

Energy System Modelling and Energy Justice - Incompatible Concepts?

Session 4: Social aspects of energy systems

Workshop @ Meccanica Feminale,
Stuttgart, 18.02 – 20.2.2025

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Workshop Sessions

Day 1: Introduction to Energy Modelling

10:00	11:30	Session 1	Basics of Energy Modelling
14:00	15:30	Session 2	Open Energy Models
16:00	17:30	Session 3	Oemof-Tutorial

Day 2: Introduction to Justice Concepts

8:30	10:00	Session 4	Social aspects of energy systems
10:30	12:00	Session 5	Setup: pycharm, oemof
14:00	15:30	Session 6	Programming exercise oemof

Day 3: Co-Creation at the Intersection of Energy Modelling & Justice

8:30	10:00	Session 7	Justice in energy systems
10:30	12:00	Session 8	Case Studies Development

Repetition: Questions regarding sessions

- Which of the energy modelling applications was most interesting for you?
- What are necessary inputs and where can you get them?



Open Questions?

Excercise: Where is the energy transition at?

- What have we accomplished so far in terms of the energy transition?
- What discussions are relevant in media at the moment?
- What trends do you see?
- What do you think are the challenges for the energy transition?



Discuss!

Current Energy Transition Issues

1. Vision
2. Goals
3. Participation and Partaking
4. Just Transition
5. Industry Transition
6. Electricity market design
7. Heating Transition
8. Transport: Shift and avoid
9. Transport: Improve
10. Electricity Grid and Stability
11. Green Hydrogen



Vision Erneuerbares Energiesystem



Ausbau- und Ausstiegsziele



Beteiligung und Teilhabe



Gerechte Energiewende



Industriewende



Strommarktdesign und Entgelte



Wärmewende



Verkehrsverlagerung- und Vermeidung



Antriebs- und Treibstoffwende



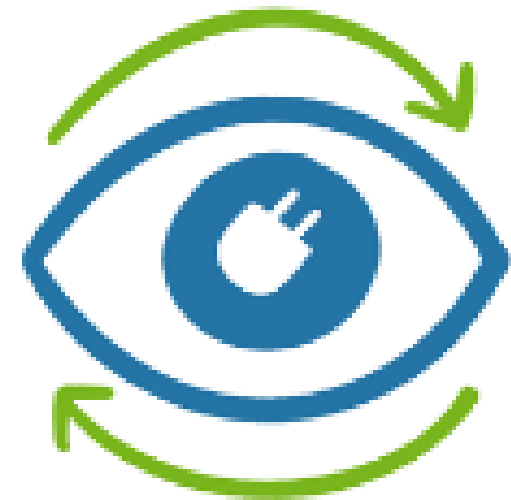
Stromnetz und Stabilität



Grüner Wasserstoff

1. Vision

- Holistic picture of energy transition
- Positive narrative regarding transition, highlighting...
 - Green economy / economic success without fossil fuels
 - Potential positive implications for social justice
 - Addressing transition fears
 - Develop trust in transition



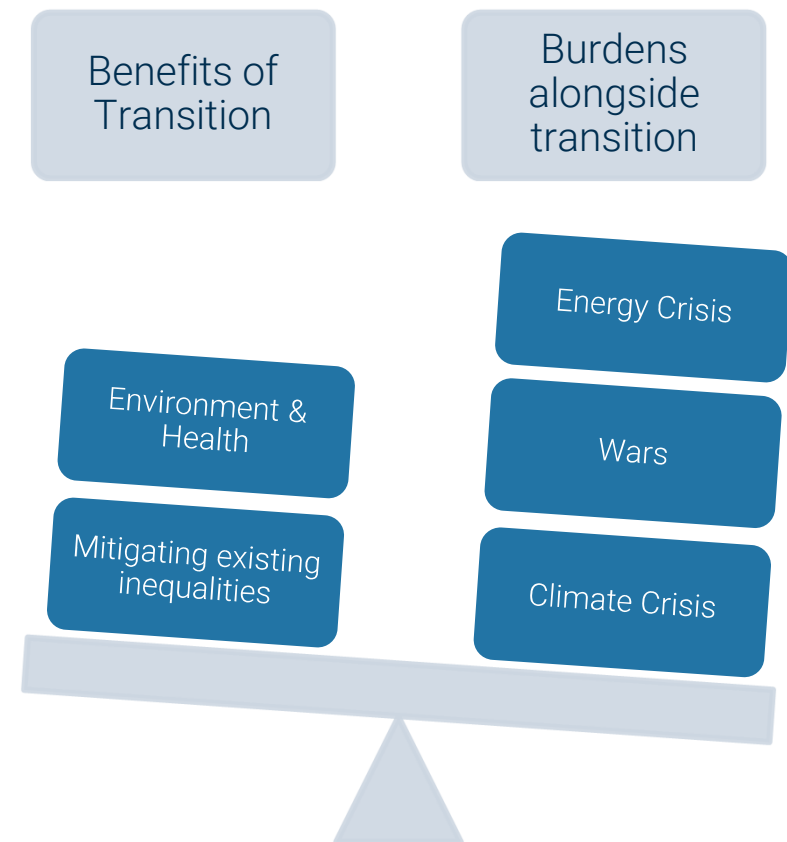
Further reading:

- Teune 2021. 'Energiewende? - ja! Aber...': <https://doi.org/10.48485/pik.2021.005>.
- Reusswig 2023. 'Klimapolitische Einstellungen Im Kontext Des Krieges Gegen Die Ukraine'. <https://www.fes.de/referat-demokratie-gesellschaft-und-innovation/gegen-rechtsextremismus/mitte-studie-2023>

Recognizing Social Context of Energy Policy

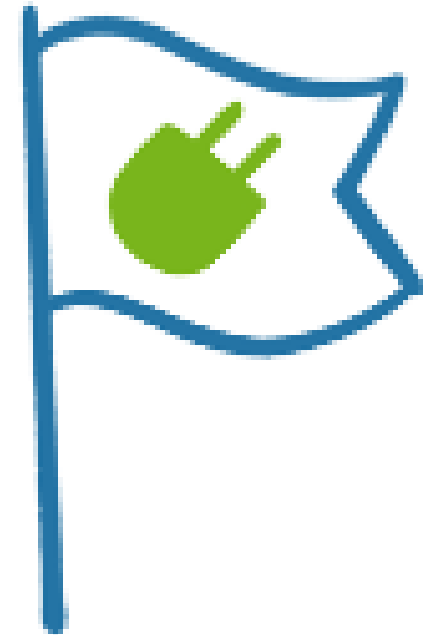
- Crisis alongside transition interplay with public reaction to transition policies
- Possibility of public opposition
- Transition policies can on the other hand ease existing distributional issues

→ Proactive efforts to address distributional efforts to strengthen transition necessary



2. Goals

- Paris agreement: 1.5 (2.0) Degree goal
- Climate protection bill (Klimaschutzgesetz):
Climate neutrality by 2045
- Accelerated capacity building of renewable generation, transmission grid, and storage
- Gas as “bridge technology” needs to be addressed in context of fossil exit
- Nuclear energy not system stabilizing not suited for necessary transition



Further reading:

- Quaschning 2016. <http://www.volker-quaschning.de/publis/studien/sektorkopplung/Sektorkopplungsstudie.pdf>.
- Herpich et al. 2023. <https://coaltransitions.org/publications/klimaschutz-in-der-lausitz-zur-einhaltung-der-15-grenze/>

3. Participation and Partaking

Including citizens into the transition is important for support and effectiveness

- Communication & Transparency
- Economic partaking (decentral energy systems, citizen energy)
- Participation in decision making processes
- Acceptance
- Representation in legislation



Further reading: Local Energy Consulting 2020. <https://www.agora-energieumwandlung.de/publikationen/akzeptanz-und-lokale-teilhabe-in-der-energieumwandlung>

4. Just Transition

Energy transition can have impact on social justice

- Distributional inequalities of today should be mitigated → Energy poverty
- Distributional inequalities of tomorrow should be avoided → Burden mitigation, just distribution of benefits, structural change connected to employment, climate dividend (Klimageld)



Further reading:

- Holzmann und Wolf 2023. <https://www.bertelsmann-stiftung.de/de/publikationen/publikation/did/klimapolitik-und-soziale-gerechtigkeit>
- Local Energy Consulting 2020. <https://www.agora-energiewende.de/publikationen/akzeptanz-und-lokale-teilhabe-in-der-energiewende>.

5. Industry Transition

- 20% of global emissions
- Climate neutral industry till 2045 (Germany)
- Technology solutions: Electrification, green hydrogen, recycling, carbon capture only for unavoidable emissions, flexibility of processes, sufficient grid capacities
- Financial support of new technologies and taxation of energy intensive processes
- Green economy and employment



Further reading:

- Diesing et al. 2025. <https://doi.org/10.1016/j.rser.2024.115023>
- Prognos, Öko-Institut, und Wuppertal-Institut 2021: Klimaneutrales Deutschland 2045. Wie Deutschland seine Klimaziele schon vor 2050 erreichen kann
- Bataille et al. 2018. <https://doi.org/10.1016/j.jclepro.2018.03.107>
- Agora Energiewende und Wuppertal Institut 2019. <https://www.agora-energiewende.de/veroeffentlichungen/klimaneutrale-industrie-hauptstudie/>

6. Electricity market design

- Necessity for reforms of electricity market
- Dynamic electricity and grid tariffs
 - Balancing supply and consumption and avoiding load peaks
 - Support of system serving use of electric vehicles, heat pumps and residential storage
 - Potential for savings for residential households



Further reading: Agora Energiewende und Forschungsstelle für Energiewirtschaft e.V. 2023. 'Haushaltsnahe Flexibilitäten Nutzen. Wie Elektrofahrzeuge, Wärmepumpen Und Co. Die Stromkosten Für Alle Senken Können'.

7. Heating Transition

- 33% of primary energy use in DE
- Necessary to increase energy refurbishment
- Replacement of fossil-powered technologies towards heating pumps, geothermal energy, power2heat, etc.



Further reading:

- Herpich, Holz, und Löffler 2023. https://doi.org/10.18723/diw_wb:2023-49-1
- Blohm et al. 2024. <https://coaltransitions.org/publications/wasserstoff-in-der-kommunalen-warmeplanung/>
- Rosenow 2022. <https://doi.org/10.1016/j.joule.2022.08.015>

8. Transport: Avoid and Shift

- 22 % of emissions in Germany
- Avoid: motorized individual transport
- Shift:
 - Motorized to public transport
 - Freight transport by train
 - Efficient use of individual transport (number of passengers)
- Requires political support and measures: Infrastructure, public transport pricing, city planning



Further reading: Prognos, Öko-Institut, und Wuppertal-Institut 2021: Klimaneutrales Deutschland 2045. Wie Deutschland seine Klimaziele schon vor 2050 erreichen kann

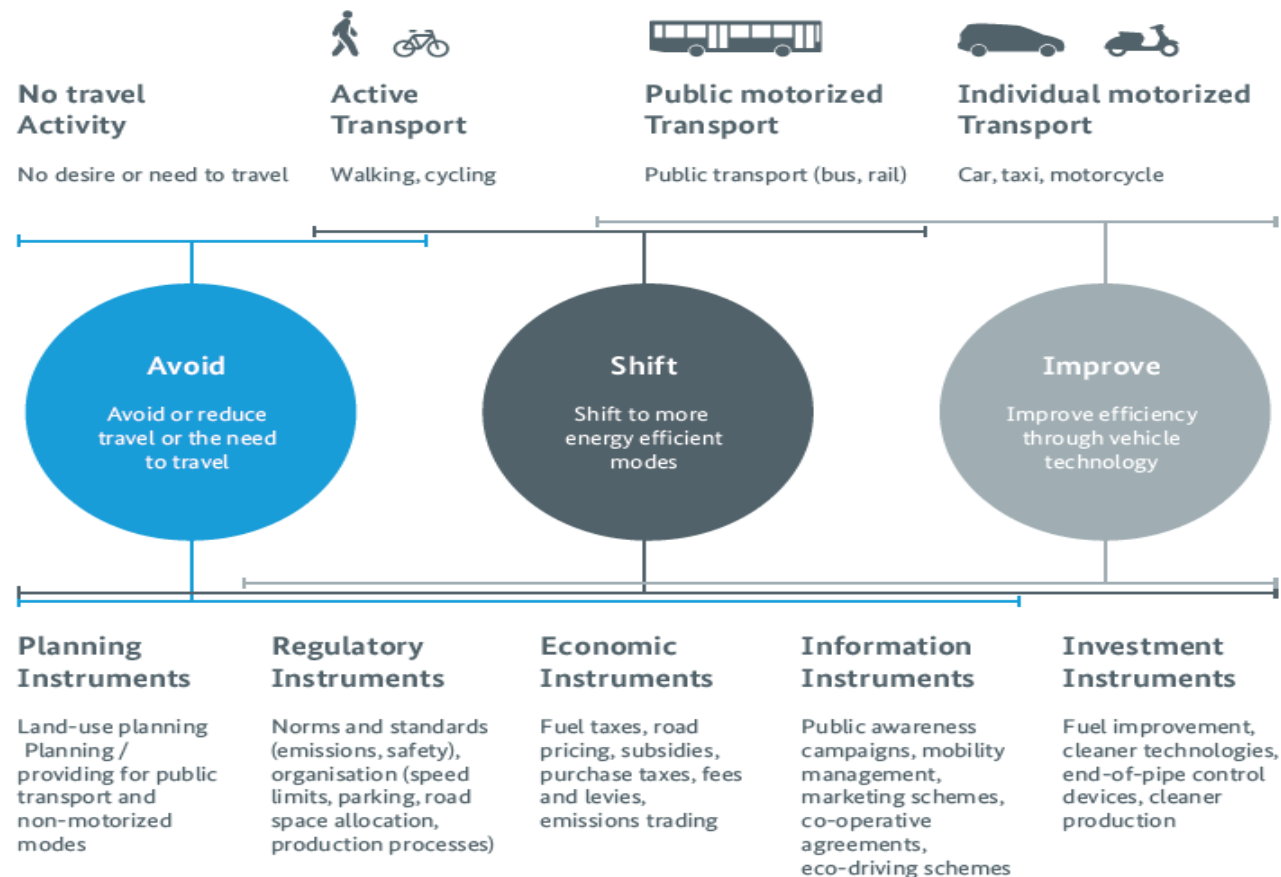
9. Transport: Improve

- Emissions of conventional assets should be avoided
- Regulatory and financial support for transition to climate neutral drive train necessary
 - Electric vehicles, where necessary, are currently the most promising for individual transport
 - Synthetic fuels for long distance travel (flight, shipping)



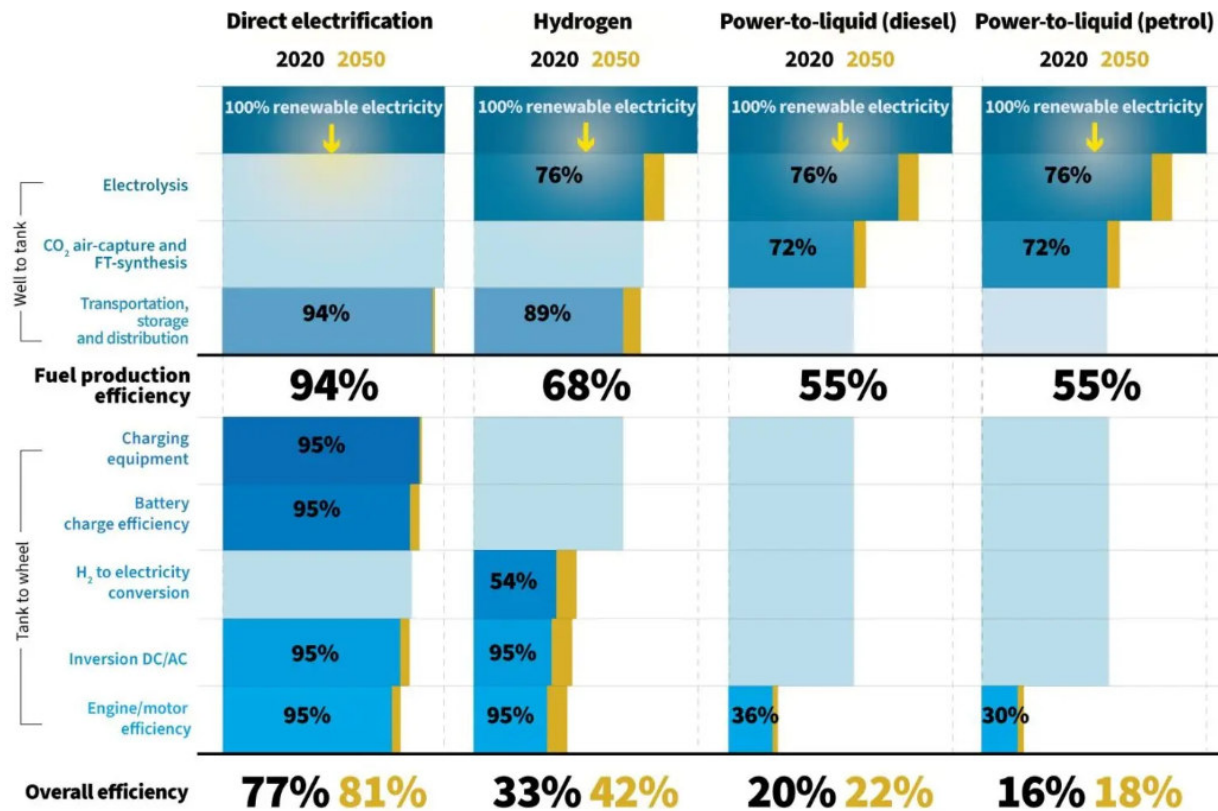
Further reading: Prognos, Öko-Institut, und Wuppertal-Institut 2021: Klimaneutrales Deutschland 2045. Wie Deutschland seine Klimaziele schon vor 2050 erreichen kann

Sustainable Transport: Avoid, Shift, Improve



<http://en.envirocitiesmag.com/articles/sustainable-transportation-for-sustainable-cities/the-A-S-I-approach.php>

Fuel options for mobility



Notes: To be understood as approximate mean values taking into account different production methods. Hydrogen includes onboard fuel compression. Excluding mechanical losses.

Source:
<https://cleantechnica.com/2021/02/01/chart-why-battery-electric-vehicles-beat-hydrogen-electric-vehicles-without-breaking-a-sweat/>

10. Electricity Grid and Stability

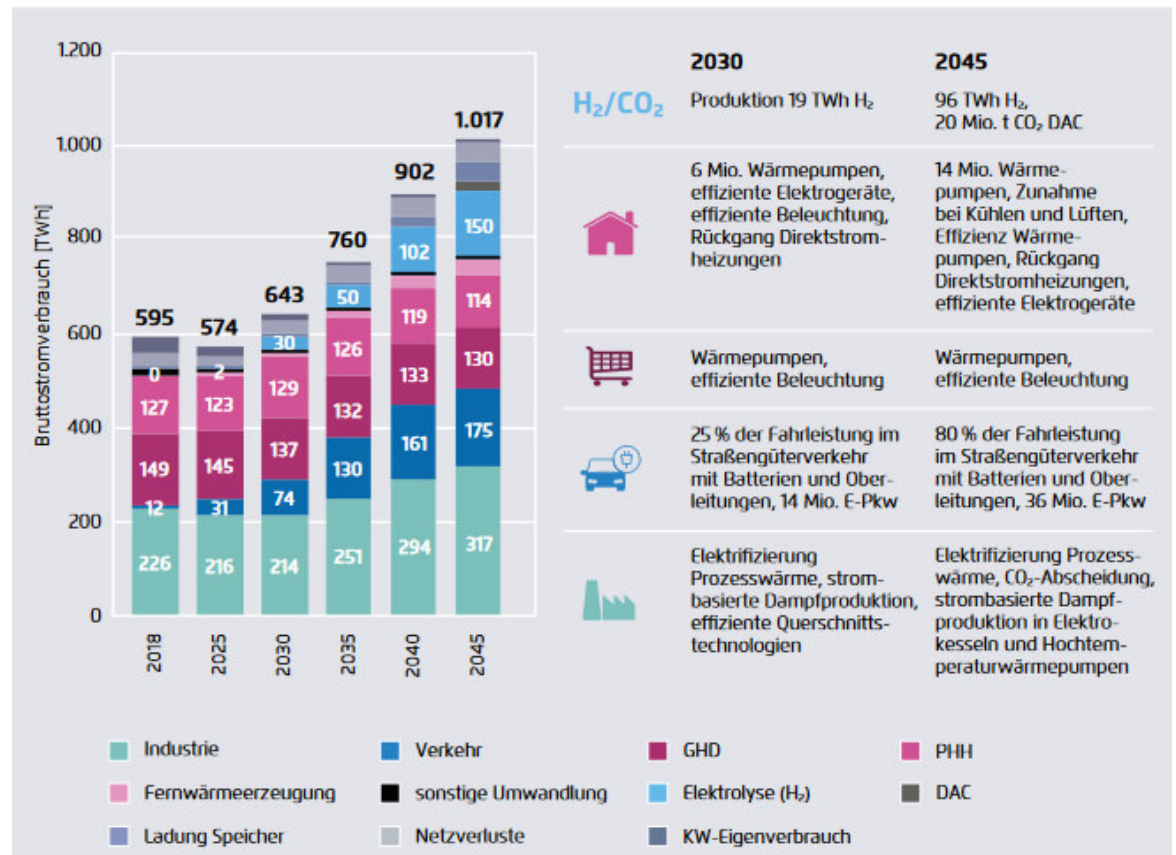
- Sector coupling = Interconnection of different power, heating/cooling, transport
- Changed requirements for providing reliable operation under increasing shares of volatile renewables:
 - Temporal matching of supply and demand necessary
 - Fewer spinning reserve of dispatchable resources
 - Operation of storage necessary
 - Transition grid restructuring or new grid lines



Further reading: Bundesministerium für Wirtschaft und Klimaschutz (BMWK) 2023

Development of electricity demand

- Electricity demand expected to increase due to electrification and sector coupling
- Estimations of demand vary largely on assumptions on technology update
- Indebatable increased volume of electricity to be transmitted via grids



Prognos, Öko-Institut, und Wuppertal-Institut. 2021. 'Klimaneutrales Deutschland 2045. Wie Deutschland seine Klimaziele schon vor 2050 erreichen kann.

11. Green Hydrogen

- Potential to decarbonize hard-to-abate industry processes, heavy transport, aviation, shipping
- Green hydrogen = generated from renewables
→ Currently > 99% of global hydrogen from fossil fuels!
- Electrolyzers should be operate in a system serving manner
- Currently comparatively expensive
- Necessary to build up hydrogen infrastructure (transport, storage, distribution)



Further reading:
































































































- International Renewable Energy Agency (IRENA) 2022. <https://www.irena.org/publications/2022/Mar/Green-Hydrogen-for-Industry>
- Prognos, Öko-Institut, und Wuppertal-Institut 2021: Klimaneutrales Deutschland 2045. Wie Deutschland seine Klimaziele schon vor 2050 erreichen kann
- Linke et al. 2023. https://green-planet-energy.de/fileadmin/docs/publikationen/Studien/RLI-GPE_Studie_sinnvoller_Wasserstoffeinsatz_und_flexible_Elektrolyse_Update.pdf

11. Green Hydrogen

- Countries with high renewable resources (and fossil infrastructure) are seen as possible export countries for green hydrogen. But...
 - Consider efficiency losses
 - Consider energy injustices
 - Consider challenges with energy export / import vs self-generation



German General Election 2025

	SPD	CDU/CSU	B90/Grüne	FDP	AfD	Linke	BSW
 Vision Erneuerbares Energiesystem							
 Ausbau- und Ausstiegsziele							
 Beteiligung und Teilhabe							
 Gerechte Energiewende							
 Industriegewende							
 Strommarktdesign und Entgelte							
 Wärmewende							
 Verkehrsverlagerung- und Vermeidung							
 Antriebs- und Treibstoffwende							
 Stromnetz und Stabilität							
 Grüner Wasserstoff							
GESAMTBEWERTUNG							



Kurzanalyse und Bewertung

WAHLPROGRAMM-CHECK:
Bundestagswahl 2025

Welche Wahlprogramme bringen die Energiewende
voran?

<https://www.reiner-lemoine-stiftung.de/veroeffentlichungen/wahlprogrammcheck-fuer-die-bundestagswahl-2025>

Excercise: Impacts of energy transition

Go through the current issues of the energy transition and find an example each:

- How can the topic impact individuals?
- How can the policies impact social justice issues?



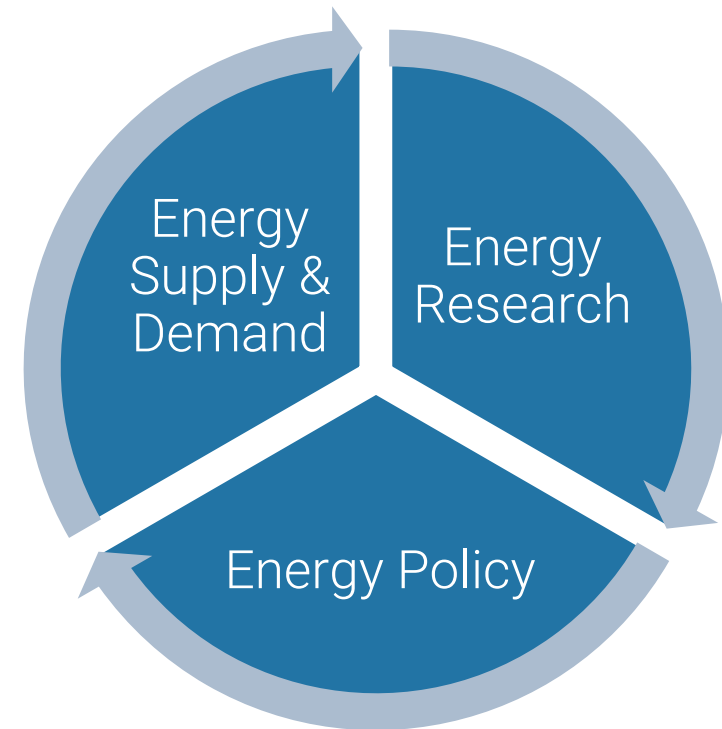
Discuss!

- Vision
- Goals
- Participation and Partaking
- Just Transition
- Industry Transition
- Electricity market design
- Heating Transition
- Transport: Shift and avoid
- Transport: Improve
- Electricity Grid and Stability
- Green Hydrogen

Energy Models Informing Policy

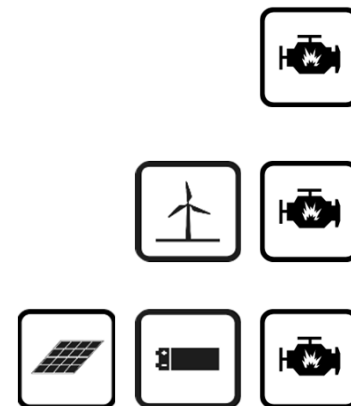
Energy policies are often shaped by energy models

- Linking desired policy outcomes with measures
- Modelling provides data-driven insights into the potential impacts of energy policies
- Policy-makers need to distribute resources effectively



Scenarios: Technology composition

- Energy Models useful to compare contrasting scenarios
- Typically involves creation and comparison of several coherent and plausible scenarios, differing through
 - Demand drivers
 - economic parameters
 - technical parameters
 - environmental constraints



Scenarios	
Name	Components
Diesel-only	Diesel plant
Wind-diesel	Diesel plant Wind farm
PV-battery-diesel	Diesel plant PV Battery storage

Scenarios: Exemplary policy options

Incentives for
adoption

Feed-in Tariffs

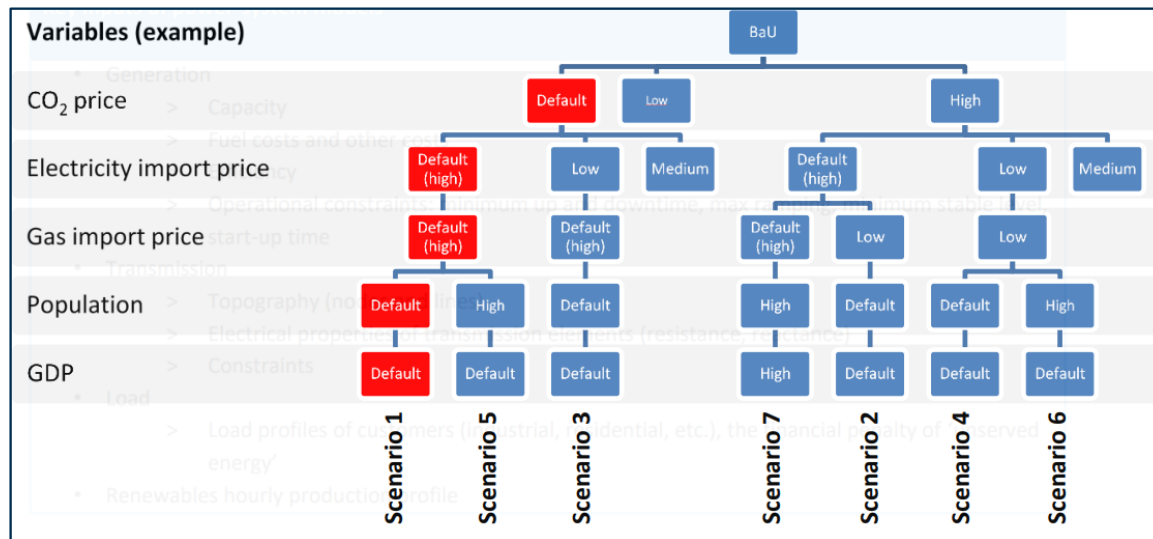
Taxation

Building standards

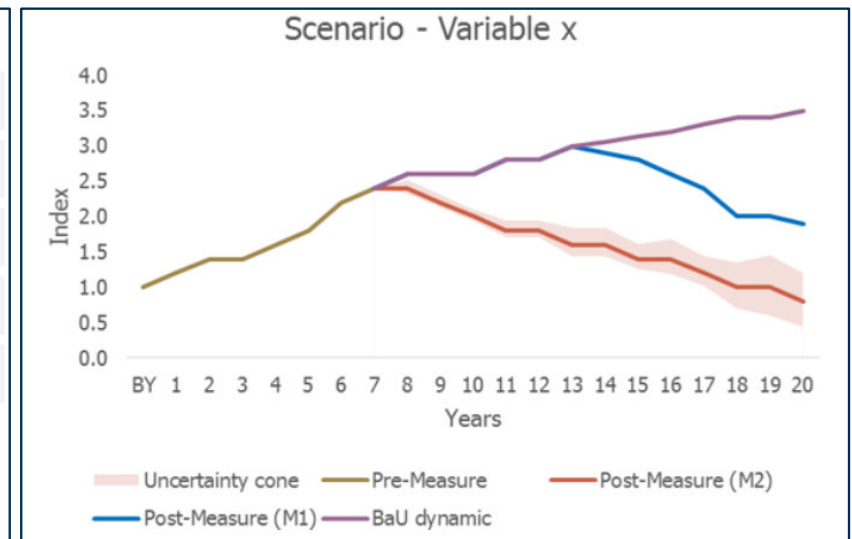
Independent power
producers

Comparative analysis of scenarios

Establishment of baseline-scenario (Business as Usual, BaU) with current conditions
→ Comparison to different policy scenarios with altered conditions from policy



Example of assessment of the impact of a policy measure
Source: Energy Planning and Modelling A Guide for Energy Planners and Policymakers 2022



Example of the composition of narratives
Source: Energy Planning and Modelling A Guide for Energy Planners and Policymakers 2022

But what is the best solution?



What are the stakeholders of the specific case study?

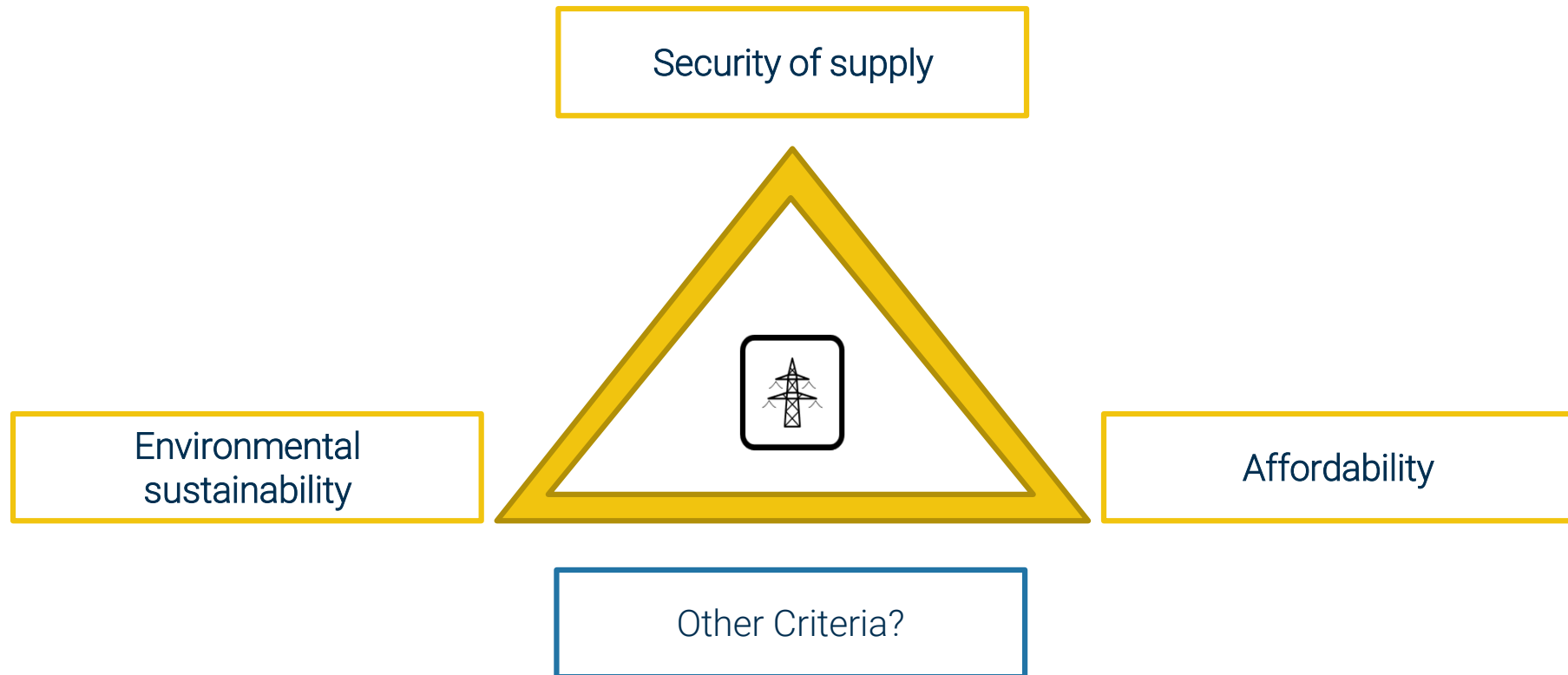


What are criteria of a good energy system or policy?



Do the results of ESM directly define policies?

Traditional targets of energy supply systems

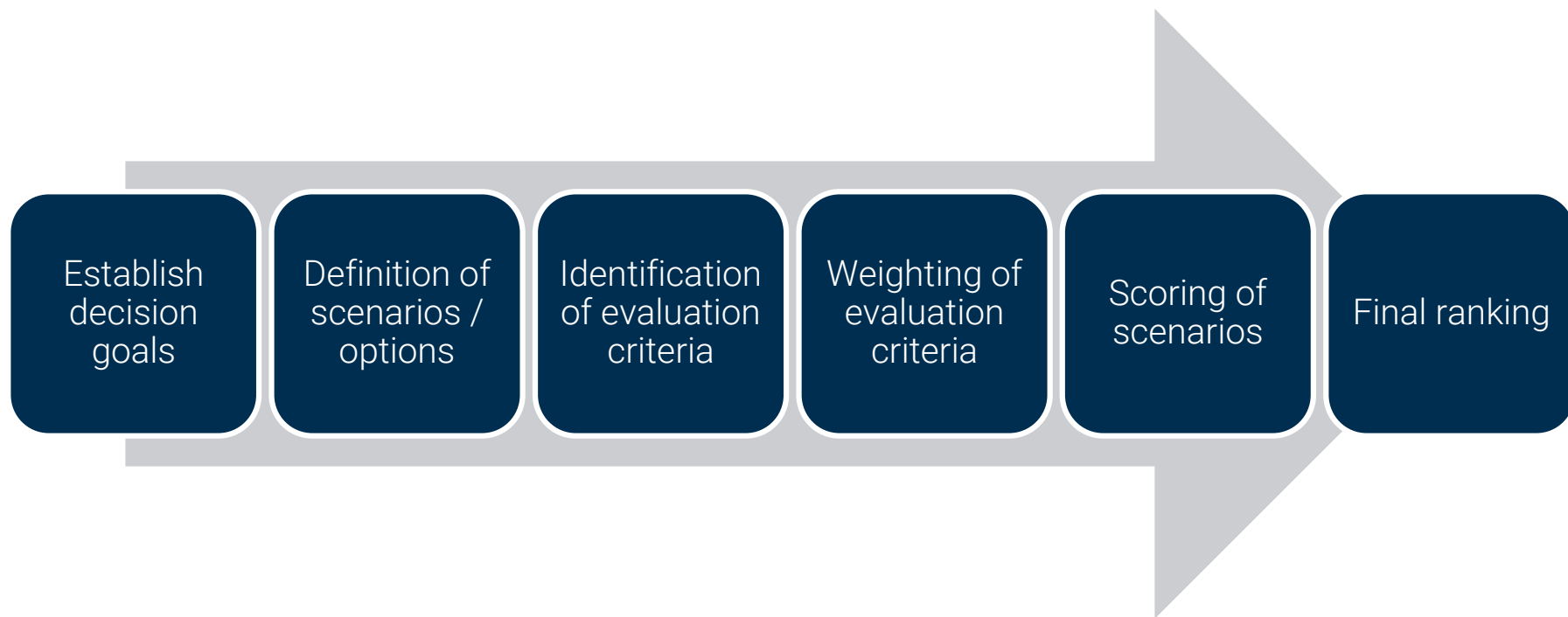


But what is the best system?

- ESM solvers determine techno-economic optimum
- BUT policy makers interested in trade-offs
 - Social, Economic, Technical, Environmental aspects
 - 2nd best techno-economical solutions may be overall better
 - Therefore: Studies often include multiple scenarios
 - Policy makers decide which one is favourable
 - = Role of scientists is advisory!

Multi-Criteria Assessment (MCA)

Decision process between different scenarios may be aided methodologically:
Multi-criteria methods derive scoring, but decision still up to policy makers!



Selection of criteria

Methods

- Simple interviews / questionnaires
- Delphi method
- Statistical methods

Technical

Environmental

Economic

Social

Criteria types

- Knock-out criteria (e.g. yes / no or upper / lower threshold)
- Quantitative criteria (e.g. costs in USD)
- Qualitative criteria (e.g. low or high environmental impact)

Importance of criteria

- MANY different options exist...
 - Scoring (e.g. election of criteria)
 - Subjective weighting (e.g. AHP)
 - Objective weighting (e.g. normalization method)

Criteria can be scored / ranked and then weighted

Ranking scale						
5	4	3	2	1	0	Z
Highest importance	High importance	Moderate importance	Low importance	Very low importance	Absolutely no importance	Don't know

Excercise

- Choose a topic from the last excercise
- Think of a policy intervention for the topic
- What are the policies aims, and potential side-effects, also on social justice?
- How can you define scenarios to find out if your policy would be overall beneficial?



Open Questions?

Learnig Outcomes of this Session

- Current discussions and trends in energy transition
- Scenario building
- Foundations of multi-criteria assessments
- Interaction of energy transition with individuals, potential implications for social justice



Thank you for your participation 😊



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