

MULTI-KRITERIELLE ENERGIESYSTEM- OPTIMIERUNG: KOSTEN VS. KRITISCHE MATERIALIEN

Karl-Kiên CAO, Lilli M. MARTENS, Eugenio S. ARELLANO RUIZ,
Steffen J. SCHLOSSER, Jan BUSCHMANN, Tobias NAEGLER

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BROUGHT TO YOU BY RESUME: MULTI-OBJECTIVE OPTIMIZATION: IMPACT OF RECYCLING POTENTIALS, CRITICAL RESOURCES, AND SUPPLY RISK ON THE GERMAN ENERGY TRANSITION



ARIANE



ARIANE

A photograph of an Ariane 5 rocket on the mobile launcher platform (MLP) at night. The rocket is illuminated by ground lights, and the MLP is supported by two tall service towers. The rocket features logos for ESA, CNES, and Airbus Space.

ARIADNE

A photograph of a road at sunset, with a large white arrow painted on the pavement pointing to the right. The sky is a mix of orange and blue, and the road is flanked by trees and buildings. A large, dark red arrow graphic is overlaid on the right side of the image, pointing towards the right.

Ariadne-Report

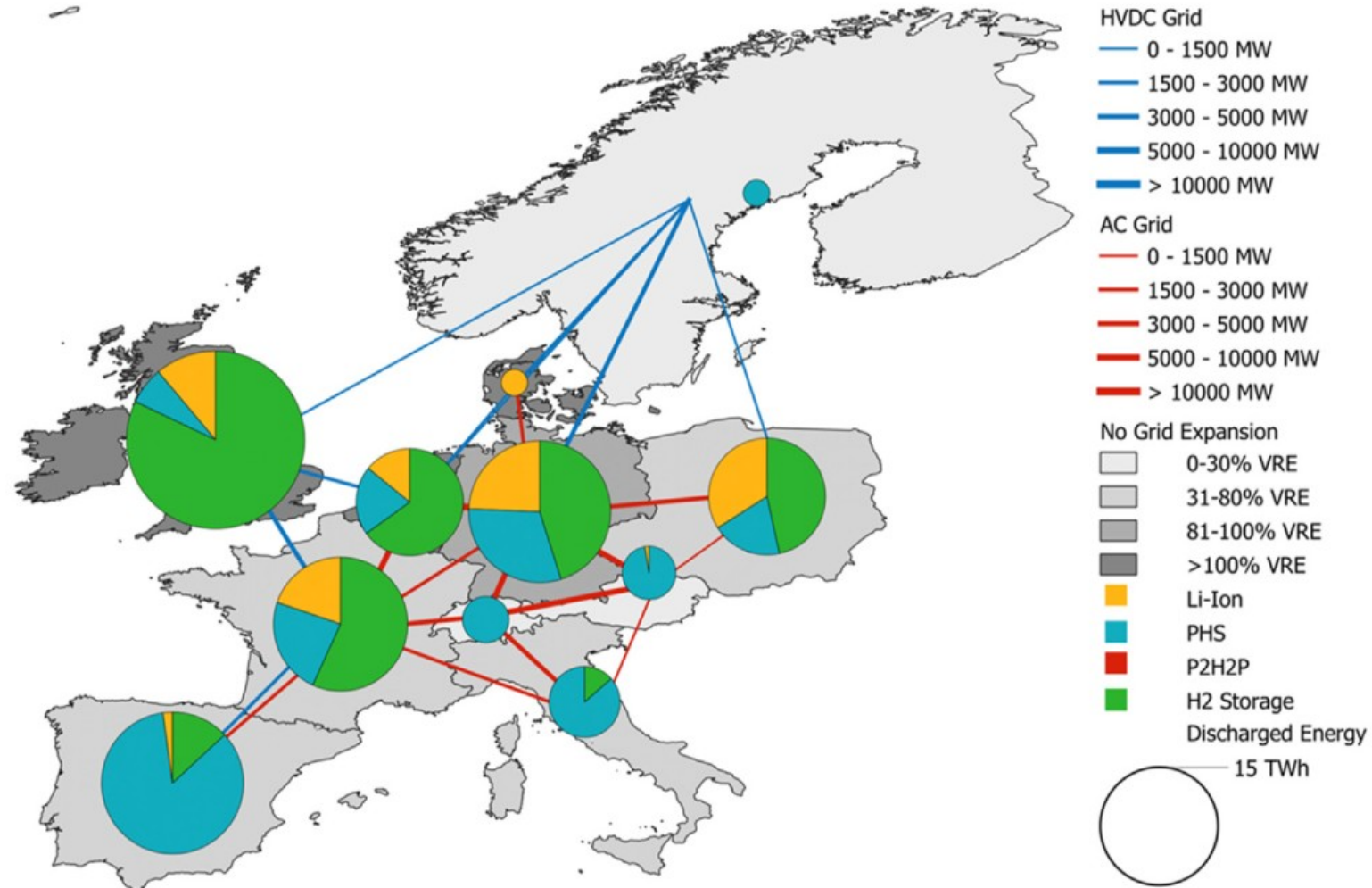
Deutschland auf dem Weg
zur Klimaneutralität 2045

Szenarien und Pfade im
Modellvergleich



MOTIVATION

Energiesystemanalyse: Beispiel 1

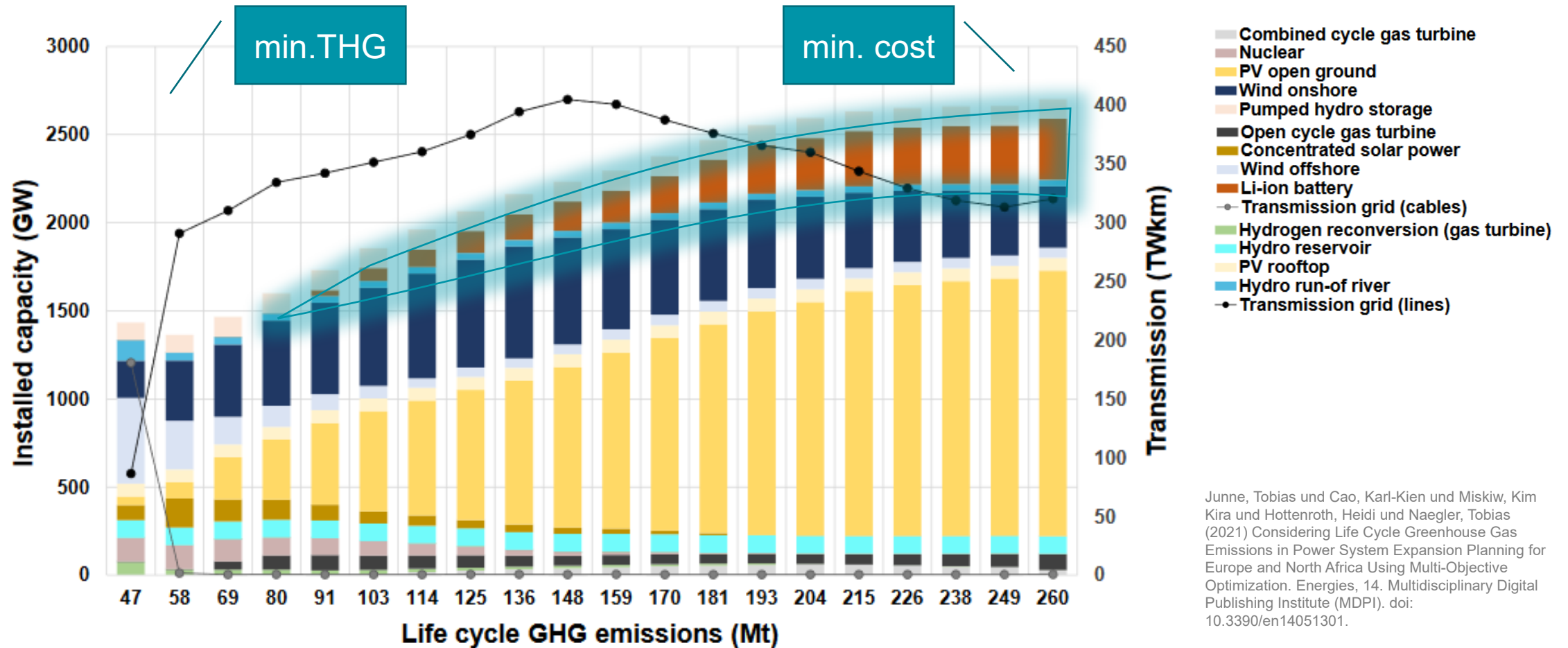


Moser, Massimo und Gils, Hans Christian und Pivaro, Gabriel (2020) A sensitivity analysis on large-scale electrical energy storage requirements in Europe under consideration of innovative storage technologies. Journal of Cleaner Production, 269 (122261). Elsevier. doi: 10.1016/j.jclepro.2020.122261

Energiesystemanalyse: Beispiel 2



Szenarien des Europäischen Stromversorgungssystems



Junne, Tobias und Cao, Karl-Kien und Miskiwi, Kim Kira und Hottenroth, Heidi und Naegler, Tobias (2021) Considering Life Cycle Greenhouse Gas Emissions in Power System Expansion Planning for Europe and North Africa Using Multi-Objective Optimization. *Energies*, 14. Multidisciplinary Digital Publishing Institute (MDPI). doi: 10.3390/en14051301.

VORGEHENSWEISE

Systemdefinition



Sektor

Betrachtungsgebiet

Betrachtungszeitraum

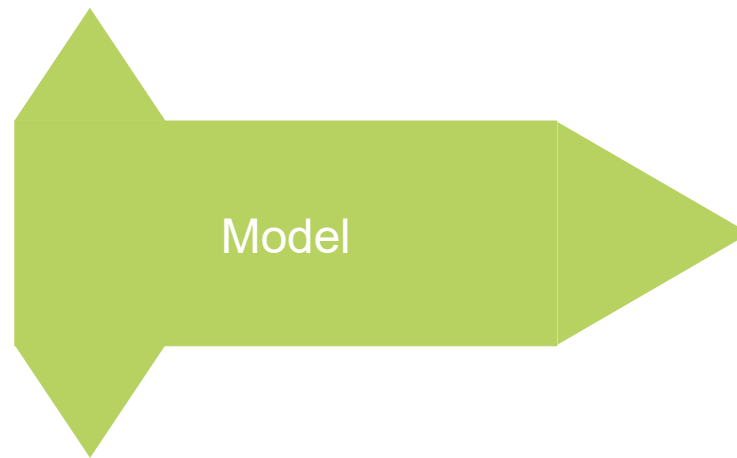
Technologien

Zielgrößen:

1. Minimierung Systemkosten
- 2. Minimierung Kritische Materialien**

| | |
|--|--|
| Sektor | Strom |
| Betrachtungsgebiet | Kontinental-Europa |
| Betrachtungszeitraum | 1 Szenariojahr |
| Technologien | „Klassisch“ + <input type="text"/> |
| Zielgrößen: 1. Minimierung Systemkosten 2. Minimierung Kritische Materialien | Investitions- & Betriebskosten <input type="text"/> |

Model





Daten

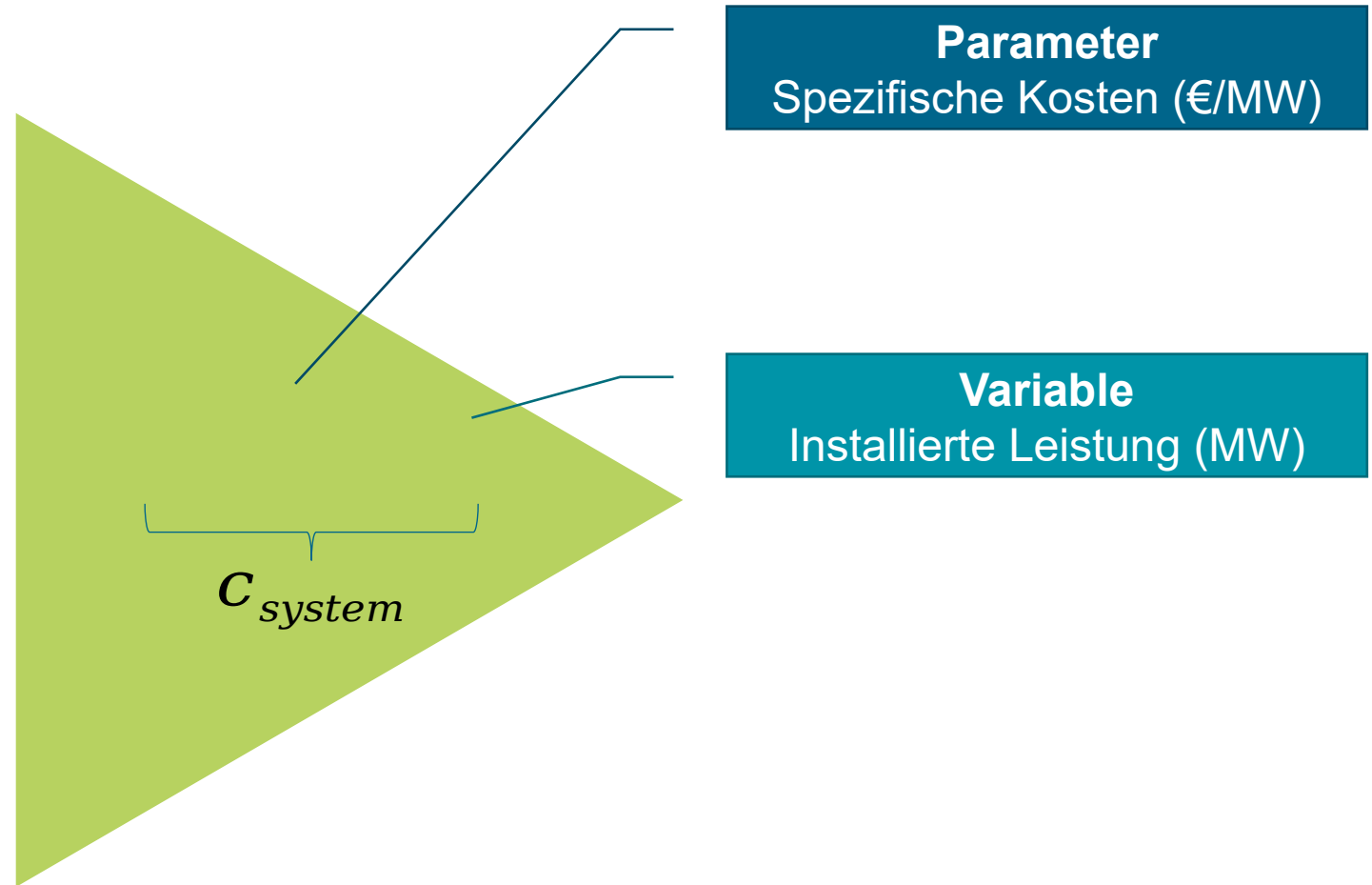


Neue Methoden

Optimierungsansatz



Systemkosten:

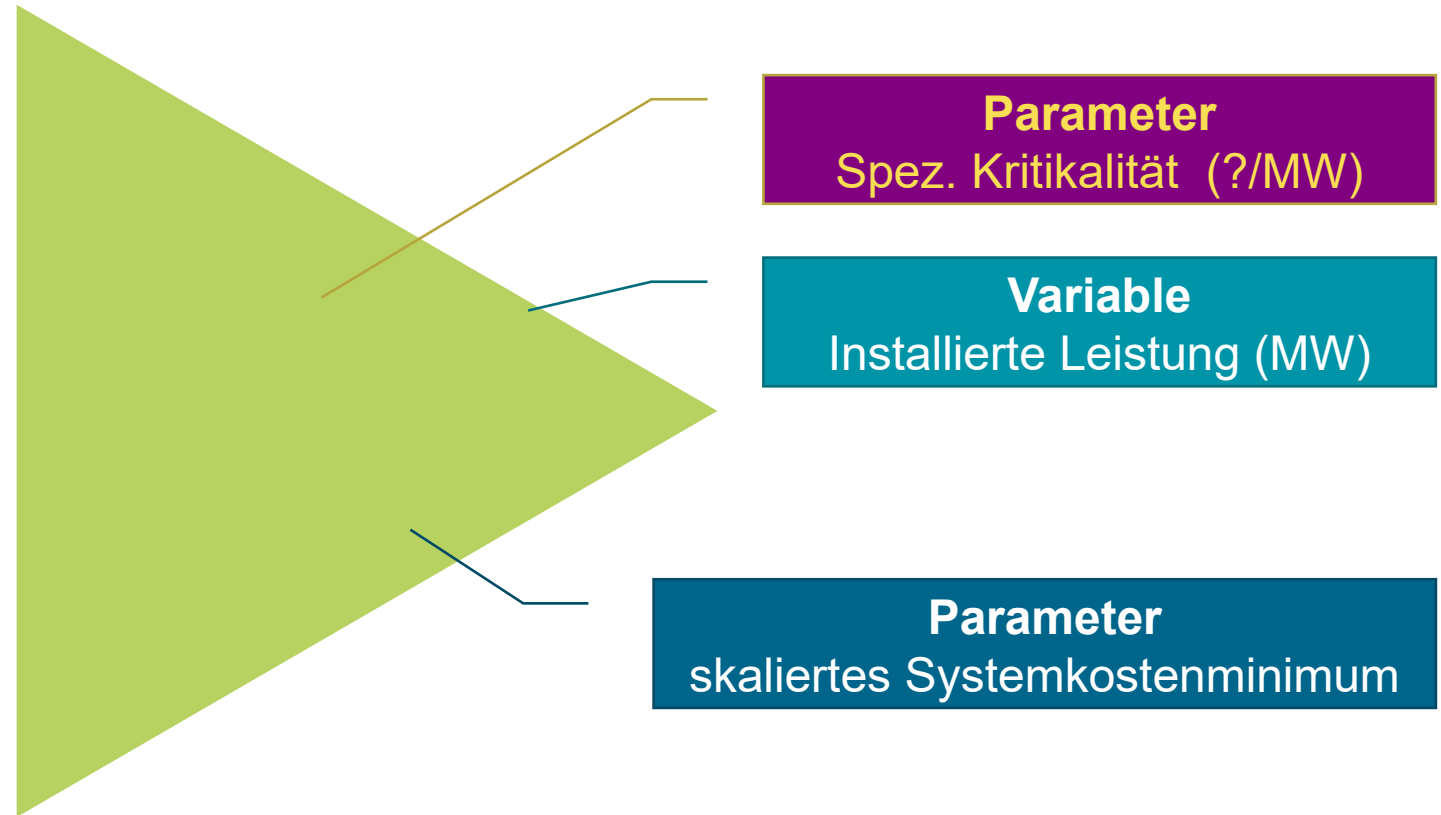


Optimierungsansatz



Systemkosten:

Systemkritikalität:



Energiesystemoptimierung



Kritikalitätsindikatoren

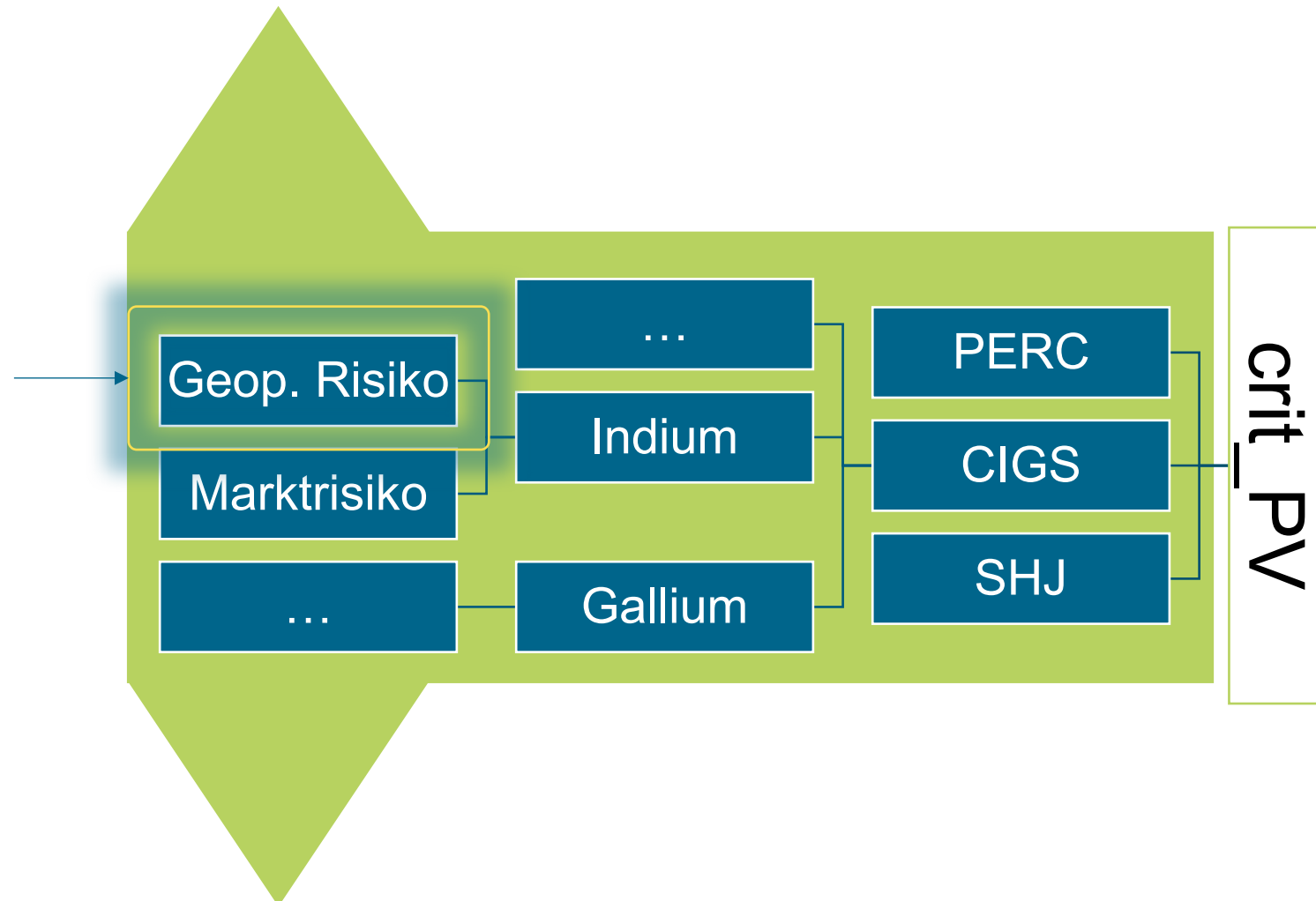


Kritikalitätsindikatoren

European Commission;
Directorate-General for Internal
Market, Industry, Entrepreneurship
and SMEs; Grohol, M.; Veeh, C.

Study on the critical raw
materials for the EU 2023

Final report; Publications
Office of the European Union,
2023. DOI: 10.2873/725585.



Modell



REMIX¹ : *RE-Europe*²
Renewable Energy Mix

Sektor

Strom

Betrachtungsgebiet

Kontinental-Europa

Betrachtungszeitraum

1 Szenariojahr

Technologien

„Klassisch“ + Subtechnologien

- Wind: EESG, PMSG
- PV: SHJ, PERC
- Batterie: LFP, NMC, Redox-Flow Blei-Säure

Zielgrößen:

1. Minimierung Systemkosten
2. Minimierung Rohstoff-Kritikalität

Investitions- & Betriebskosten

Geopolitisches Risiko
„kritischer Rohstoffe“

1: <https://gitlab.com/dlr-ve/esy/remix/framework>

2: <https://gitlab.com/dlr-ve/esy/remix/projects/re-europe>

A satellite image of Earth from space, showing the curvature of the planet and the dark blue of the oceans. Overlaid on the image is a dense network of bright yellow lines representing satellite orbits or data paths. The lines are most concentrated over the landmasses of Europe and Africa, with many lines radiating outwards from specific points on the continents. The background is the blackness of space with some faint stars.

ERGEBNISSE

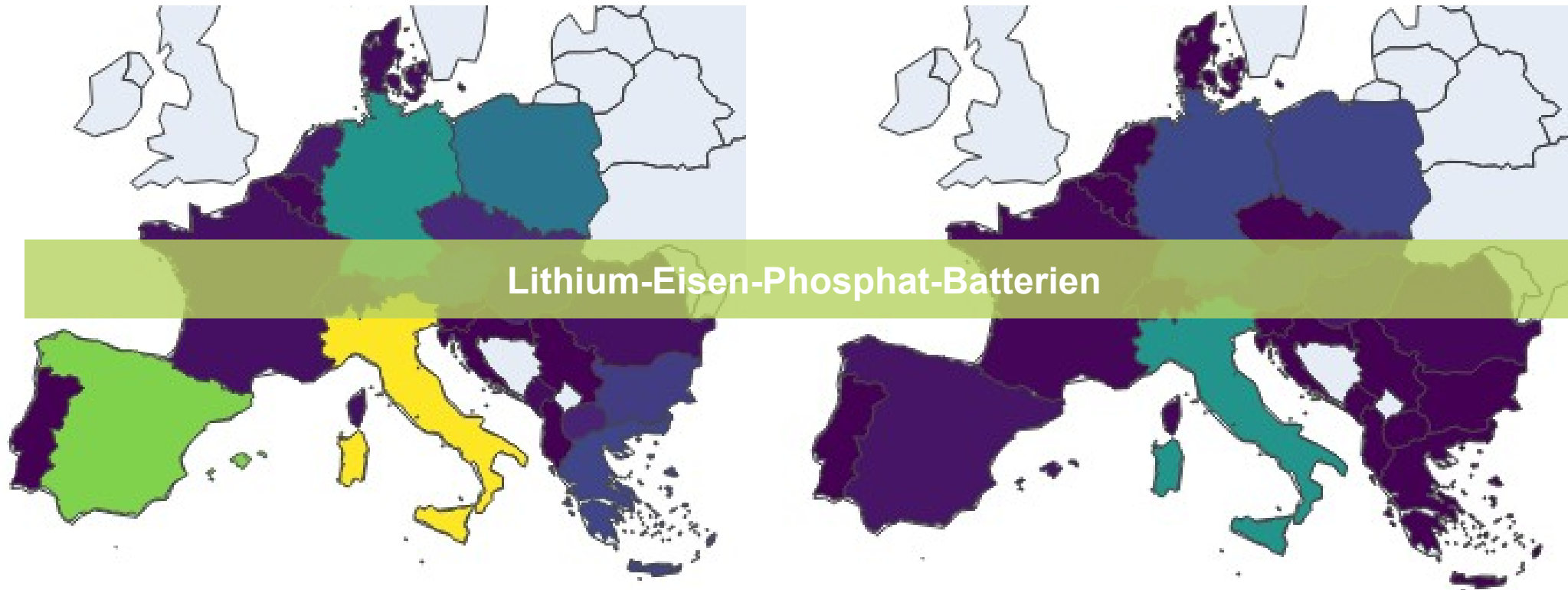
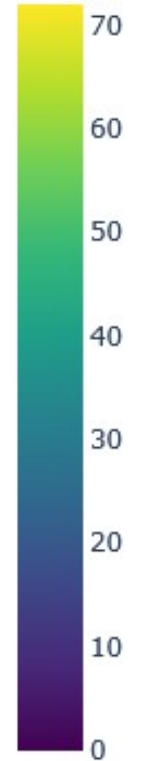
Experiment 1: Speicherausbauplanung



Minimale Systemkosten

Minimierte Systemkritikalität

TWh



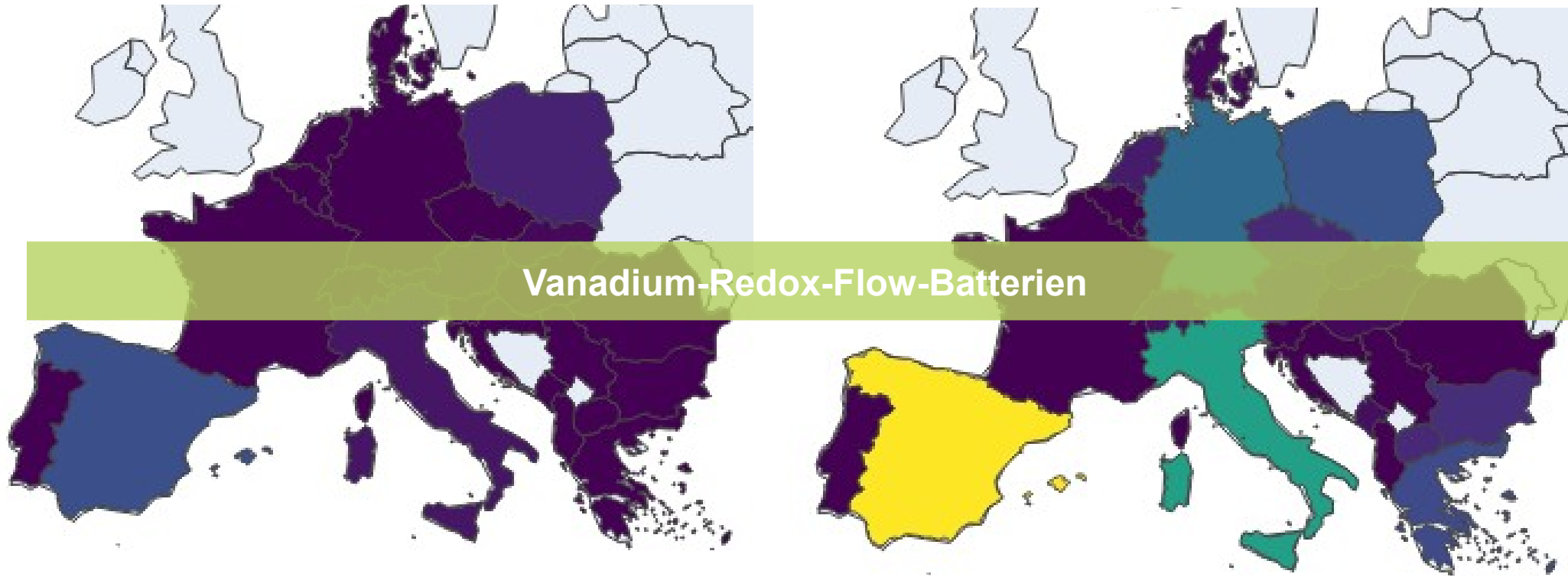
Experiment 1: Speicherausbauplanung



Minimale Systemkosten

Minimierte Systemkritikalität

TWh



Vanadium-Redox-Flow-Batterien

50

40

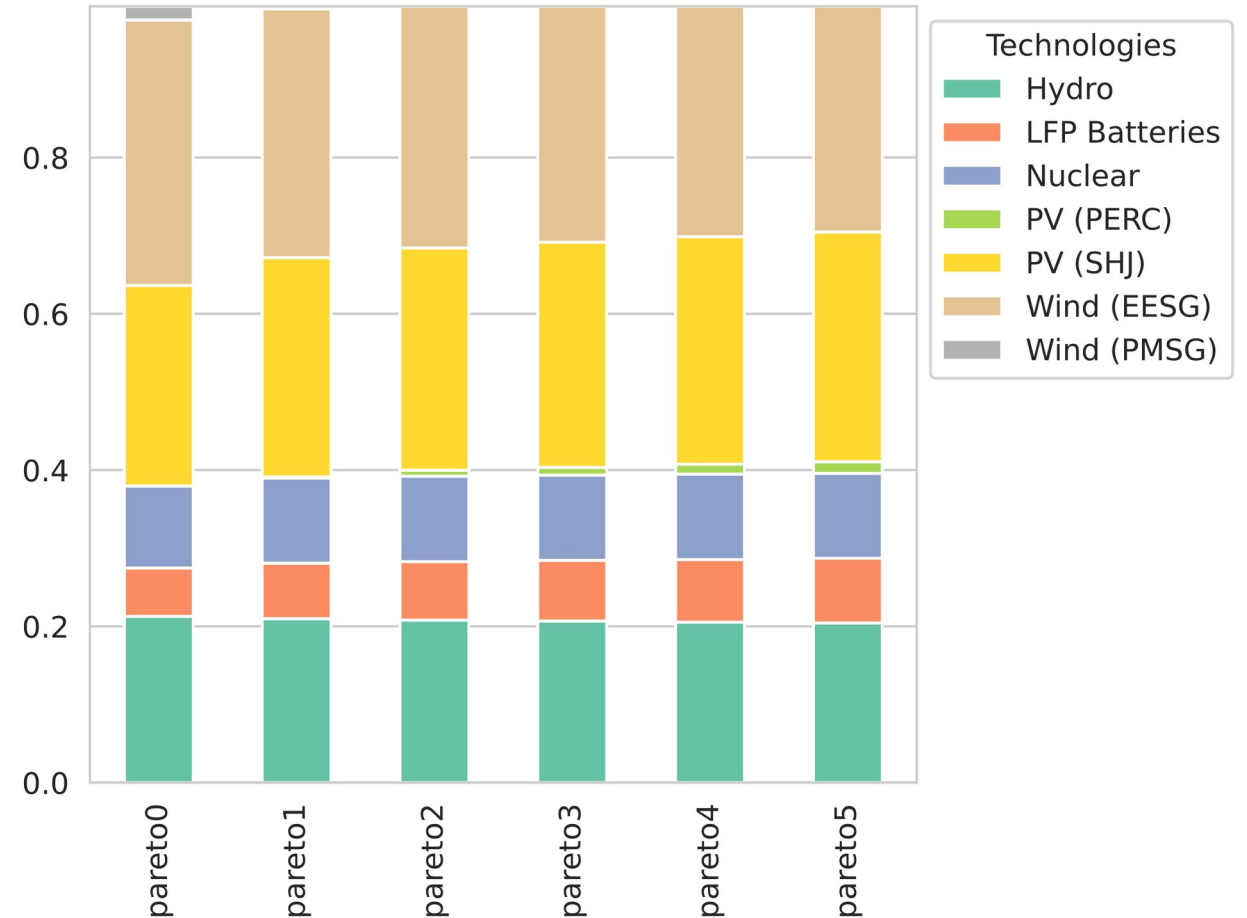
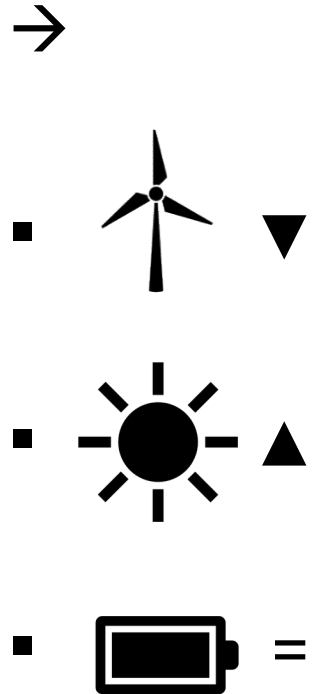
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20

10

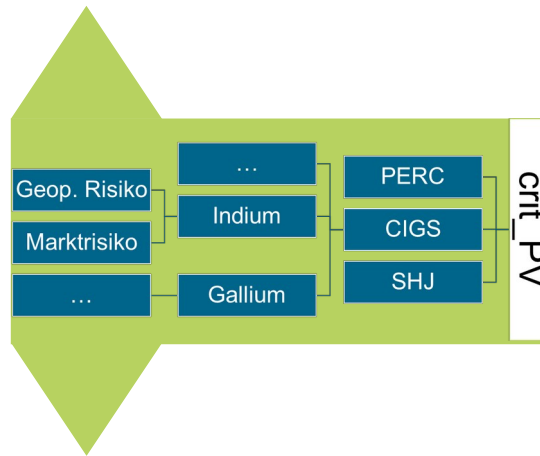
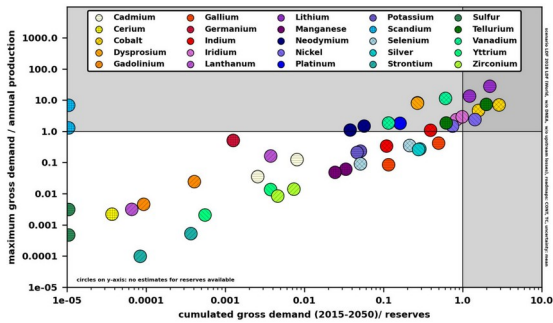
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Experiment 2: Erneuerbare und Speicher

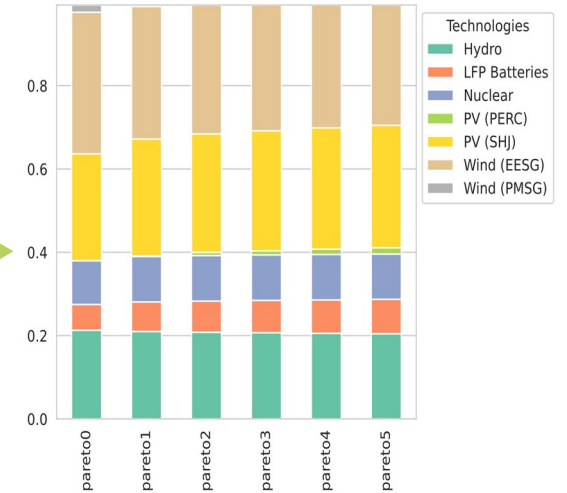


Zusammenfassung

Critical raw materials



crit_{tech}



- 3 Dimensionen (Marktrisiken)
- Daten & Sub-Technologien
- Transformationspfade
- Methodenvergleich & Performance
- Unsicherheiten

VIELEN DANK!

karl-kien.cao@dlr.de

