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# How solid are energy futures? A systematic assessment of 63 prominent outlooks

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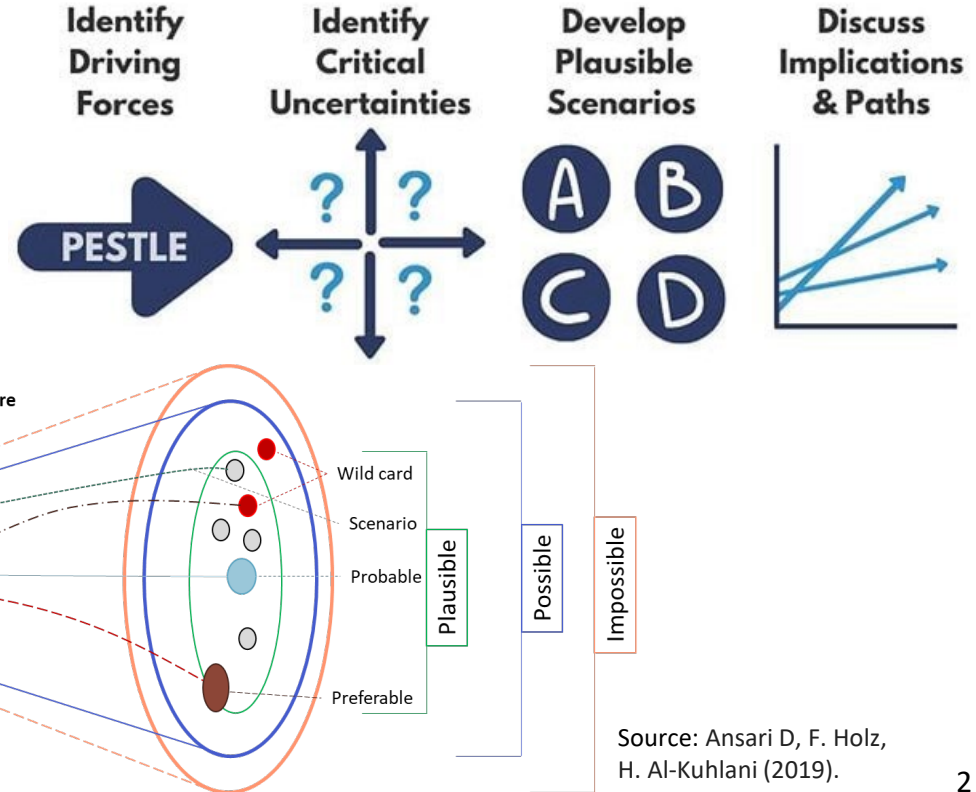
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# What are scenarios?

- ▶ Not forecasting or predicting the future, but **foreseeing** the range of different futures. Focus on **plausibility rather than probability**.
- ▶ **“Memories of the future”** [...] plausible imaginaries capturing hypothetical futures and sequences of events that lead to them (Ingvar, 1985).



# Our Sample: 63 outlooks, 230 scenarios, 2019-2021

## WEIRD



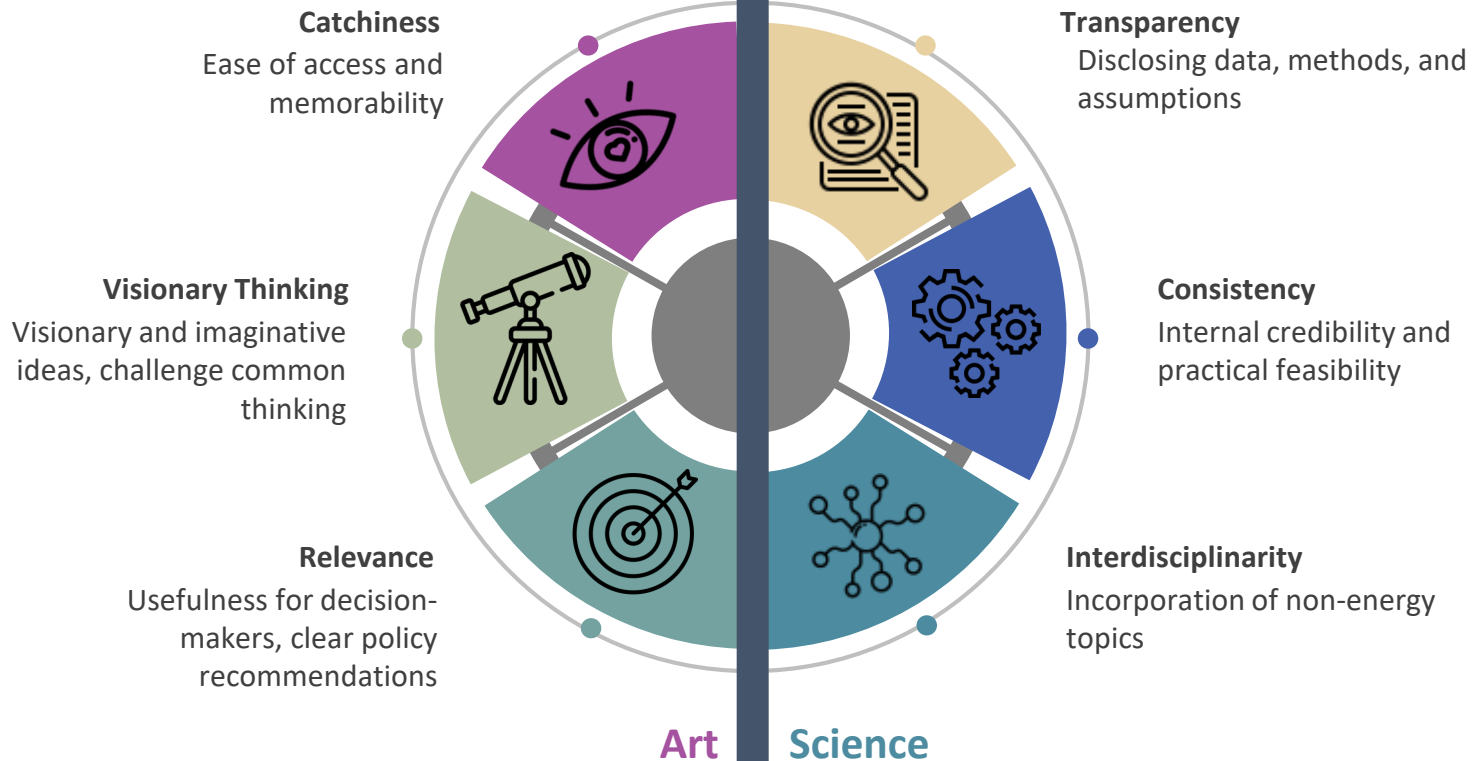
## Non-WEIRD



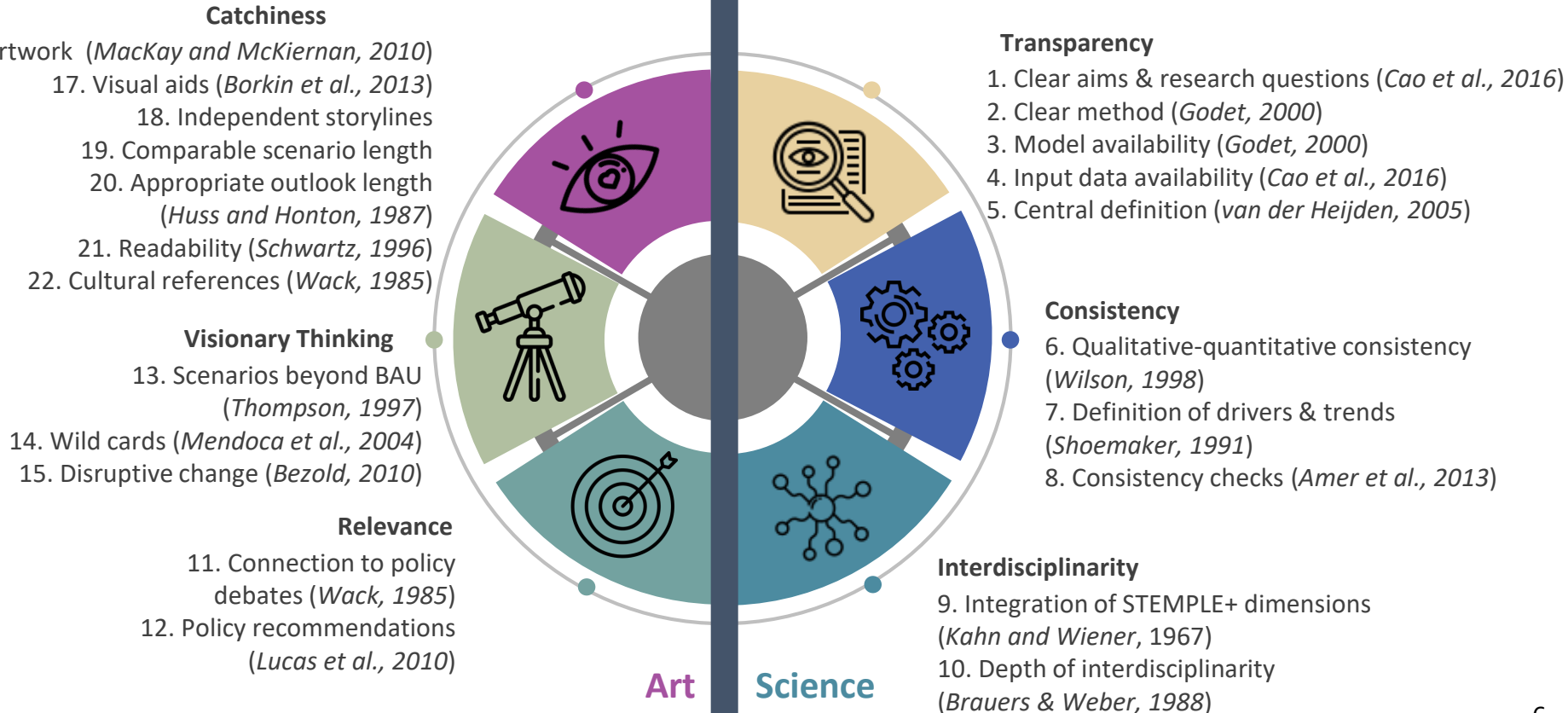
# Most Prominent Technologies: Corpus Word Count



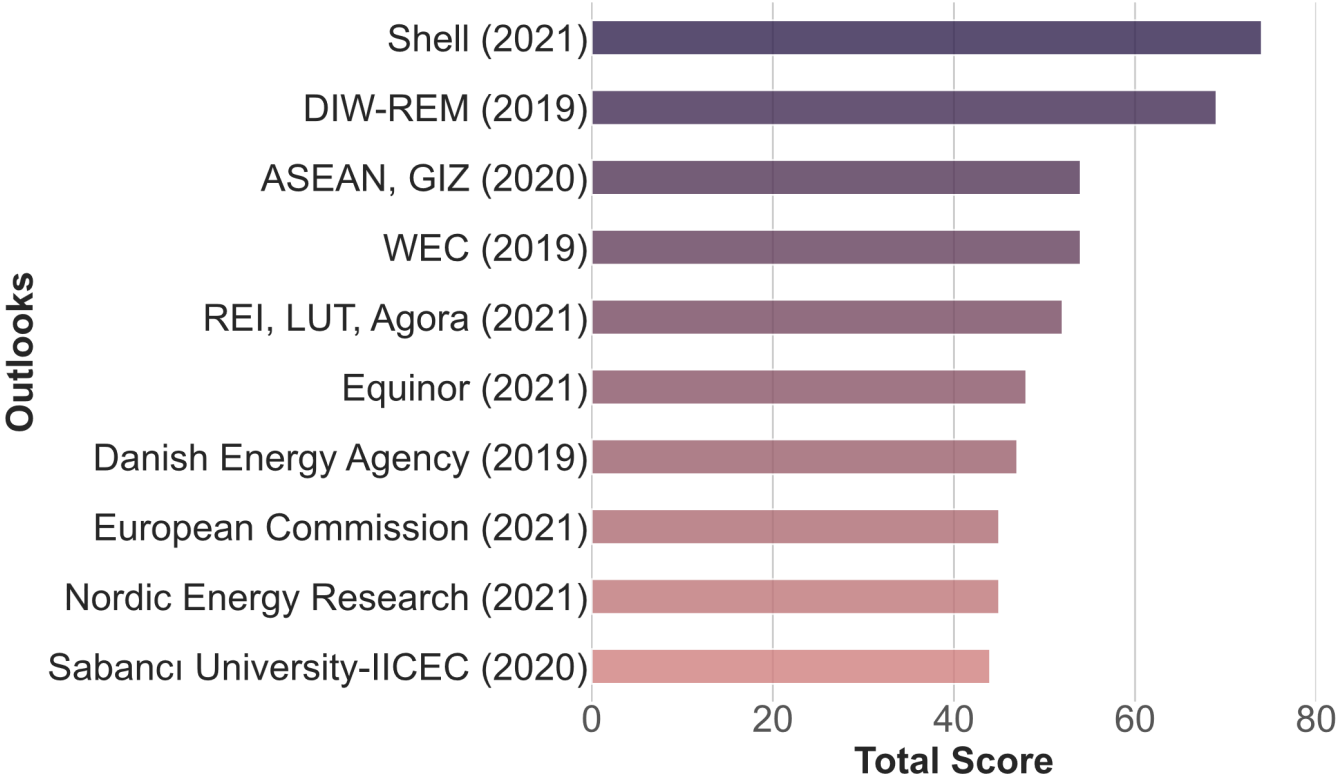
# Methodology: Dimensions



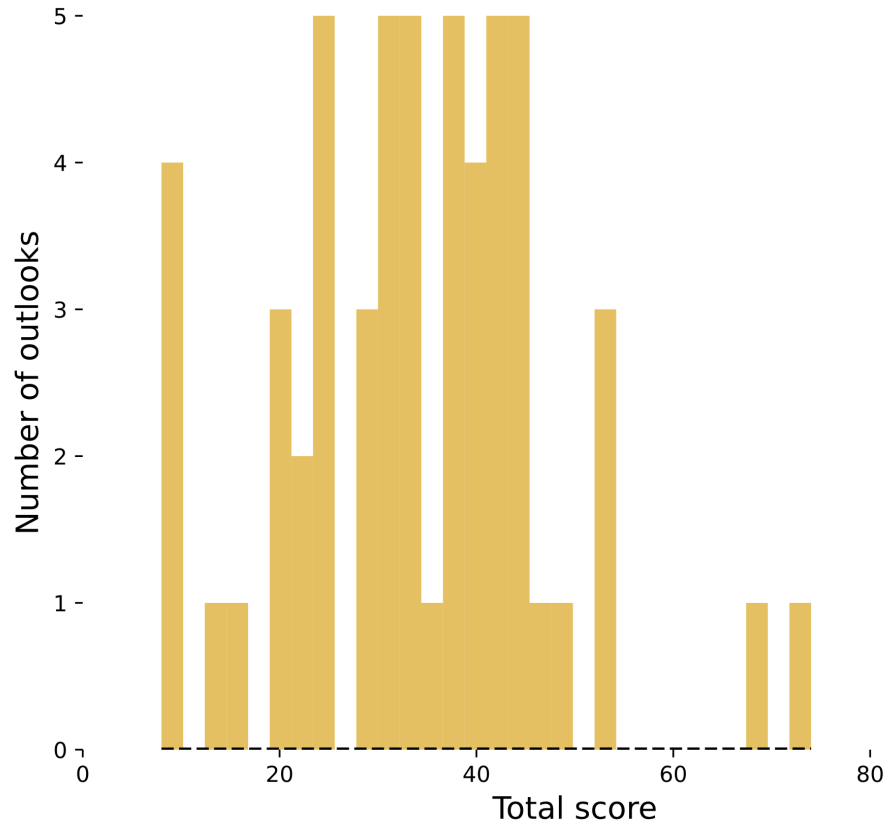
# Methodology: Indicators



# Top 10 outlooks in our sample



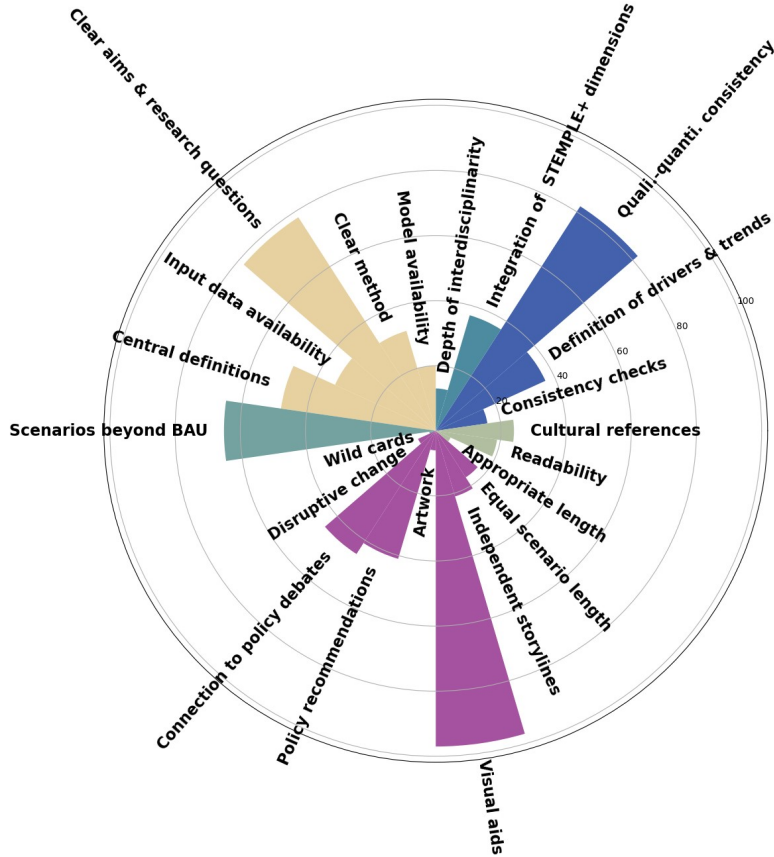
# Distribution of all outlooks' scores



Sample size=63



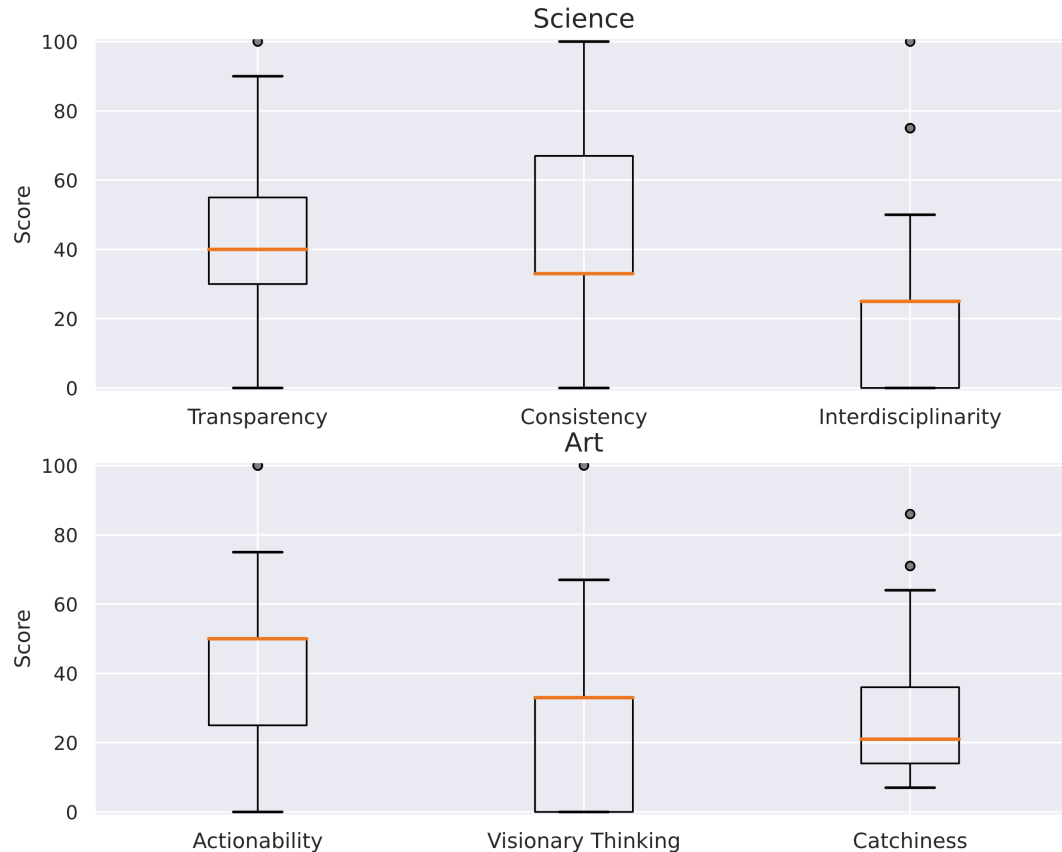
# Outlook Evaluation



- ▶ Visual aids, cultural references, and clear aims are often present.
- ▶ Almost no wildcards (only DIW and Equinor) or disruptive change
- ▶ Weak results regarding the depth of interdisciplinarity, consistency checks, artwork, and appropriate length



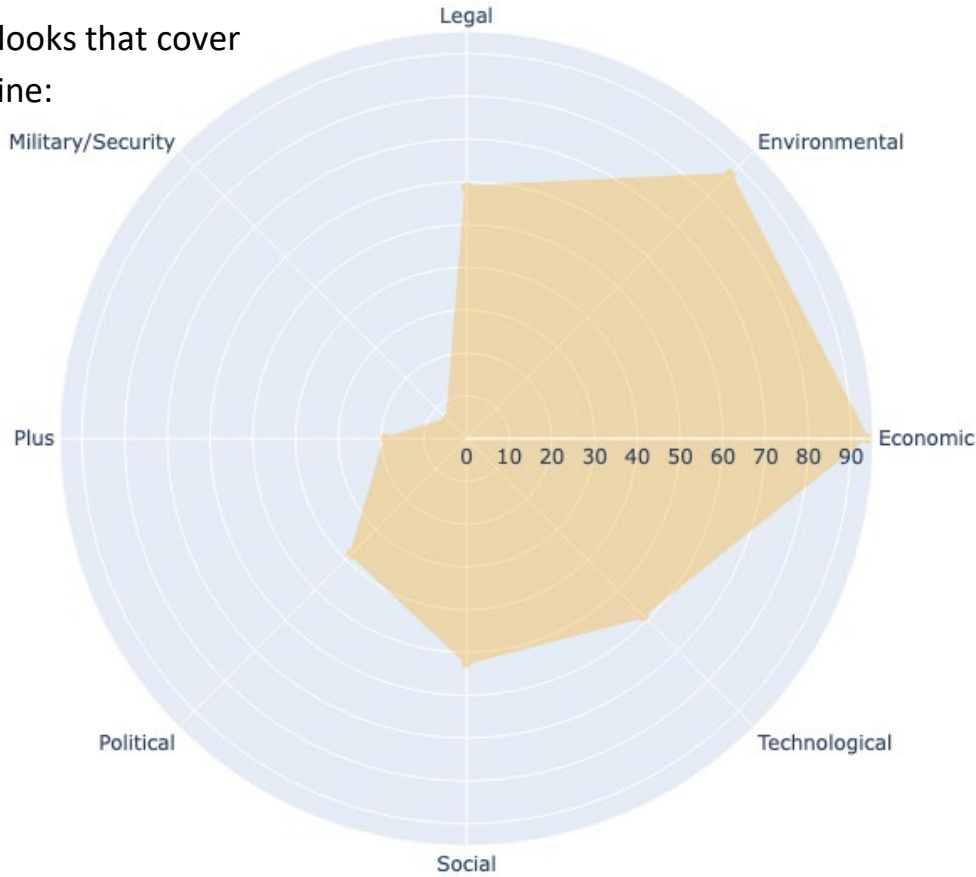
# Outlook Evaluation



- ▶ Large differences between dimensions
- ▶ Low median scores for catchiness, interdisciplinarity, visionary thinking
- ▶ Distributions rather concentrated

# Interdisciplinarity in the STEMLE-Plus framework

Share (%) of outlooks that cover a specific discipline:



- ▶ Only 24 outlooks consider political aspects.
- ▶ Military and security aspects are rarely covered.

# Does the quality depend on the institution's observables?

|                  | Category                     | n  | Average Score | t statistic | F statistic | p value       |
|------------------|------------------------------|----|---------------|-------------|-------------|---------------|
| Scope            | Global                       | 30 | 35.5          | -0.5616     |             | 0.5764        |
|                  | non-global                   | 32 | 33.7          |             |             |               |
| Institution type | NGO                          | 7  | 41.6          |             | <b>2.71</b> | <b>0.0389</b> |
|                  | National public organisation | 14 | 26.9          |             |             |               |
|                  | Oil & gas companies          | 8  | 39.4          |             |             |               |
|                  | Research providers           | 22 | 33.0          |             |             |               |
| Institution goal | Advocacy                     | 7  | 32.4          |             | 0.16        | 0.8494        |
|                  | For-profit                   | 8  | 35.8          |             |             |               |
|                  | Non-profit                   | 11 | 34.6          |             |             |               |
| Origin           | Non-WEIRD (Global South)     | 25 | 35.5          | 0.4674      |             | 0.6418        |
|                  | WEIRD (Global North)         | 38 | 33.9          |             |             |               |

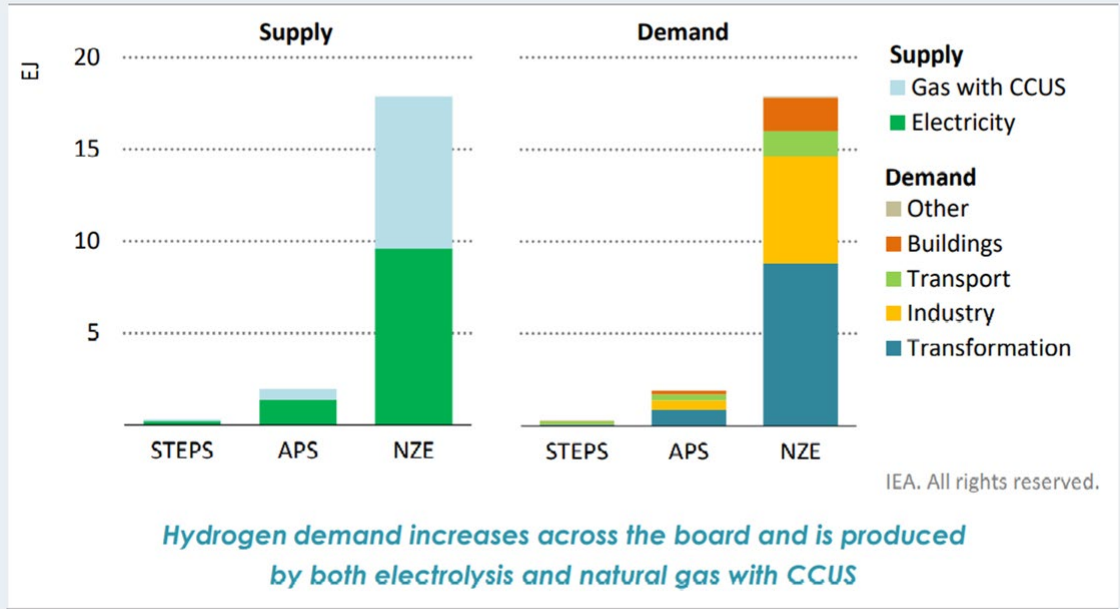
# Conclusions

- ▶ Majority of outlooks score **below 50/100**. *Overall: all 6 dimensions need to be strengthened.*
- ▶ Transparency, relevance, and catchiness dimensions are more developed; **catchiness, visionary thinking, and interdisciplinary** are most in need of better integration.
- ▶ Art and science dimensions correlate: **good scenarios** fare well in both fields.
- ▶ **Hydrogen** is mentioned often, but its role is limited to **below 5%** in the primary energy mix even in net-zero visions.
- ▶ **Geopolitics** is a large blind spot – and so is security in general (**only 7%** of outlooks mention it).
- ▶ Significant **differences based on organisation type** but no other observables
- ▶ **Only 2** outlooks (DIW, Equinor) integrate **wild cards** (nuclear fusion, blue death, colonisation of Mars, geo-engineering boom). Scenarios fail to prepare us for the unexpected.

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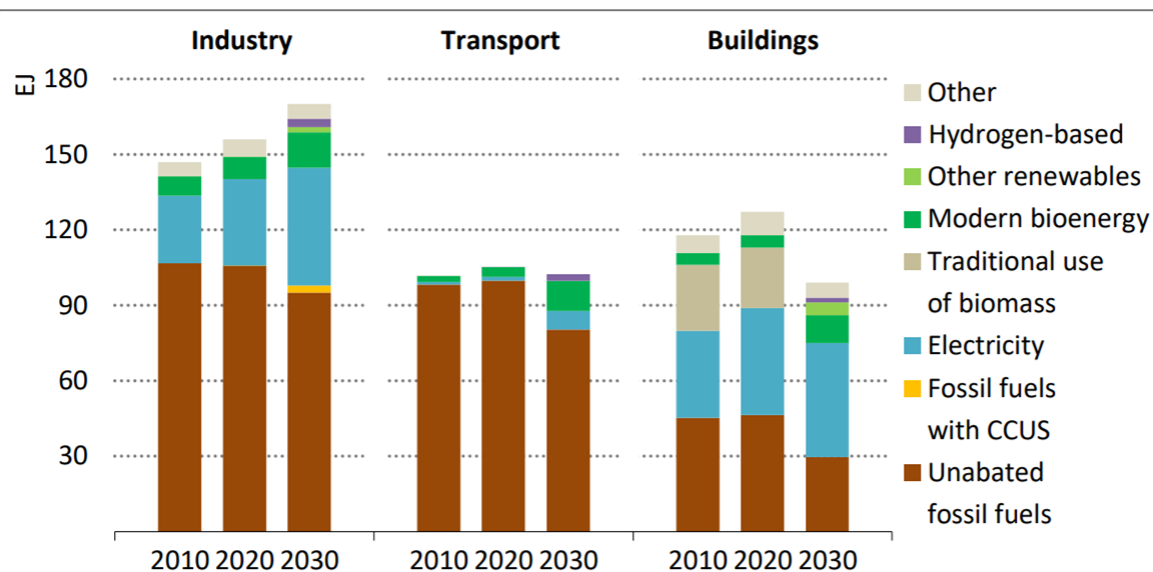
**Figure 1.27** ▶ Low-carbon hydrogen and hydrogen-based fuel demand and supply by scenario in 2030



*Hydrogen demand increases across the board and is produced by both electrolysis and natural gas with CCUS*

Note: Transformation includes electricity and heat, production of hydrogen-based fuels and refineries.

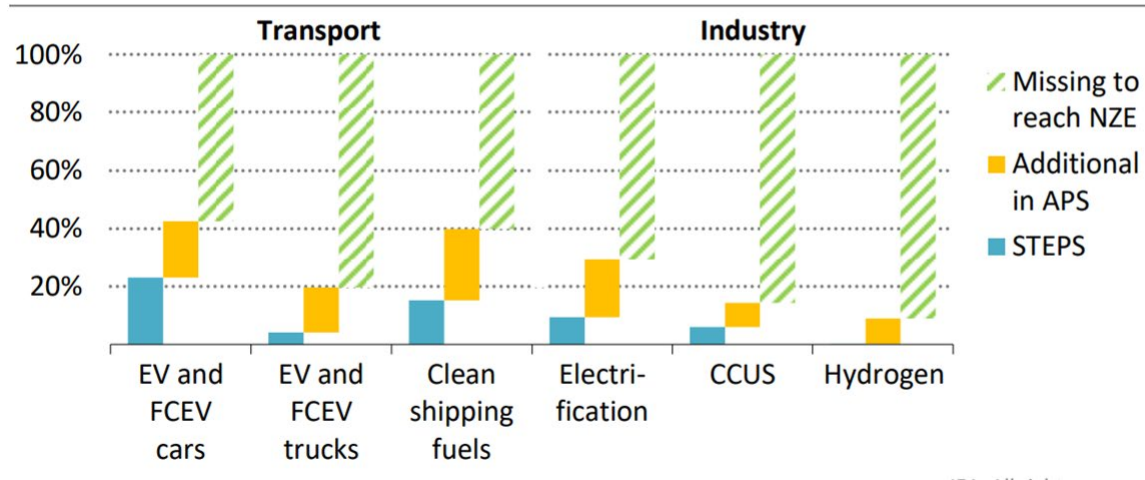
**Figure 3.3** ▶ Final energy consumption by source and sector to 2030 in the Net Zero Emissions by 2050 Scenario



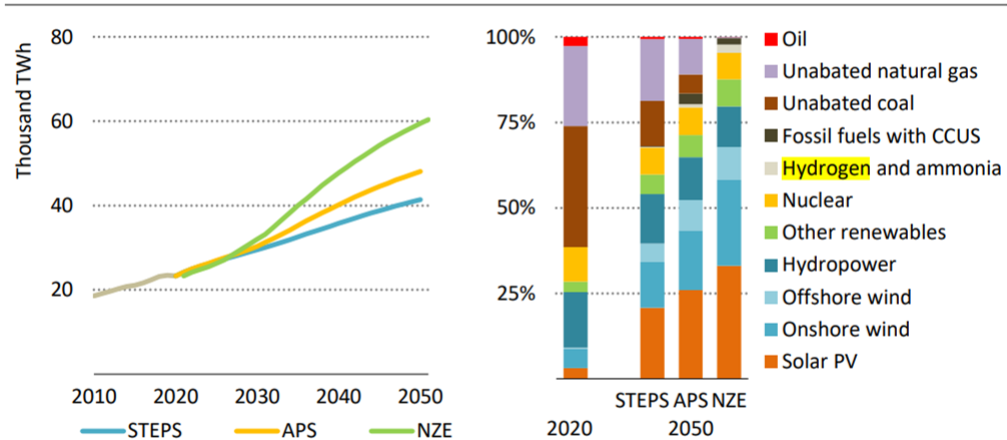
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**Figure 3.10** ▶ Tracking progress towards 2030 milestones in transport and industry by scenario



**Figure 4.20** ▶ Global electricity demand and generation mix by scenario



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**Table 3.1** ▶ **Examples of commercial-scale project development for industrial clusters, hydrogen and CCUS**

| Project                                 | Country        | Technologies  | Source of finance                     | Commercial arrangement  | Status                    |
|---|----------------|---|---------------------------------------|---|---------------------------|
| <b>Puertollano Green Hydrogen Plant</b> | Spain          | Solar PV, battery storage, hydrogen electrolysis                                    | Utility balance sheet                 | Use of hydrogen to produce ammonia and electricity by a fertiliser company.                                 | Construction              |
| <b>Humber Industrial Cluster</b>        | United Kingdom | CCUS, hydrogen infrastructure/ electrolysis, wind                                   | Private consortium, government grants | Use by heavy industry, refiners, power plants, mobility and grid injection.                                 | Planned                   |
| <b>Western Green Energy Hub</b>         | Australia      | Solar PV, wind, hydrogen electrolysis   | Private consortium, government grants | Off-take by mining companies, ammonia supply for export.  | Planned                   |
| <b>Porthos Port of Rotterdam</b>        | Netherlands    | CCUS, hydrogen  | Private consortium, government grants | Companies supply CO <sub>2</sub> , public-private partnership manages transport/storage, use by refineries. | Planned                   |
| <b>Haru Oni Hydrogen Project</b>        | Chile          | Wind, hydrogen electrolysis, synthetic fuels, direct air carbon capture and storage | Private consortium, government grants | Export-oriented supply of synthetic fuels.  | Construction (demo phase) |
| <b>Varenes Project</b>                  | Canada         | Hydrogen electrolysis, synthetic fuels  | Private consortium, government grants | Feedstock from landfills, sale of synthetic fuels.  | Planned                   |

# Interdisciplinarity using STEMLE-Plus framework: clustering results

- ▶ We use hierarchical clustering to classify the outlooks' performance in term of the STEMLE-Plus dimension.

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| Cluster Name   | average score(%) |          |               |       |                   |      |           |        |               |
|----------------|------------------|----------|---------------|-------|-------------------|------|-----------|--------|---------------|
|                | Size             | Economic | Environmental | Legal | Military/Security | Plus | Political | Social | Technological |
| The incomplete | 22               | 100      | 100           | 100   | 18                | 41   | 100       | 100    | 100           |
| The minimalist | 37               | 100      | 86            | 41    | 0                 | 8    | 5         | 30     | 41            |
| The fragile    | 4                | 0        | 25            | 0     | 0                 | 0    | 0         | 0      | 0             |

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