EA EUROPEAN ACADEMY
OF TECHNOLOGY AND INNOVATION ASSESSMENT

# Multi-perspective system analyses for robust energy decision support

# Contents

# 1. Multi-Perspective System Analyses

# Basic elements of a technical energy supply system


(Pictures from Pixelio, Siemens, Wikipedia, everystock, dpa 2014)

# …are surrounded by societal framework conditions


(Pictures from Pixelio, Siemens, Wikipedia, Everystock, dpa 2014, Background: Siemens online game „Power Matrix" (2014))

# Multi-Perspective System Analyses (the „Systems-Web-Approach“)

## System

A phenomenon which is characterised by regular correlations between circumstances.

**determined and separated from its environment by**

## 1. System Description

formal reconstruction of regular correlations between circumstances with a certain purpose and with certain defining perspective (determined by formal means used/a certain **operation *O ()*** chosen)

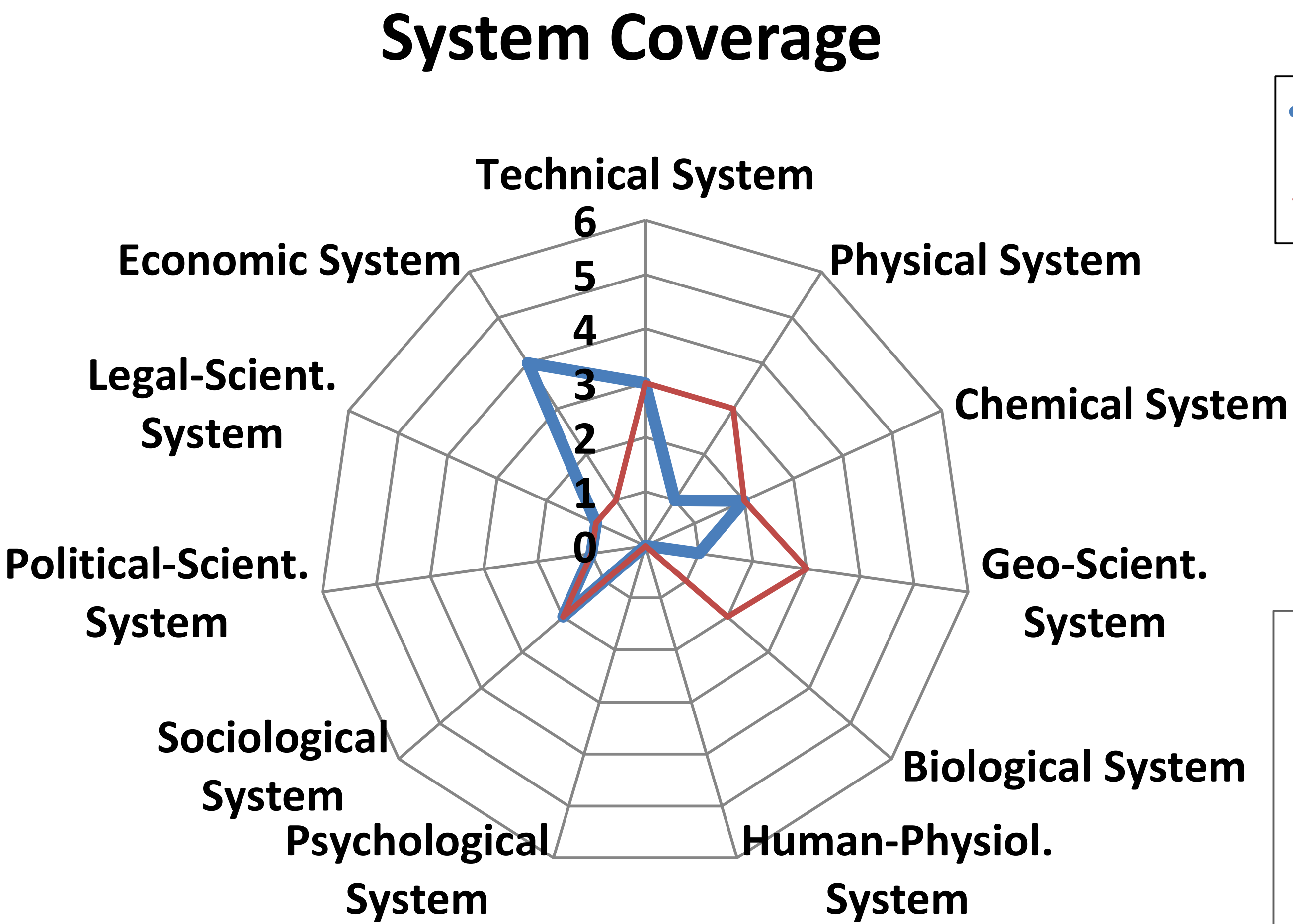
$$Ch_n\,(E_i\,(t+1)) = O\,(Ch_m\,(E_j\,(t)))$$

with: $E_{i,j}$: Entities, $Ch_{n,m}$: characteristics, $t$: point in time

***O ()*** could be: energy flows, chemical reaction, communication, …

and by **2. Its Purpose** (e.g. Energy Supply)

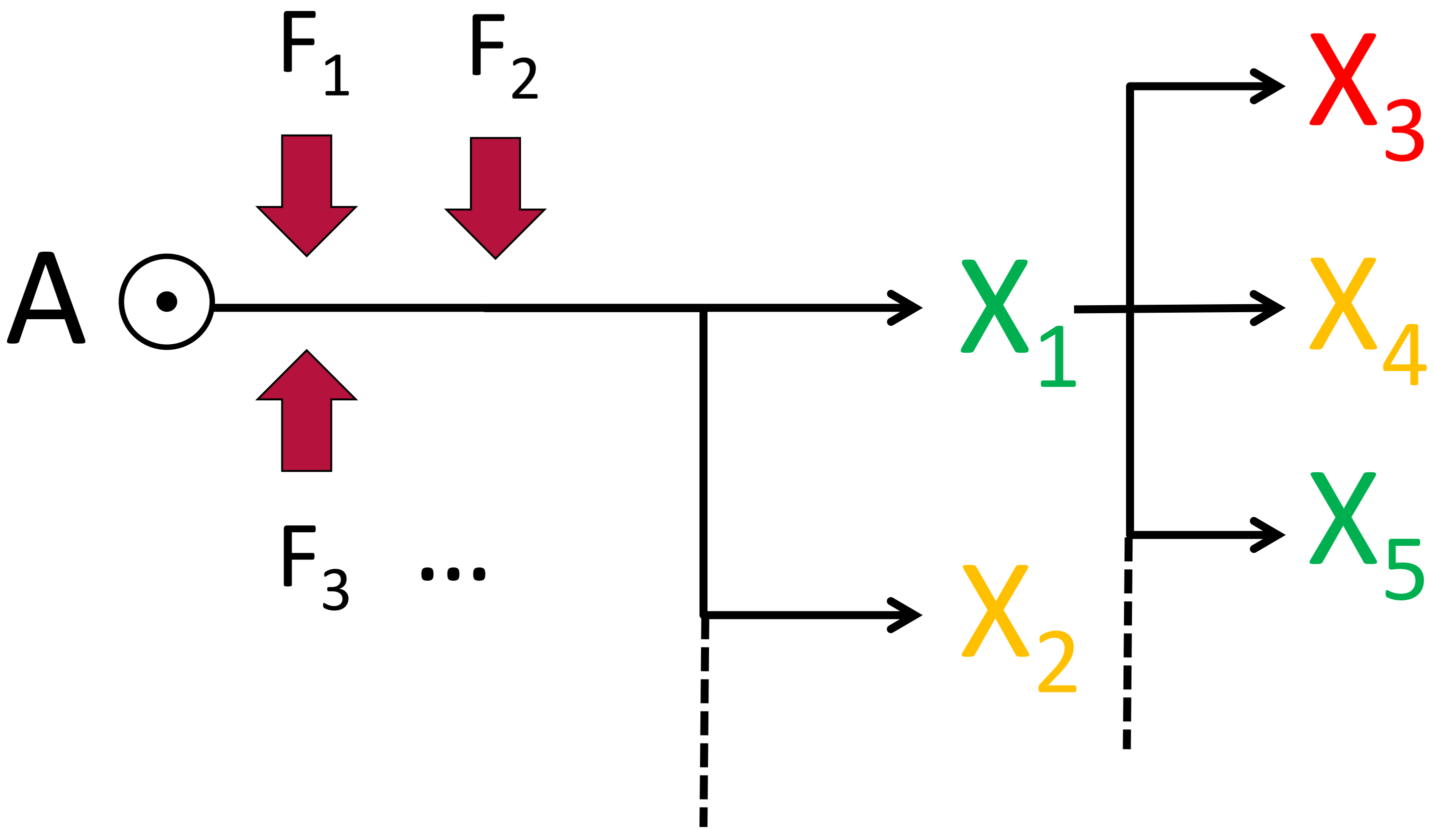
# System perspectives relevant for analysing energy systems




Extent of consideration
0: none
1: parameters assumed
2: part of structure rough
3: part of structure detailed
4: whole structure rough
5: whole structure detailed

# 2. Challenges for Robust Policy Advice

# Policy Advice: providing knowledge for action




The action A with the purpose X
leads under the (legal, societal, technical, …) framework conditions ($F_n$)
to the circumstances $X_n$ (desired/undesired impacts)

# Desirable and Robust Solutions

**Aim of responsible policy decisions:** Realising desirable long-term viable solutions

Concentrating on the aim of **Safe&Secure/Robust Solutions**:

- **Dynamic stability**:
  - **Robustness**: Solutions need to be stable against adverse impacts from the outside
  - **Opportuneness:** Solutions should enable to take advantage of unexpected fortune developments
- **Social robustness**:
  The solutions are acceptable within a wide range of diverse interests and value commitments.

# Robust Solutions require Robust Policy Advice

Policy advice, i.e. statements about the success and the impacts of an action provided, needs to be **reliable**:

- **Epistemically robust**
  invariant against fluctuating or unknown pertinent causal factors and factual conditions
- **Socially robust**
  invariant with respect to a large range of interests and value commitments

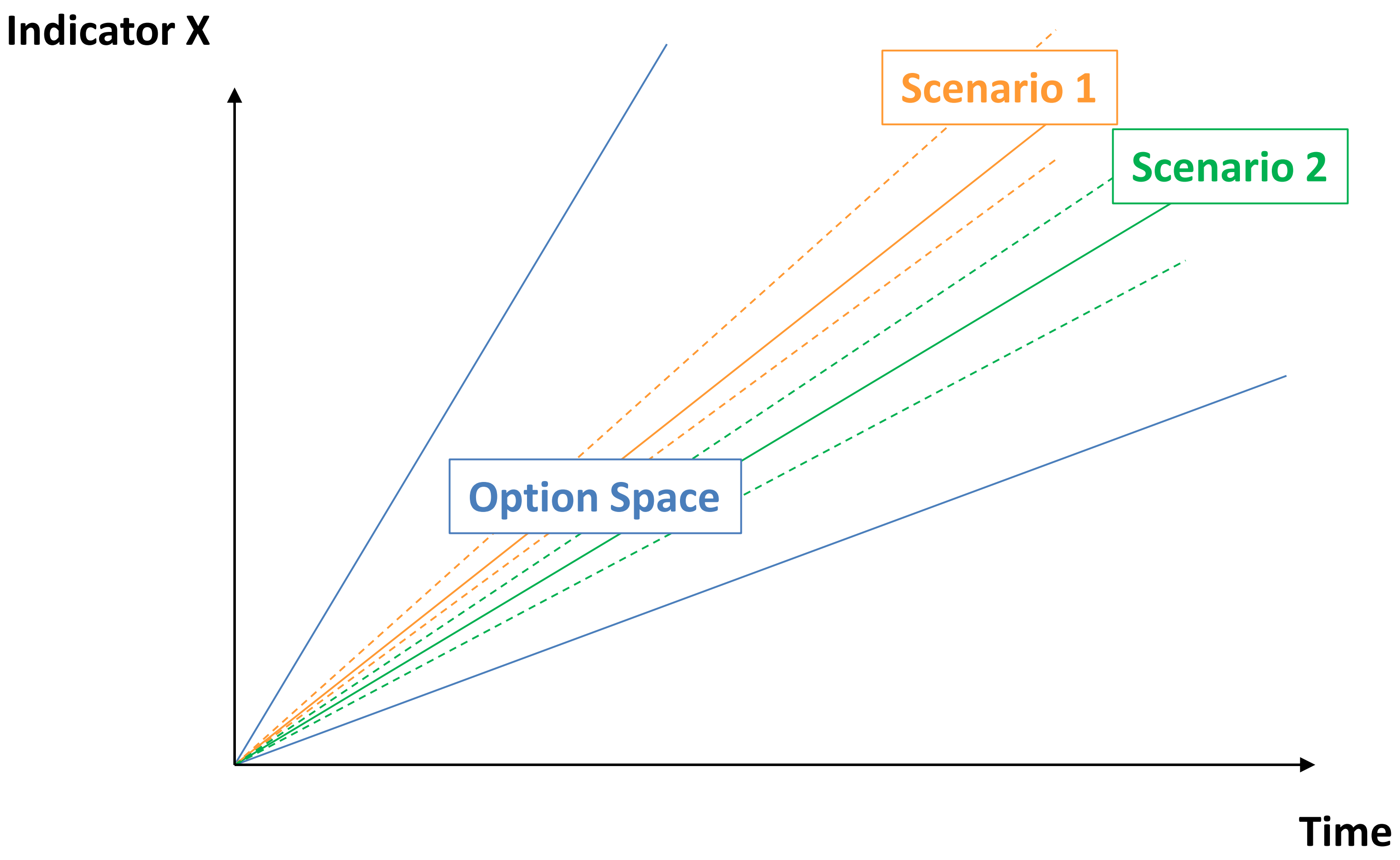
# Some Prerequisites for Robust Policy Advice

- Analyses and underlying knowledge needs to **fit to the purpose**
  - Considering relevant technical, professional, scientific and local, experience based knowledge
  - Setting normative/non-epistemic elements right (e.g. preferences for „false-positives/negatives“)
- Analyses need to follow a **large spectrum of options**, and acquainting decision makers with the **underlying uncertainties**
- **Exploring the option space** via Meta- and reflective analyses (transparency, implicit commitments, vary/exchange premises)
- Selecting those options which do **not contradict major societal values** and fit well with respect to evaluations by interest groups
- Concentrate on analysing **decisive issues and correlations**

# Specific Challenges: Scientific Expertise vs. Academic Research

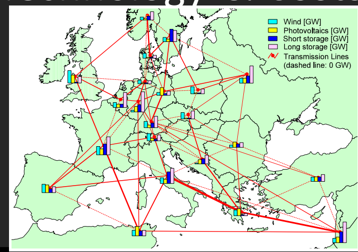
1. Application to **real world problems** → helpful answers are not readily available → combining various general „truths“ + practical demands → **unavoidable incoherencies**
2. Challenges selected by **urgency** → potential difficulty in tractability, non-laboratory conditions → **much higher uncertainty**
3. New expert scientific knowledge produced under **close scrunity of the public** → internal controversies, contrasting conceptual frameworks become visible → **distrust may be caused**
4. Bringing **scientific generalisations to bare on specific practical problems** → additional **local knowledge/lay participation needed**
5. Practical **impact of** science-based **recommendations** → appropriateness partly assessed by **non-epistemic (normative) criteria which are not part of academic research** (efficiency, economic benefit, environmental impacts, social issues)

# Approach, 1st Step: Analysing the Option Space



# Approach, 2nd Step: Selecting Acceptable Solutions

Technology & Costs




Climate & Weather

Society

Regulation

Environment

Politics

Markets

**Scenarios/ Alternatives**

**Evaluation of options with**

- **Experts**
- **Interest groups**
- **Decision makers**

(Pictures from Pixelio, Siemens, Wikipedia, Everystock, dpa 2014, Background: Siemens online game „Power Matrix“ (2014))

# 3. Supporting Methods and Instruments

# Instrument 1: Combine Expertise via variants of EA project groups

## Considering relevant expertise with respect to

- Relevant content aspects
- Kind of knowledge: scientific and practical expertise

## Enabling problem-related reflexive discussions

- Working problem-related
- Analysis of the whole option space including uncertainties
- Considering known substantial societal evaluations
- Mutual recognition of validity of arguments

## Example "EnAHRgie": energy concept and sustainable land use

- "Innovation group" with scientists and practitioners
- Scientific expert group
- Multiple participatory elements + knowledge management (s. www.enahrgie.de)

EnAHRgie

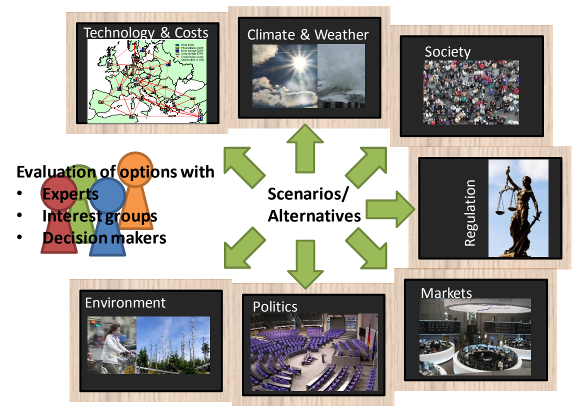
Bundesministerium für Bildung und Forschung FONA

Innovationsgruppen Nachhaltiges Landmanagement

ahrtal-werke difu evm ffu Forschungszentrum für Umweltpolitik Handwerkskammer Koblenz Institut für Energiesysteme, Energieeffizienz und Energiewirtschaft IfaS

KREIS AHRWEILER BAD NEUENAHR AHRWEILER DIALOGIK SRUR Fraunhofer UMSICHT EA EUROPEAN ACADEMY

# Instrument 2: Co-Design via modified EA-Lab-Workflow



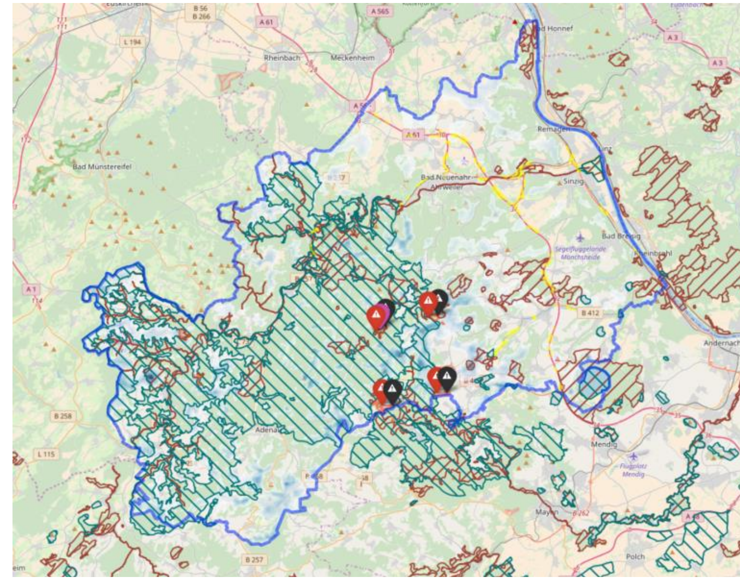

ggf.

1. Identification of **interesting questions / targets** (with experts, interest groups, decision makers)
2. Identification / development of **relevant models, data, analyses** (data search/-surveys, data analyses, translating questions to analyses)
3. Identification and formulation of „experiments“/„scenarios“ and adequate (interactive) **analysis and presentation/visualisation of the option space**
4. Further **adaption of results / answers** to the questions, discussion of uncertainties/options/limits
5. Adapted **presentation, publication and communication of results**

# Instrument 3: Transparency of the Argument / Evaluation

## Interactively visualising matrices/morphological fields, other data (e.g. in EA-Lab)

| | Negative Impacts: Harm | Positive Impacts: Beneficience | Options for action: Freedom/ autonomy | Limits for action: Dignity/justice/ fairness |
|---|---|---|---|---|
| Energy Supplier | | | | |
| Consumers | | | | |
| Local Economy | | | | |
| Local Politics | | | | |
| Regional / national Politics | | | | |
| Local Population | | | | |
| Close Environment | | | | |
| Far Environment | | | | |
| Global Environment | | | | |



(Source: EA-Lab using Leaflet, ©OpenStreetMap contributors, ©CC-BY-SA, © LANIS RLP, © ATKIS-Daten des LVermGeo RLP, © Windatlas RLP)

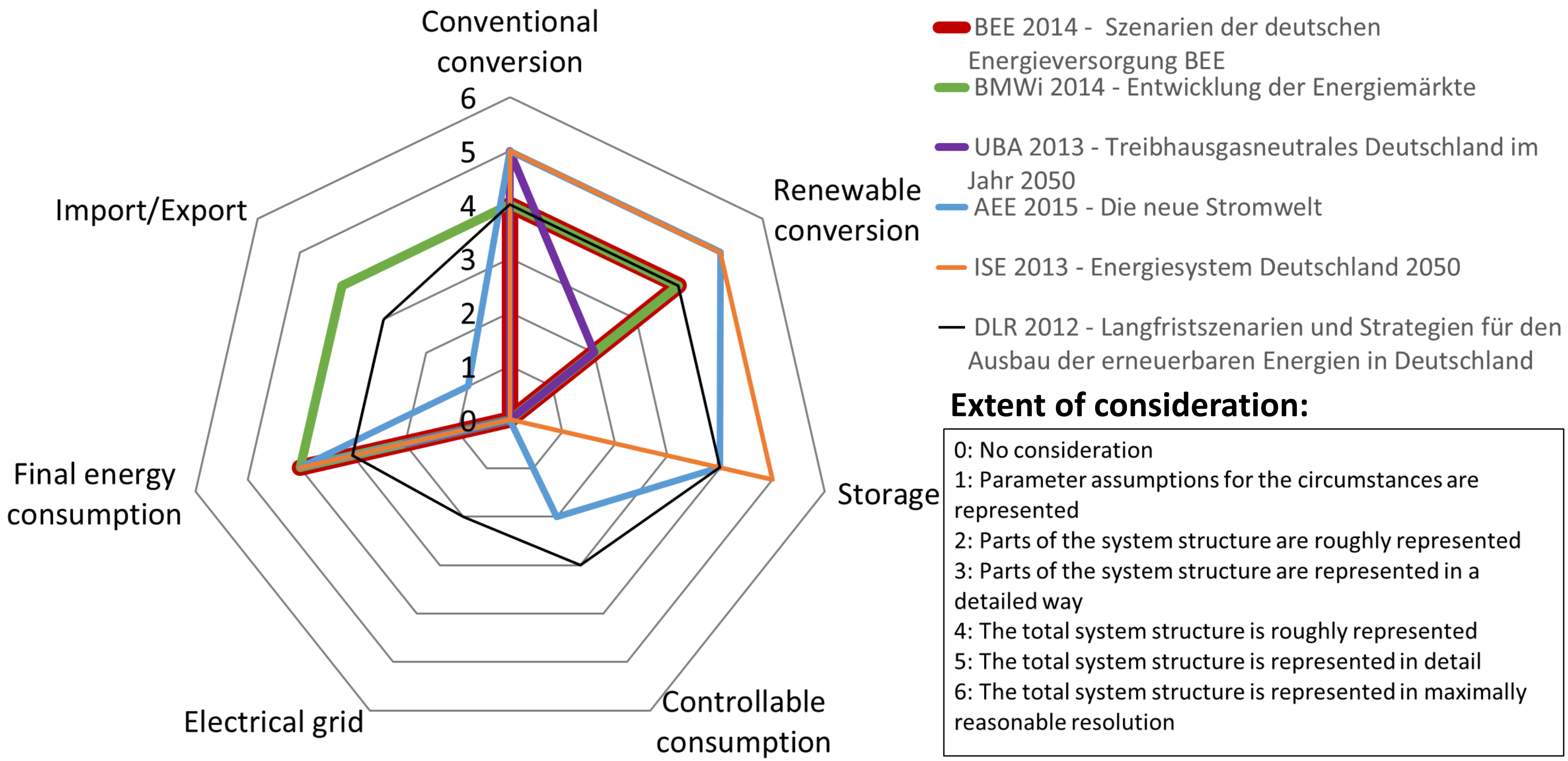
## Zielindikatoren

| Szenario | Regionale Wertschöpfung | Gestehungskosten Energieumwandlung | Endenergieverbrauch | Versorgungsgrad EE Strom - Wärme | Treibhausgase | Flächeninanspruchnahme |
|---|---|---|---|---|---|---|
| Szenario 0 (Business-As-Usual) | Keine Zielvorgabe | Keine Zielvorgabe | Keine Zielvorgabe | Keine Zielvorgabe | Keine Zielvorgabe | Keine Zielvorgabe |
| Szenario 1 | ++ | ++ | ++ | ++ | ++ | ++ |
| Szenario 2 | + | + | + | + | + | + |
| Szenario 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| | - | - | - | - | - | - |
| | -- | -- | -- | -- | -- | -- |

Source: EA-Lab

# Instrument 4: Transparency of Analyses (Systems Web Approach)

## Extent of considered model elements varies strongly between studies




**Extent of consideration:**

0: No consideration
1: Parameter assumptions for the circumstances are represented
2: Parts of the system structure are roughly represented
3: Parts of the system structure are represented in a detailed way
4: The total system structure is roughly represented
5: The total system structure is represented in detail
6: The total system structure is represented in maximally reasonable resolution

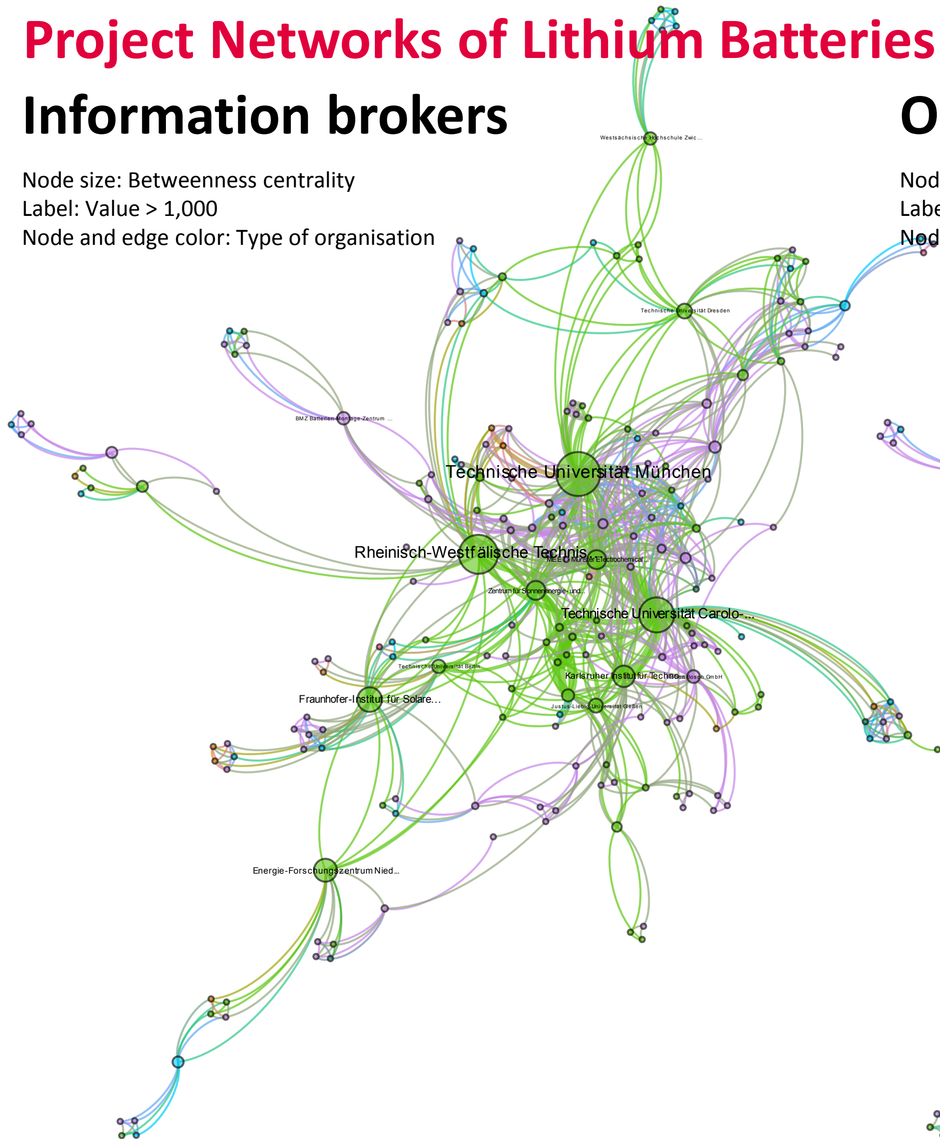
(Source: Droste-Franke and Weidle 2017)

# Instrument 5: Extended (System) Analyses – Innovation Networks

## Project Networks of Lithium Batteries

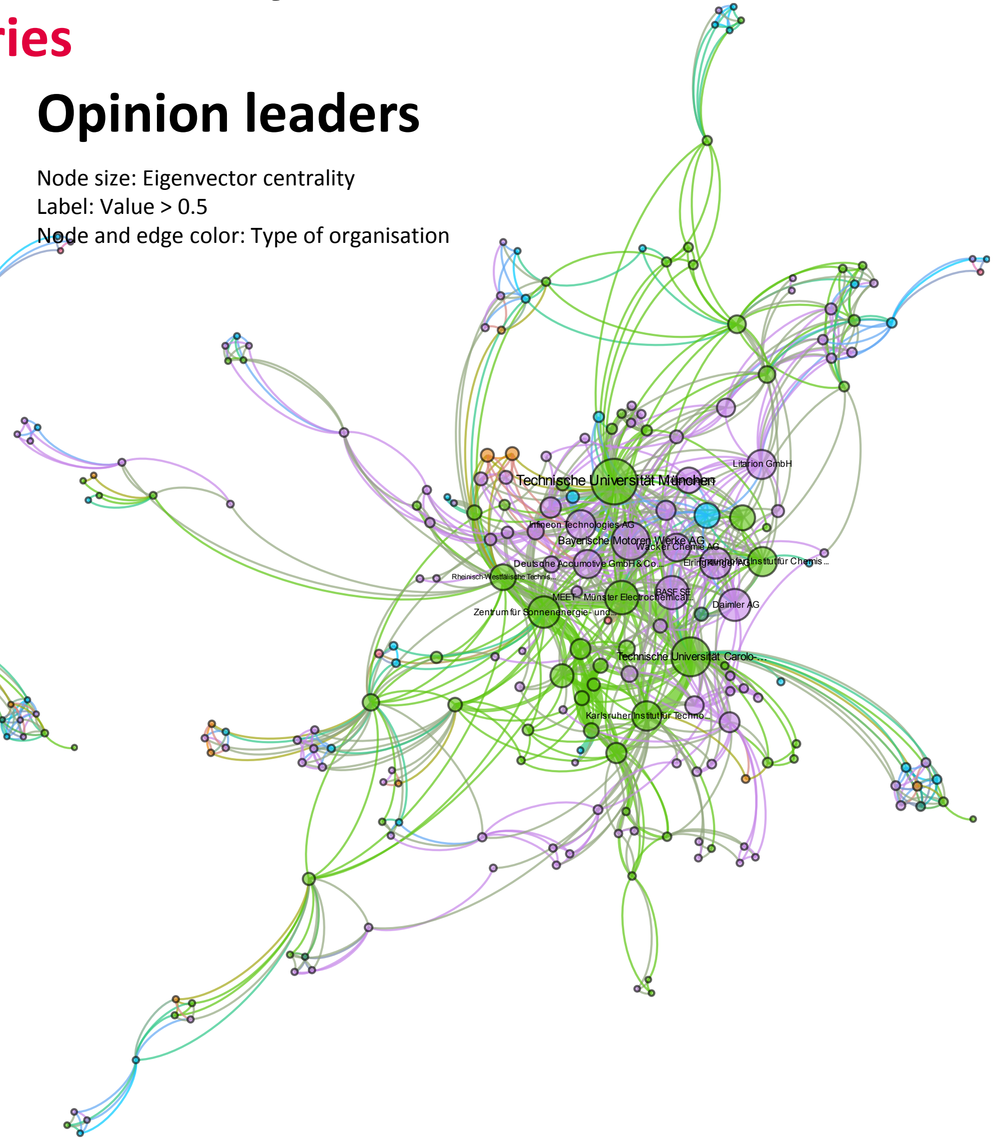
### Information brokers

Node size: Betweenness centrality
Label: Value > 1,000
Node and edge color: Type of organisation




### Opinion leaders

Node size: Eigenvector centrality
Label: Value > 0.5
Node and edge color: Type of organisation




(Gabriele Fohr 2017)

# Instrument 5: Extended (System) Analyses – Innovation Networks

- **Simulating Knowledge Dynamics in Innovation Networks (SKIN)-Modell** (Gilbert et al. 2010):
  - **Agent-based simulation** of innovation networks
  - Central aspect: **knowledge vector/"kene"** of agents (e.g. corporations):

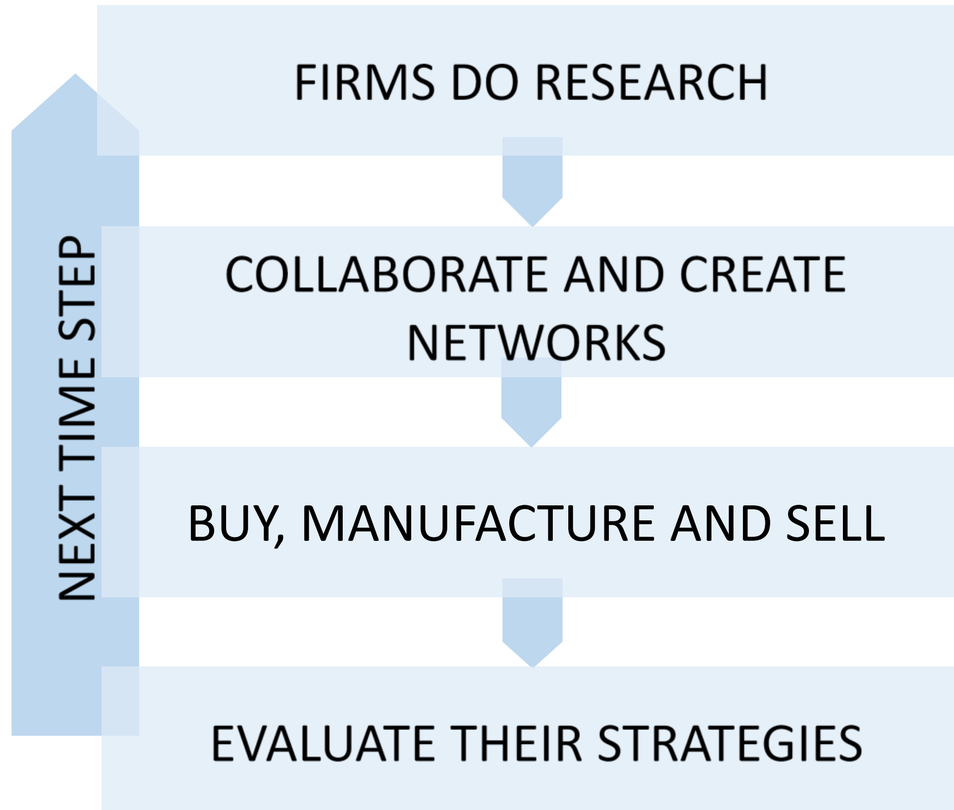
    {C: Capability (subject area), A: Ability (Specialisation), E: Expertise (skills)}, {C, A, E}, {C, A, E}, …

    e.g.: {C: molecular biology, A: protein design, E: much expertise}
  - Substantial activities: beside others co-operations, research, production of innovative goods, trade, buying and selling
  - Aim: **Answering "if-then-questions"** to innovation activity
- **Basis: beside others data/network analyses, empirical surveys:** calibration, characterisation of agents, validation

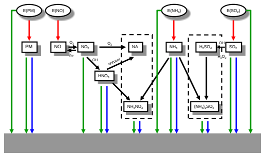
# Instrument 5: Extended (System) Analyses – Innovation Networks

## Example for lithium batteries (project InnoSEn)

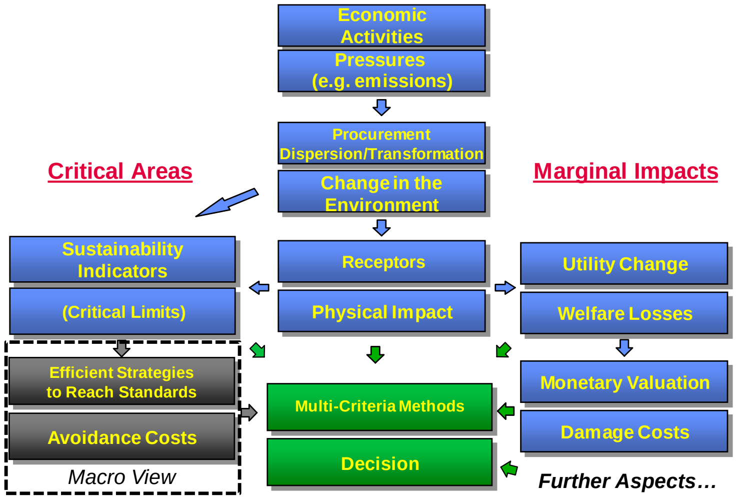
- **Actors Space**
  - Firms, research institutes, …
  - Size, research activity, co-operation strategies, location in value chain
  - Knowledge exchange
  - Financing environment
- **Market representation** stationary energy market by ABM AMIRIS, others: aggregated
- **Product representation** products with varying characteristics
- **Knowledge representation** considering knowledge exchange extensities



# Instrument 5: Extended (System) Analyses – Environmental Effects

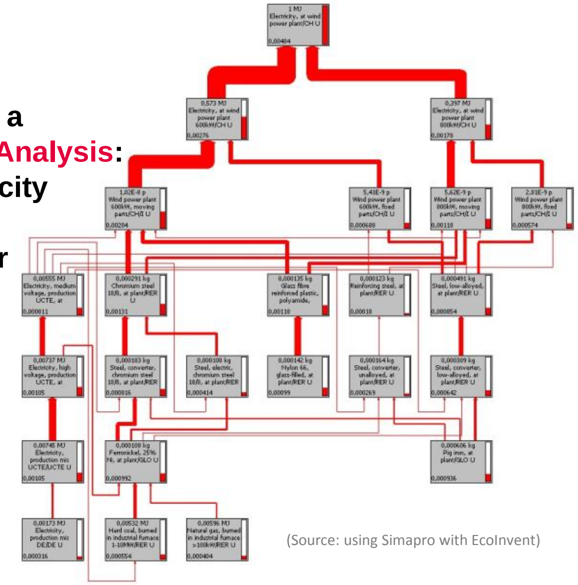





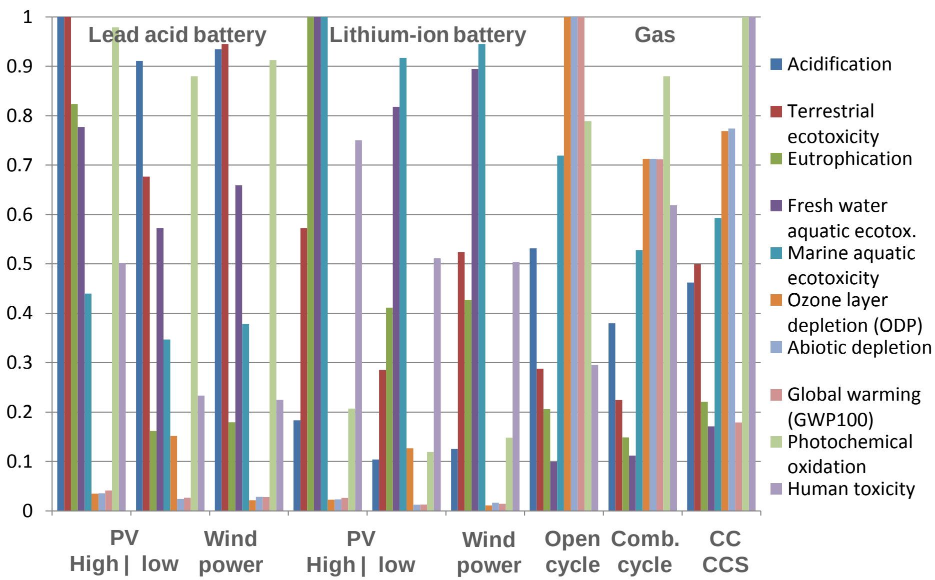


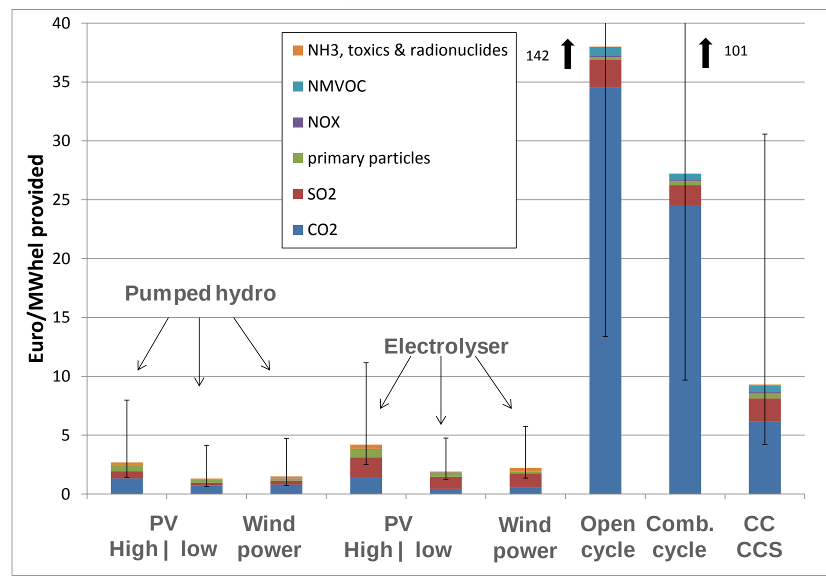

Network of a **Life Cycle Analysis**: 1MJ electricity in a wind power plant

shown: GWP100 $kgCO_{2eq}$



(Source: using Simapro with EcoInvent)



# 4. Conclusions

# Conclusions

- **Multiple perspectives are needed** to be able to analyse energy systems in their societal framework conditions
- Various challenges arise for **Robust Policy Advice**
  - **Purpose related expertise** needed
  - Considering **large option space**
  - **Transparency** as precondition for reflexive (meta-)analyses
  - Selecting options by **relevant, adequate evaluation**
- **Various supporting methods and instruments exist** and are currently adopted, used and tested, e.g. at the EA for regional energy concepts and innovation analyses

# Thank you!

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Innovationsgruppen Nachhaltiges Landmanagement

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