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Disruptive Events within the RESUR Project: Identification and Modeling

Helmholtz platform for the design of robust energy systems and their supply chains

Dickler, Sebastian; Ardone, Armin; Poganietz, Witold-Roger; Ross, Andrew; Weinand, Jann; Zapp, Petra; Shamon, Hawal; Rösch, Christine; Haase, Martina; Kraft, Emil; Kebrich, Sebastian; Kullmann, Felix; Kleinebrahm, Max; Hoffmann, Julian, Vögele, Stefan; Goerge, Marius

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Contact: s.dickler@fz-juelich.de

Presentation Outline

1. **RESUR project: Overview**
2. **Initial working terms: Energy system, disruptive event**
3. **Identification of disruptive events**
4. **Model-based analysis of disruptive events**
5. **RESUR project: Outlook**

RESUR Project: Overview (1/2)

RESUR: Helmholtz platform for the design of robust energy systems and their supply chains

Goal

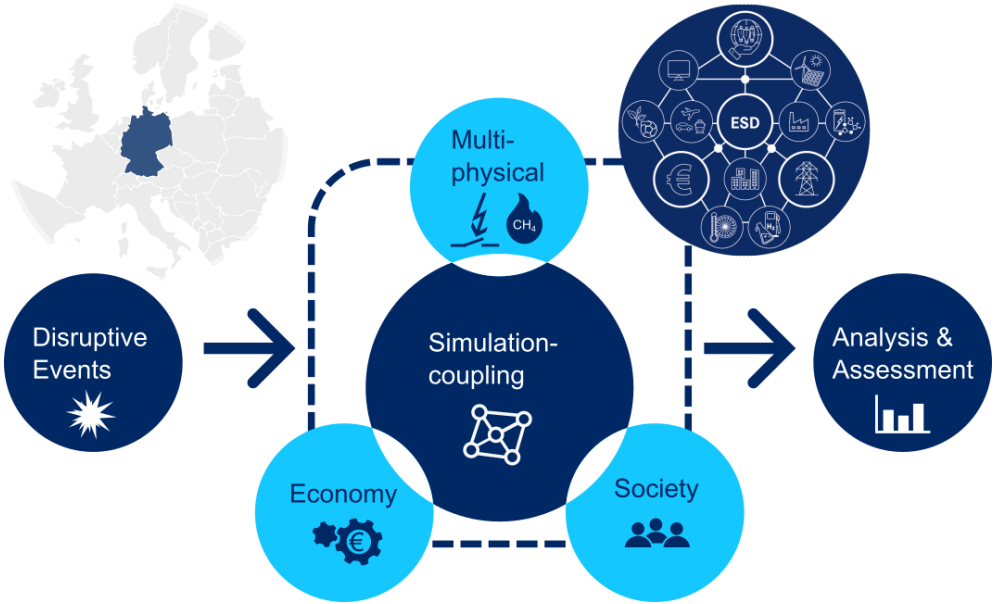
- Proactive and reactive support of decision makers and stake holders
- Developments of the energy market
- View on the future European energy system
- Social acceptance and participation
- Acceleration of the energy transition

Duration: Sep ’22 – Dec ’25

Related Helmholtz Energy Program

- Energy System Design (ESD)

Participating Helmholtz Energy Partners

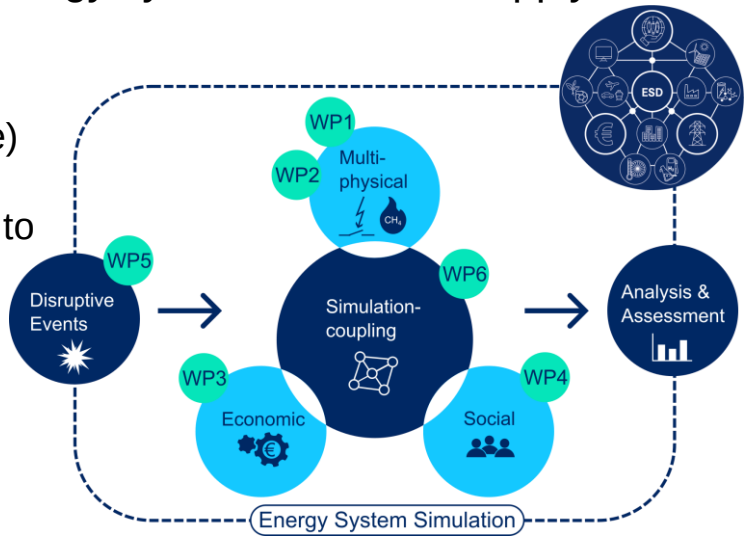


RESUR Project: Overview (2/2)

RESUR: Helmholtz platform for the design of robust energy systems and their supply chains

Features

- Inclusion of major energy sectors (electricity, gas & heat)
- Coupling of simulation tools (validated, modular and flexible)
- Geostrategic, socio-ecological, economic
- Agglomeration and detailing (from transportation grid down to neighbourhoud level)
- Multiscale temporal resolution
- Bottom-up and top-down models



WP1 Transportation-Grids: European electricity (incl. DE 110kV grid) and gas grid

WP2 Multiphysical co-simulation for heat, electricity and gas on neighborhood level

WP3 Energy and commodity markets, energy market design and economic evaluation of measures

WP4 Socio-technical analysis and evaluation of possibile actions of social groups

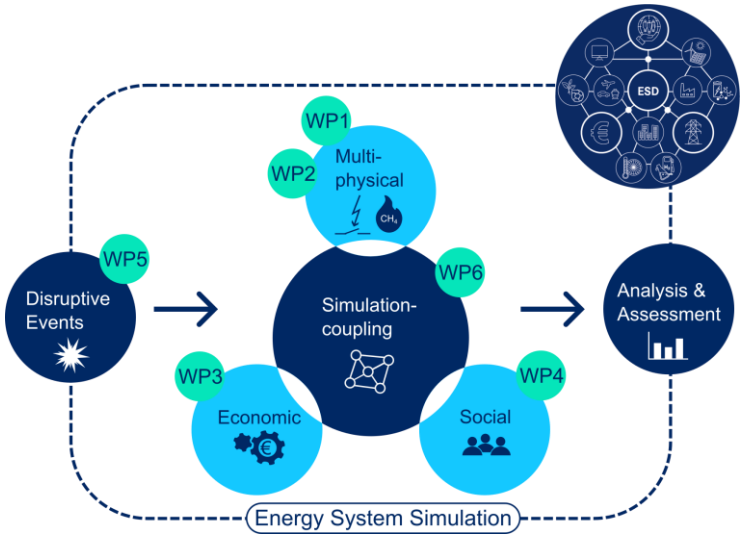
WP5 Disruptive events and robustness of the energy system

WP6 Platform for model and simulator coupling

RESUR Project: Examples of Disruptive Events

Examples of disruptive events

- Russia-Ukraine war
- Extreme heat waves / droughts
- Hurricane on North Sea destroys entire wind farms
- Collapse of the European electricity grid
- Shortage of energy system relevant rare earths
- …

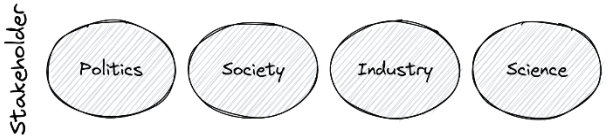


→ Proactive and reactive support: What are potential disruptive events and how can we assess their impacts on the energy security?

→ Robustness of the energy system: How can we use model-based analysis to design our energy system (and its transition) so that it is robust against disruptive events?

Definition of Terms: Working Status

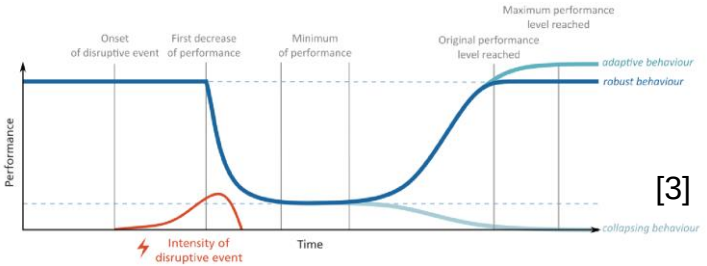
Energy System



- "The energy system comprises all components related to the production, conversion, delivery, and use of energy".[1]:1261
  - Spatial: German energy system in a European context
  - Temporal: Short-term (1-2 years) and medium-term scenarios (e.g., until 2030)

Disruptive Event in the energy system / in the supply of energy and raw materials

- "A disruptive event is a dynamic occurrence that impedes the normal functioning of a system"[2]
- "An […] disruptive event is the cause of a loss of performance"; "the system is not able to fully absorb its impact"[3]



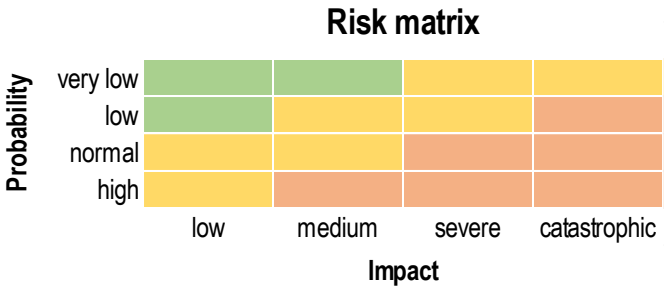
[3]

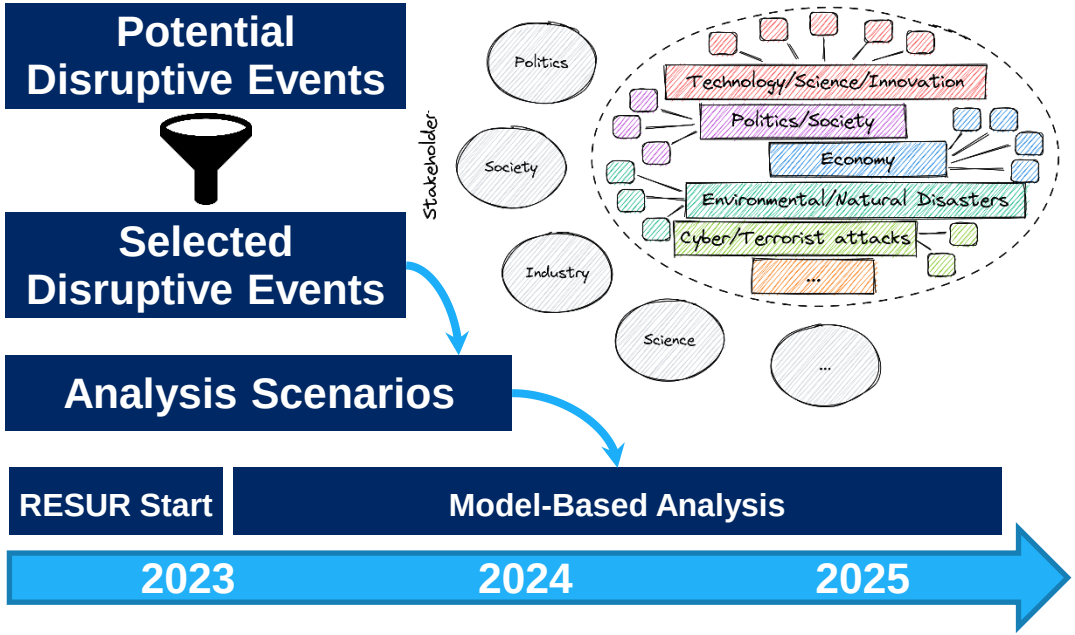
[1] IPCC, 2014: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
[2] L. H. Broska, W.-R. Poganietz, and S. Vögele, "Extreme events defined—A conceptual discussion applying a complex systems approach," Futures, vol. 115, p. 102490, 2020, doi: 10.1016/j.futures.2019.102490.
[3] Mentges, Andrea, et al. "A resilience glossary shaped by context: Reviewing resilience-related terms for critical infrastructures." arXiv preprint arXiv:2302.04524 (2023).

Identification of Potential Disruptive Events

Goals of WP5 “Disruptive Events and Robustness of the Energy System”

- Identify/model potential disruptive events and scenarios from different stakeholder perspectives
- Model-based Analysis of the robustness of the integrated (sector-coupled, German) energy system under disruptive scenarios





Disruptive Events in the RESUR Project: Identification and Modeling

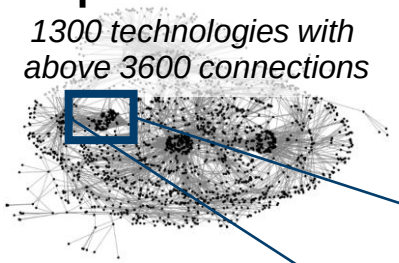
Model-Based Analysis: ETHOS Model Suite

JÜLICH | IEK-3
Forschungszentrum

ETHOS	Energy Transformation PatHway Optimization Suite
ETHOS.NESTOR	National Energy System with SecTOR Coupling

Superstructure

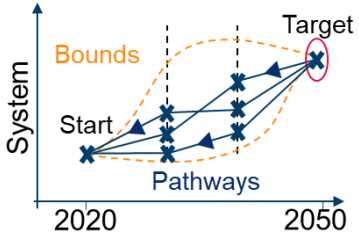
1300 technologies with above 3600 connections

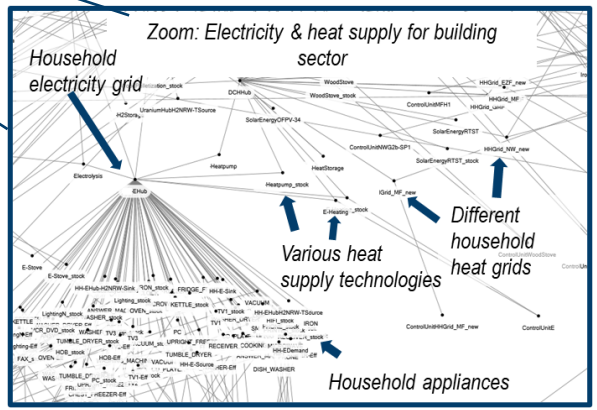


Input information on each technology:

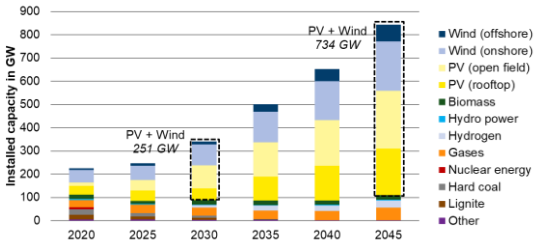
- Investment cost
- Operational costs
- Efficiency
- Interest rate
- Lifetime
- Currently installed
- Potential
- etc.

Myopic Optimization





Scenario



Output information on each technology:

- For every year
  - Installed capacity
  - Investment
- For every hour in every year
  - Stage of charge
  - Energy flows of components
  - Operation

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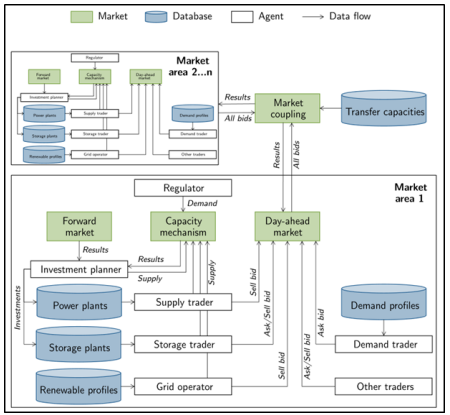
Disruptive Events in the RESUR Project: Identification and Modeling

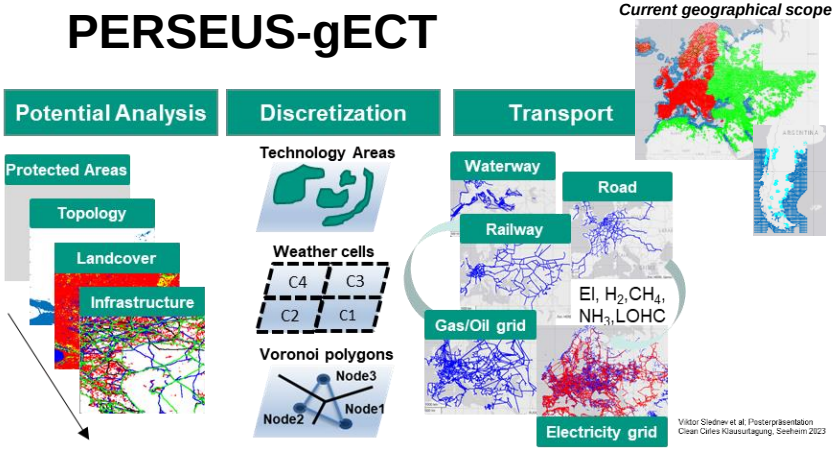
Model-Based Analysis: PowerACE & PERSEUS-gECT

PowerACE



- Agent-based electricity market simulation model
- Day-ahead market simulation (daily)
- Investment decisions (yearly)
- Time horizon: 2015-2050 at hourly resolution (8760 h/a)

PERSEUS-gECT



- Context: European energy system expansion in a world-wide context
- Multi-commodity flow modelling
- Integrated energy system expansion of generation, conversion, and transmission
- Time horizon: 2020-2050 at hourly resolution (~energy carrier) in 5-year steps

Disruptive Events in the RESUR Project: Identification and Modeling

Further Assessments: Macro-Economic Effects & Resource Criticality

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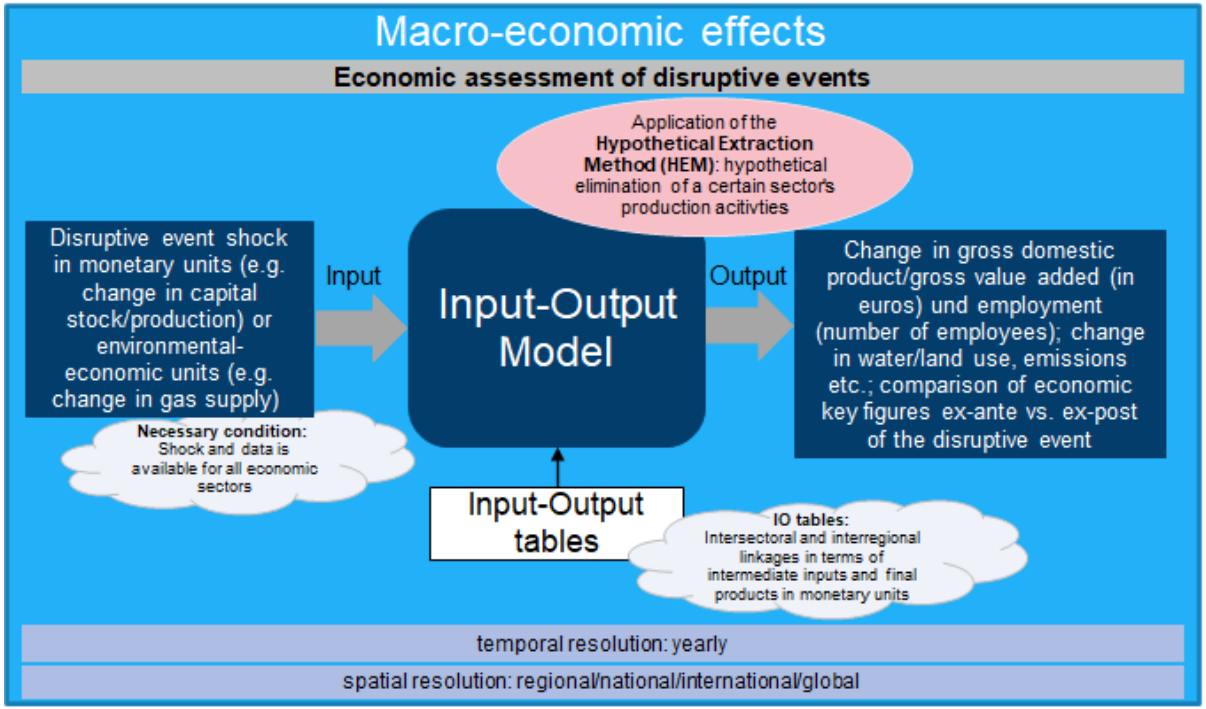

Resource criticality

Impact of disruptive events

- Production rates
- Distribution of producing countries
- Supplying countries for EU
- Change in sectors and gross value added
- Trade index
- ....

➢ New criticality rating

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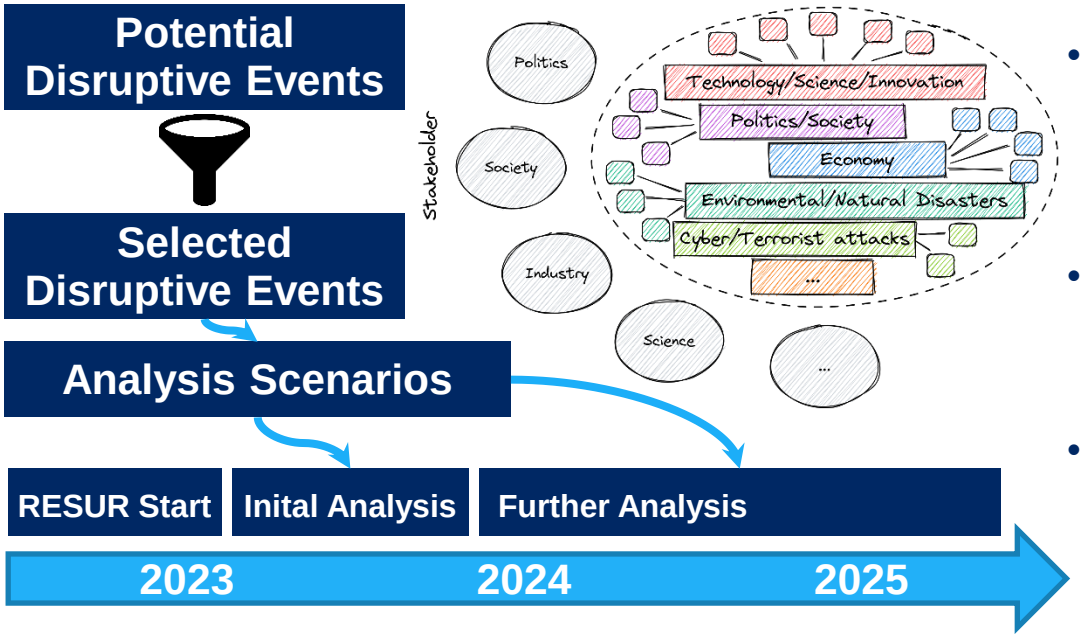
RESUR Project: Outlook



- Description and modeling of major selected disruptive events and scenarios (e. g., extreme heat waves / droughts)
- Demonstration of the robustness of the energy system under selected disruptive scenarios
- Model coupling of certain Helmholtz models: Implementation of model interfaces / Simulative coupling of first disruptive events

Thank you for your attention!