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European Energy Research Alliance
clean Energy tranSition for Sustainable Society



SP 3 Sustainability of the Energy Transition

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Motivation

Remark

- **Aim of SP 3: Assessing of the energy transition**

- **Challenges**
  - Comprehensive description and analysis of future energy systems and their pathways or of technologies
    - ⇨ scenario creation and analysis
  - Comprehensive sustainability assessment
    - Defining and assessing indicators
    - Assessing the sustainability of future energy systems, pathways or technologies

Sustainability

- **Aim of transformation process:**
  Establishment of a climate-neutral *and* sustainable energy system
- **What means sustainability?**
  - "Sustainable development is [a] development that meets the needs of the present without compromising the ability of future generations to meet their own needs."
    (Report of the World Commission on Environment and Development: Our Common Future, 1987, p. 41)

    Systemic and systematic conflicts between two generations, at least
  - Sustainable Development Goals (SDGs)
    - 17 Goals with each goal with 8-12 targets and each target with 1-4 indicators
    - conflicting aims are likely, even only SDG Energy is considered
- **Main question: how to deal with conflicting aims while developing sustainability strategies?**

Multicriterial Decision Approach

- **Need for approaches to assess and settle conflicting aims:**
  Multicriterial Decision Approach (MCDA)

- **General idea**
  Goals are weighted along societal preferences and necessities

- **Challenges**
  - How to weight goals?
  - How to combine quantitative with qualitative indicators?

2 Multicriterial Decision Approaches

Multicriterial Decision Approaches

- **Multi Objective Decision Making (MODM) vs. Multi Attribute Decision Making (MADM)**
- **Multi Objective Decision Making (MODM)**
  – decision between a continuous number of alternatives: Optimization of an objective function
  - Objective function w/o or w/ explicit weighting
    - $\min\left(\sum_{k=1}^{l} F_k(x) : x \in X\right)$
    - $\min\left(\sum_{k=1}^{l} |F_k(x) - z^*| : x \in X\right)$ where: $z^* = (z_1^*, \dots, z_l^*)$, i.e., the respective unconstrained optimum for each indicator
    - $\min max(|F_k(x) - z^*| : x \in X)$
    - $\min\left(\sum_{k=1}^{l} w_k F_k(x) : x \in X\right),\ where\ 0 < w_k < 1\ and\ \sum_{k=1}^{l} w_k = 1$
    - Lexicographical method
  - Pareto Curve
  - …

Multicriterial Decision Approaches

- **Multi Attribute Decision Making (MADM)**
  – decision between (discrete number of) alternatives
  - Classical approaches (“Decision maker know their preferences”)
    - Weighted sum method
    - Analytical Hierarchy method
  - Outranking approaches
    (“Decision maker don’t know their preferences,
    but could compare alternatives“)
    - „Elimination Et Choix Traduisant la Réalité“ (ELECTRE)
    - „Preference Ranking Organisation Method for Enrichment Evaluations“ (PROMETHEE)
  - Miscellaneous
    - „Technique for Order of Preference by Similarity to Ideal Solution“ (TOPSIS)
    - „VIseKriterijumska Optimizacija I Kompromisno Resenje“ (VIKOR)

Multicriterial Decision Approaches

Challenges

- **Weighting of goals, targets or indicators**
  - Non-Weighting is no solution
  - Econometric approaches to estimate weighted preference functions
  - Typification of perspectives, e.g. individualist, hierarchist, egalitarian
  - Involvement of experts, stakeholder, citizens

- **Combining quantitative with qualitative information**
  - Not every information is prima facie quantifiable,
    e.g. participation options
  - Defining appropriate data / numbers
  - Ranking of alternatives, with translating the result in numbers

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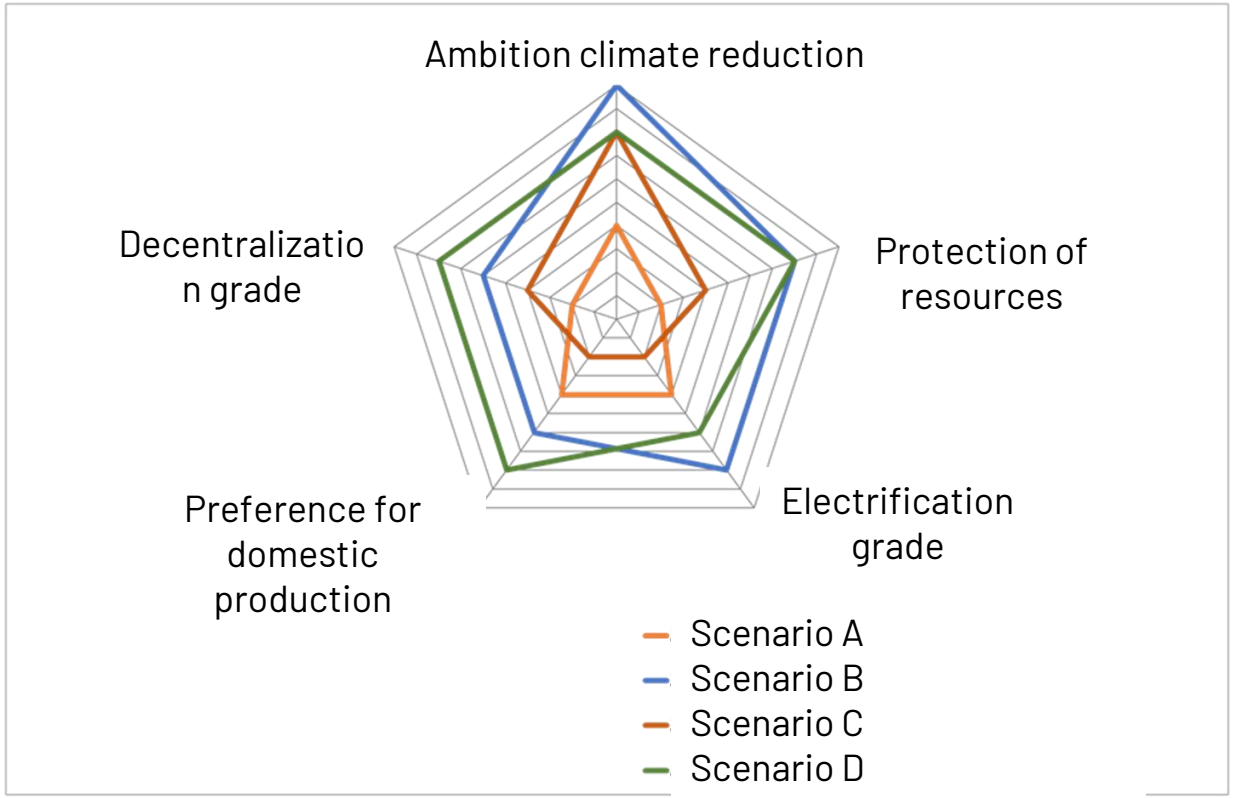
Example: Sustainability assessment of regional energy scenarios

Sustainable assessment of the future energy system of the district Steinburg, Germany

- **District Steinburg:**
  - North-west of Hamburg, North Germany
  - 130,000 inhabitants
  - Long tradition in generating electricity (nuclear power plants)
- **Four different possible future energy systems in 2050, derived from regionalized national scenarios**
- **Local energy system contains**
  - Energy generation
  - Transport within and through the district
  - Storage
  - Use within and outside (export)
- **Aim: Sustainability assessment of the local energy system, considering local and induced upstream impacts on global scale**

Scenarios

- **Scenario A:**
  - reference, follows the national development plan for the electricity system (NEP 2019 Scenario B)
  - Greenhouse gas reduction by 85% until 2050
- **Scenario B**
  - Aims to contribute to the 1.5°C target
- **Scenario C**
  - Aims to contribute to the 2.0°C target
  - European oriented electricity system
- **Scenario D**
  - Aims to contribute to the 2.0°C target
  - Decentralized oriented electricity system



Sustainability assessment

No.	Criterion	Scenario A	Scenario B	Scenario C	Scenario D
1	Air pollutant emissions	0.00	0.69	1.00	0.60
2	Optical and noise emissions	0.82	1.00	0.22	0.00
3	Energy import dependency	0.47	0.91	1.00	0.00
4	Energy poverty	0.35	1.00	0.52	0.00
5	Employment effects	0.00	1.00	0.55	0.11
6	Distributive justice	0.00	1.00	0.19	0.19
7	Financial participation	0.00	0.92	0.74	1.00
8	Land use conflict due energy plants	0.04	0.31	0.00	1.00
9	Direct land use of energy system	1.00	0.03	0.00	0.81
10	Resource use non-renewable energy	0.00	0.86	1.00	0.51
11	Resource use non-energy	0.61	0.39	1.00	0.00
12	Contribution to climate change	0.00	0.89	1.00	0.65
13	Eutrophication	0.55	1.00	0.00	0.00
14	Acidification	0.38	1.00	0.09	0.00
15	Regional value added	0.00	0.84	0.50	1.00
16	Regional participation	0.00	1.00	0.50	1.00
17	Landscape	1.00	0.31	0.44	0.00
18	Human rights				

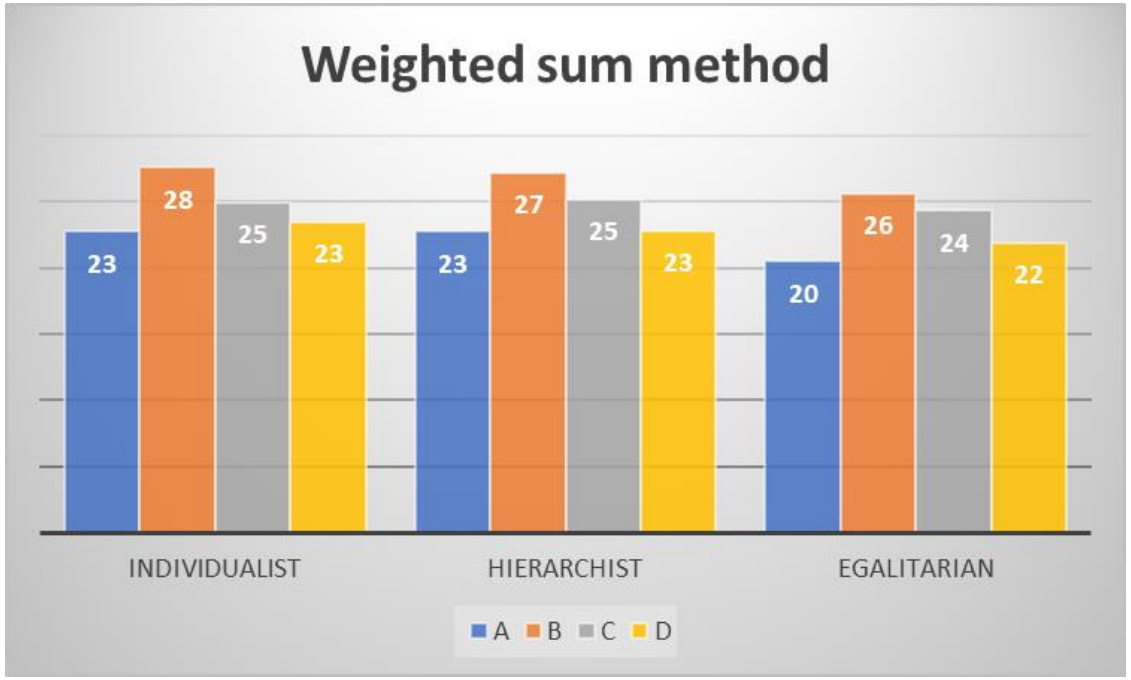
Note: 1 := best performance; 0 := worst performance

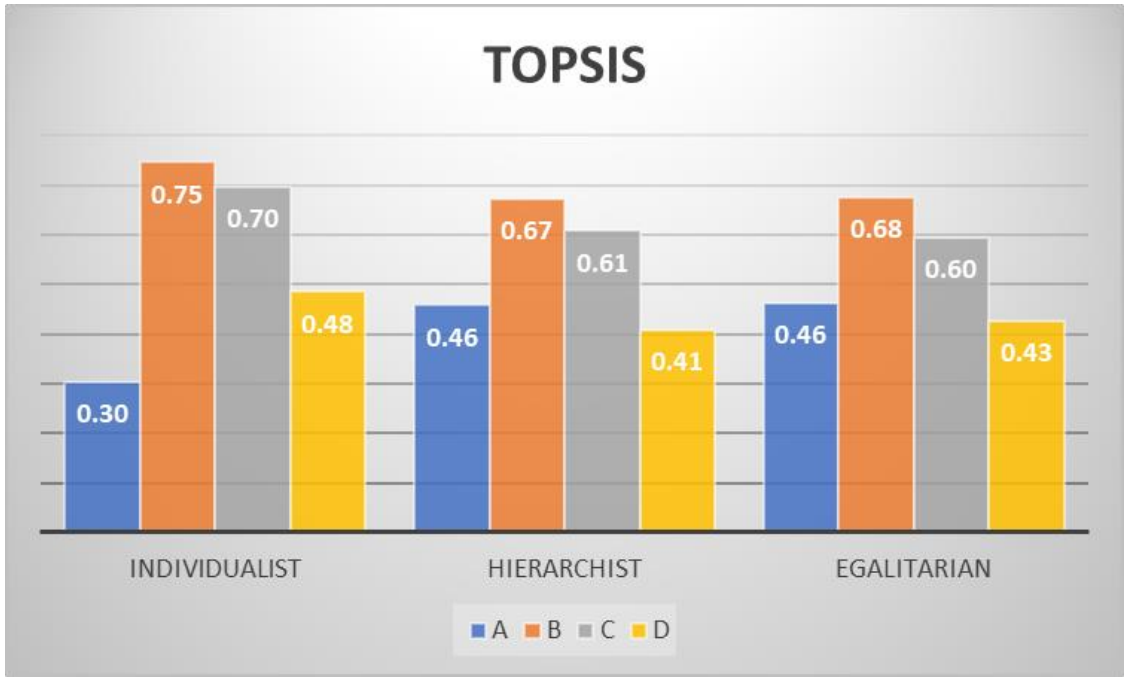
Weighting

- **Individualist**
  - Not accepting social pressure
  - Weak solidarity beyond rules
- **Hierarchist**
  - High relevance of social order
  - Strong “tribal” identity
- **Egalitarian**
  - Strong solidarity and cooperation
  - Strong peer pressure

No.	Criterion	Weights		
		Individualist	Hierarchist	Egalitarian
1	Air pollutant emissions	3.30	7.70	9.00
2	Optical and noise emissions	8.70	7.70	3.00
3	Energy import dependency	9.20	5.50	3.20
4	Energy poverty	6.50	4.40	4.50
5	Employment effects	9.20	5.50	3.20
6	Distributive justice	0.90	2.20	10.30
7	Financial participation	9.20	5.50	3.20
8	Land use conflict due energy plants	10.50	7.70	2.60
9	Direct land use of energy system	3.50	7.70	6.90
10	Resource use non-renewable energy	3.10	5.50	8.60
11	Resource use non-energy	3.50	9.90	13.70
12	Contribution to climate change	2.60	6.60	5.20
13	Eutrophication	2.60	6.60	5.20
14	Acidification	10.50	4.40	0.90
15	Regional value added	2.60	2.20	3.90
16	Regional participation	6.50	4.40	4.50
17	Landscape	6.50	4.40	4.50
18	Human rights	1.30	2.20	7.70
	Sum	100	100	100

MCDA based sustainability assessment





- The proximity of a value of an indicator to the best-possible value determines the assessment value (using Euklidian distance)

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Use for SP 3

Use for SP 3

- **Huge amount of energy scenarios in Europe**
- **Main questions:**
  - Climate-neutrality achievable? When and where?
  - Future energy mix / electricity mix?
  - Import (from where?) vs. domestic production of hydrogen?
- **But, the sustainability of the future energy systems are seldom questioned**
- **Idea for SP 3:**
  - Developing a proposal for a general MCDA-based sustainability assessment
  - Conducting a MCDA-based sustainability assessment of a small set of energy scenarios
- **Approach**
  - Identification a set of comprehensive indicators using SDG Energy as a reference
  - Using a small set of scenarios assessing the indicators
  - Identification and using an appropriate MCDA-approach conducting a sustainability assessment
- **Output: a report and (at least) one paper**

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Thank you

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