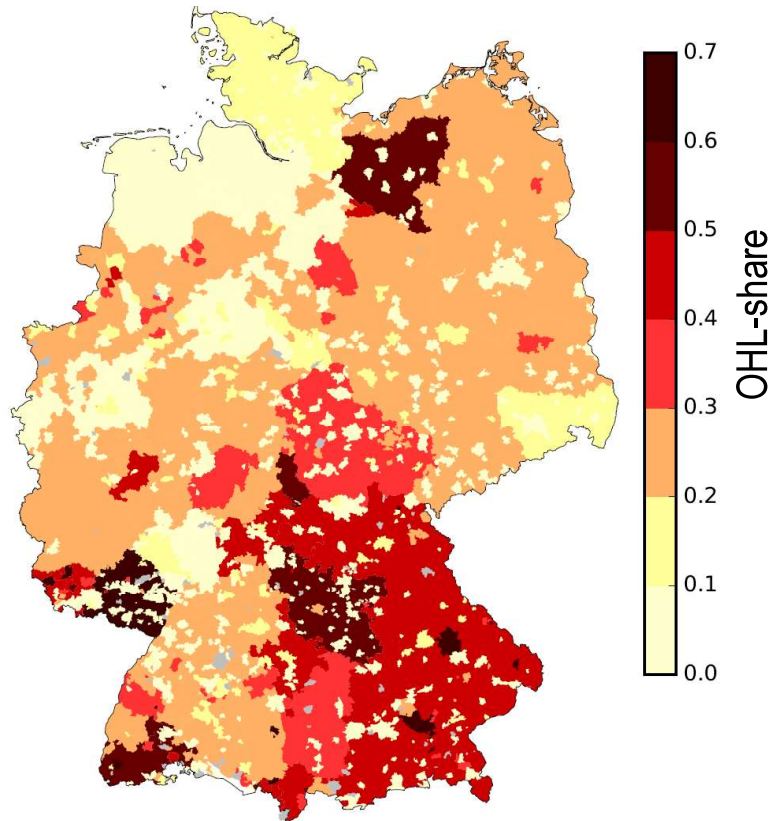


Fig: Share of overhead lines (OHL) in the medium voltage grid of the distribution grid operators; Based on reporting of distribution grid operators; grey-colored domains indicate lacking data.

Economic Implications of Grid Interruptions

Concept: Value of Lost Grid (VoLG)

- Estimates the economic value of a non-interrupted distribution grid

$$VoLG(l, o) = \frac{EP(l, o) \cdot EC(l, o)}{L(l, o)}$$

- l voltage level
- o distribution grid operator
- EP electricity productivity
- EC electricity consumption
- L grid length

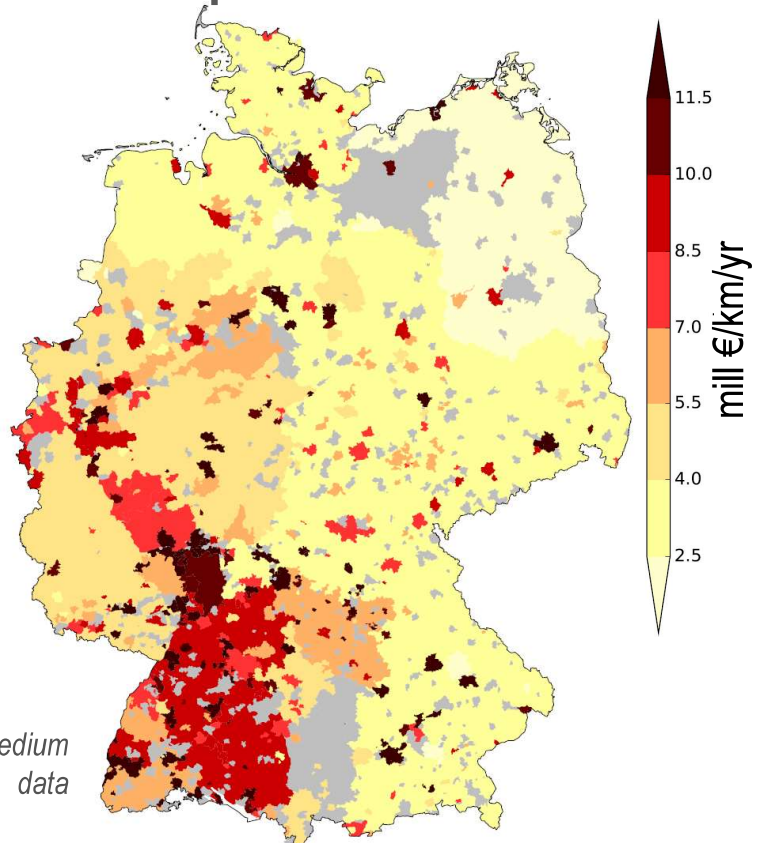


Fig: Value of Lost Grid (VoLG) in million €/km/yr in the medium voltage level; grey-colored domains indicate lacking data [Stankoweit et al., Energy Journal, submitted 09/2017]

■ Economic Value at Risk (VaR)

Concept: Value of Lost Grid at Risk (VaR)

- Where may atmospheric events actually lead to large economic damages

$$VaR(l, o) = VoLG(l, o) \cdot OHL(l, o)$$

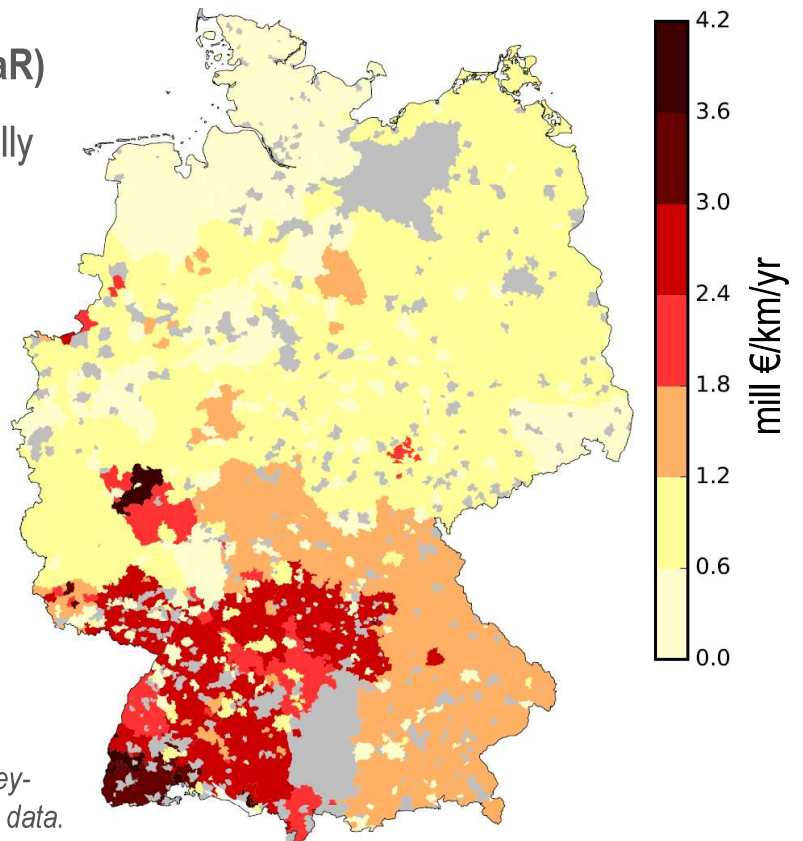
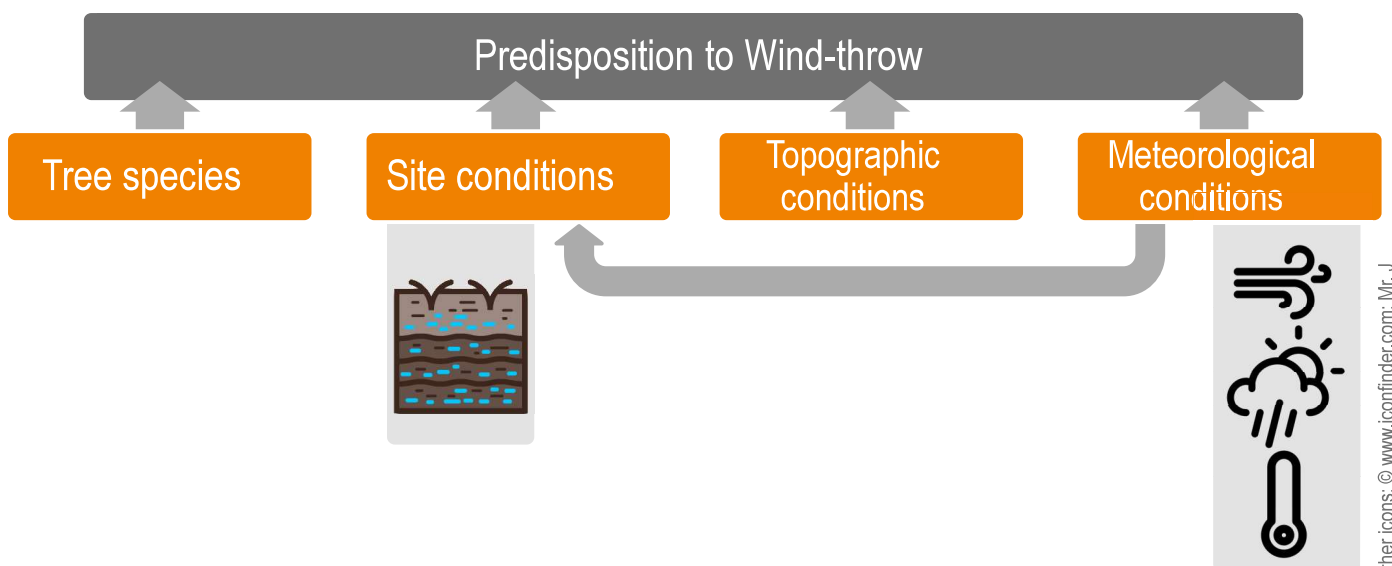


Fig: Value of Lost Grid at risk; grey-colored domains indicate lacking data.

■ Wind-throw probability under climate change



Projected Changes in Extreme Wind Speeds

Data:

- 17 regional climate model simulations (EURO-CORDEX; 0.11°x 0.11°; RCP8.5; 2031-2060 vs. 1971-2000)

Analysis:

- Fitting to extreme value probability distribution
- Differences of occurrence of extreme wind speeds (5-year return period)
- Robustness criterion: 66% of simulations agree on direction of change with at least 85% significance

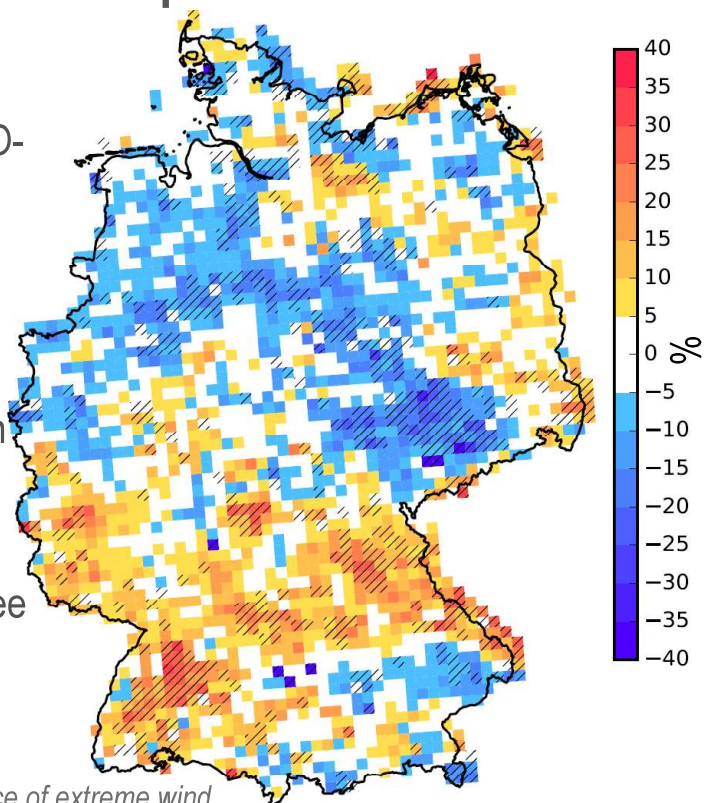


Fig: Changes in occurrence of extreme wind speeds; hatching indicates robust changes.

Comparison

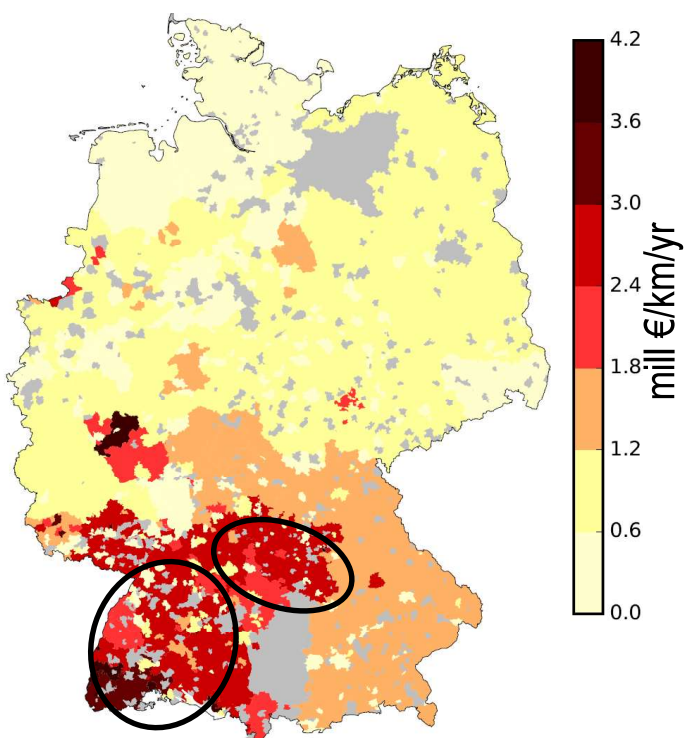


Fig: Value of Lost Grid at risk

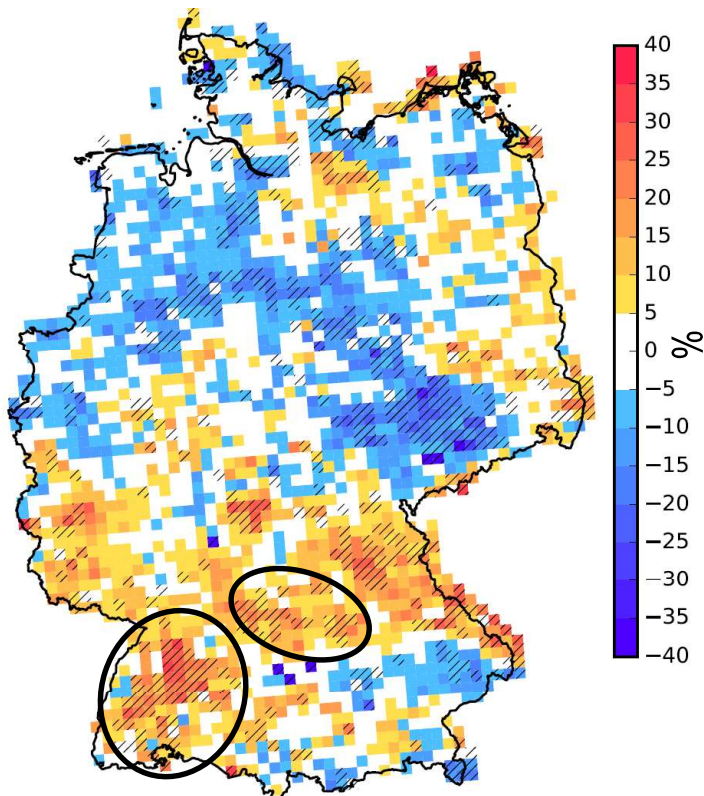


Fig: Changes in occurrence of extreme wind speeds

■ Relevance

- **For decision makers:** how to minimize risks related to electricity outages?
- **For regulators:** how to incentivize that distribution grid operators design their grids in accordance with regionally varying risks?

■ Summary & Outlook

- **Hypothesis:** Risks related to climate change impacts on the electricity grid infrastructure are locally very different in Germany
- **Value of Lost Grid at risk:** new concept to identify where weather-related outages could lead to high economic losses
- **Large ensemble of climate simulations:** determine changes in predisposition to wind-throw under climate change
- **Finding:** Domains of high economic value at risk (in the South of Germany) overlap with robust increases in the occurrence of extreme wind speeds
- **Outlook:** Wind-throw index based on wind speed, soil moisture, frozen soil