The energy transition – an integrative analysis

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AK Geographische Energieforschung
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The issue

Bürgermeister pessimistisch

Durchhänger beim Projekt Energiewende?

Mayors pessimistic: Sagging in the energy transitions?

100% Renewable Energy Regions

Vision

The region flourishes

Integriertes Klimaschutzkonzept für den Landkreis Bad Tölz-Wolfratshausen

Concept for climate protection does not affect politicians
The issue

• Technological, institutional, and social “lock ins”
• Technological innovations alone are not sufficient for a transition towards more sustainable energy systems
• Social innovation is required:
  – Multi-level governance; New actor constellations and governance
  – Behavioral changes
• Necessity to study co-evolution of socio-technical systems (STS)
• Interdisciplinary research is required at theory, framework, methodological, and empirical level
Goal and Research Questions

Goal

Integrative and interdisciplinary analysis of energy transitions considering: (i) “technical” energy system; (ii) institutional development; (iii) individual behavior.

Focus: regional level

Research questions addressed

1. Which factors and behaviors affect(ed) the transition of the energy region?
2. How can these behaviors (buildings) be explained?
Conceptual framework
The transition process

Indicators for sustainable energy system

- Predevelopment
- Take off
- Acceleration
- Stabilization

Initial focal variables
Terminal focal variables

After: Martens & Rotmans, 2002
The transition process

Boundary conditions
(Social-ecological technical landscape)

norms, prices
climate change

Dominant social-ecological urban regime

markets
ecology
technology
culture

New social-ecological urban regime

Pioneers (niches)

adapted from Geels 2002; Geels and Schot, 2007
Elements of transition analysis and management

- Energy flow analysis
- Agent analysis
- Institutional analysis
- Scenarios / visions
- Acceptance analysis
- Simulation modeling
- Sustainability assessment

Current state
Initial focal variables

Envisioned future state
Terminal focal variables

After: Binder et al., 2004
Actors decision making and institutional development

Expert interviews

Behavioral model
Acceptance

*Scenarios, vision, & policy development

Household survey

*Transition process

Interdisciplinary simulation model

Dynamic energy demand model

Energy flow analysis

*Assessment

Recommendations

Simulation and assessment of policies and strategies
Study areas
Study areas

• ökoEnergieland / Güssing
  – Burgenland (AT)
  – 14 communities
  – Founded 1990 (2005)
  – Biomass
  – High unemployment and migration

• Energy region Weiz-Gleisdorf
  – Steiermark (AT)
  – 18 communities
  – Founded 1996
  – Energy technologies
  – Good employment possibilities
ÖkoEnergieland
Decentralized local energy production

Hecher, 2012; PSI, 2008

Community heating Güssing (1996)
Block heating station Güssing (2001)
Photovoltaic Güssing (2001)
SNG-plant Güssing (2001)
Community heating Deutsch-Schützen (2005)
Community heating Urbersdorf (1996)
Biogas Strem (2001)

http://www.eee-info.net
Weiz-Gleisdorf
Light-house projects

Gemini Haus (2001)
Plus energy house (1997-2001)
Solar tree (1998)
Fueling station

Source: Bedenik and Hecher, 2012
Research questions

1. Which factors and behaviors affect(ed) the transition of the energy region?
   – Energy flow parameters and milestones
   – Future energy demand from buildings and regional supply

2. How can these behaviors be explained?
# Milestones in the energy transition

<table>
<thead>
<tr>
<th>Milestones</th>
<th>Definition</th>
<th>Examples (ökoEnergieland)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visionary</td>
<td>Densification of guiding ideas</td>
<td>Energy Charta</td>
</tr>
<tr>
<td>Institutional</td>
<td>Permanent and binding agreements of varying degrees</td>
<td>Foundation of ökoEnergieland</td>
</tr>
<tr>
<td>Physical</td>
<td>Infrastructural measures in the energy sector</td>
<td>SNG-plant district heating plant</td>
</tr>
<tr>
<td>External</td>
<td>Events affecting the development from outside</td>
<td>Joining EU / Leader program at EU level</td>
</tr>
</tbody>
</table>

Source: Hecher, et al. 2016; Binder et al., 2014
Linking energy demand to energy supply

Scenarios for regional energy demand

- **Bottom up simulation** of 15 scenarios
  - Envelope renovation rate
  - Legislative standards
  - Heating technologies

- **Entities**
  - Individual buildings (SFH, MFH, NRB)
  - Construction period
  - Heating system

- **Data source**
  - Statistical office Austria

Regional supply of renewable energy

- **Top down scenarios for supply potential**
  - Technical maximum
  - Competing use
  - Spatial accessibility

- **Entities**
  - Forest
  - Agriculture
  - Solar energy (PV, solar-thermal)

- **Data source**
  - Statistical office Austria

Binder et al., 2016
Energy standards and energy demand in 2050

**BAU**
- Ren. rate: 0.8%
- Energy standards
  - New B.: 80 kWh/m²a
  - Ren. B.: 100 kWh/m²a

**REN**
- Ren. rate: 1.6%
- Energy standards
  - New B.: 80 kWh/m²a
  - Ren. B.: 100 kWh/m²a

**LEG**
- Ren. rate: 0.8%
- Energy standards
  - New B.: 25 kWh/m²a
  - Ren. B.: 50 kWh/m²a

**TRANS**
- Ren. rate: 1.6%
- Energy standards
  - New B.: 25 kWh/m²a
  - Ren. B.: 50 kWh/m²a

Binder et al., 2016
Energy demand per carrier:
Business as usual scenario (2000-2050 GWh/year)

Binder et al., 2016
Aligning supply and demand

<table>
<thead>
<tr>
<th>Demand scenarios</th>
<th>DEMAND</th>
<th>SUPPLY POTENTIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating systems scenarios</td>
<td>BAU</td>
<td>BAU</td>
</tr>
<tr>
<td>Wood &amp; Woodchips (2050) [GWh/a]^1</td>
<td>161</td>
<td>59</td>
</tr>
<tr>
<td>Solar-thermal (2050) [GWh/a]^2</td>
<td>11</td>
<td>56</td>
</tr>
<tr>
<td>Heat from DHS (2050) [GWh/a]^3</td>
<td>29</td>
<td>85 (15)</td>
</tr>
<tr>
<td>Electricity (2050) [GWh/a]^4</td>
<td>206</td>
<td>17</td>
</tr>
</tbody>
</table>

Binder et al., subm.
Summary (I)

- Visionary leaders, political agents at regime level were key for creating a vision and promoting the transition.
- Co-evolution of the STS ⇒ Visionary and institutional milestones precede physical milestones.
- Path dependency of technical strategies selected linked to infrastructural measures such as district heating grid
- Trade-off between “faster” transition and “stock” of high energy efficient houses.
- Energy supply has to be planned in a flexible way.
  - Regional versus short distance?
  - Electricity supply
Research questions

1. Which factors and behaviors affect(ed) the transition of the energy region?

2. How can these behaviors be explained?
   - Decisions on energy efficiency in the building sector
Methods

• Explorative expert interviews (owners and experts)

• Survey (N=127 valid questionnaires) random sample from list of building permits (2008-2013)

• Multiple regressions
  – Decision on own energy efficiency standard
  – Preferred energy efficiency standard today
  – Energy efficiency standard recommended to a friend
Three phases in selecting and evaluating energy efficiency in renovation and new buildings

Orientation

Outcome: Highest preferred energy standard

Planning and Implementation

Outcome: Selected energy efficiency standard

Evaluation

Outcomes:
- Highest preferred energy standard today
- Highest energy standard recommended to a friend
Factors affecting decision on energy efficiency

Energy efficiencies: $A^{++} = 10\text{kWh/m}^2\text{a}$, $A^+ = 15\text{kWh/m}^2\text{a}$, $A = 25\text{kWh/m}^2\text{a}$, $B = 50\text{kWh/m}^2\text{a}$, $C = 100\text{kWh/m}^2\text{a}$

$N=127$ / *** $p< 0.001$, ** $p< 0.01$, * $p< 0.05$; $+ p< 0.1$ ; Overall model, $p< .001$, $R^2 = 0.31$ (Adjusted $R^2 = .28$)

Bedenik et al., 2015
Energy efficiency standard preferred today

Energy efficiencies: $A^{++} = 10\text{kWh/m}^2\text{a}$, $A^+ = 15\text{kWh/m}^2\text{a}$, $A = 25\text{kWh/m}^2\text{a}$, $B = 50\text{kWh/m}^2\text{a}$, $C = 100\text{kWh/m}^2\text{a}$

N=127 / *** $p<0.001$, * $p<0.05$; Overall model, $p<.001$, $R^2 = 0.30$ (Adjusted $R^2 = .29$)

Bedenik et al., 2015
Energy efficiency standard recommended

Energy efficiencies: A'' = 10kWh/m²a, A' = 15kWh/m²a, A = 25kWh/m²a, B = 50kWh/m²a, C = 100kWh/m²a

Com. in social networks

Expert recommendation

Specific knowledge

Attitude

Technology acceptance

Age

New building vs. renovation

HOUSEHOLD 1

Contextual factors

Regional consequences

Evaluation

Perceived consequences

Energy standard recommended

Energy standard preferred today

β = -0.35***

β = -0.15+

β = -0.16+

β = -0.14+

β = -0.24**

r = 0.21*

β = 0.47***

β = -0.19*

β = 0.17*

β = 0.15*

N=127 / *** p< 0.01, * p< 0.05, + p< 0.1, Overall model, p < .001, R² = 0.31 (Adjusted R² = .29)

Bedenik et al., 2015
Summary (II)

• Between the orientation phase and the final decision the desired energy efficiency decreases.
• Key decision factors are: expert recommendation > age > attitude and knowledge.
• The energy efficiency aimed at today and recommended to a friend are higher than the one the owners implemented themselves.
• Social networks do not play a significant role yet
Conclusions

• Delay between institutional development and technical energy system
• Path-dependency / socio-technical lock ins
• Supply has to be aligned to changes and dynamics in energy demand, otherwise recommendations might lead to “overshoot” or inflexible supply structures → need to include space in supply analysis
• Experts are key to change behavioral patterns → role of universities and higher education
• Feedbacks between decisions and social environment not measurable yet.
Thank you for your attention!

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