Is the more complex model always the better one?

Evidence from the assessment of security of electricity supply

ENERDAY 2019 – The 13th International Conference on Energy Economics and Technology

April 12, 2019

Authors: Lars Nolting and Aaron Praktiknjo

FCN | Future Energy Consumer Needs and Behavior

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MOTIVATION

Varying studies with different approaches and different results regarding the security of electricity supply in Germany

Öko-Institut e.V.
Institut für angewandte Ökologie
Institute for Applied Ecology

LBD | Beratungsgesellschaft | Berlin

RAUE LLP

Focused capacity markets. A new market design for the transition to a new energy system (10/2012)

Need for capacity markets to guarantee security of supply

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MOTIVATION

Varying studies with different approaches and different results regarding the security of electricity supply in Germany

Energy Brainpool

Demand for a capacity reserve from coal-fired power in the German market until 2023 (09/2015)

No need to maintain reserve capacities in Germany to guarantee security of supply

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MOTIVATION

Varying studies with different approaches and different results regarding the security of electricity supply in Germany

Agora Energiewende

Coal phase-out, electricity imports and exports and security of supply (11/2017)

Security of electricity supply in Germany is not at risk, if both nuclear and coal-fired power plants are phased-out, exports even increase

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MOTIVATION

Varying studies with different approaches and different results regarding the security of electricity supply in Germany

PENTA
Pentalateral Energy Forum

2nd report on generation adequacy assessment within PLEF region (01/2018)

In 2023/24 the situation in Germany regarding security of supply tightens. Possibly, there are situations with loss of load.

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STARTING POINT: RESEARCH QUESTION

*What is the right **modeling approach** to assess **security of electricity supply** in Germany?*

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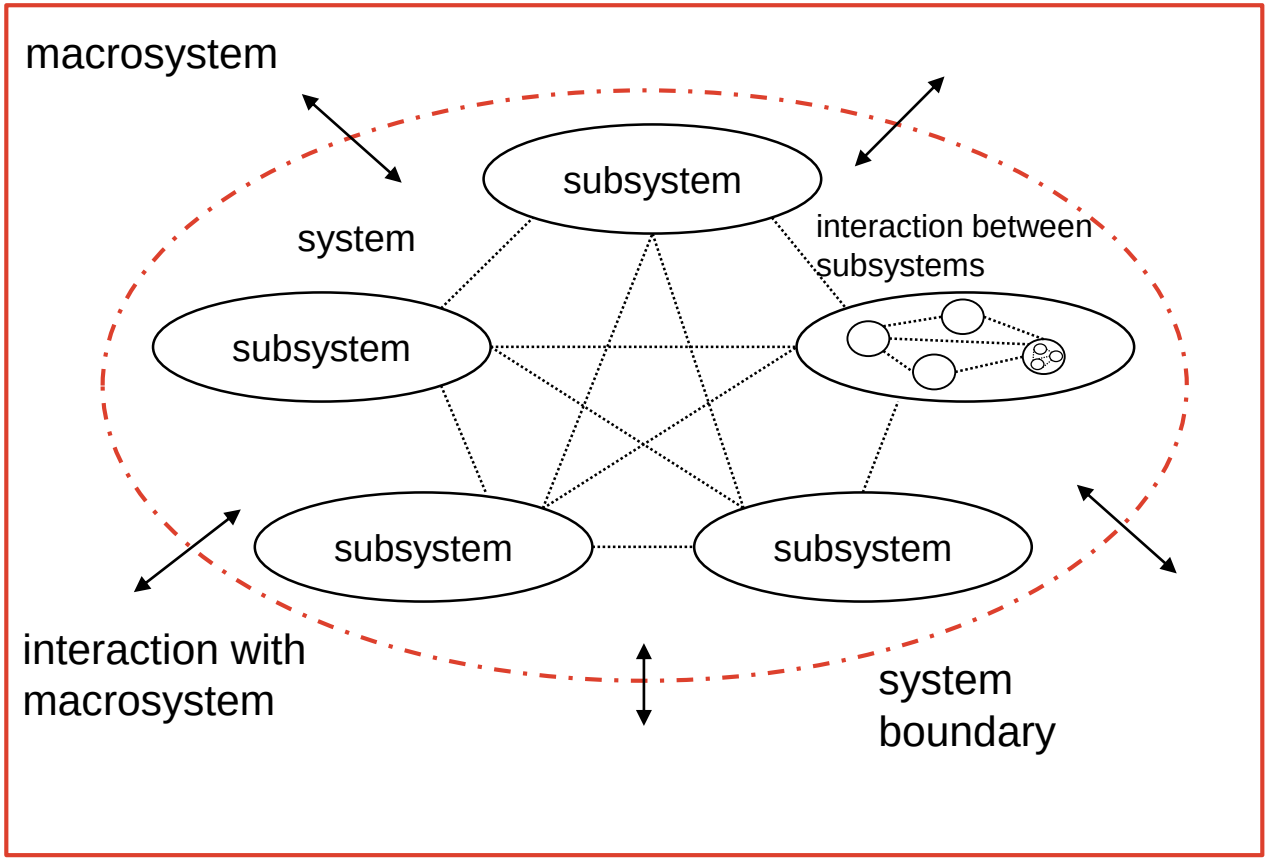
INTRODUCTION & MOTIVATION

The energy system is complex and needs to be simplified for scientific analyses



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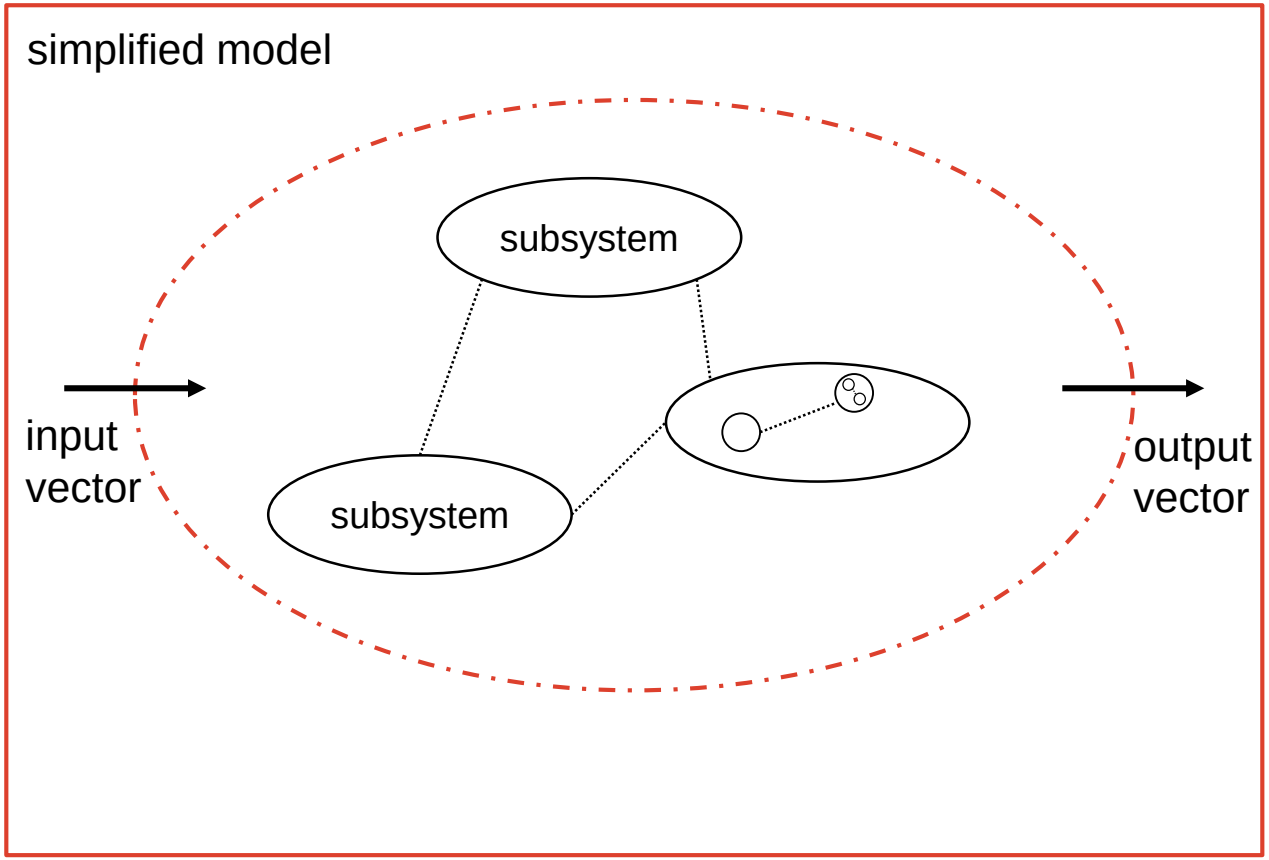
INTRODUCTION & MOTIVATION

The physical reductionist idea is “wrong a great deal of time, and perhaps always” (Nobel price lecture by Robert B. Laughlin, 1999)



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POSSIBLE MODELING APPROCHES

Different approaches to model energy system aim at different levels of the system's emergent behavior

Deterministic balance sheets

- Top-down
- High level of emergence
- Low model complexity
- Usual approach:
  - Focus on peak load hour
  - Analysis of worst-case weather year
  - Computation time ~0 h

Probabilistic simulation models

- Bottom-up
- Low level of emergence
- High model complexity
- Usual approach:
  - Calculation of 8,760 hours
  - Analysis of different weather years (≤ 30)
  - Computation time ~10 h

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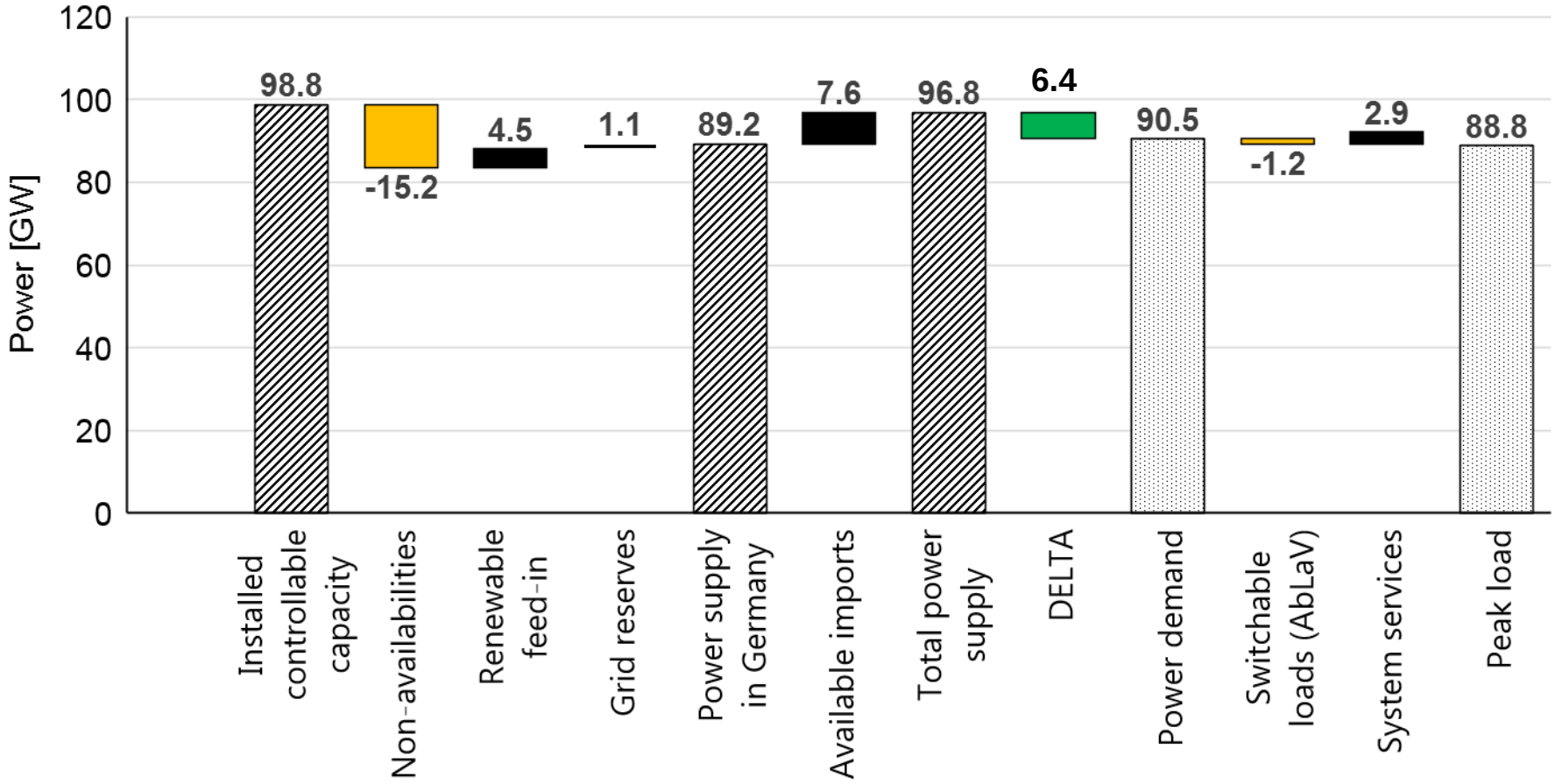
DETERMINISTIC BALANCE SHEETS IN GERMANY FOR 2023

~~Nuclear power~~

Coal capacities →

Capacity surplus of more than 6 GW, however imports are needed



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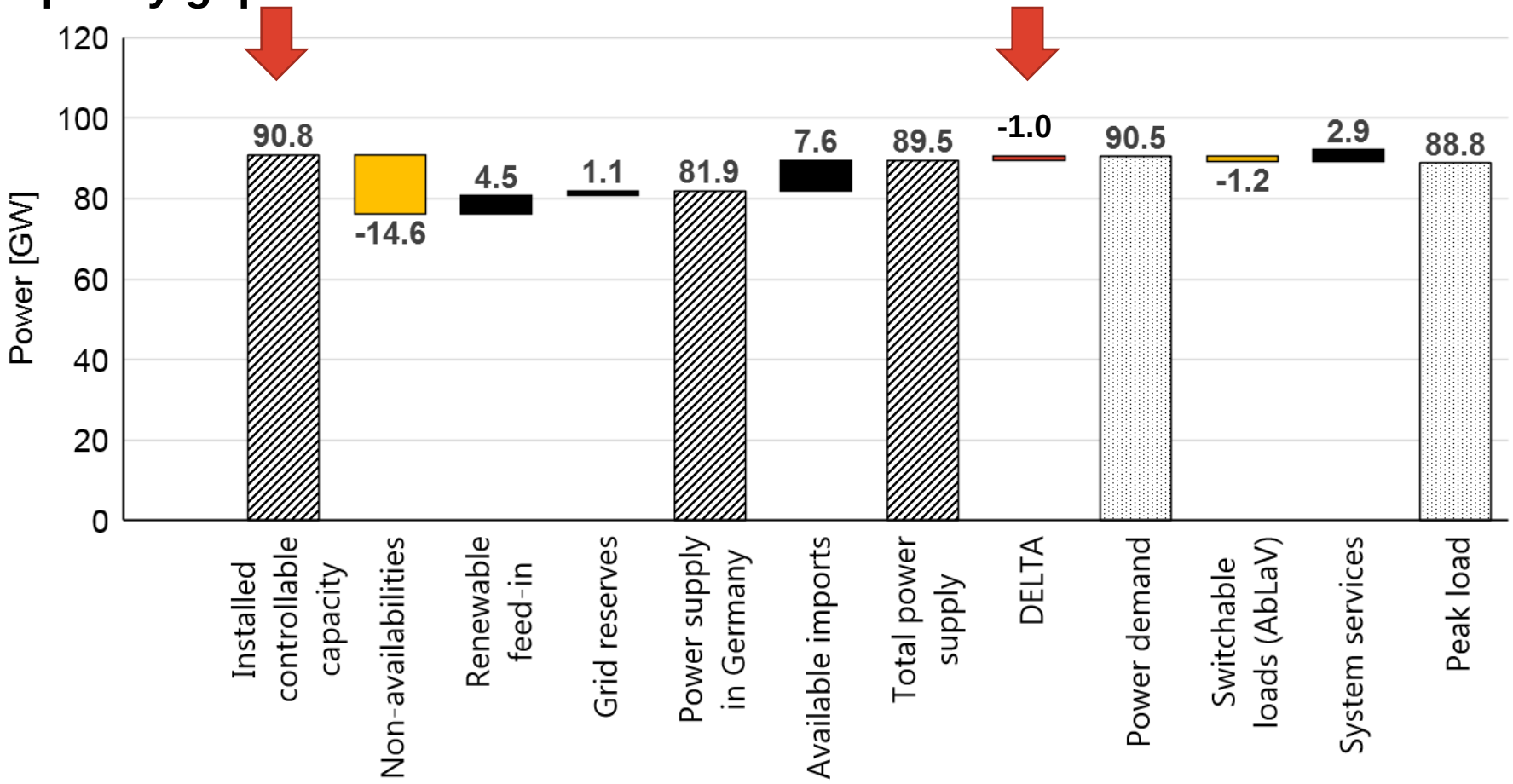
DETERMINISTIC BALANCE SHEETS IN GERMANY FOR 2023

~~Nuclear power~~

Coal capacities ↓

Additional mothballing of 8 GW coal-fired power plants might cause capacity gap



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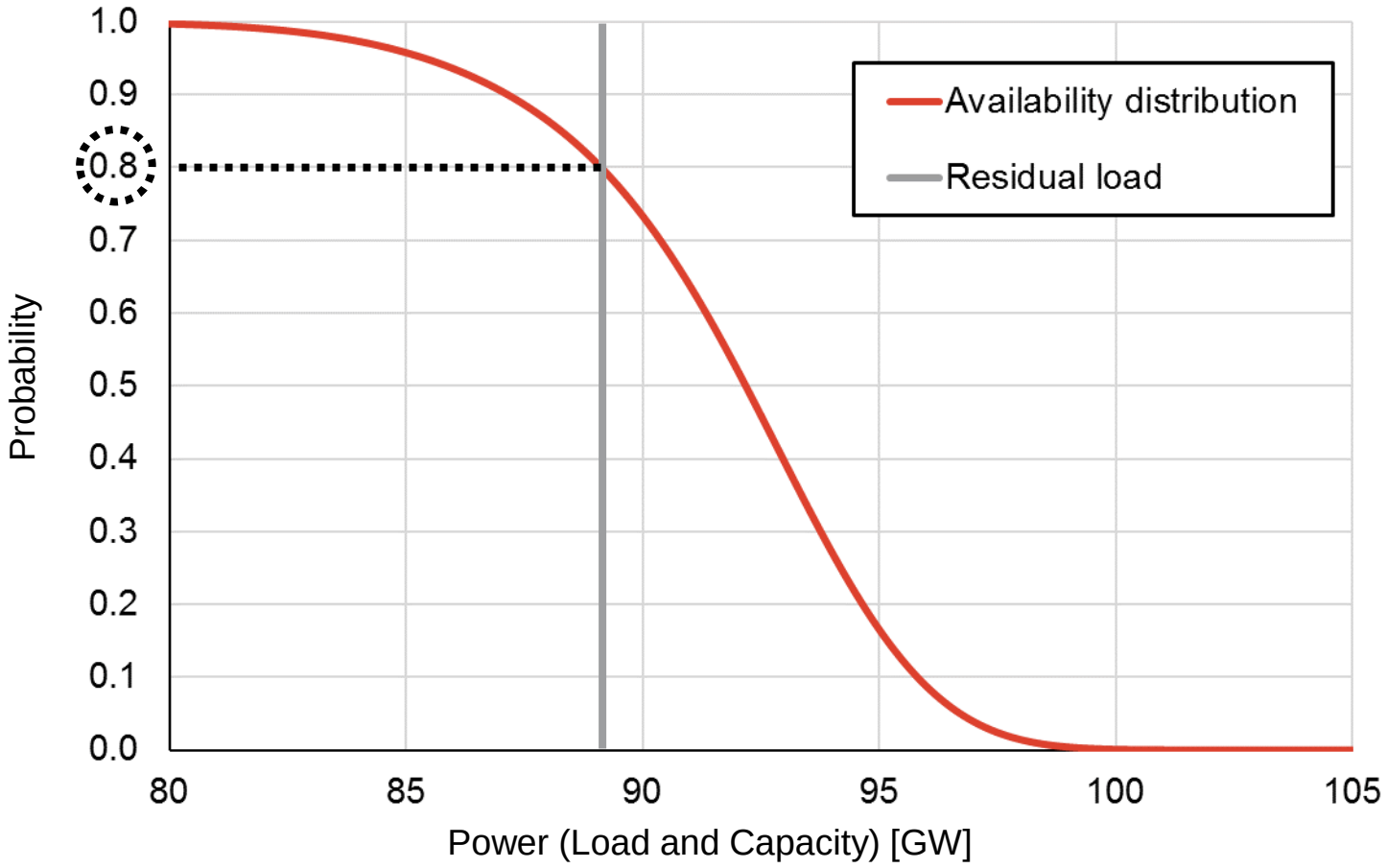
PROBABILISTIC SIMULATION MODEL

Hourly calculation of probability to cover load



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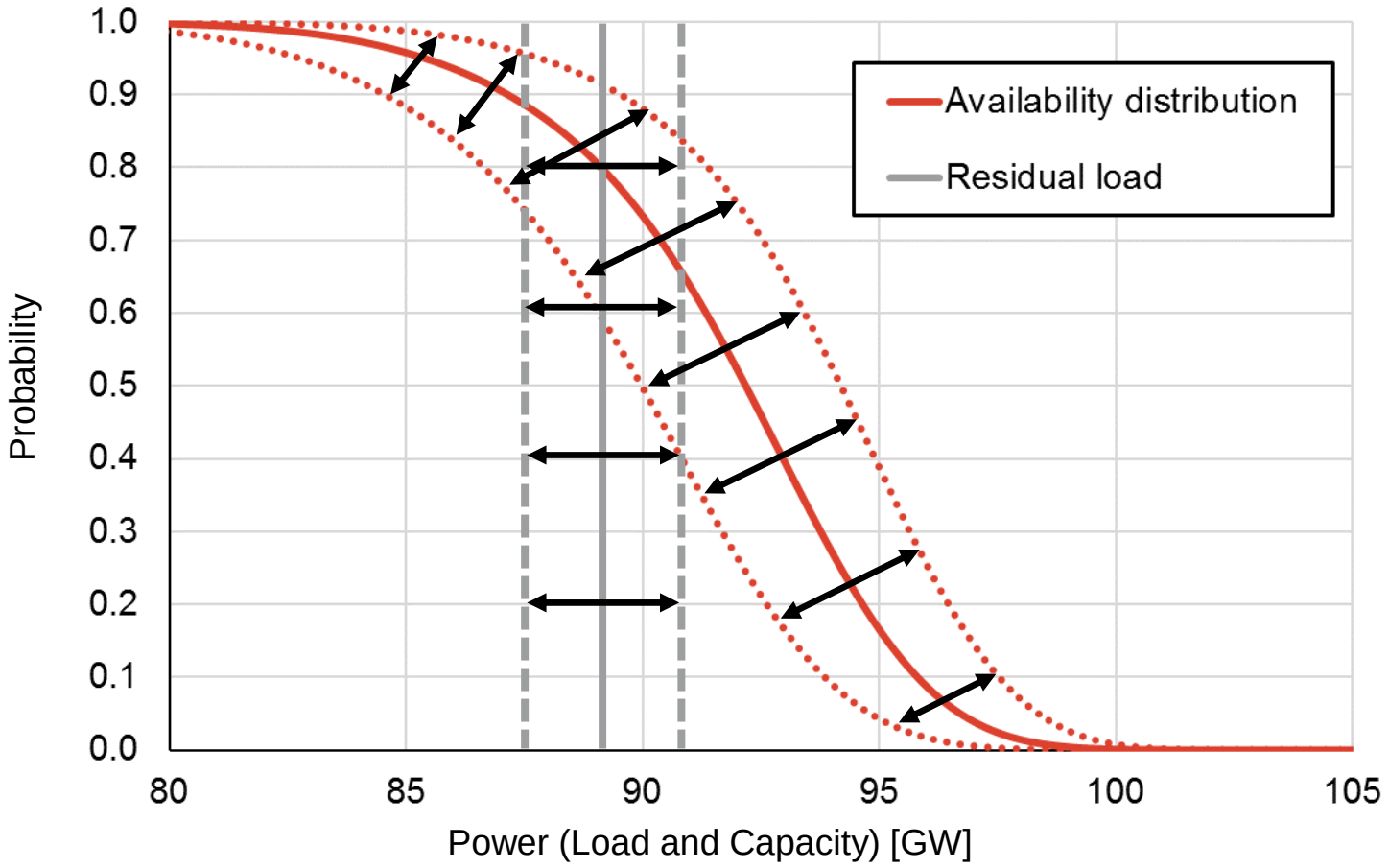
PROBABILISTIC SIMULATION MODEL

Consideration of stochastic influences both on load and supply side



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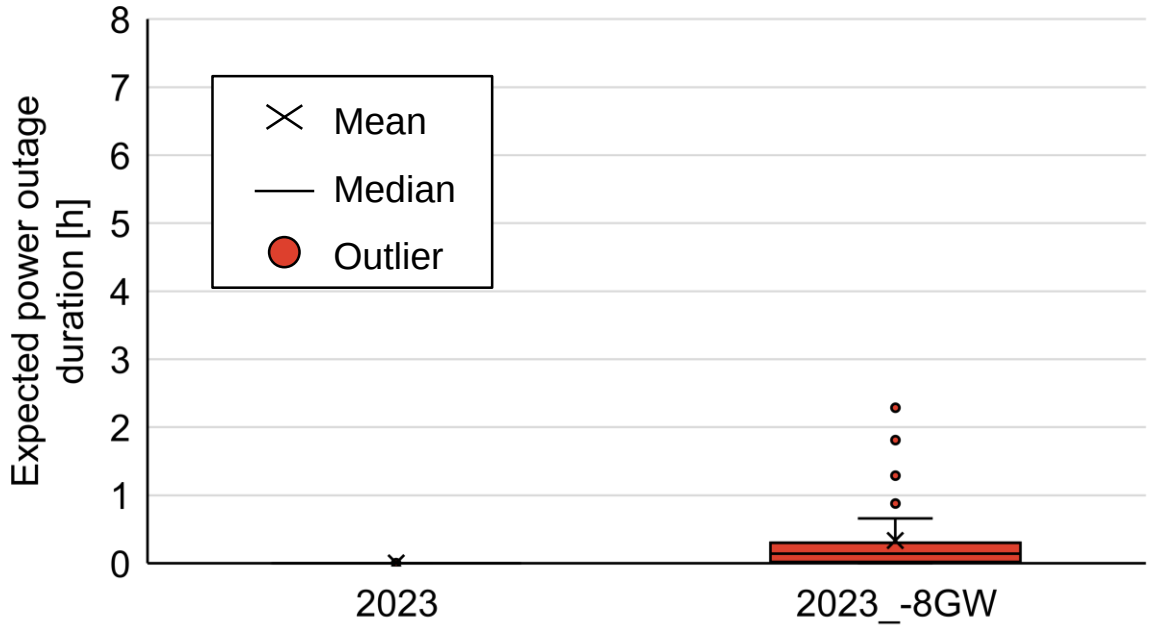
RESULTS OF PROBABILISTIC SIMULATION MODEL IN GERMANY FOR 2023

Loss of load is only to be expected in cold and calm weather years



Expected loss of load duration [h]

	Mean	Median	Max	Min
2023	0.0	0.0	0.1	0.0
2023_-8GW	0.3	0.1	2.3	0.0

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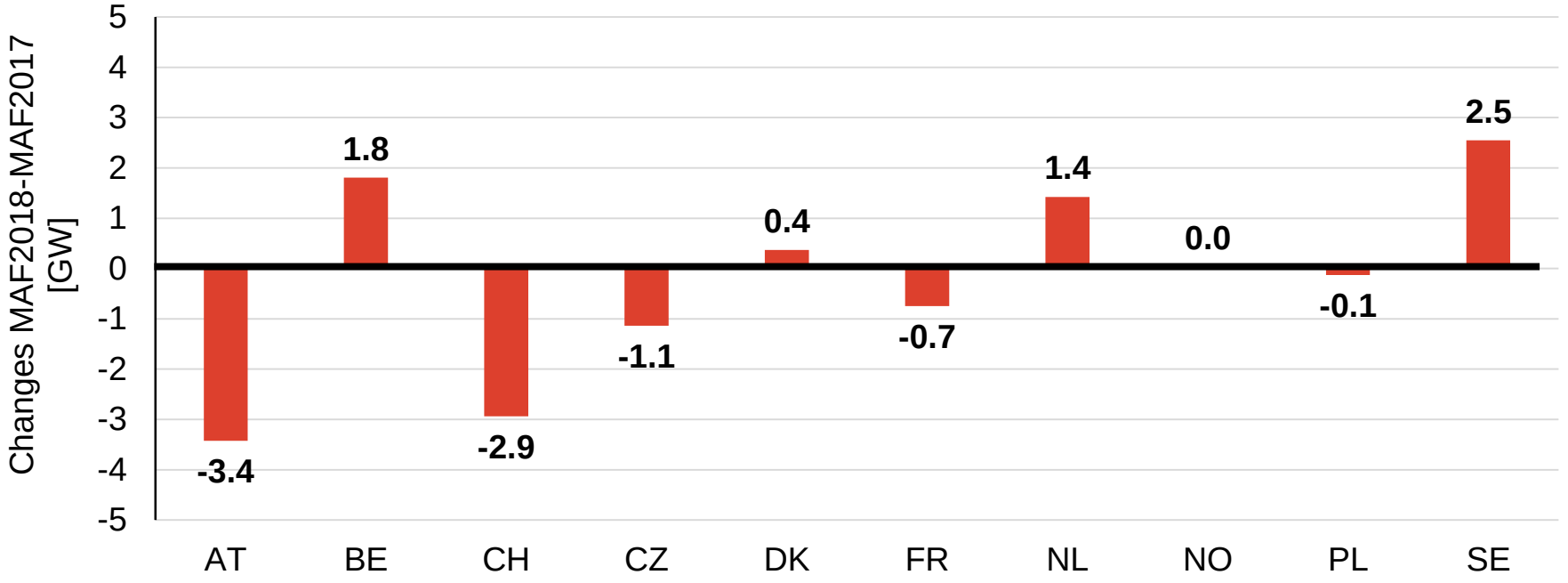
INFLUENCE OF UNCERTAINTY IN INPUT DATA

Changes in installed capacities in neighboring countries for 2023



"In fact, the reason behind this difference is not an error but an update of data due to better information-availability compared to last year."
(e-mail communication with representative from entso-e 2018)

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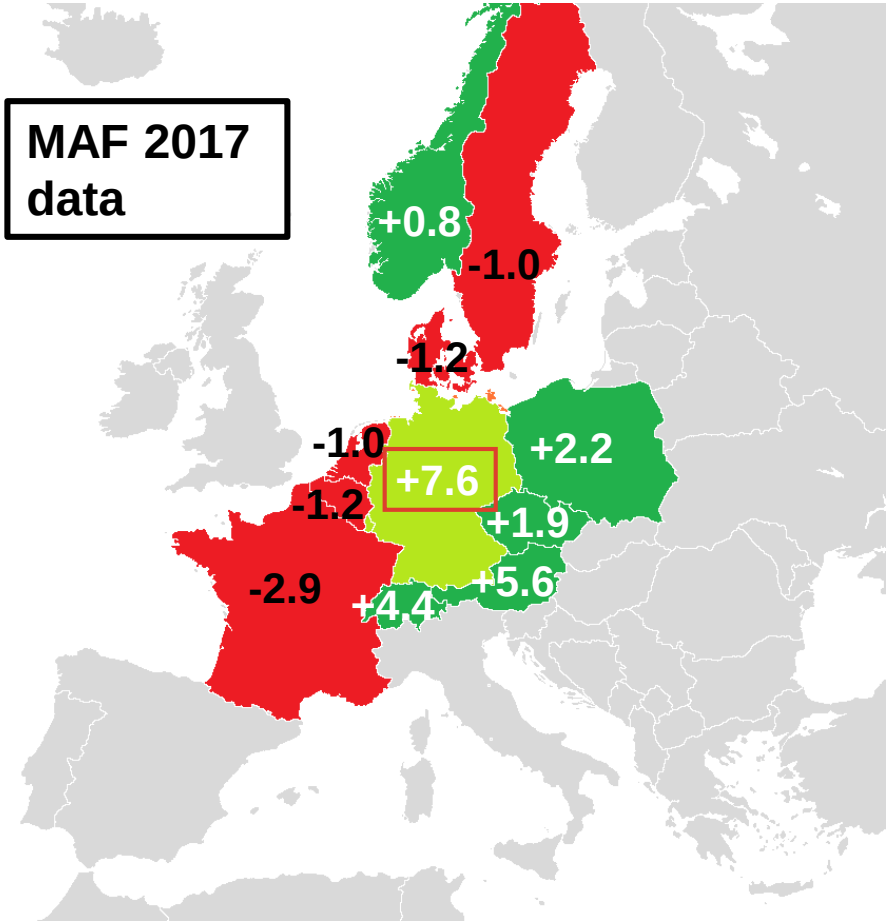
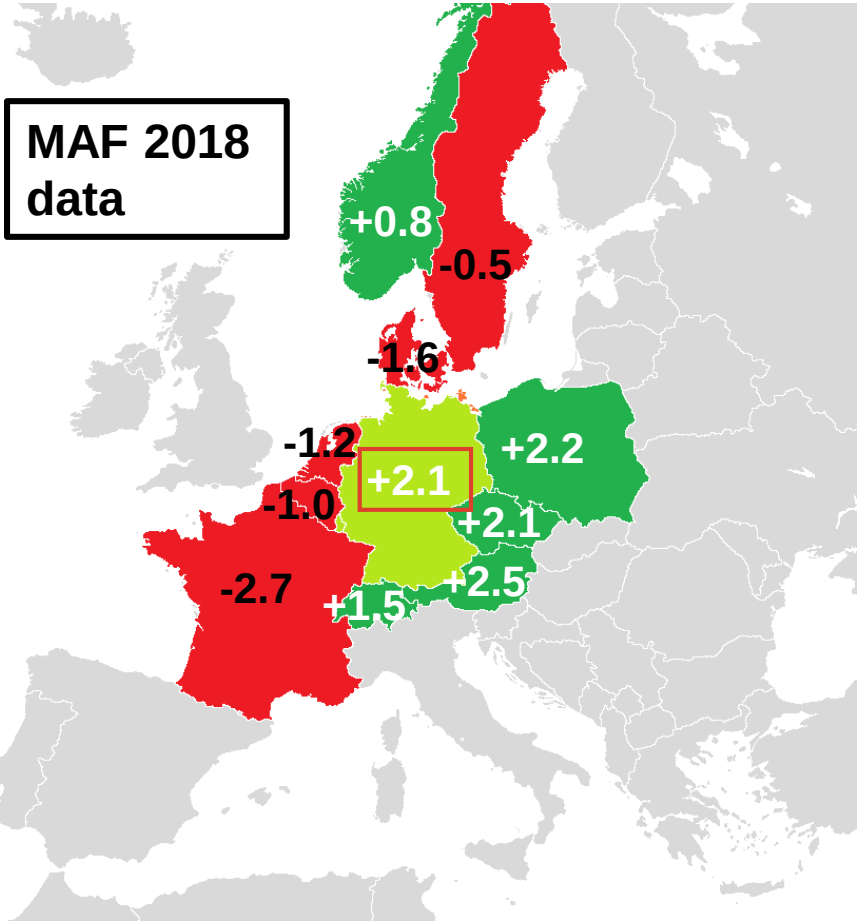
INFLUENCE OF UNCERTAINTY IN INPUT DATA

Change in available import capacities during peak load hour [GW]





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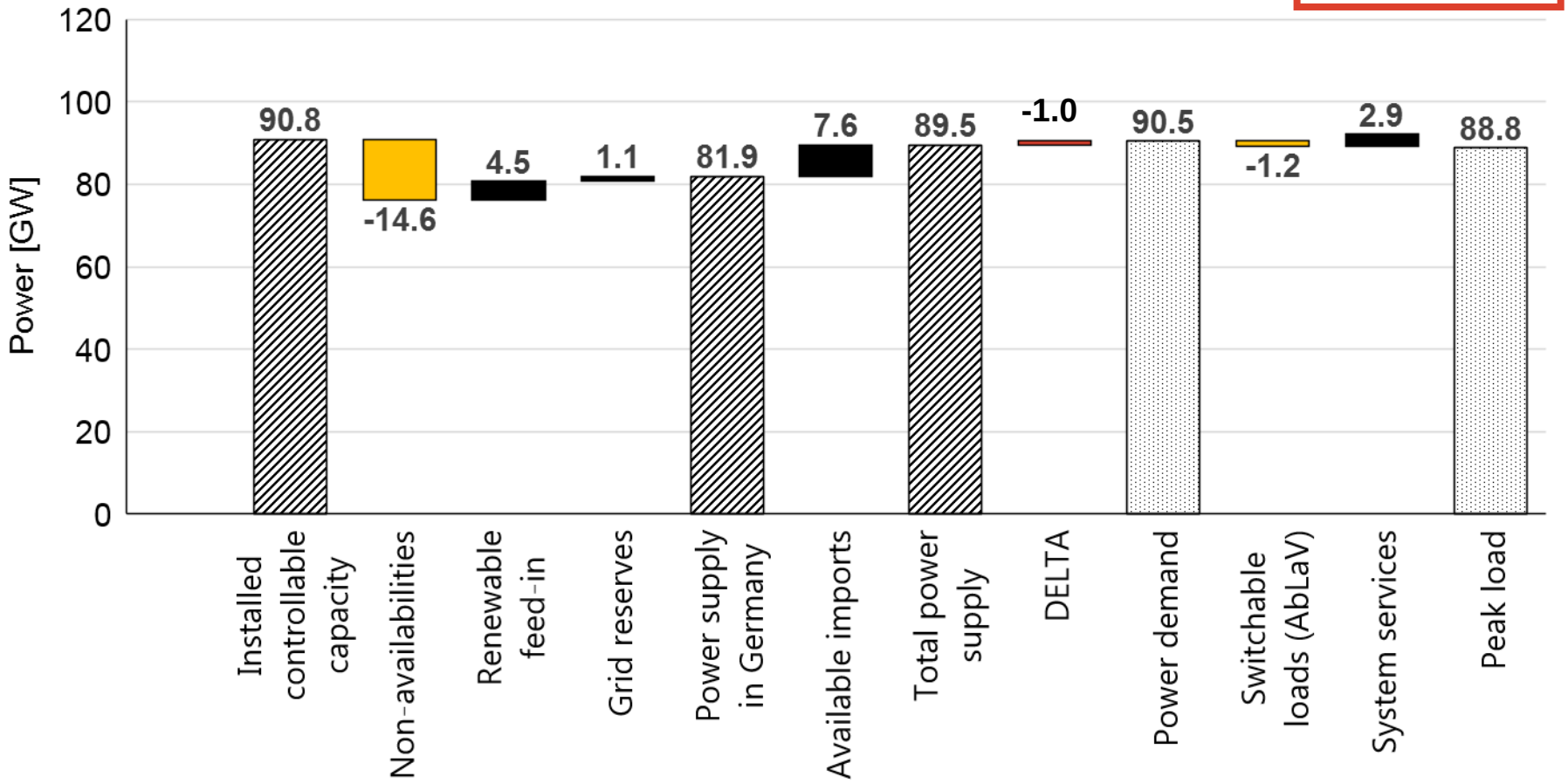
SENSITIVITY OF MODEL OUTPUT – BALANCE SHEET YEAR 2023, BASED ON MAF 2017 DATA

~~Nuclear power~~

Coal capacities ↓

Additional mothballing of 8 GW coal-fired power plants might cause capacity gap

MAF 2017 data



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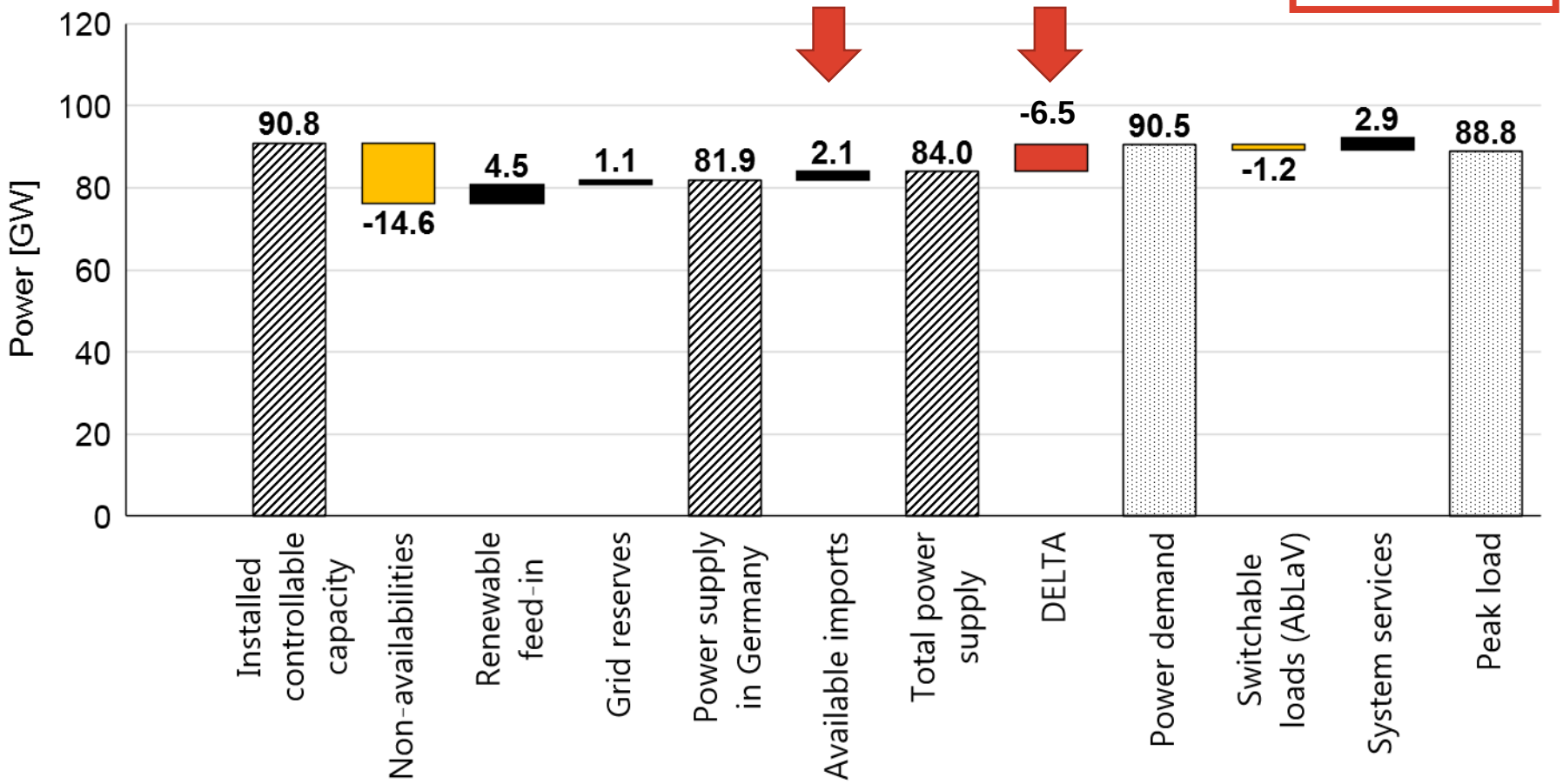
SENSITIVITY OF MODEL OUTPUT – BALANCE SHEET YEAR 2023, BASED ON MAF 2018 DATA

~~Nuclear power~~

Coal capacities ↓

Additional mothballing of 8 GW coal-fired power plants causes severe capacity gap during peak load hour

MAF 2018 data



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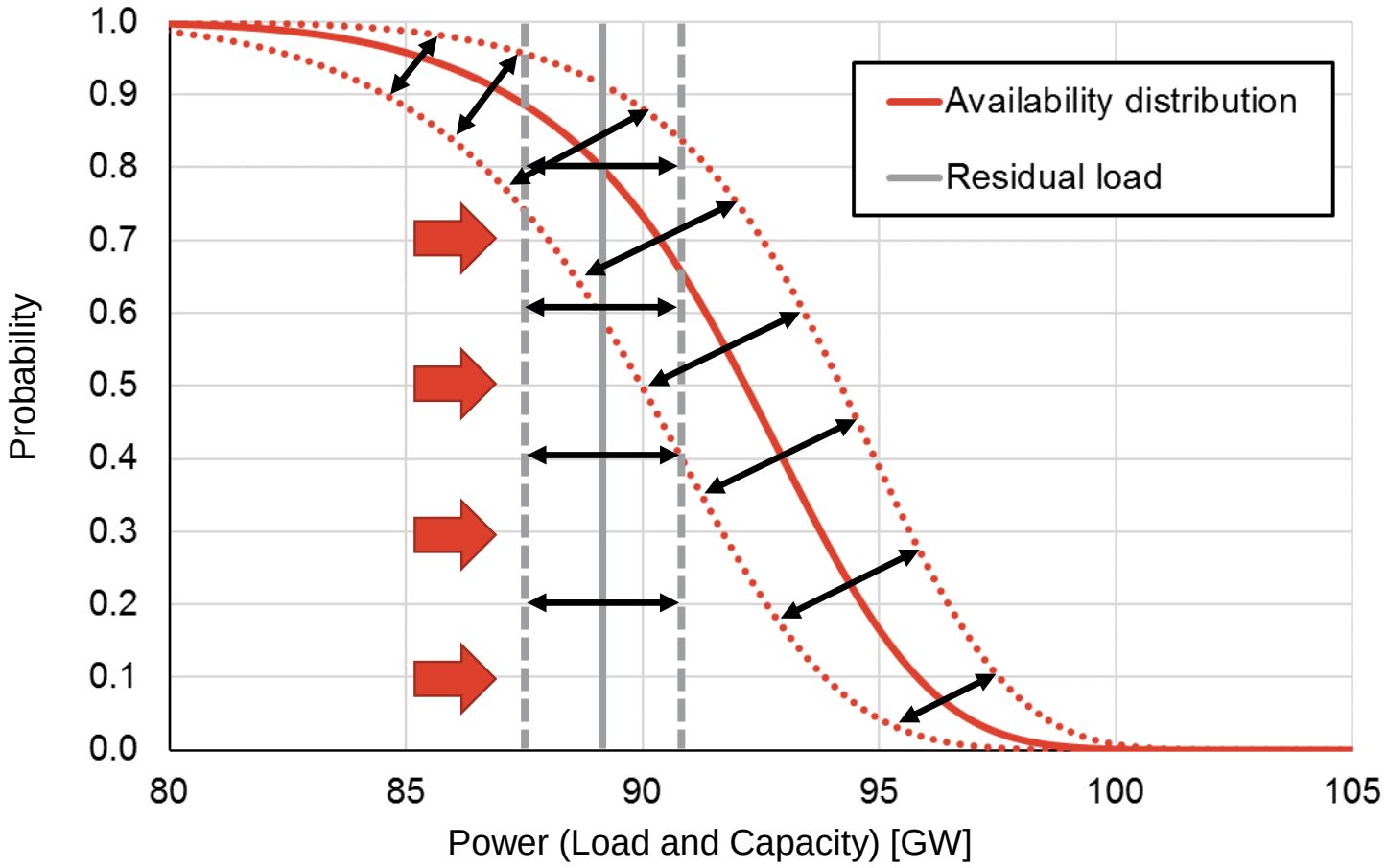
SENSITIVITY OF PROBABILISTIC SIMULATION MODEL

Changes in residual load cause non-linear reactions



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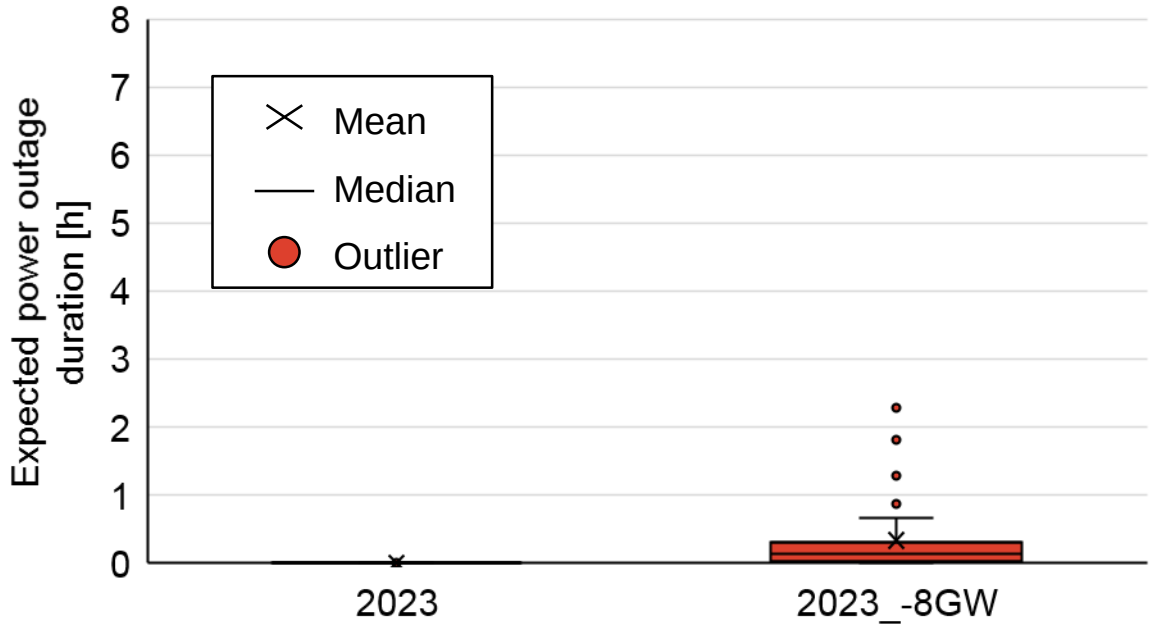
SENSITIVITY OF MODEL OUTPUT – SIMULATION MODEL BASED ON MAF 2017

MAF 2017 data

Loss of load is only to be expected in cold and calm weather years



Expected loss of load duration [h]

	Mean	Median	Max	Min
2023	0.0	0.0	0.1	0.0
2023_-8GW	0.3	0.1	2.3	0.0

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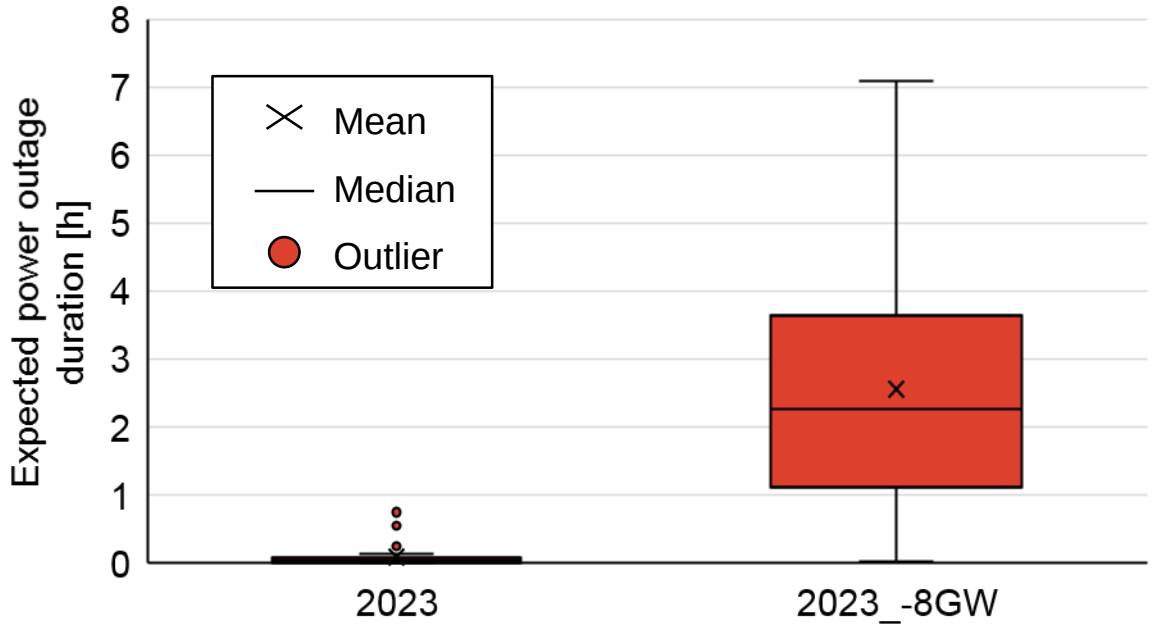
SENSITIVITY OF MODEL OUTPUT – SIMULATION MODEL BASED ON MAF 2018

MAF 2018 data

Capacity shortages can reach up to 7 h per year



Expected loss of load duration [h]

	Mean	Median	Max	Min
2023	0.1	0.0	0.8	0.0
2023_-8GW	2.6	2.3	7.1	0.0

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COMPARISON OF MODELING APPROCHES

Deterministic balance sheets

- Direct visualization of input-output relation
- Ease of interpretation: will peak load be covered at predefined significance level?
- Implicit assumption: peak load hour represents worst-case for the system

Probabilistic simulation models

- Relation between input and output is hard to anticipate
- Statistical capabilities needed to interpret results (e.g. boxplots)
- All hours are investigated

Deterministic capacity balance sheets allow for **well-traceable modeling**, but their **scope is further limited** by the expansion of fluctuating renewables and the decrease of controllable capacities

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CONCLUSION & OUTLOOK

More complex models are not superior *per se* and can not compensate for uncertainties in input data

- **Parsimony** (DeCarolis et al., 2017) vs. **“Keep it complex!”** (Stirling, 2010)
- Sometimes the **system’s emergent behavior** can also be depicted using rather simple models
- To provide **deep insights** and **guarantee ease of interpretation**, the combination of models with **different levels of complexity** can be appropriate

The modeling approach needs to be chosen in accordance to

1. The **research question** under investigation
2. The **quality of available data**
3. The **audience** of the **results**

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Thank you for your attention!

Do you have any questions or comments?

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