Socio-technical scenarios and sustainability: towards an integrative approach

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Motivation

Requirements to manage a transition process (in a nutshell):
- Knowledge of the aims
- Knowledge of ways and means
- Knowledge of the frame and its dynamic interdependencies (→ socio-technical systems)

Methods to provide the required knowledge considering the aims

Objective:
Discussion of integrated socio-technical scenario approach

Note: On-going research within ENERGY-TRANS
Thesis 1:
A (double) integrated scenario approach is required, to support transition processes of socio-technical systems towards more sustainability:

- Integration of social, economic and technological perspectives,  
  (→ socio-technical scenarios)
  plus
- Integration of an appropriate (sustainability) assessment tool into socio-technical scenarios  
  (→ integrated socio-technical scenarios)

Thesis 2:
Integrated socio-technical scenarios can be neither merely explorative nor merely normative

Basic understanding
The approach

Step 1:  
Determination of relevant socio-technical system characteristics

Step 2:  
Development of socio-technical scenarios

Step 3:  
Development and application of sustainability indicators

Step 4:  
Reflection

[Step 5:  
Development of recommendations for action]
Step 1: Socio-technical system characteristics

- Identification of relevant socio-technical elements and dynamics of the system

Socio-technical elements

- Growth of renewables
- Infrastructure extension
- Efficiency technologies
- Smart grids
- ... 

- Energy carrier prices
- Technology development
- ...

Techno-economic system

- New actors and actor coalitions
- Ubiquitousness of energy systems
- Change of daily routines
- (Apparently) higher prices
- Omnipresence of energy
- Change in social life
- New consumer roles (prosumer)
- ...

Societal system

- Energy policy measures
- Demographic change
- Economic development
- Global challenges
- EU policy development
- National policy priorities
- Social coherence
- Governance styles
- Knowledge society
- Change of values and lifestyles
- Societal acceptance
- ...

Present
Step 1: Socio-technical system characteristics

- Identification of relevant interdependencies

**Techno-economic system**
- Growth of renewables
- Infrastructure extension
- Efficiency technologies
- Smart grids
- ... 

**Societal system**
- New actors and actor coalitions
- Ubiquitousness of energy systems
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**Energy policy measures**
- Demographic change
- Economic development
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**Present**
- Energy carrier prices
- Technology development
- ...
Step 1: Socio-technical system characteristics

- Translation into relevant drivers to describe scenarios

**Techno-economic system**
- Growth of renewables
- Infrastructure extension
- Efficiency technologies
- Smart grids
- Smart grids
- New actors and actor coalitions
- Ubiquitousness of energy systems
- Change of daily routines
- (Apparently) higher prices
- Omnipresence of energy
- Change in social life
- New consumer roles (prosumer)
- ...
Step 1: Socio-technical system characteristics

Elaboration of future development options for these drivers

„Changes“
- Growth of renewables
- Infrastructure extension
- Efficiency technologies
- Smart grids
- ...

„Drivers“
- Energy carrier prices
- Technology development
- ...

Techno-economic system

Societal system

Present

Growth of renewables
Infrastructure extension
Efficiency technologies
Smart grids
...

Energy policy measures
Demographic change
Economic development
Global challenges
EU policy development
National policy priorities
Social coherence
Governance styles
Knowledge society
Change of values and lifestyles
Societal acceptance
...
Step 2: Socio-technical scenarios

Normative-explorative (energy) scenarios

Context scenarios

Population
Crude oil price
Transport
GDP

Crude oil price
Regulations
Life style

Population
Political visions
Transport
Preferences and values
Potentials and advantages

• Improved understanding of socio-technical system development
  ✓ Systematic revealing of interdependencies between drivers of development
  ✓ Combination of interdependencies into consistent scenarios
  ✓ Quantification of changes of underlying interdependencies

• Improved quality of findings
  ✓ Enhanced transparency of societal / institutional framework conditions
  ✓ Improved consistency
  ✓ Increased robustness of transition path proposals

Improved orientation knowledge for decision-makers
Step 3: Sustainability indicators

• Methodological requirements
  • A sound theoretical and conceptual basis (criteria)
  • A translation of criteria into suitable sustainability indicators, considering context conditions, socio-technical elements, etc.
  • An appropriate application of criteria / indicators to assess scenarios

• Methodological approach:
  Integrative Sustainability Concept of the Helmholtz Association with its substantial sustainability rules (criteria)
  • Securing human existence
  • Maintaining society’s productive potential
  • Preserving society’s options for development and action

• Institutional rules
Step 3: Sustainability indicators

Set of about 40, preferred spatial, indicators, which could be assigned to the criteria and to institutional rules

- Mainstream (total energy use, energy efficiency, share of renewables, …)

- Not yet established socio-technical (societal concerns regarding health risks due to the energy system, acceptance in the neighborhood, installed smart meters, energy cooperatives, …)

- Not yet established ecological-economic (capacity of biogas plants per km² agricultural land, degree of internalization of energy-related external costs, …)

<table>
<thead>
<tr>
<th>Sustainability rules</th>
<th>Selected sustainability indicators</th>
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<tbody>
<tr>
<td><strong>Securing human existence</strong></td>
<td>• Accidents and accident fatalities of employees</td>
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<td>• Population concerned about health risks due to the energy system</td>
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<td>• Energy import dependency and diversification</td>
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<td>• Energy expenditures of lower-income households</td>
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<td>• SEAI (System Average Interruption Duration Index)</td>
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<td>• Employment in the energy industry</td>
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<td><strong>Maintaining society’s productive potential</strong></td>
<td>• Land use of the energy system and capacity of biogas plants</td>
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<td>• Impacts of renewable energy technologies deployment on biodiversity</td>
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<td>• Share of renewable energy in total primary energy use</td>
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<td>• Share of buildings with low energy demand</td>
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<td>• Fuel consumption of newly registered cars</td>
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<td>• Share of public and non-electrified transportation in total transportation</td>
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<td>• End energy consumption per GDP and of the industry per production unit</td>
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<td>• Consumption of fossil materials for electricity generation</td>
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<td>• Energy-related greenhouse gas emissions in total, per capita and share of the energy sector</td>
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<td>• Number of electric passenger cars and station wagon cars</td>
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<td>• Total air pollution and share of the energy sector concerning air pollution</td>
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<td>• Energy-related emissions of heavy metals</td>
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<td>• Energy-related non-hazardous and hazardous solid wastes</td>
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<td>• Number of incidents in nuclear power plants</td>
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<td>• Share of total cumulative radioactive waste in interim storage</td>
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<td>• Investments in energy efficiency measures, maintenance and construction</td>
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<td>• Number of university graduates in the field of energy sciences</td>
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<td>• Research expenditures by federal and regional governments</td>
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<td>• Number of patients in the field of renewable energy</td>
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<td>• Added value creation from the energy sector</td>
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<td><strong>Preserving society’s options for development and action</strong></td>
<td>• Share of women in management positions</td>
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<td>• Income of women in relation to the income of men</td>
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<td>• Satisfaction with opportunities for participation in decision making</td>
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<td>• Share of tourists who feel disturbed by impairments on cultural functions of nature</td>
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<td>• Acceptance of the energy system, e.g. of different types of electricity production in the neighborhood</td>
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<td><strong>Instrumental rules</strong></td>
<td>• Degree of internalization of energy-related external costs</td>
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<td>• Share of development aid expenditures for energy-related projects</td>
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<td>• Emission reduction in CO2 equivalents due to the Kyoto mechanism</td>
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<td>• Number of households producing renewable energy for own use</td>
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<td>• Percentage of households buying certified renewable electricity</td>
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<td>• Number of certified energy consultants per capita</td>
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<td>• Number of smart meters</td>
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<td>• Volume of public funds to subsidize private energy-related investments</td>
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<td>• Expenditures to provide public information on the energy transition</td>
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<td>• Number of people active in energy cooperatives and volume of investments in renewable energy projects by them</td>
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<td>• Share of population living in regions shifting to 100% renewable energy</td>
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<td>• Market share of the four biggest energy supply companies</td>
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Step 3: Sustainability indicators

Matching indicators and socio-technical scenario variables
Case 1: Identical quantitative indicators and quantitative scenario variables
Case 2: Qualitative indicators could correspond to quantitative scenario variables
Case 3: No identical indicators and scenario variables
Step 4: Critical reflection of method and results

• Motivation:
  • To make weak points and open questions transparent
  • Required to improve the methodology and the generation of orientation knowledge

• Main questions are:
  • Are the stories told correctly? If not, why not? Can it be changed?
  • Is the approach appropriately used:
    • Is each (sub-)approach – i.e. model-based techno-economic scenario; context scenario; sustainability indicators – consistently used?
    • Is the integration between each approach appropriate? If not, why not? Can it be changed?
      If yes, how it has to be changed?
Conclusions – perspectives

- To support decision-makers with relevant knowledge regarding transition processes an integrative socio-technical scenario approach seems to be required.
- In ENERGY-TRANS research is under way to develop such scenario approach.
- More application experience and methodological research are needed to fully understand the strengths and limitations of the approach.
- Applications in ENERGY-TRANS and accompanying research could lead to a blueprint for energy systems analysis in general.
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