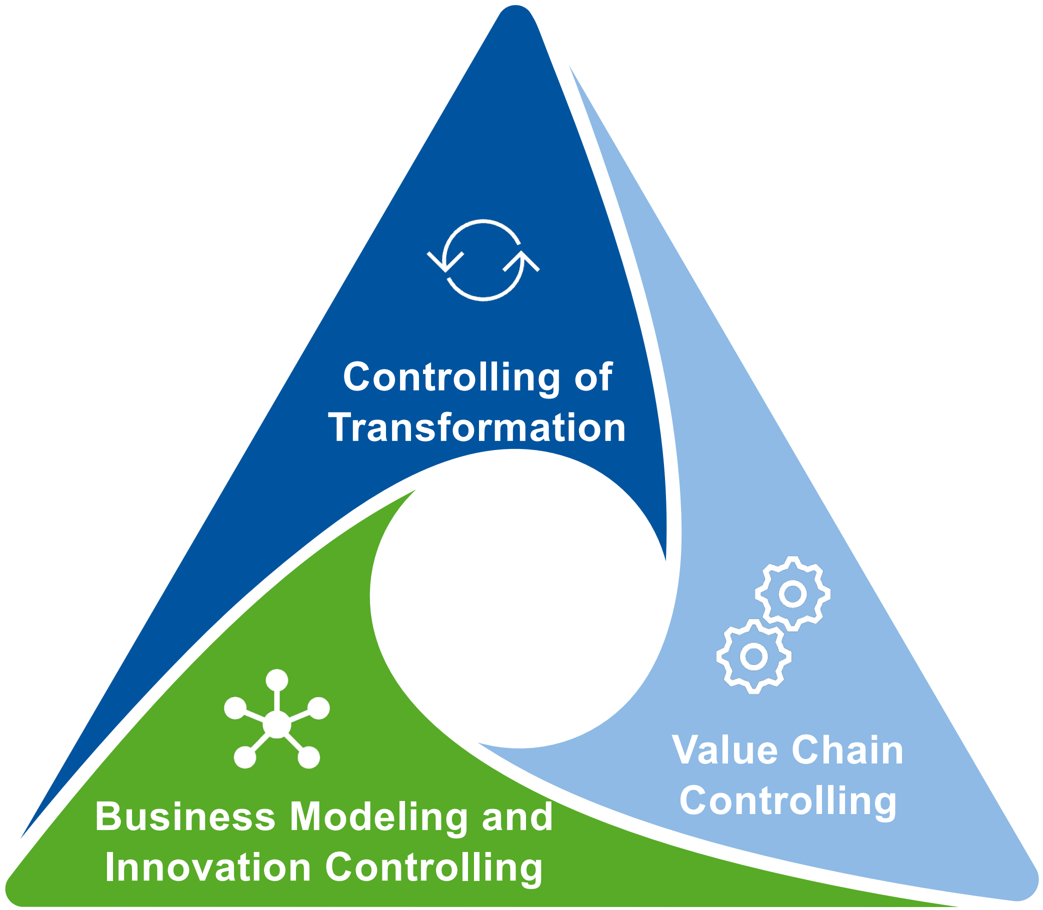
Controlling of Transformation Processes

Peter Letmathe

Center for Circular Economy | RWTH AACHEN UNIVERSITY

Research Areas



Research Projects

ACCESS

Phase 2: Transformationspfade zu einer nachhaltigen Mobilität

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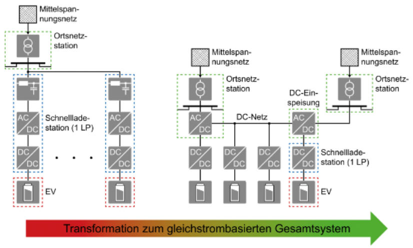
IDEAL



unIT-e2

UN|IT|E²

Reallabor für verNETZte E-Mobilität

Lehrstuhlcontrolling

NeuroSys

GEFÖRDERT VOM

Bundesministerium für Bildung und Forschung

Wandel im Rheinischen Revier

REVIERa

Weiterdenken

Vernetzen

Integrieren

VERBUND

FH MÜNSTER University of Applied Sciences

Forschungskolleg Verbund.NRW

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WASCAL

IMP-EGH

Internat. Masters Programme in Energy and Green Hydrogen

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Definition of Societal Transformations

***Societal transformation** encompasses fundamental and simultaneous or time-shifted changes of technological, economic, ecological, and social systems, which are highly complex in terms of the systems to be considered, the path dependencies and the effects of alternative courses of action, and therefore require inter- and transdisciplinary solutions.*

Drivers of societal transformations:

- Problems and challenges, e.g. overexploitation of our planet, climate change, collapse of biodiversity
- Social and technological innovations, e.g. digitization, artificial intelligences, social media
- Singular events, e.g. Fukushima, invasion of the Ukraine

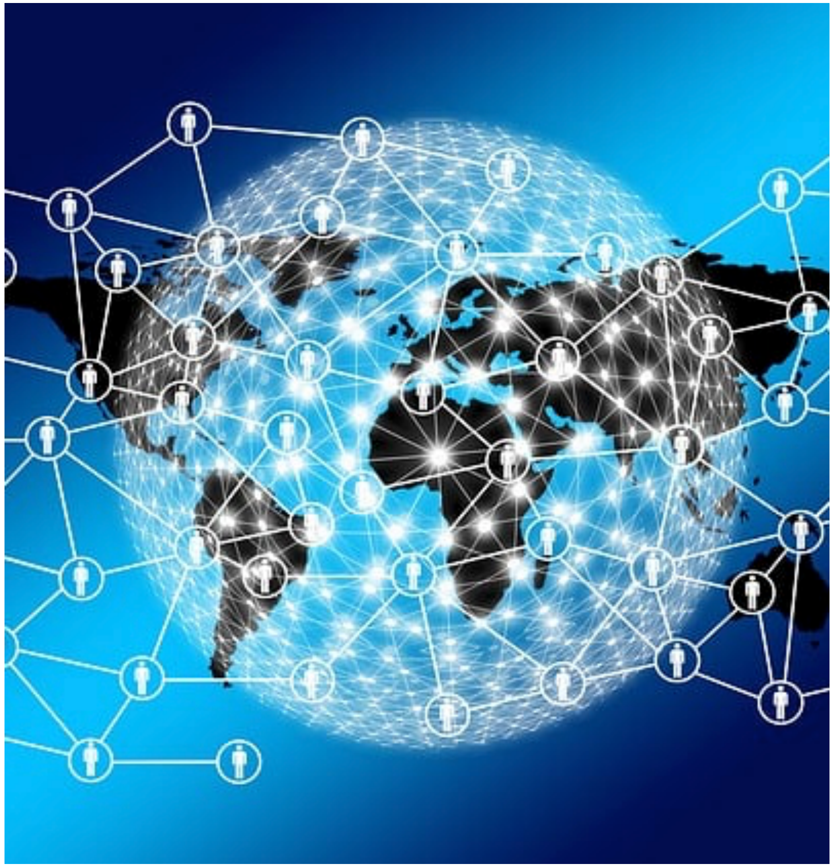
Transformation Challenges: System Complexity

System complexity:

- Systems in which transformation processes are embedded are often highly complex, i.e. the cause-effect relationships of underlying changes are usually unclear and understanding them is therefore an important subject of transformation research.

- Complexity concerns the understanding of technological, economic, ecological, and social systems, as well as the relevant relationships among these systems.

- Not all changes occur at the same time, but relevant patterns emerge over time and may be recognized too late when negative consequences are difficult to prevent.



Transformation Challenges: Path Dependencies

Path dependencies (backward complexity):

- Transformation processes often have to overcome path dependencies resulting from investments already made or established behavioral norms and value attitudes.

- Inertia of established systems entails that transformation processes are delayed and associated with high costs.

- “Stuck in the past” problems require convincing alternative courses of action and the participation of relevant stakeholders on the basis of clearly formulated objectives.

- Compensation mechanisms must (at least partially) offset the costs or other disadvantages of affected stakeholders.

Transformation Challenges: Outcome Uncertainty

Outcome uncertainty (forward complexity):

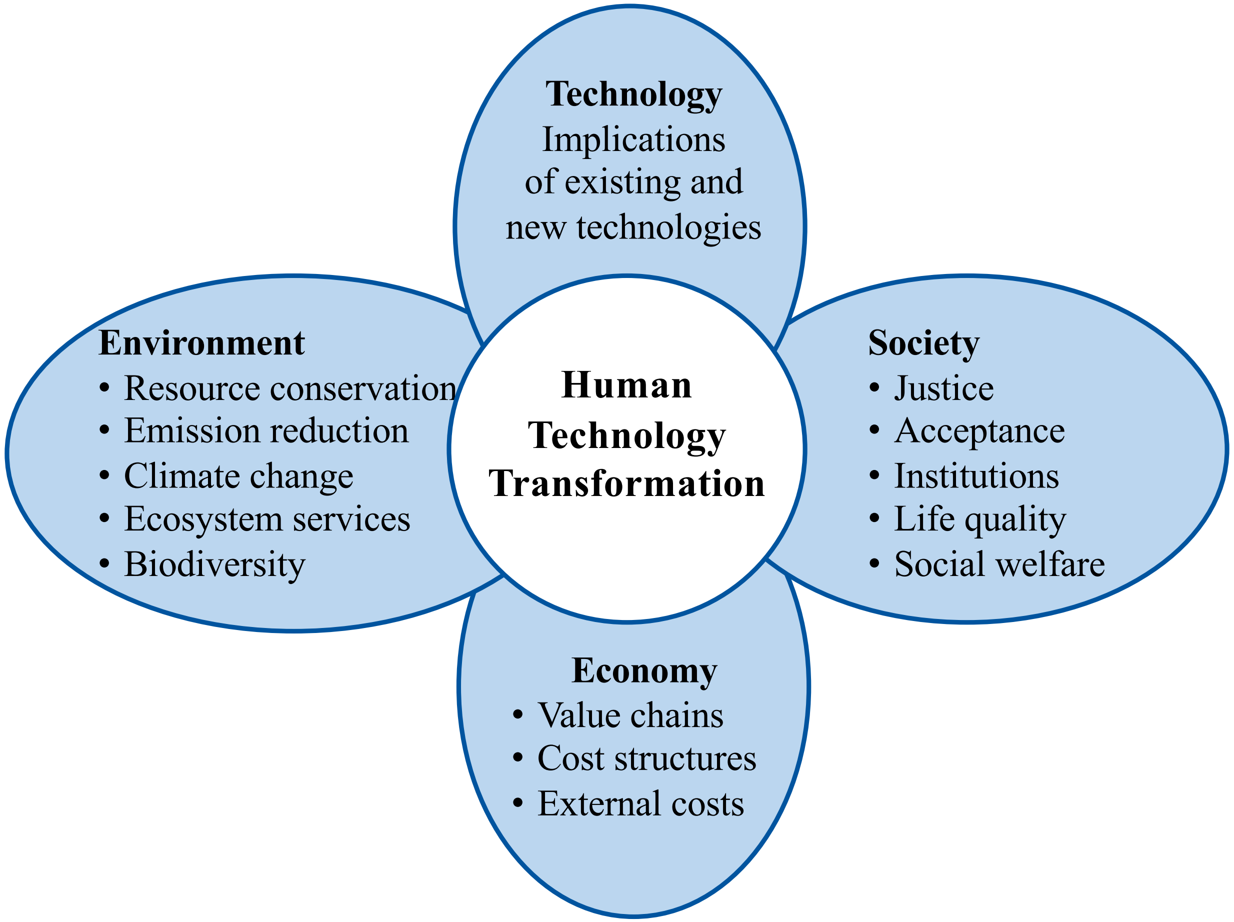
- Due to system complexity, the effects of targeted system interventions are often unclear or difficult to predict.
- Uncertainty relates both to the level of success of measures and to possible (unintended) side effects, encompassing technological, economic, ecological and social systems and their interdependencies.
- Uncertainty is used by transformation critics to question transformation processes.
- Forward-looking complexity thus often reinforces existing path dependencies.
- Control mechanisms are needed to counteract undesired side effects and to strengthen desired outcomes.

1.1 Definition of Societal Transformations

Role of Management Accounting in Societal Transformations:

- Methodologically sound information basis for decision makers
- Correction of irrationality and bias
- Documentation, planning and monitoring
- Information for corrective action in case of undesired effects
- Inputs for the public discourse
- Identifying opportunities (business models)
- Identification of regulatory needs to correct market failures (externalities!)
- Maintaining institutional health

Aachener Transformation Model



Aachener Transformation Model

Inputs

Visions:
Goals and compasses to create joint understanding

Know how:
Tangible and intangible knowledge (transfer/spillover)

Actors:
Scientists, workforce, institutions such as universities, communities, political parties, other stakeholder groups (facilitators and preventers)

Platforms:
Knowledge exchange, decision-making (e.g. budgets), vision refinement

Frameworks:
Regulations, finance, economic architectures and incentives

Transformation activities

Combination of inputs and their conversion into (desired?) outcomes

Conversion processes:

- “Black box”
- Deterministic or nondeterministic: Schrödinger‘s cat
- Trial and error (better outcome through more trial?)
- Evolutionary paths
- Event-based reaction patterns (natural disasters, technological breakthroughs, elections)

Understanding of conversion processes is key to successful transformation

Outcomes

Characteristics:
Specific outcomes uncertain
Timing unknown
Quantity not predictable
Quality uncertain

Stages:
Conceptual ideas
Prototypes
Innovation ecosystems
Marketable outputs successfully launched

Performance measures:
Economic profitability
Number of workplaces
Social impact
Environmental sustainability (SDGs)

Concepts and Methods

- Business Modeling
- Participation of Stakeholders
- Environmental Life Cycle Assessment
- Social Life Cycle Assessment
- Life Cycle Costing
- Total Cost of Ownership
- Accounting for Ecosystem Services and Biodiversity
- External Costing
- ESG and Sustainability Reporting

External Costing

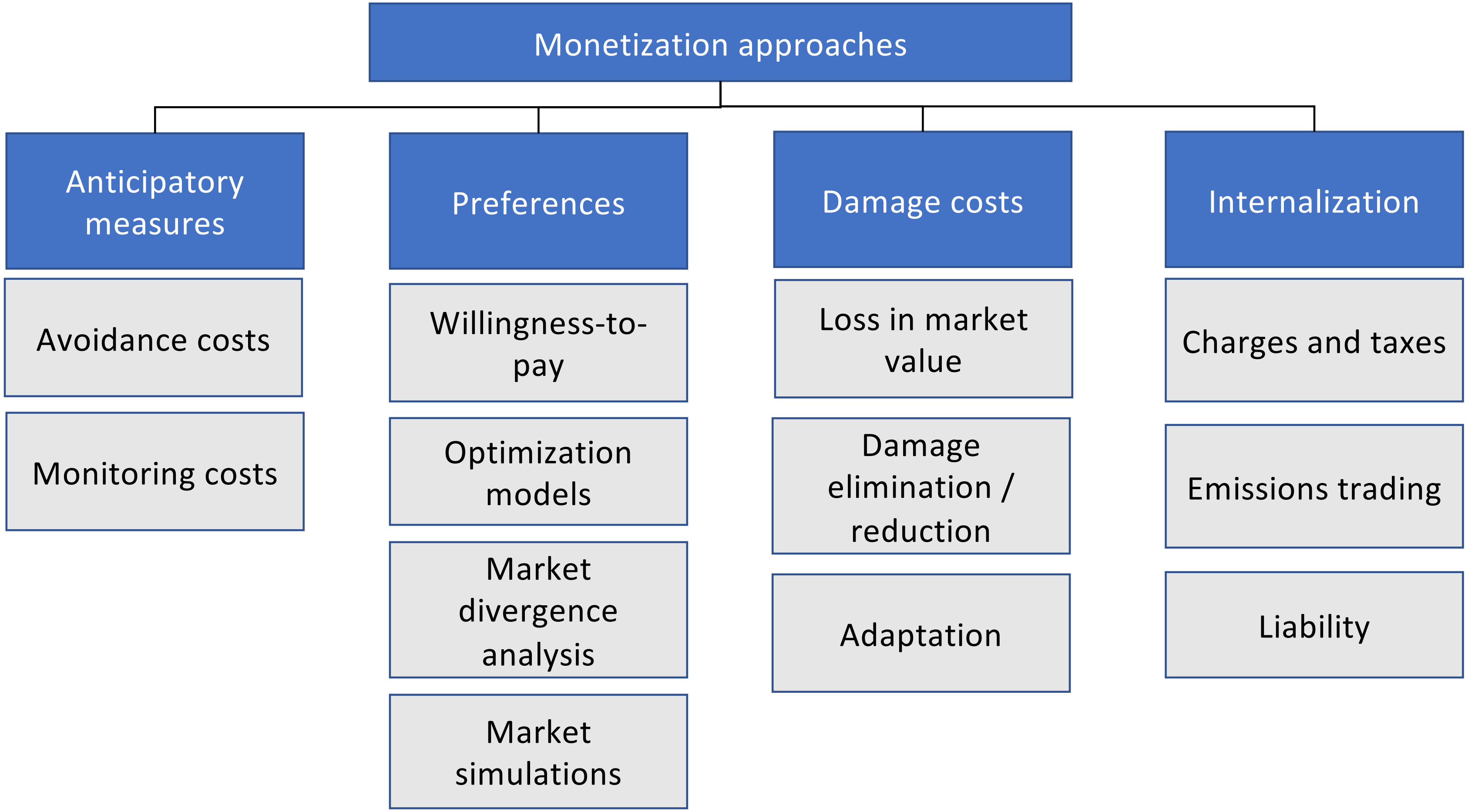
Prof. Dr. Peter Letmathe
Lehrstuhl für Controlling

External costs

External costs:
Monetizable effects of consumption and production decisions that are not borne by the polluter(s) themselves.

- In principle, external costs can affect **all SDGs** (environmental and social impacts)
- **Recording problem:** quantification of causes of external effects, cause-and-effect effects, (non-linear) damage functions often difficult to determine
- **Valuation problem:** as there is generally no market price, often only subjective valuation possible
- **Non-valuation trap:** if decisions are made on the basis of economic rationality, this induces a non-valuation with a price of zero
- **Neglect trap:** failure to take external effects into account generally leads to **market failure**
- **Valuation approaches:** Avoidance costs, damage costs, monitoring costs, avoidance costs, damage elimination or reduction costs, willingness to pay

External costs



External Costs: Diesel Affair

Transportation Research Part D 87 (2020) 102501

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journal homepage: www.elsevier.com/locate/trd

ELSEVIER

External costs of the Dieselgate – Peccadillo or substantial consequences?

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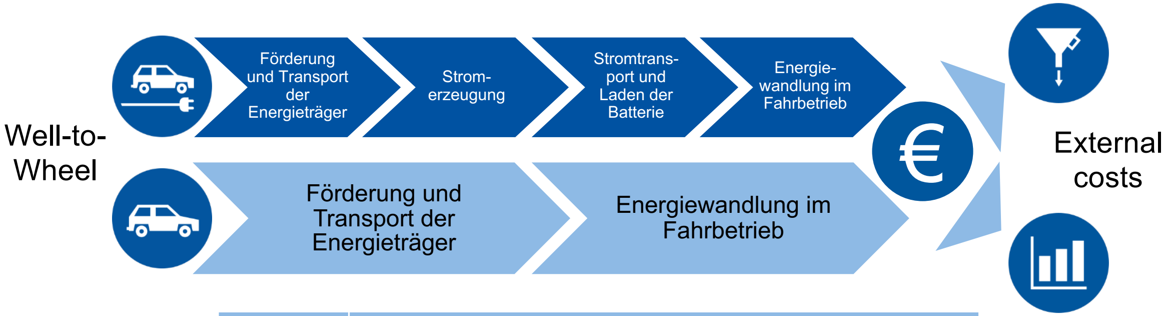
ARTICLE INFO

Keywords:
External costs
Dieselgate
Diesel vehicle
Well-to-wheel analysis
Nitrogen oxide (NO_X)

ABSTRACT

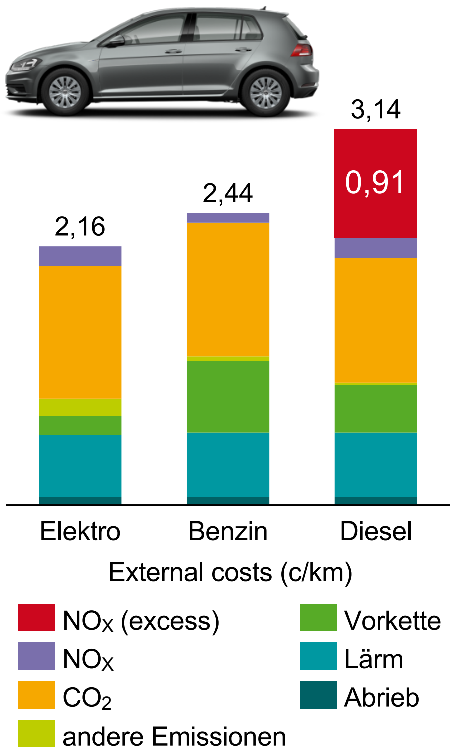
The Dieselgate has changed the public view of diesel powertrains and local authorities have issued first driving bans on diesel cars in Germany. Nevertheless, a systematic calculation of the external costs of the Dieselgate considering different car models and a variety of emissions has not yet been conducted. We compare the results, which reflect emissions under test bench conditions, with those of diesel cars under the assumption that NO_X emissions reflect realistic driving behavior. We find that diesel cars with idealized emissions are superior to petrol cars with regard to external costs and that electric cars have only partially lower external costs than diesel cars. However, when realistic driving behaviors are considered, diesel engines constitute the worst powertrain in all cases. Our results show that the Dieselgate has led to substantially higher external costs than cars which would comply with environmental regulations under realistic driving conditions.

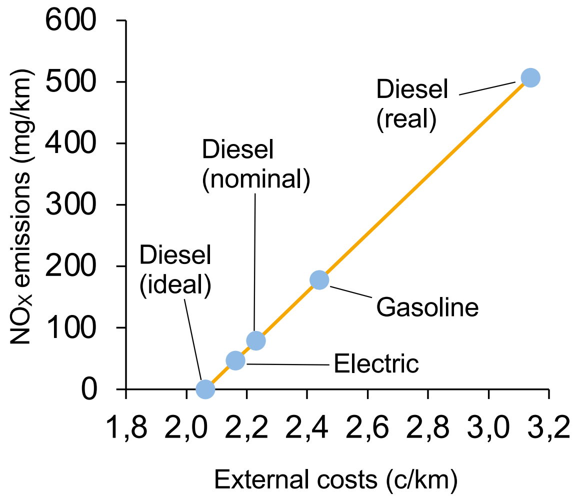
External Costs: Diesel Affair



Segment	Fahrzeugmodelle				
	Elektro	Benzin Hybrid	Diesel Hybrid	Benzin	Diesel
Minis	Smart ForTwo ED, VW e-Up, Mitsubishi i-Miev	-	-	Smart ForTwo, VW up, Mitsubishi Space Star	-
Kleinwagen	BMWi3, Renault Zoe Z.E.	Honda Jazz, Toyota Yaris	-	BMW 120i, Renault Clio TCe, Honda Jazz 1.4, Toyota Yaris 1.3	BMW 120d, Renault Clio dCi, Toyota Yaris 1.4
Kompakt-klasse	VW e-Golf, Nissan Leaf	Toyota Auris, Lexus CT 200h	-	VW Golf TSI, Nissan Pulsar DIG-T, Toyota Auris 1.6	VW Golf TDI, Nissan Pulsar dCi, Toyota Auris 2.0
Mittelklasse	-	Lexus IS 300h	Peugeot 508 RXH	Lexus IS 200t	Peugeot RXH
Obere Mittelklasse	-	-	Mercedes E300h	Mercedes E250	Mercedes E300
Oberklasse	Tesla S	Mercedes S400h	-	Mercedes S400	Mercedes S350d
Mini-Vans	Mercedes B250e	Toyota Prius+	-	Mercedes B250, Toyota Verso 1.6	Mercedes B220d, Toyota Verso 1.6-D
SUVs	Tesla X	Lexus RX450h	-	Lexus RX200t, BMW X5 XDrive35i	BMW X5 xDrive30d

External Costs: Diesel Affair





- Annual damage in Germany: approx. € 2.5 billion
- Newest vehicles are tested on the road It is possible to build clean diesel engines

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External Costs: Diesel Affair

External costs: the diesel affair

Dieselaffäre

20 Milliarden Euro Kosten für die Gesellschaft

● Der Dieselbetrug hat in Deutschland einen gesellschaftlichen Schaden von rund 20 Milliarden Euro verursacht. Das ergab eine Studie der RWTH Aachen. Die Wirtschaftswissenschaftler Frank Baumgärtner und Peter Letmathe analysierten die Daten von 49 Fahrzeugmodellen und berechneten die volkswirtschaftlichen Kosten der überhöhten Abgaswerte, die sich etwa aus der verstärkten Luftverschmutzung ergeben. Den Preis für die schädlichen NO_x-Emissionen ermittelten die Forscher mithilfe der sogenannten NEEDS-Datenbank der EU. Demnach erzeugten die Abgastricks gesellschaftliche Kosten von jährlich 2,5 Milliarden Euro. Durch eine teils sechsfache Überschreitung der Grenzwerte sei der Diesel zum umweltschädlichsten Antrieb geworden. Der manipulierte VW-Motor EA189 wurde zwischen 2008 und 2015 eingebaut, ab Anfang 2016 versah der Konzern betroffene Autos mit einem Update. Der Vergleich mit neueren Fahrzeugen zeigt laut Studie aber auch, »dass es durchaus möglich ist, saubere Dieselmotoren zu konstruieren«. SH

www.spiegel.de/wirtschaft/unternehmen/dieselaffaere-kostet-deutschland-rund-20-milliarden-euro-laut-rwth-studie-a-6df6c386-299f-4970-96bb-5f68d9d3fe09

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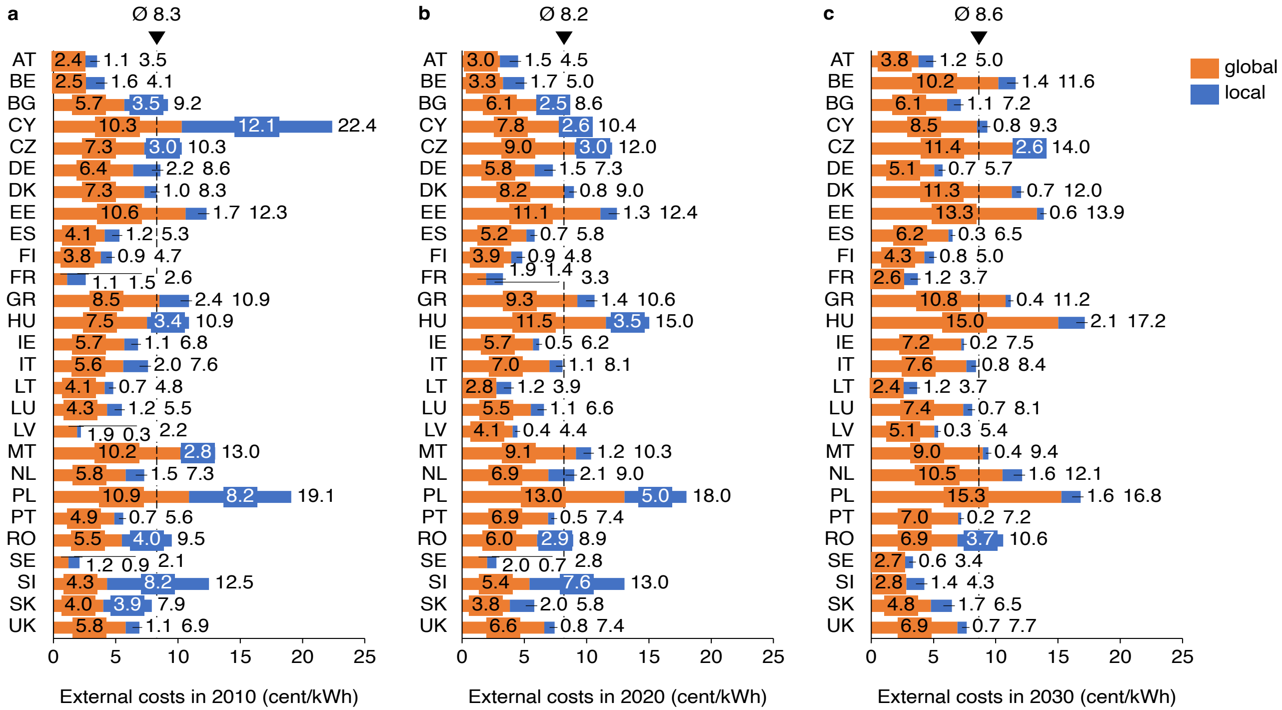
External Costs of Energy Systems in Europe

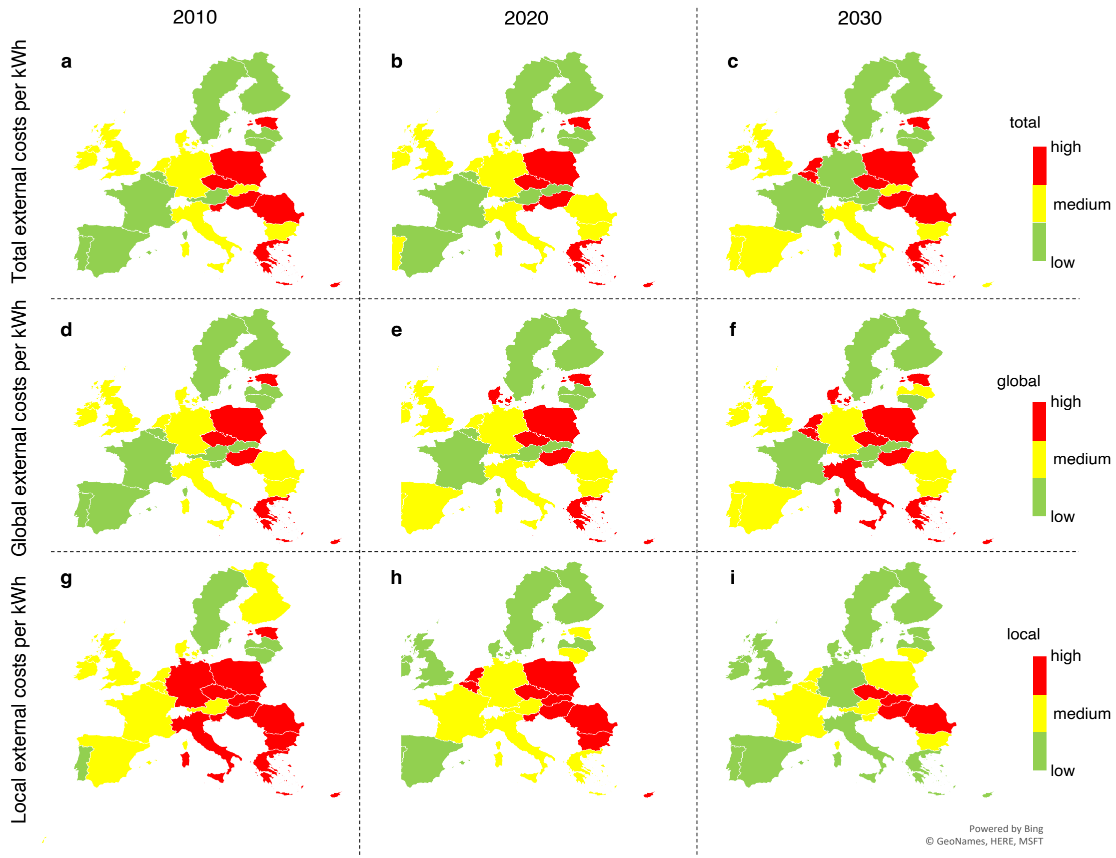


Source: Baumgärtner, F.; Letmathe, P. (2024). External costs of electricity generation in 27 European countries from 2010–2030: Pathway toward sustainability or business as usual? PLOS One. (forthcoming).

External costs of electricity in Europe in the years 2010 (a), 2020 (b) and 2030 (c): Austria (AT), Belgium (BE), Bulgaria (BG), Cyprus (CY), Czechia (CZ), Germany (DE), Denmark (DK), Estonia (EE), Spain (ES), Finland (FI), France (FR), Greece (GR), Hungary (HU), Ireland (IE), Italy (IT), Lithuania (LT), Luxembourg (LU), Latvia (LV), Malta (MT), Netherlands (NL), Poland (PL), Portugal (PT), Romania (RO), Sweden (SE), Slovenia (SI), Slovakia (SK), United Kingdom (UK).

External Costs of Energy Systems in Europe

Classification of external costs of energy systems:



Source: Baumgärtner & Letmathe (2024)

Energy System Transition

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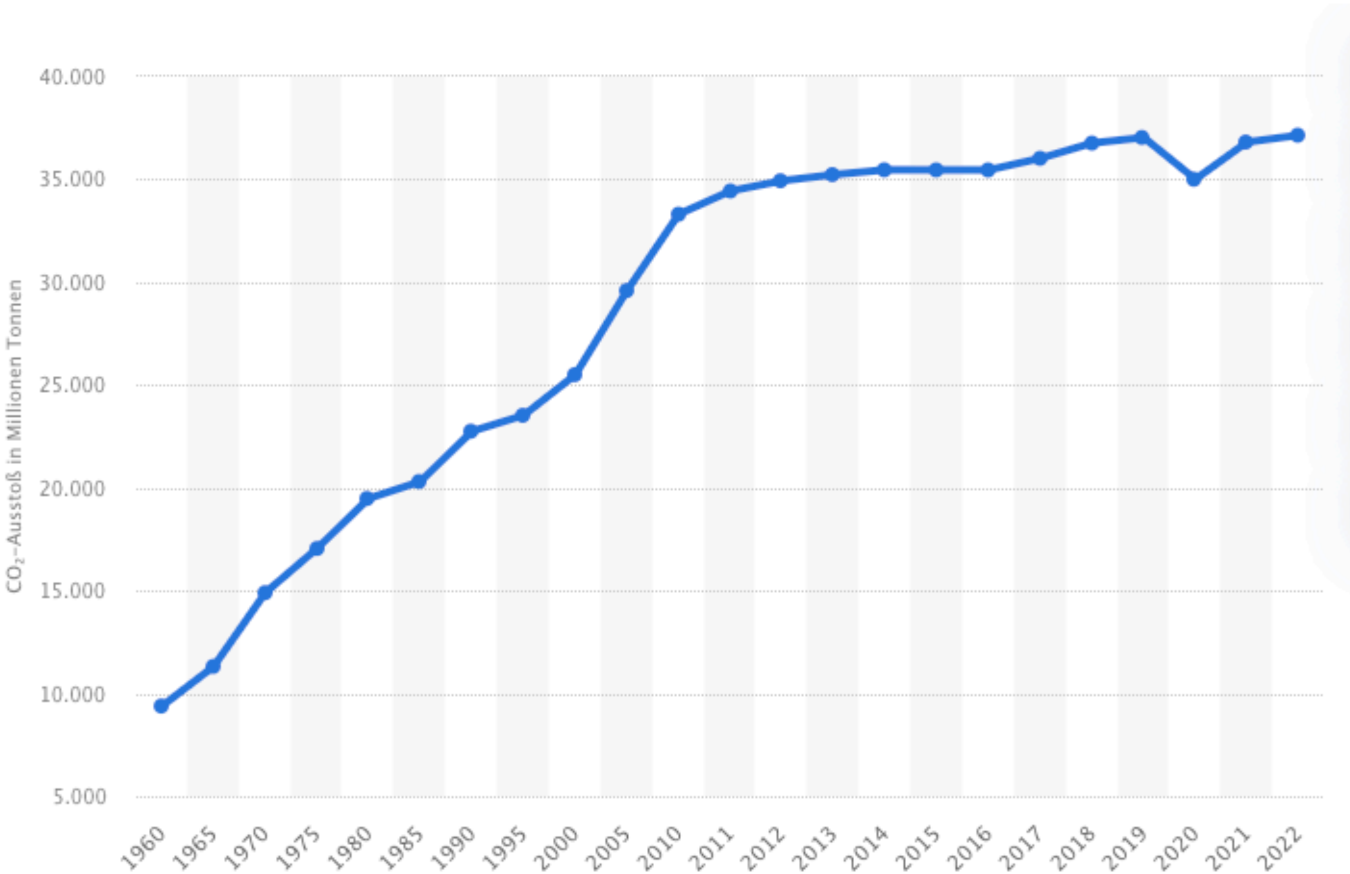
Transformation of the Energy System



Source Statista (2023): https://de.statista.com/statistik/daten/studie/37187/umfrage/der-weltweite-co2-ausstoss-seit-1751/#:~:text=Der%20weltweite%20Ausstoß%20von%20Kohlenstoffdioxid,in%20einem%20deutlich%20geringeren%20Maße.

Hydrogen Society – Vision or Illusion?

Transformation of our Energy System is one of the key challenges of the first half of this century

Business Model View	**Institutional Framework View**
Energy System View	**Capacity Building View**

Energy System Simulation Tool: EnergyPLAN

Research Questions:

1. How and to what extent does the operation of water electrolysers enhance system flexibility, and how does EHP-based flexibility translate into decarbonisation?

2. How will the timing of the coal phase-out and the rate of EHP shape the decarbonisation of the German energy system during the next decade?

3. What will the economic consequences of upscaling EHP and the coal phase-out be?

EHP: Electric Hydrogen Production

Energy System Simulation Tool: EnergyPLAN

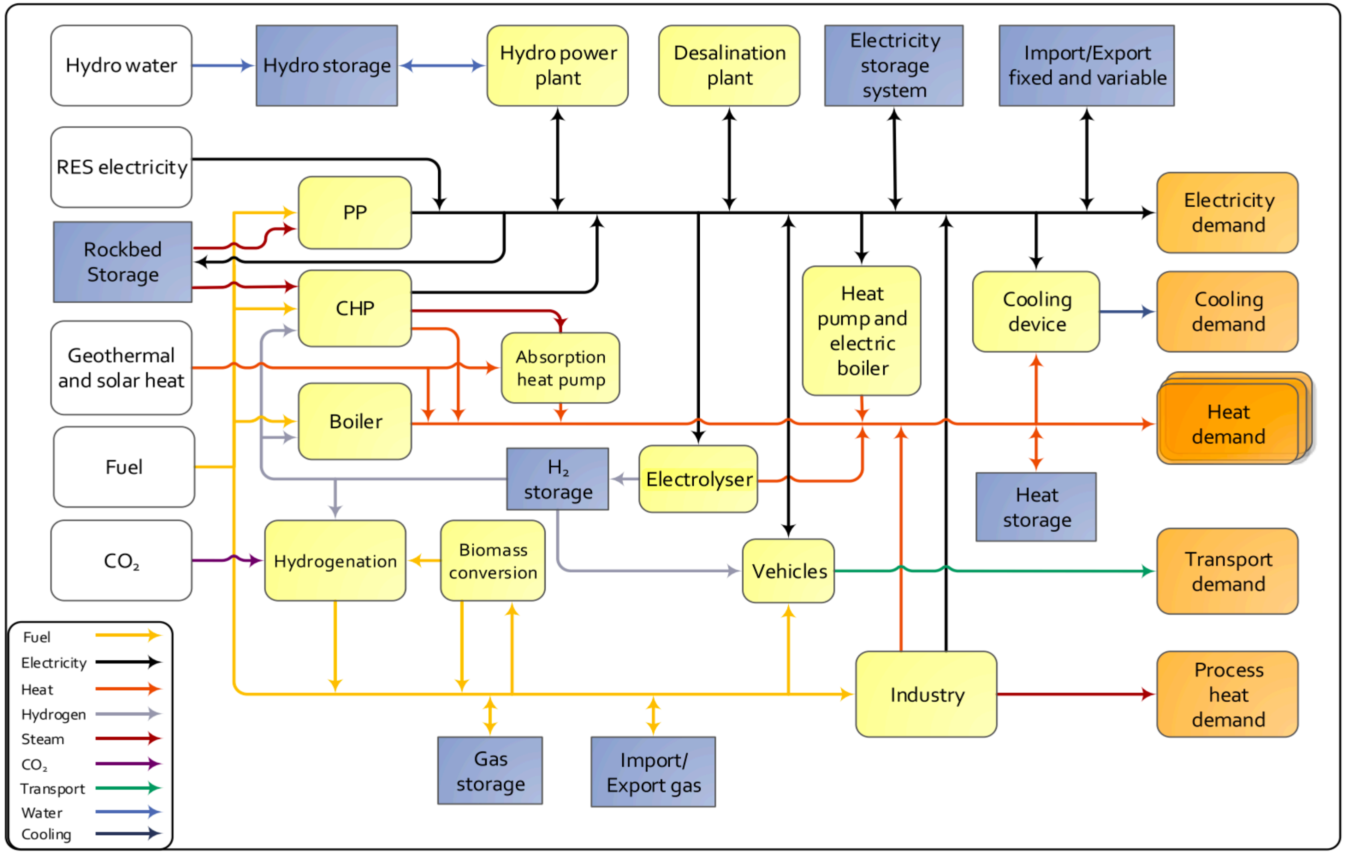
- Deterministic bottom-up simulation tool (developed at Aalborg University)
- Simulates the operation of national energy systems on an hourly basis, including the electricity, heating, cooling, industry, and transport sectors (www.energyplan.eu)

Data Types	Input	Output
Annual data	➢ Power plant capacities ➢ Production & consumption volumes ➢ Efficiencies ➢ Emission factors …	➢ Complete energy balances ➢ CO_2 emissions …
Hourly profiles	➢ Demand patterns ➢ (Intermittent RES) generation profiles …	➢ Generation & load profiles per technology ➢ Import/export profiles …

Work Steps

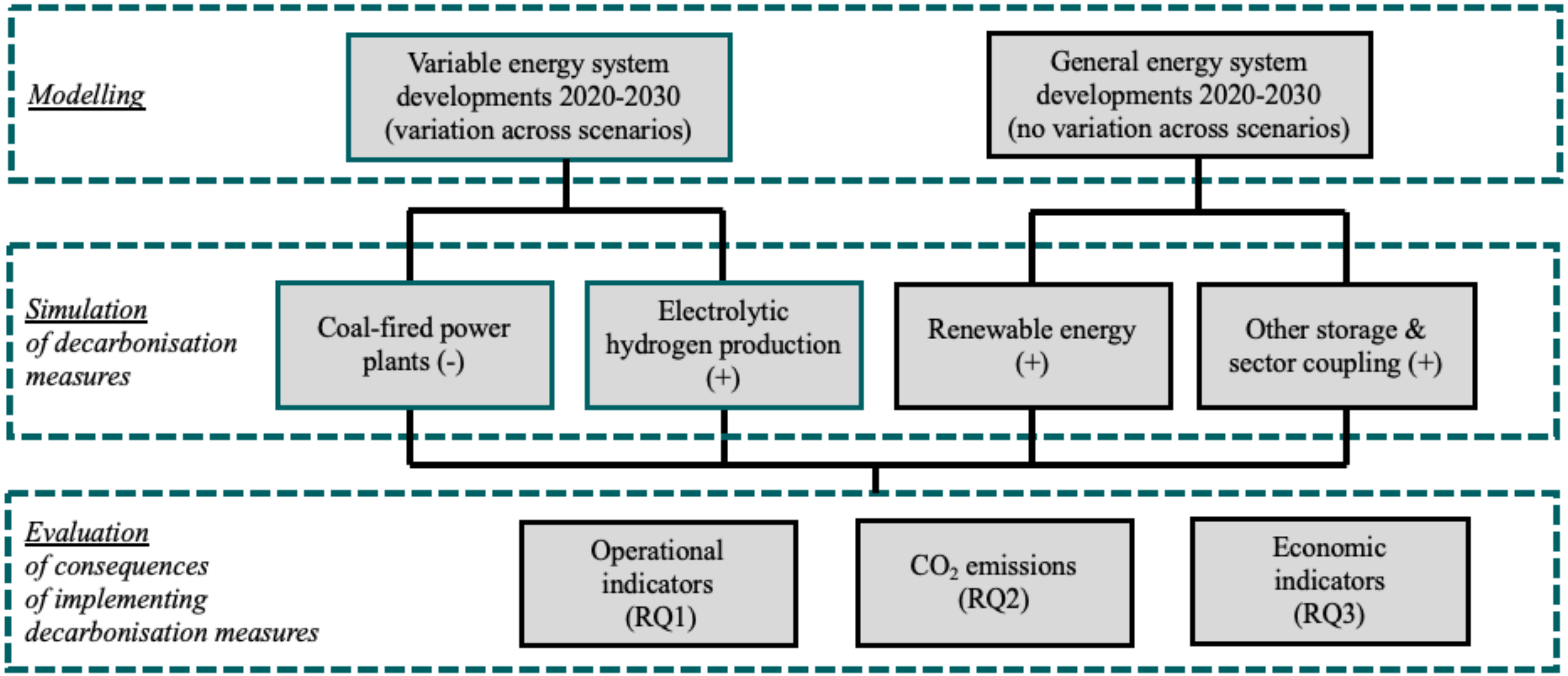
1. Data collection (Sources: Federal statistics, environmental associations …)
2. Model calibration
3. (Pathway) Modelling
4. Simulation (strategy: balancing both heat and electricity demand)

Energy System Simulation Tool: EnergyPLAN



Coal Phase-out and Electrolytic Hydrogen Production

Methodological Procedure



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Coal Phase-out and Electrolytic Hydrogen Production - Scenarios

Scenario pathways *2020-2030*			Coal-fired power plant closures		
			Commission on Growth, Structural Change and Employment	Greenpeace	Bund für Umwelt und Naturschutz Deutschland (BUND)
Hydrogen production	None		*BAU*	*GP*	*BUND*
	LOW	Fixed & flexible hydrogen demand	-	*LOW_GP*	*LOW_BUND*
	HIGH		-	*HIGH_GP*	*HIGH_BUND*
		Only flexible operation of electrolyzers	*BAU_Flex*	*GP_Flex*	*BUND_Flex*

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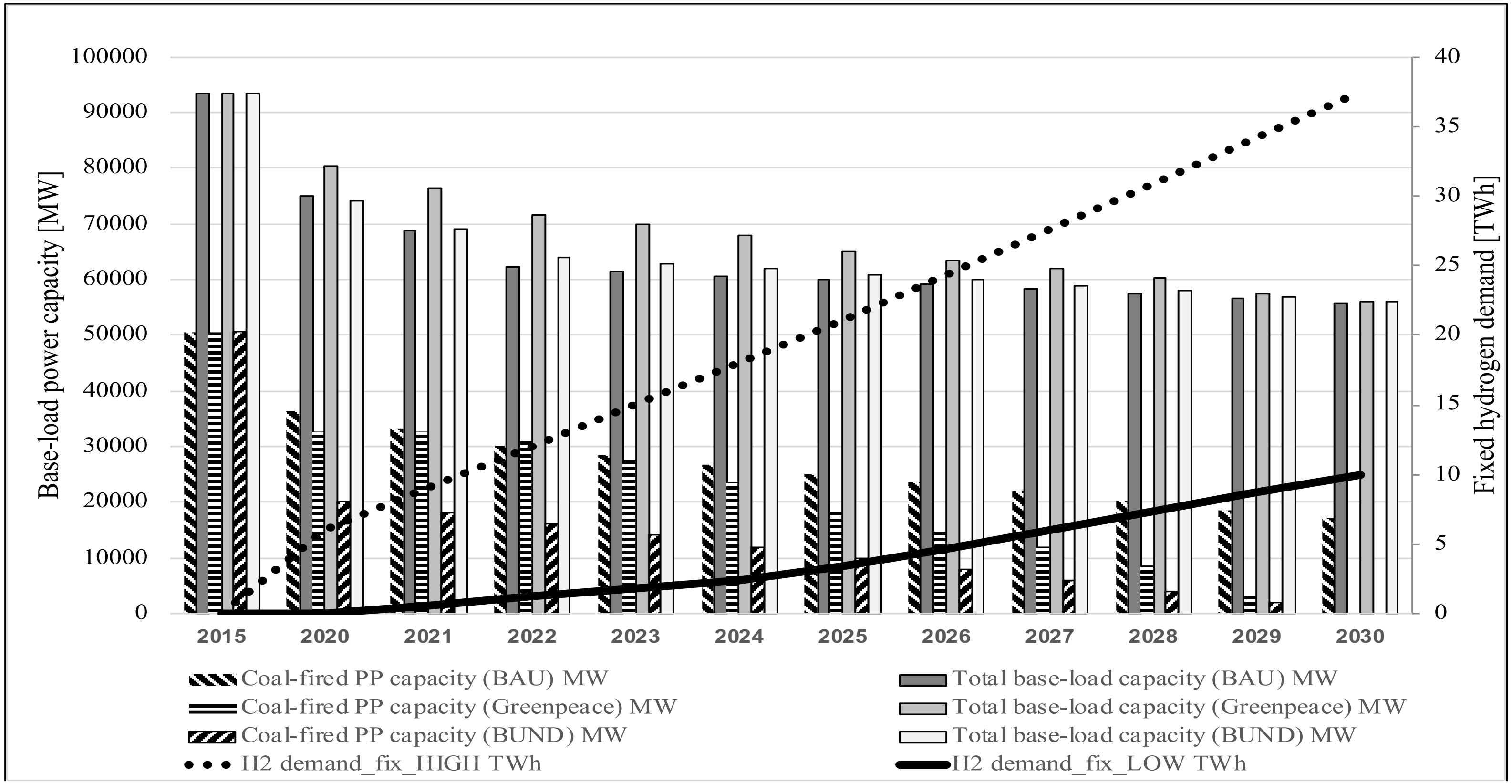

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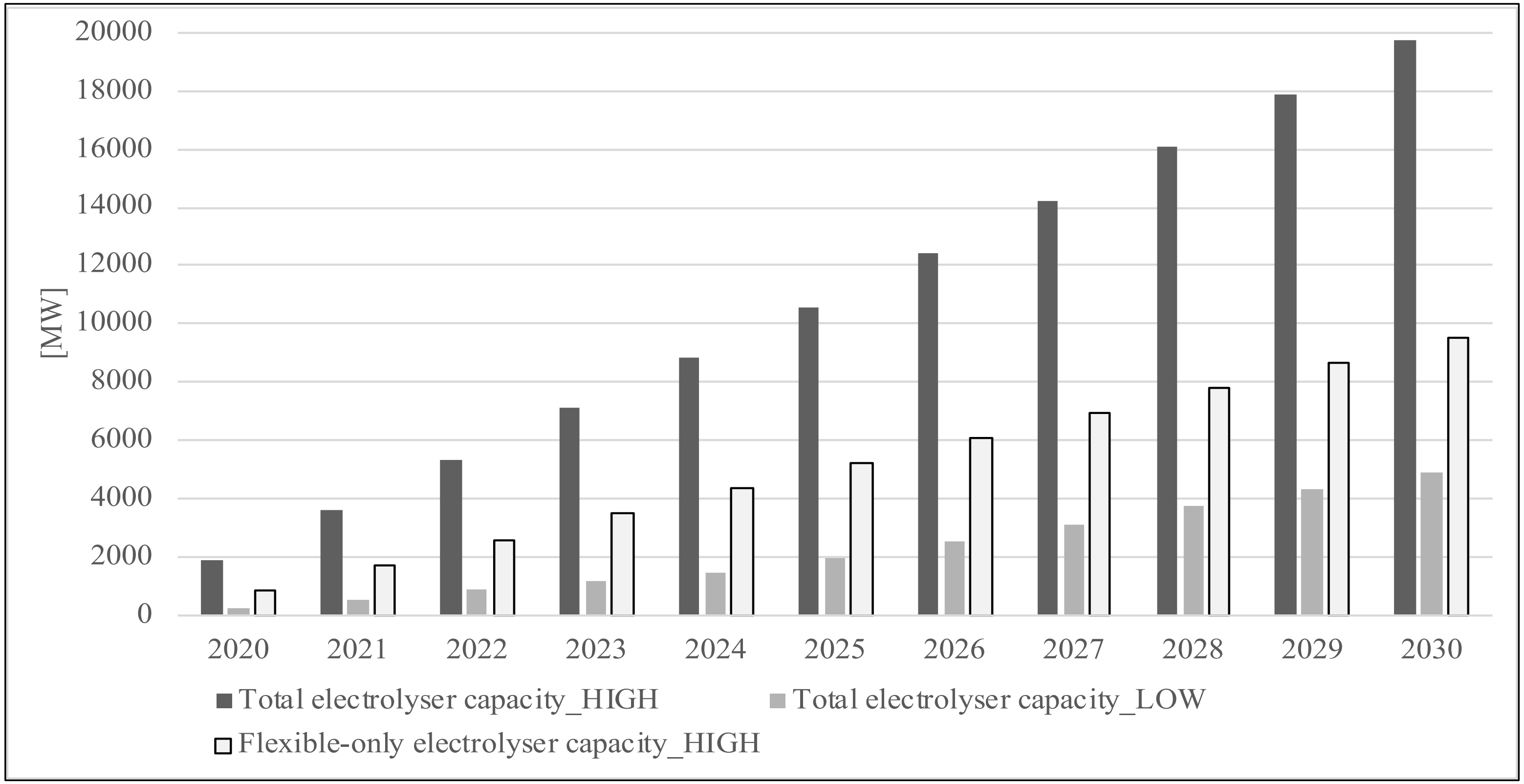

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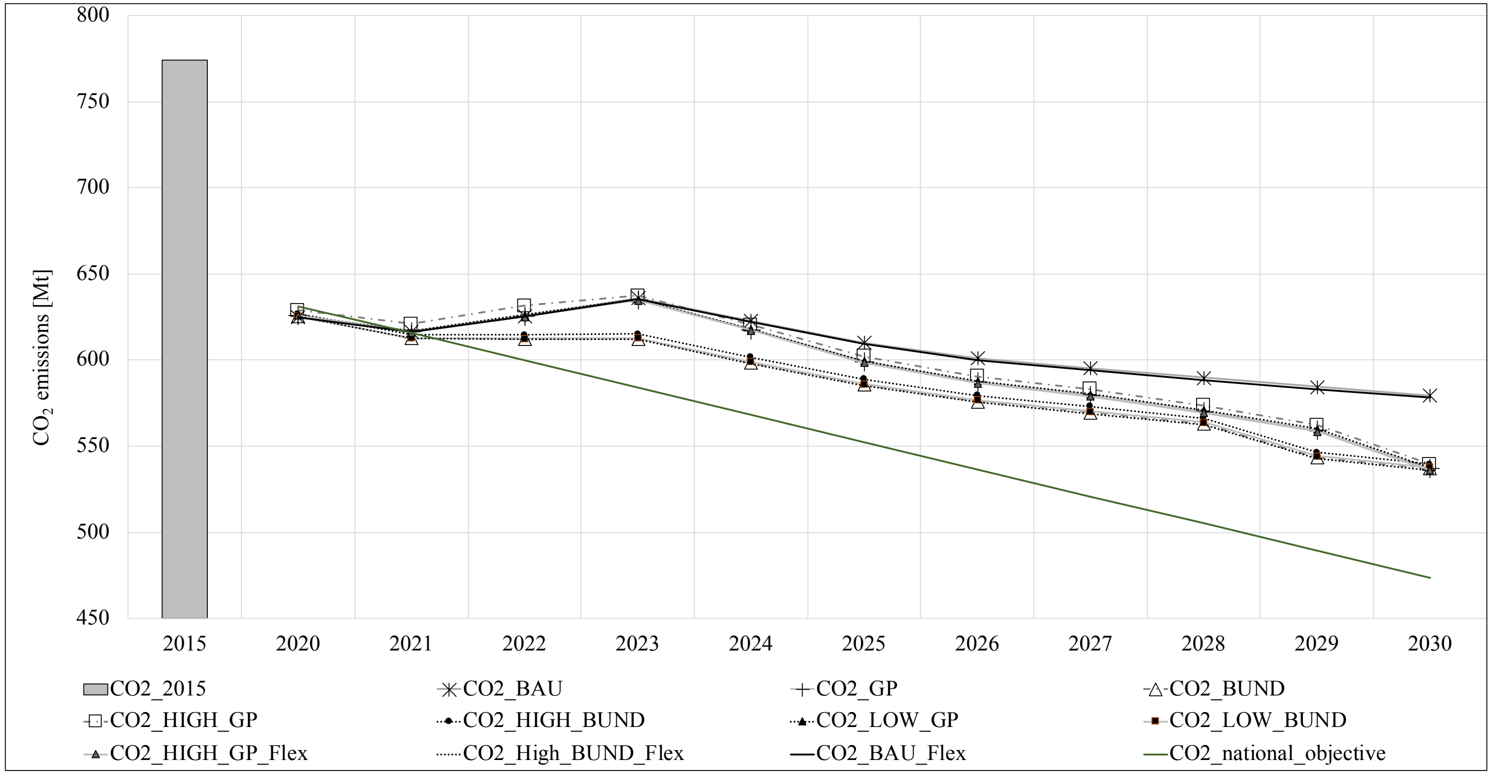

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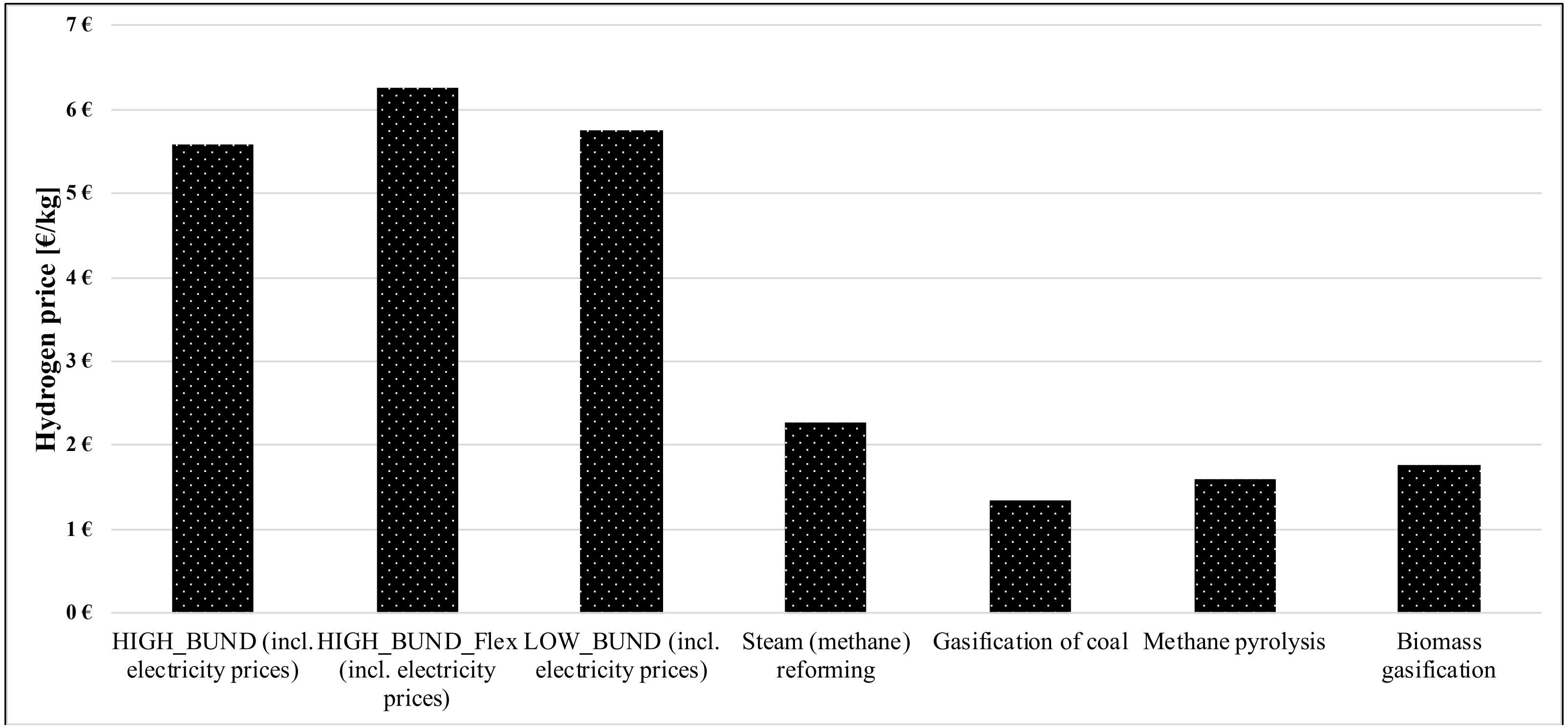
Coal Phase-out and Electrolytic Hydrogen Production - Results



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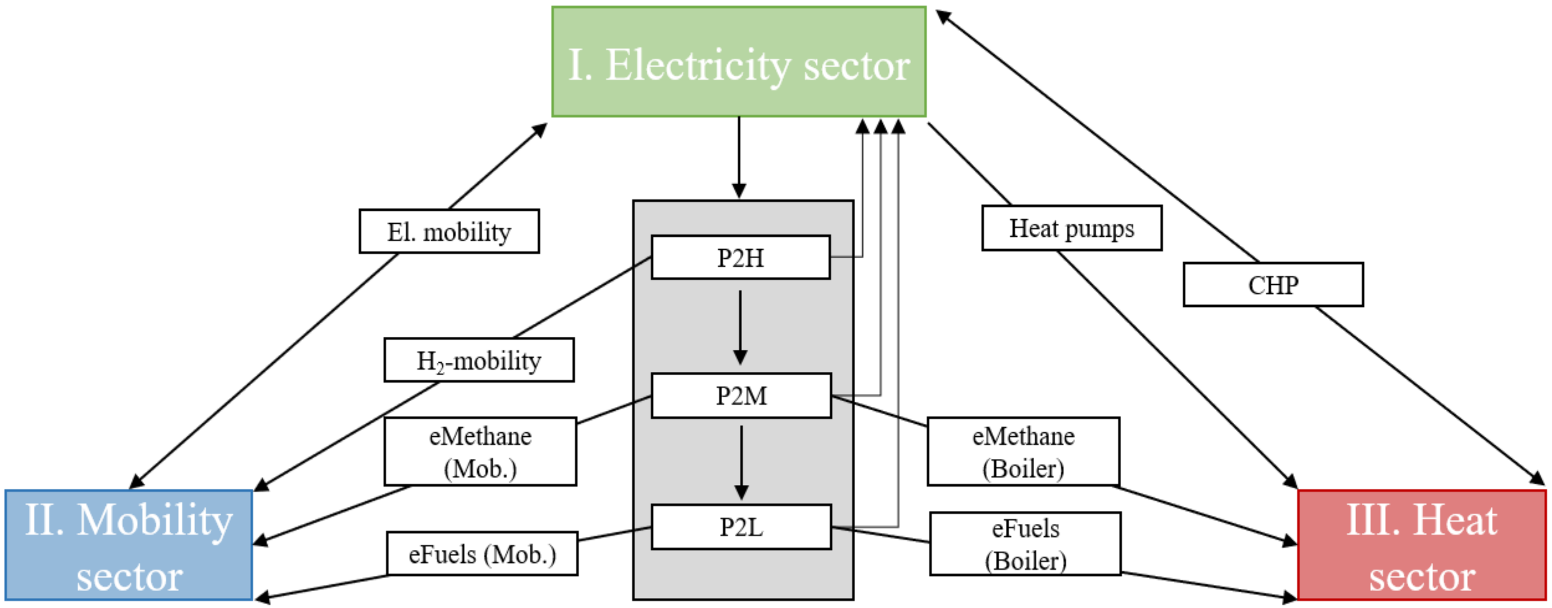
Coal Phase-out and Electrolytic Hydrogen Production - Results

- Decarbonization targets will clearly be missed in each scenario!
- Timing of phasing out coal affects the environmental effectiveness of EHP.
- Earlier coal phase-out will not threaten security of electricity supply.
- Deployment of flexible-only operating electrolysers of up to 9554 MW by 2030 is required to enhance system flexibility and is beneficial from an environmental perspective.
- EHP is not expected to become competitive unlike alternative methods of hydrogen production (e.g. natural gas-based steam reforming) by 2030.

➔ Current market conditions for electrolytic hydrogen production restrict the diffusion of water electrolysis technology, and policy makers are not sufficiently guiding technological change in the direction of achieving decarbonisation targets achievement by 2030.

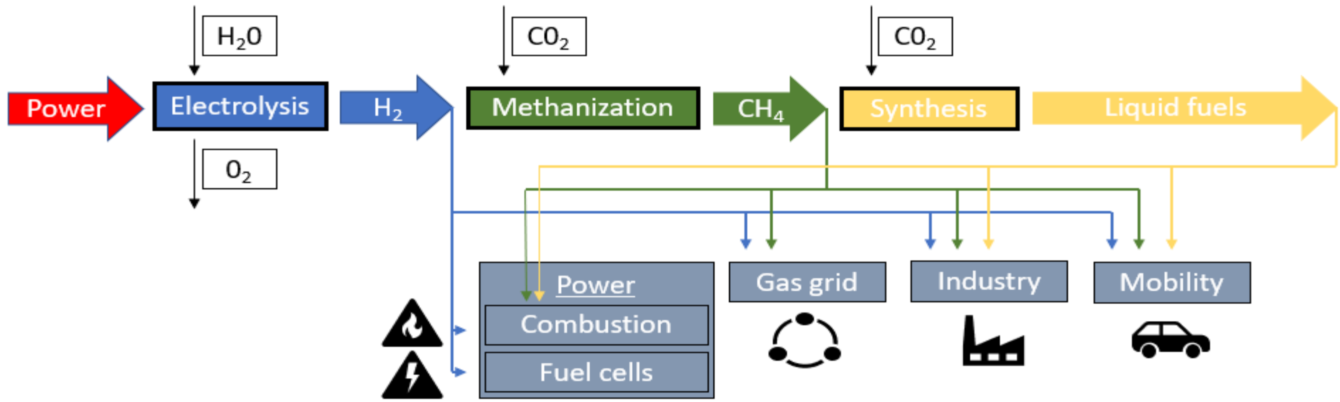
Power-to-X potentials in Germany – Scenarios

Research Question:
Which extent of P2X usage is technically and socioeconomically reasonable for Germany, given the utilization of the conservatively estimated maximum potential of RES?



Revise and Resubmission in the Journal Energy:
Beckmann, J., Klöckner, K., & Letmathe, P. (2023). Power-to-X: Simulation, multicriteria evaluation, and recommendations for political measures in Germany

Power-to-X potentials in Germany – Scenarios



Scenarios	Simulated Decarbonisation Measures
maxRES S1	Renewable hydrogen fed into natural gas grid
maxRES S2	+ Renewable hydrogen as a partial substitute for industrial hydrogen demand so far met by hydrogen production processes based on fossil fuels
maxRES S3	+ Renewable methane as a partial substitute for natural gas demand
maxRES S4	+ Liquid fuels to fulfill the kerosene demand
maxRES S5	Hydrogen society (remaining fossil inputs are industrially used oil and coal)

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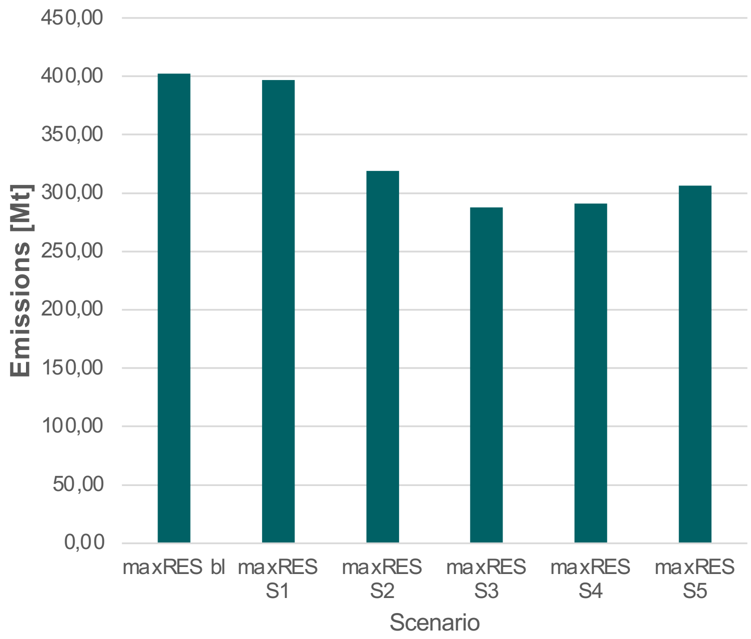

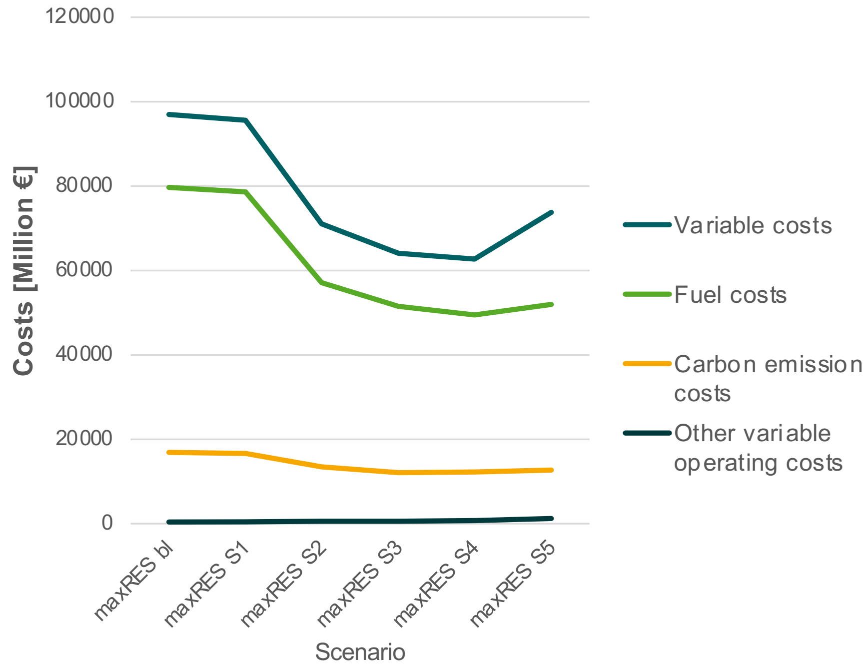

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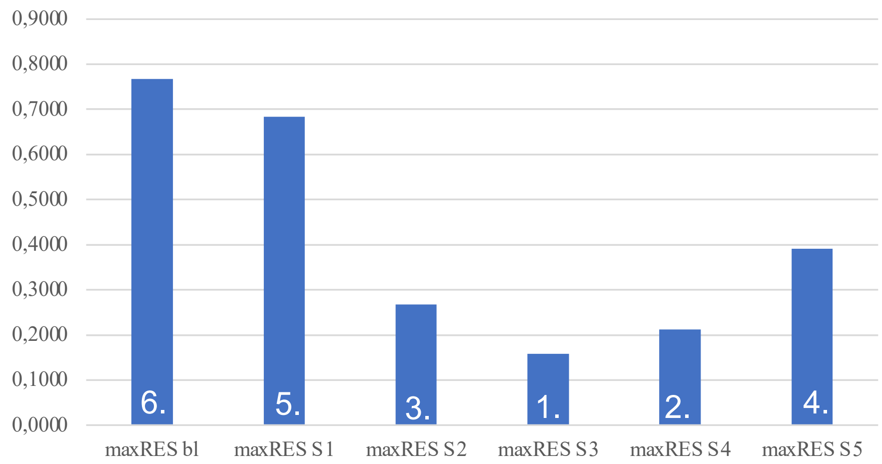

- Use of hydrogen in the transportation sector (spec. heavy duty, air traffic): S1 → S2
- S3 includes Power-to-Methane (compared to S3 and S5)
- A carbon-free economy is not feasible under the assumed conditions
- Hydrogen society is not recommendable (within the assumed assessment framework)

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Implications

Key directions:

- Redesign market architectures and create economic incentives (e.g. carbon trading)
- Make energy systems smart
- Think local (village and city economics)
- Think global (global energy systems and use of flexibility mechanisms, e.g. CDM)
- Cross-market thinking (sector coupling)
- Adjust lifestyles: participation of citizens
- Think interdisciplinary
- Apply lifecycle thinking (LCA and TCO methods)