The energy transition – an integrative analysis

Prof. Dr. Claudia R. Binder

Human-Environment-Relations in Urban Systems

School of Architecture, Civil and Environmental Engineering

École polytechnique fédérale de Lausanne

In collaboration with: Dr. Christof Knoeri, ETHZ; Maria Hecher, UniGraz

AK Geographische Energieforschung

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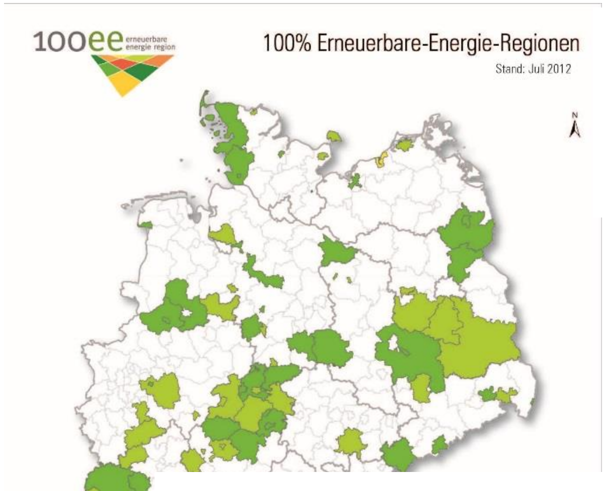
The issue



100% Renewable Energy Regions

Vision
The region flourishes

Bürgermeister pessimistisch

Durchhänger beim Projekt Energiewende?

Mayors pessimistic:
Sagging in the energy transitions?


Video | Fotostrecken | Wett
merkur-online.de
Lokales Sport Video Panorama Outdoor Leben Reise
Regionen Prospekte Blitzer Veranstaltungen Wetter Lokalsport Kommunalwahl
merkur-online > Lokales > Bad Tölz > Stadt Bad Tölz > Klimaschutz-Konzept lässt Kreisräte kalt
17.10.13 | Bad Tölz | 0

Klimaschutz-Konzept lässt Kreisräte kalt

Bad Tölz-Wolfratshausen - Der Aufwand war groß - doch das Ergebnis sorgte für wenig Begeisterung: Kritisch hat der Kreistag am Mittwoch die Präsentation eines Klimaschutzkonzepts für den Landkreis aufgenommen.

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.

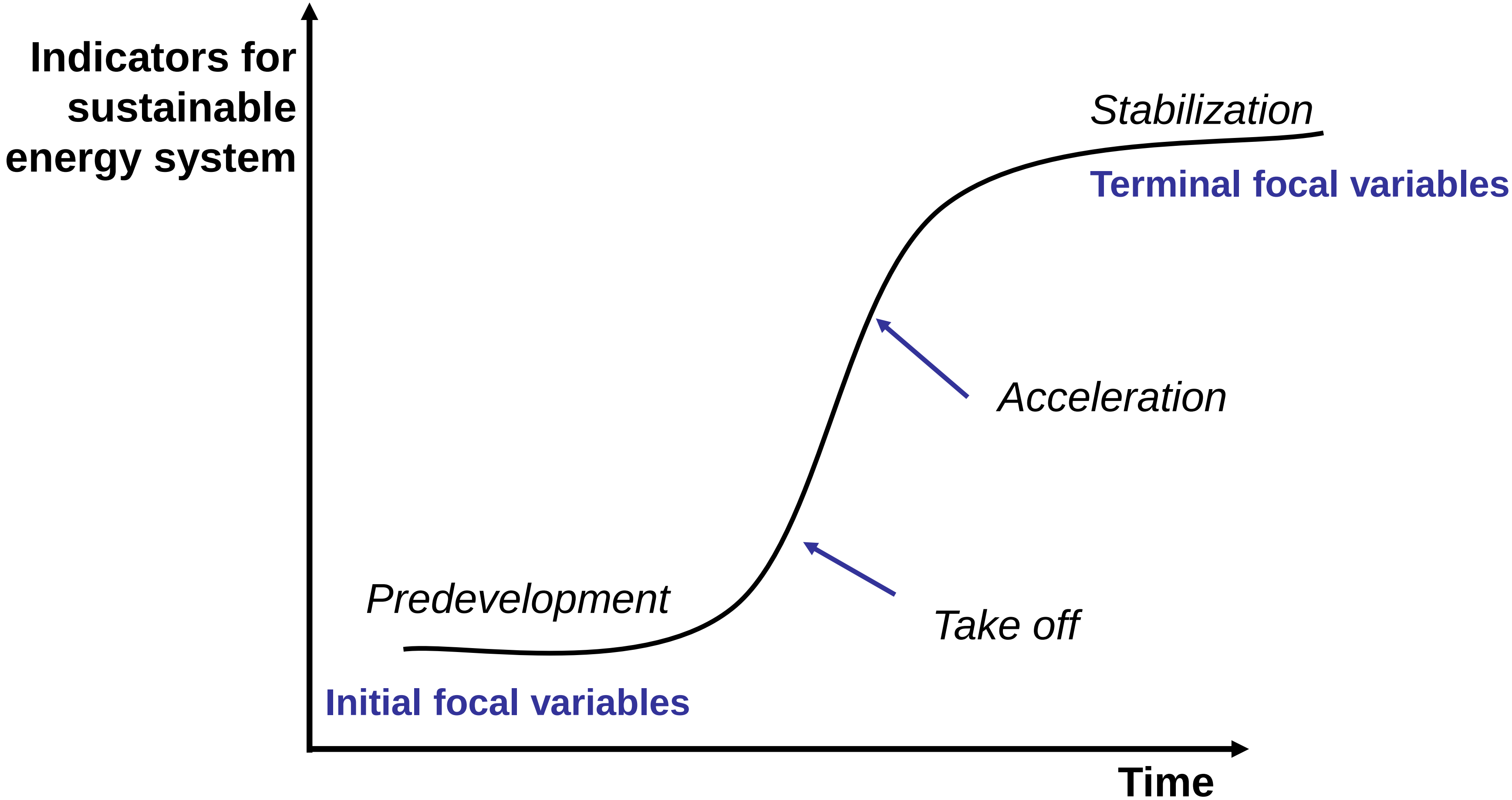
Focus: regional level

Research questions addressed

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

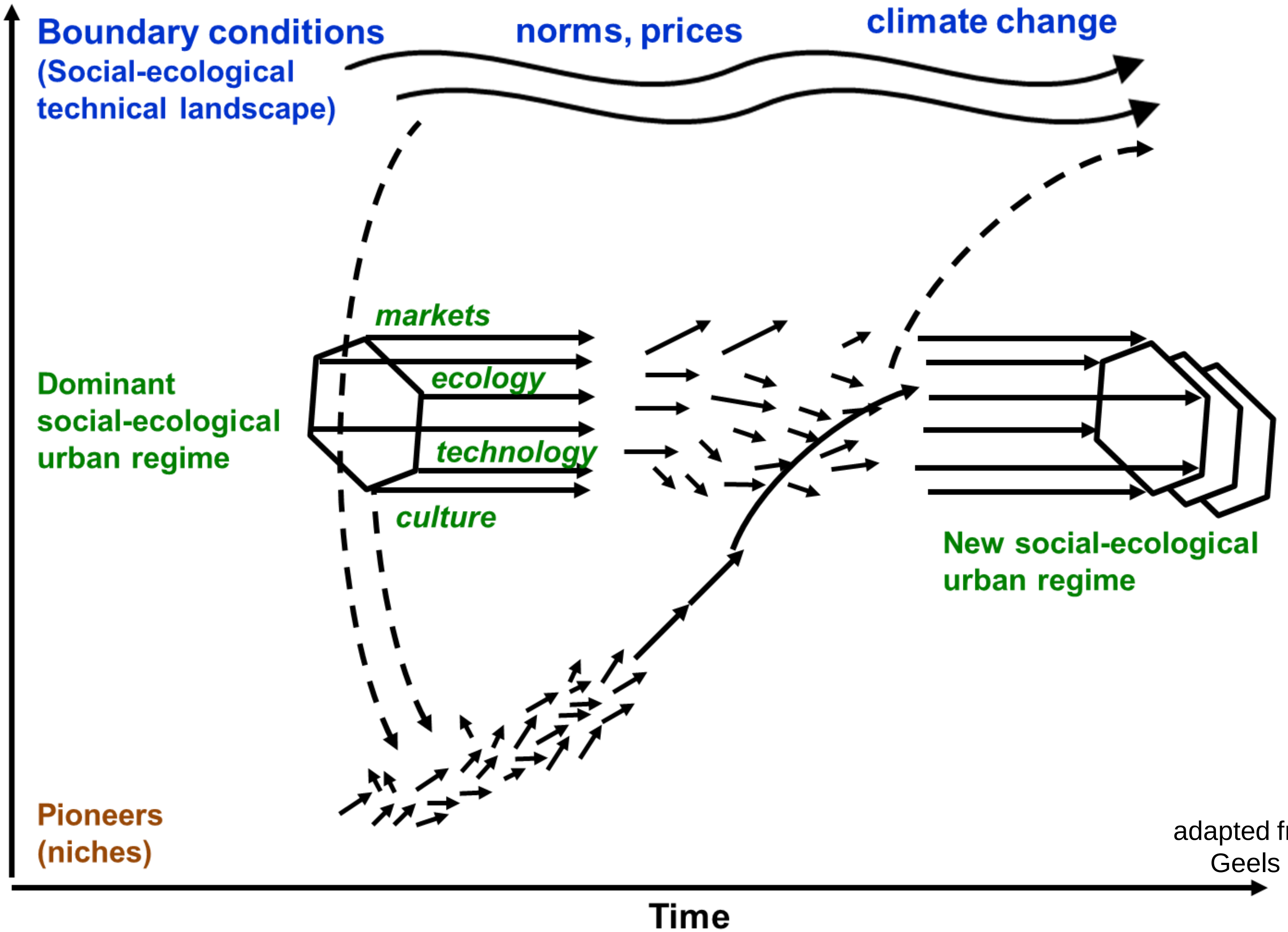
Conceptual framework

The transition process



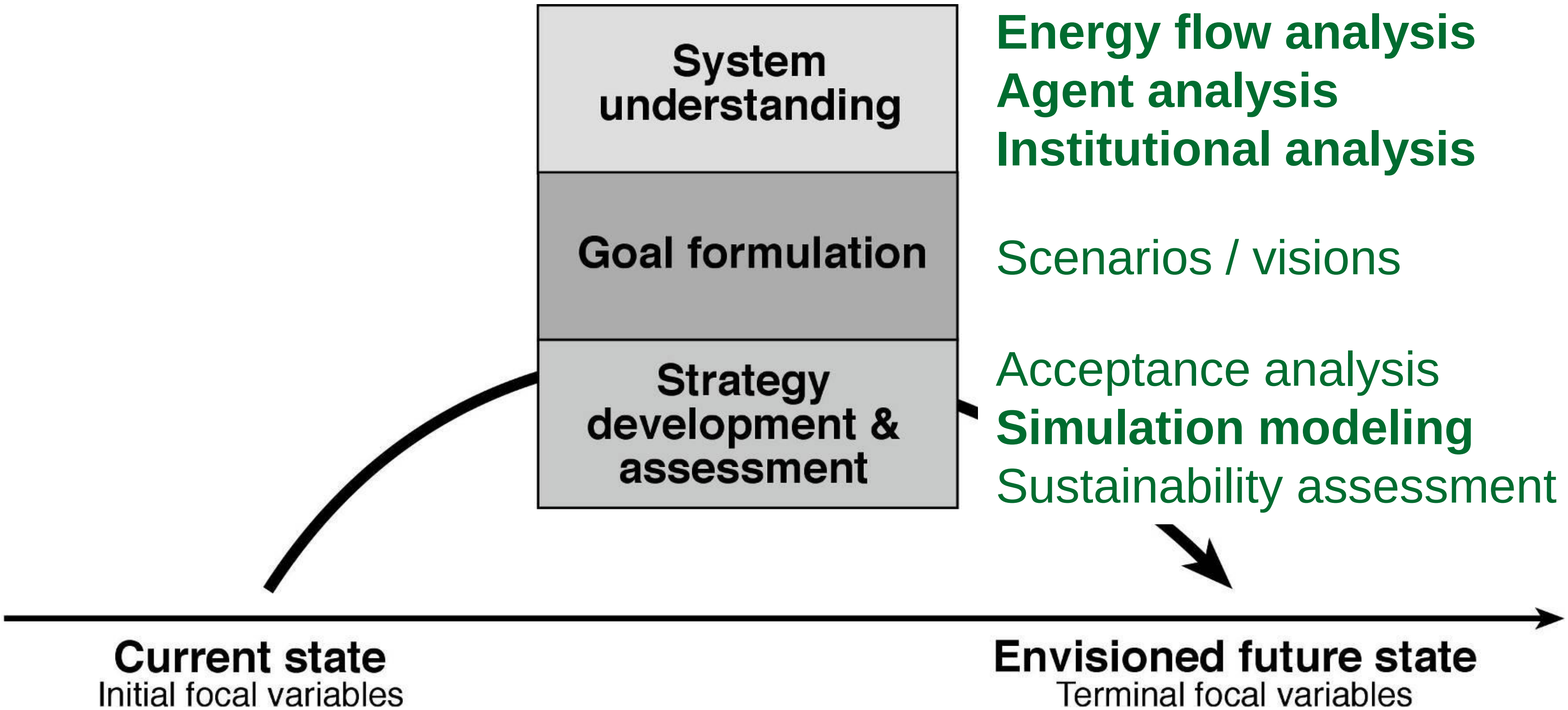
After: Martens & Rotmans, 2002

The transition process



adapted from Geels 2002;
Geels and Schot, 2007

Elements of transition analysis and management

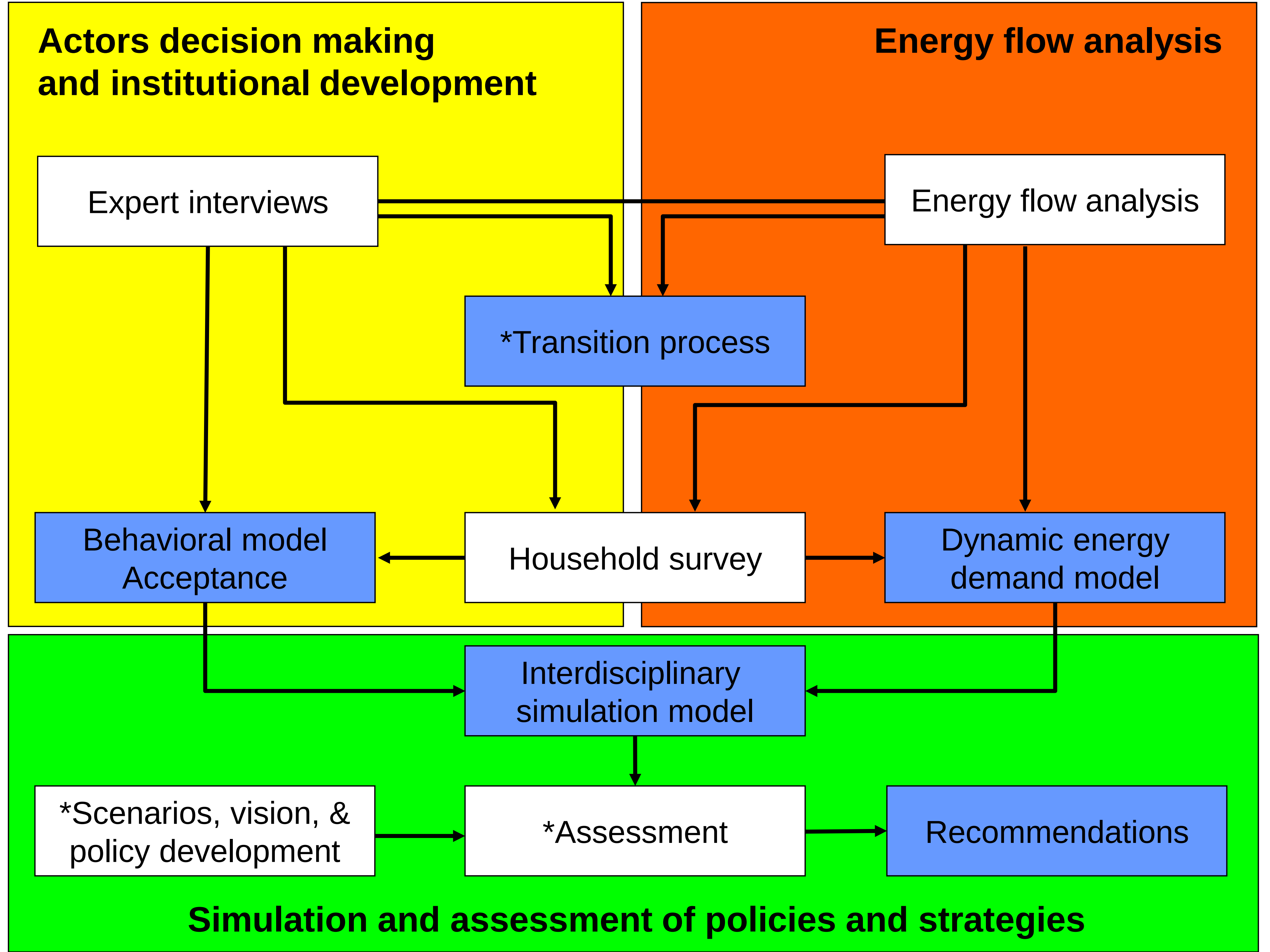


Energy flow analysis
Agent analysis
Institutional analysis

Scenarios / visions

Acceptance analysis
Simulation modeling
Sustainability assessment

After: Binder et al., 2004

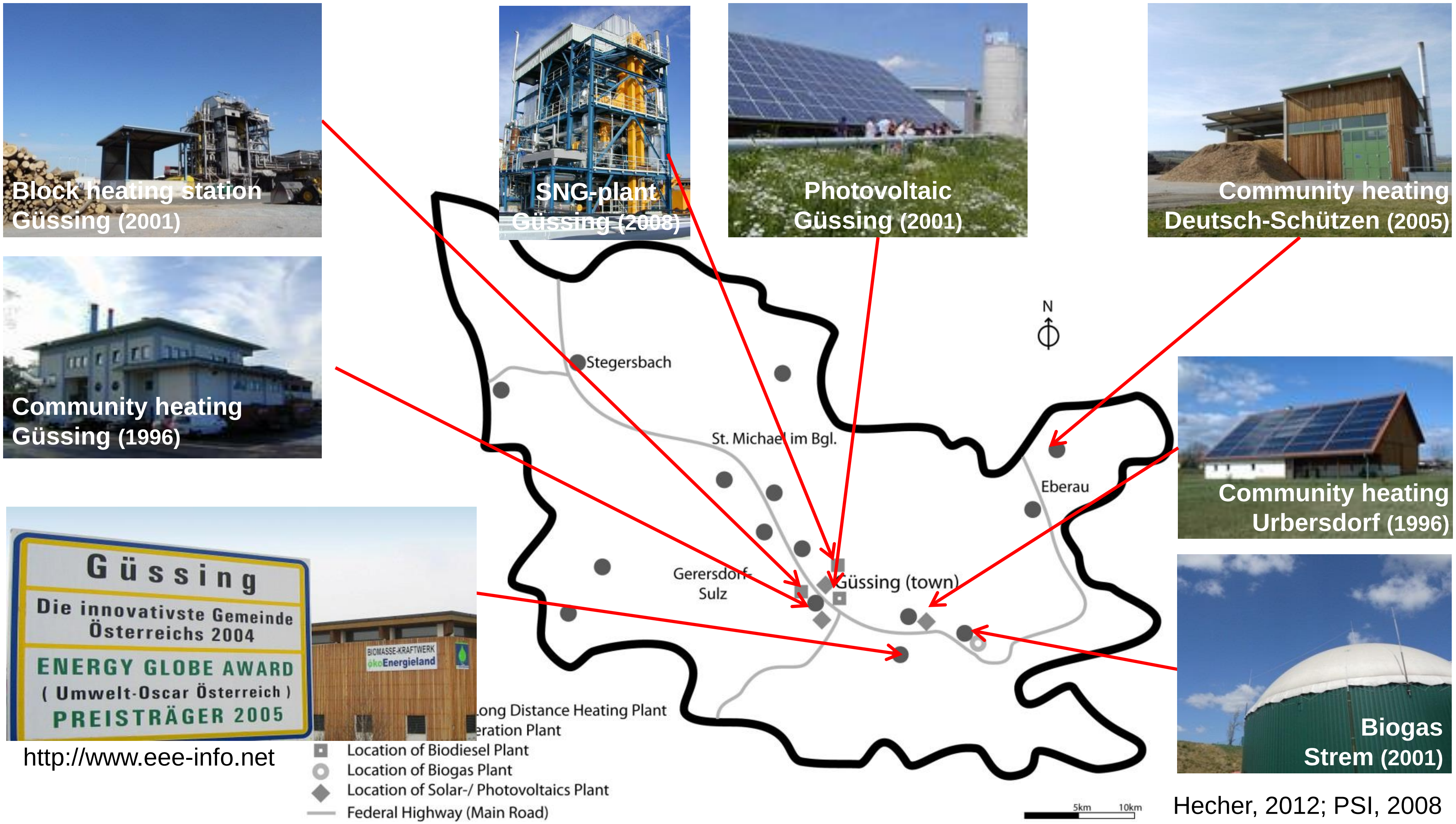

Actors decision making
and institutional development
Energy flow analysis
Expert interviews
Energy flow analysis
*Transition process
Behavioral model
Acceptance
Household survey
Dynamic energy
demand model
Interdisciplinary
simulation model
*Scenarios, vision, &
policy development
*Assessment
Recommendations
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



Weiz-Gleisdorf
Light-house projects

Gemini Haus (2001)

Plus energy house (1997-2001)

Solar tree (1998)

Fueling station

Bezirkshauptmanschaft (2010-11)

Source: Bedenik and Hecher, 2012

Research questions

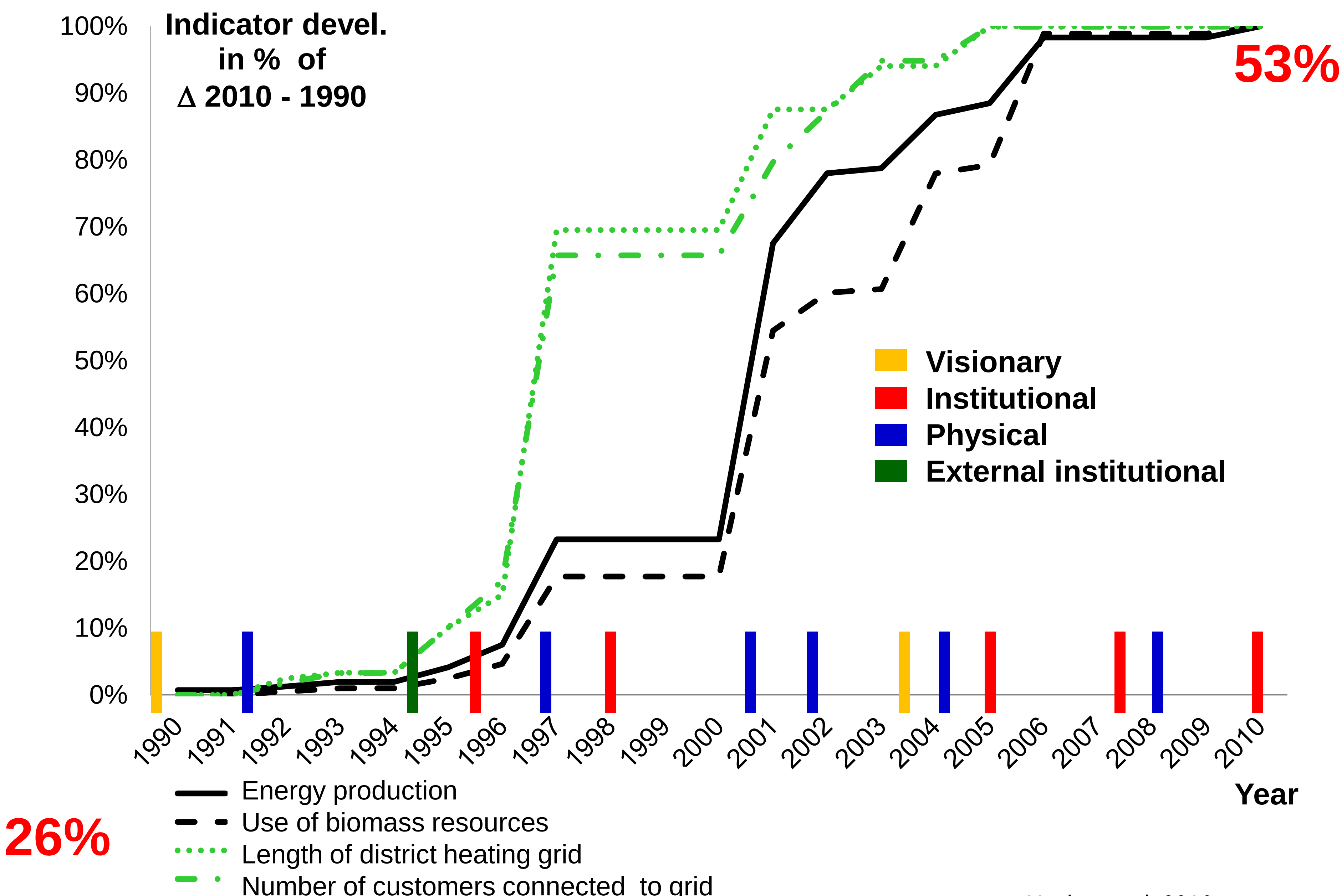
1. Which factors and behaviors affect(ed) the transition of the energy region?
   - **Energy flow parameters and milestones**
   - **Future energy demand from buildings and regional supply**
2. How can these behaviors be explained?

Milestones in the energy transition

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

Source: Hecher, et al. 2016; Binder et al., 2014

Milestones in the energy transition



Hecher et al, 2016

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/m^{2}a
Ren. B.: 100 kWh/m^{2}a

REN

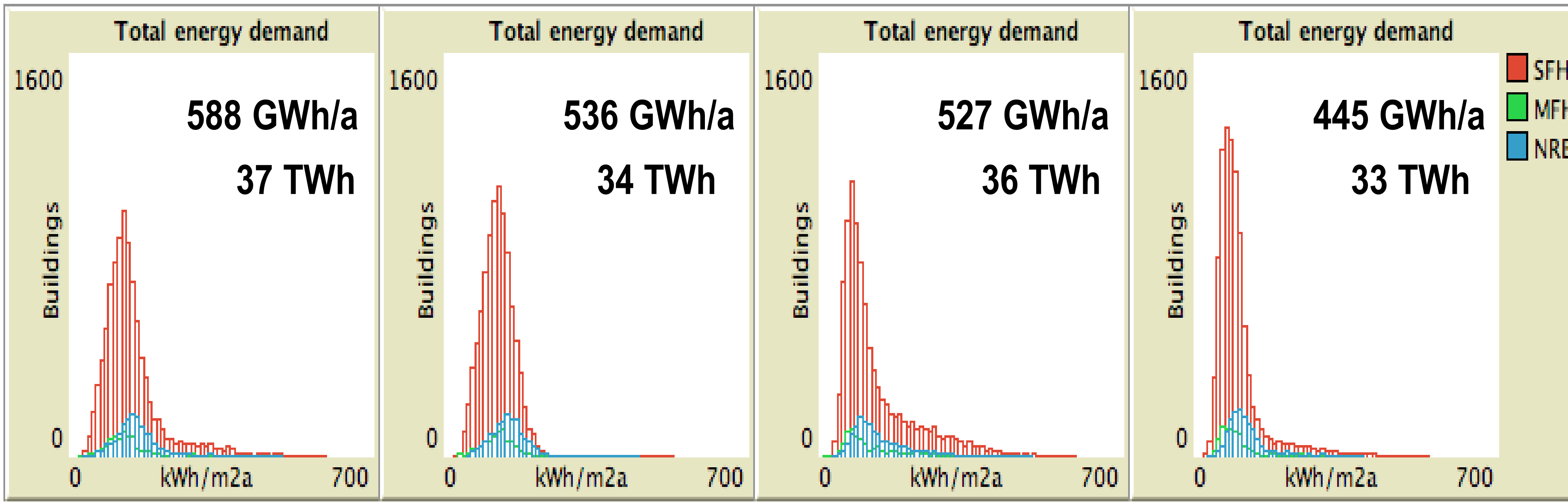
Ren. rate: 1.6%
Energy standards
New B.: 80 kWh/m^{2}a
Ren. B.: 100 kWh/m^{2}a

LEG

Ren. rate: 0.8%
Energy standards
New B.: 25 kWh/m^{2}a
Ren. B.: 50 kWh/m^{2}a

TRANS

Ren. rate: 1.6%
Energy standards
New B.: 25 kWh/m^{2}a
Ren. B.: 50 kWh/m^{2}a

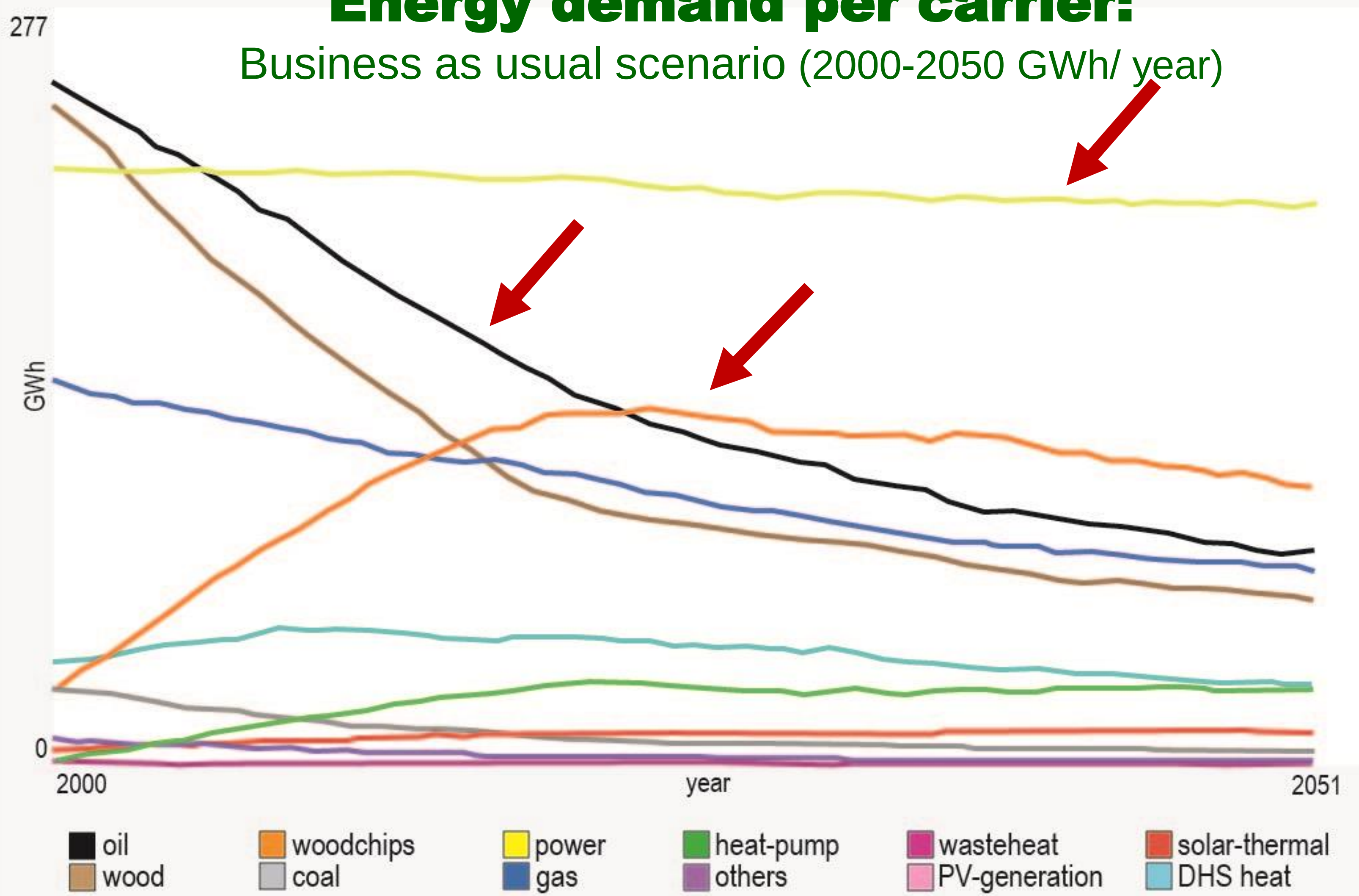


Single family houses Non residential buildings Multiple family houses

Binder et al., 2016

Energy demand per carrier:

Business as usual scenario (2000-2050 GWh/ year)



Binder et al., 2016

Aligning supply and demand

	DEMAND			SUPPLY POTENTIAL	
Demand scenarios	BAU			BAU	MAXI
Heating systems scenarios	BAU	ALT	BIO		
Wood & Woodchips (2050) [GWh/a][1]	161	105	264	59	296
Solar-thermal (2050) [GWh/a][2]	11	24	6	56	1692
Heat from DHS (2050) [GWh/a][3]	29	30	27	85 (15)	425 (77)
Electricity (2050) [GWh/a][4]	206	229	196	17	177

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 $\Rightarrow$ **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

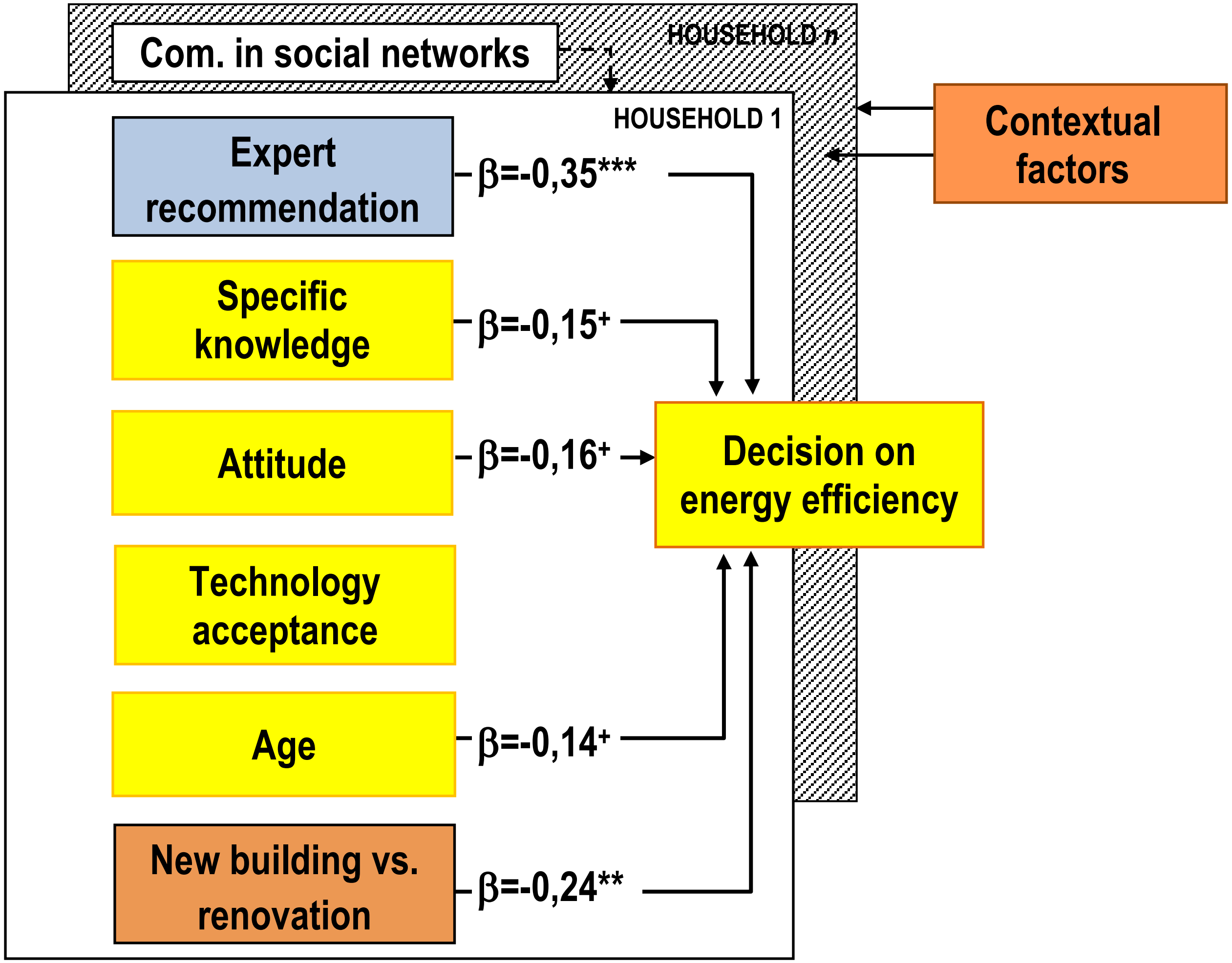
Evaluation

Outcomes:
Highest preferred energy standard today

Highest energy standard recommended to a friend

Factors affecting decision on energy efficiency

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

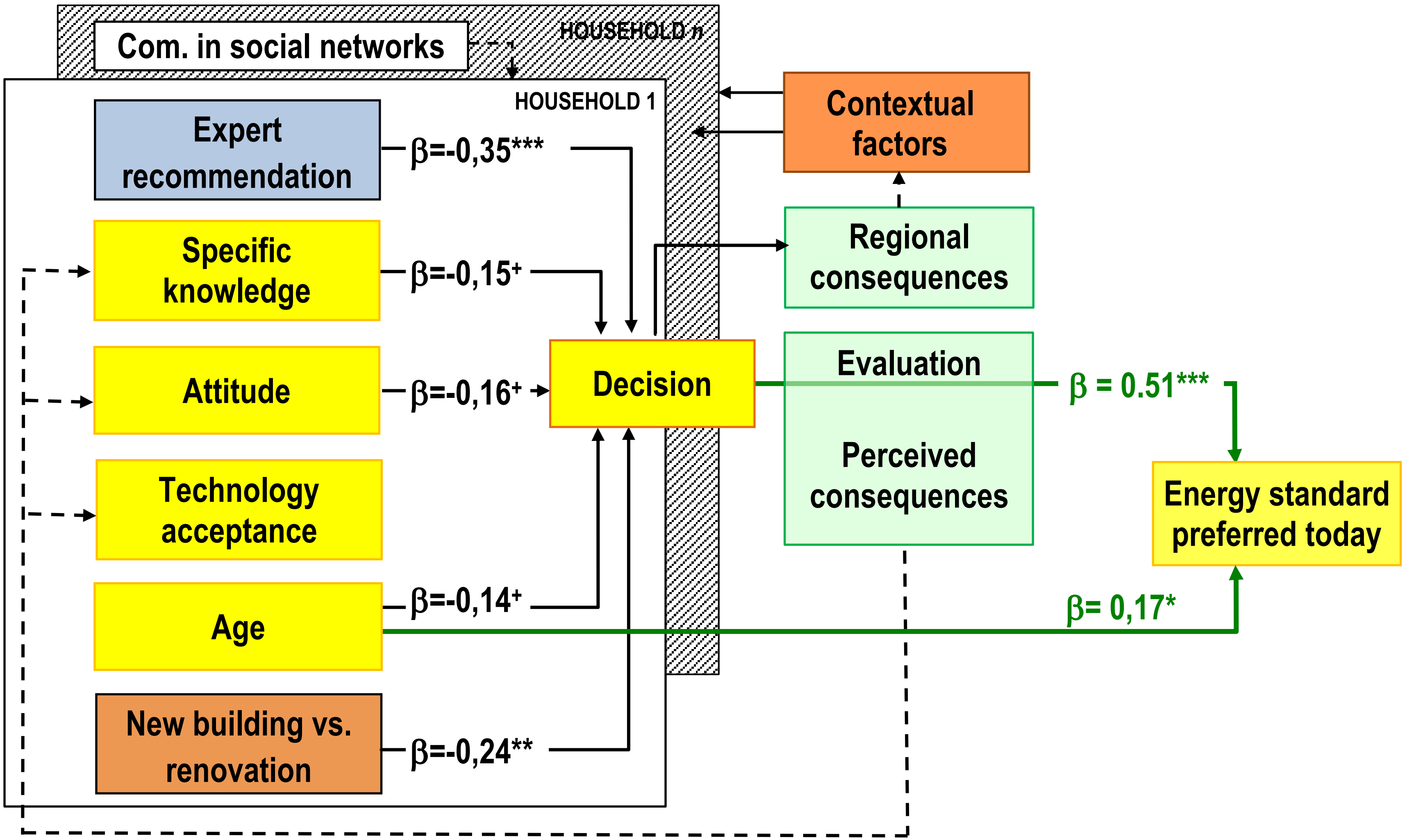


N=127 / *** $p< 0.001$, ** $p< 0.01$, * $p< 0.05$; + $p< 0.1$; Overall model, $p < .001$, $R^2 = 0.31$ (Adjusted $R^2 = .28$)

Bedenik et al., 2015

Energy efficiency standard preferred today

Energy efficiencies: A^{++} = 10kWh/m²a, A^{+} = 15kWh/m²a, A = 25kWh/m²a, B = 50kWh/m²a, C = 100kWh/m²a

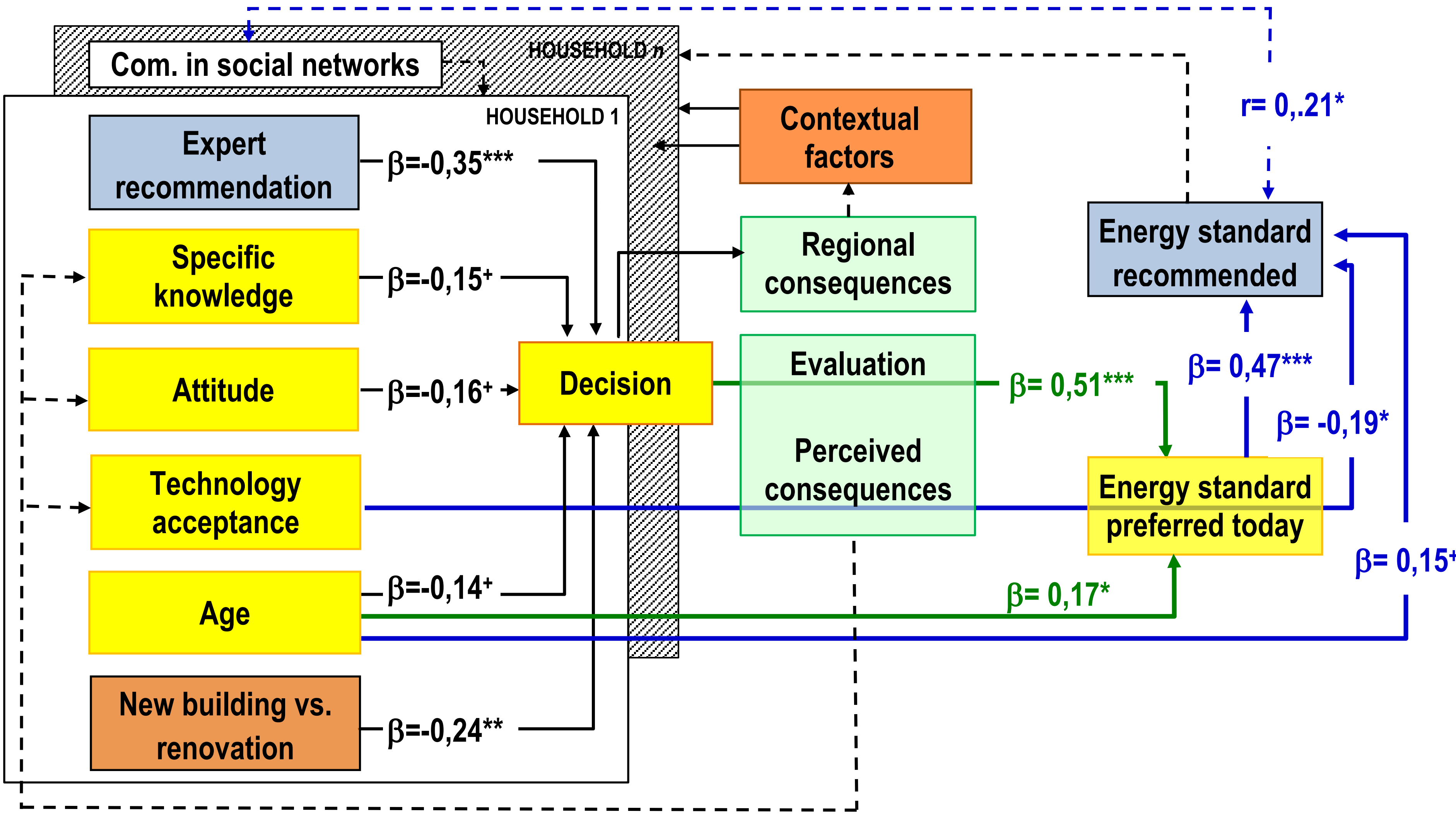


N=127 / *** $p< 0.001$, * $p< 0.05$; Overall model, $p < .001$, $R^2 = 0.30$ (Adjusted $R^2 = .29$)

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



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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!

Contact: claudia.binder@epfl.ch

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References

Bedenik, K., Hansmann, R., Popp, M., v. Streit, A., Binder, C.R., 2015. Energy efficiency standards of single-family houses: Factors of homeowners´ decision-making in two Austrian regions, *Energy and Environment Research,* 5 (2). http://dx.doi.org/10.5539/eer.v5n2p49.

Binder, C.R., Hecher, M., Vilsmaier, U., 2014. Visionen, Institutionen und Infrastrukturen als Elemente der Energietransformation, in: Böschen, S., Gill, B., Kropp, C., Vogel, K. (Eds.), Klima von unten - Regionale Governance und gesellschaftlicher Wandel.

Binder, C.R., Knoeri, Ch., Hecher., M., 2016. Modeling transitions towards energy autonomy at regional level *Raumforschung und Raumordnung*. Forthcoming (accepted with minor revisions)

Hecher, M., Vilsmaier, U., Akhavan, R., Binder, C. R., 2016. An integrative analysis of energy transitions in energy regions: A case study of ökoEnergieland in Austria. *Ecological Economics,* 121, 40-53. doi:10.1016/j.ecolecon.2015.11.015.