Presentation at International Workshop to prepare an
IEA Energy in Buildings and Communities Programme (EBC) Annex on Building Energy Epidemiology: Analysis of Real Building Energy Use at Scale

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Matching real energy use data with modeling data in building stock models

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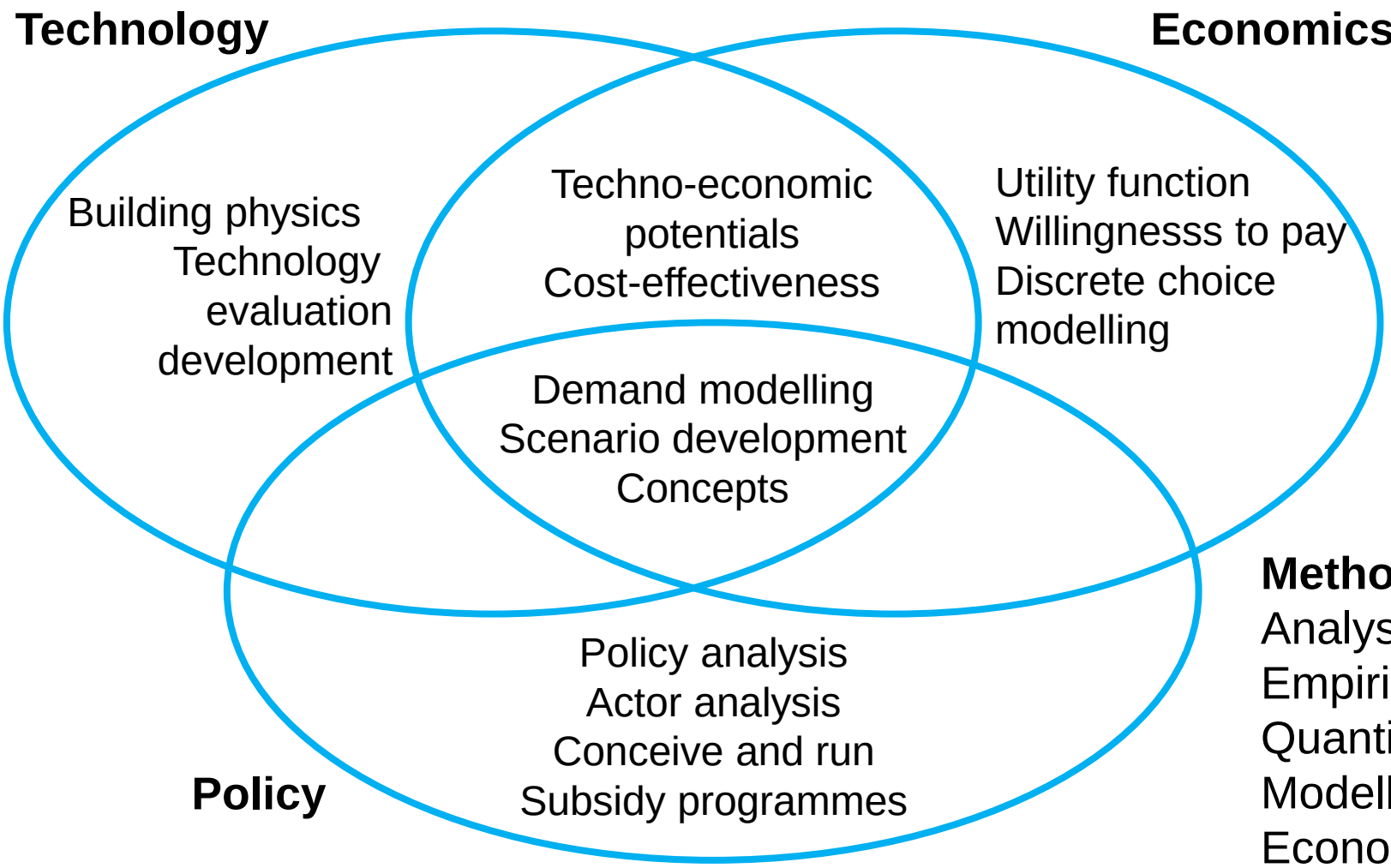
TEP Energy

Technology, Economics, Policy – research and advice



Methods

Analysis
Empirical studies
Quantitative
Modelling
Econometrics

Evaluating options and limitations of current and future policy targeting the building sector

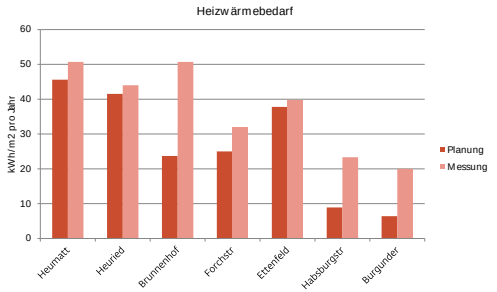
Problem setting and research questions

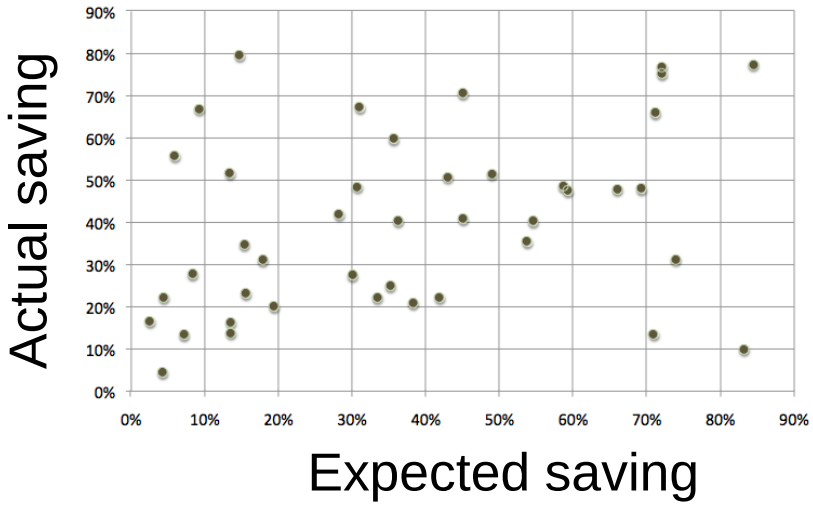
1. Performance gap 1: Does actual saving of energy-efficiency measures meet expectation (e.g. from calculation)?
   - Hypothesis: No => scientifically to be verified
   - What are the reasons for deviations?
2. Performance gap 2:
   Do policy instruments (PI) deliver (as expected)?
   - Observation of related activity (e.g. retrofits) at building/owner level
   - What are the causal effect of policy measure on (retrofit) behaviour?
   - Are there any desired or undesired side-effects?
   - Concretely what was and could be the socio-economic impact of PI?
3. Given the findings, which recommendations to be drawn with regard to the design of policy instruments?

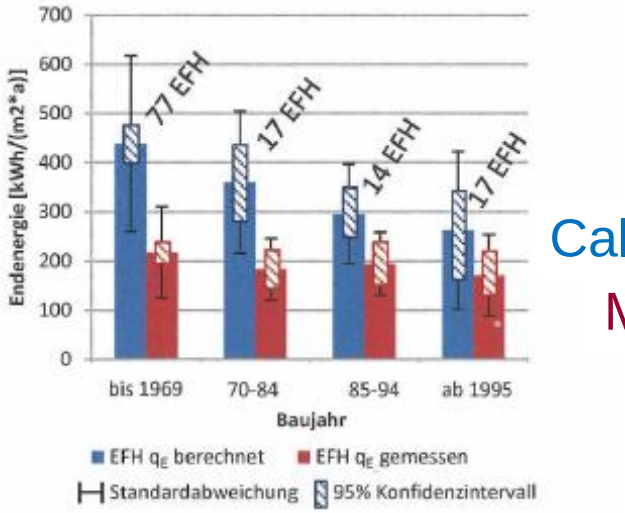
Problem setting and research questions

Performance gap 1 at the scale of individual buildings

1. Does actual saving of energy-efficiency measures meet expectation (e.g. from calculation)?
   - Hypothesis: No => scientifically to be verified
   - **What are the reasons for deviations?**
   - **What are the causal effect of policy measure (retrofit) behaviour?**







Calculated

Measured

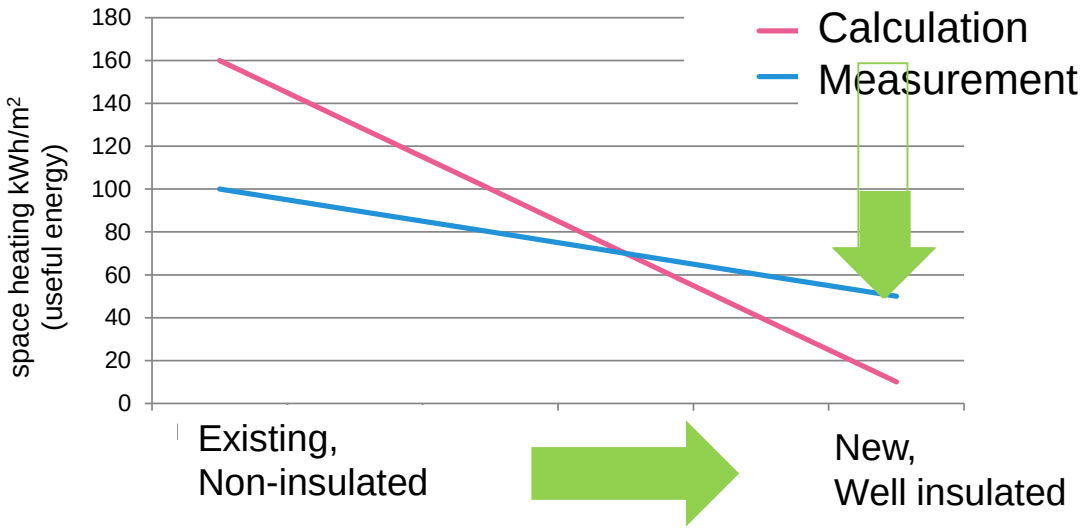
Source: EGON (Switzerland), Energy audits in Luxemburg

Problem setting and research questions

Performance gap 1 at the scale of individual buildings

Performance gap 1: Does actual saving of energy-efficiency measures meet expectation (e.g. from calculation)?

- Hypothesis: Calculations from SIA 380/1 and EN ISO 13790 are
  - overestimating consumption of non-insulated buildings
  - underestimating consumption of nearly zero energy buildings



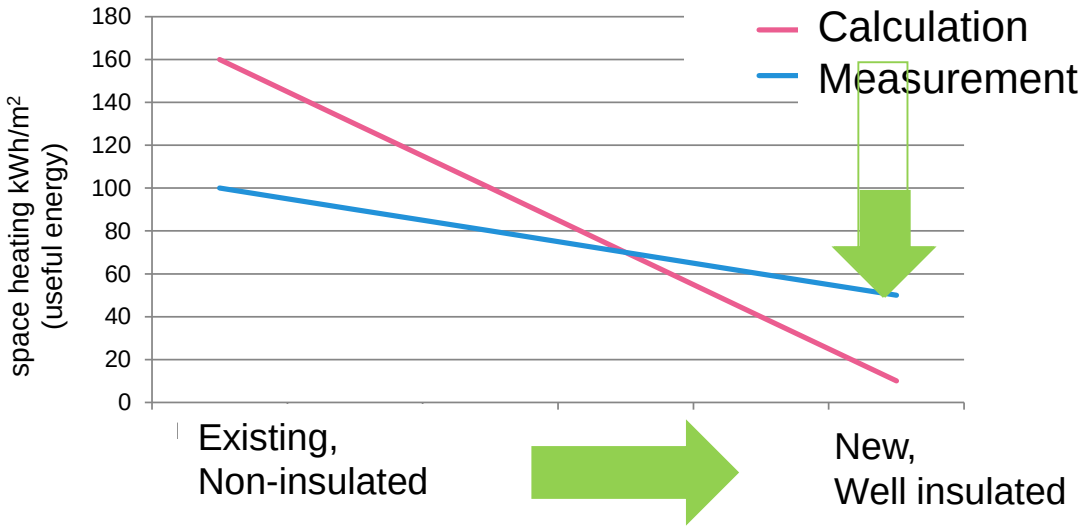
- Implication, bottom-line
  - Calculations too optimistic in case of MEPS
  - **Effects of energy-efficiency measures overestimated**

Problem setting and research questions

Performance gap 1: at the scale of individual buildings

Performance gap 1: usual suspects (of potential reasons)

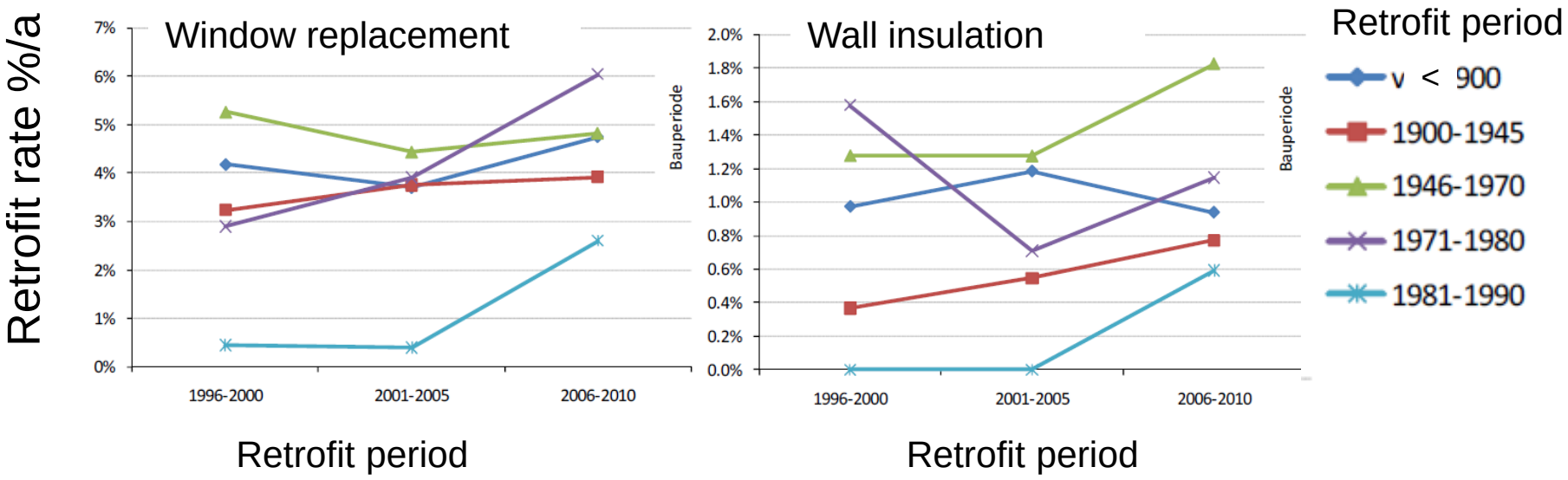
1. **Implementation quality** (of energy-efficiency measures)
2. Indoor conditions (before and after), **delta T**
3. **Air exchange rates**
4. Inefficient operation, **non-adjusted controls**
5. **Calculation method** (buildings physics, thermal bahaviour, delta U)



Problem setting and research questions

Performance gap 2: Policy instruments – actual vs. expected

Observation of retrofit activity at building/owner scale



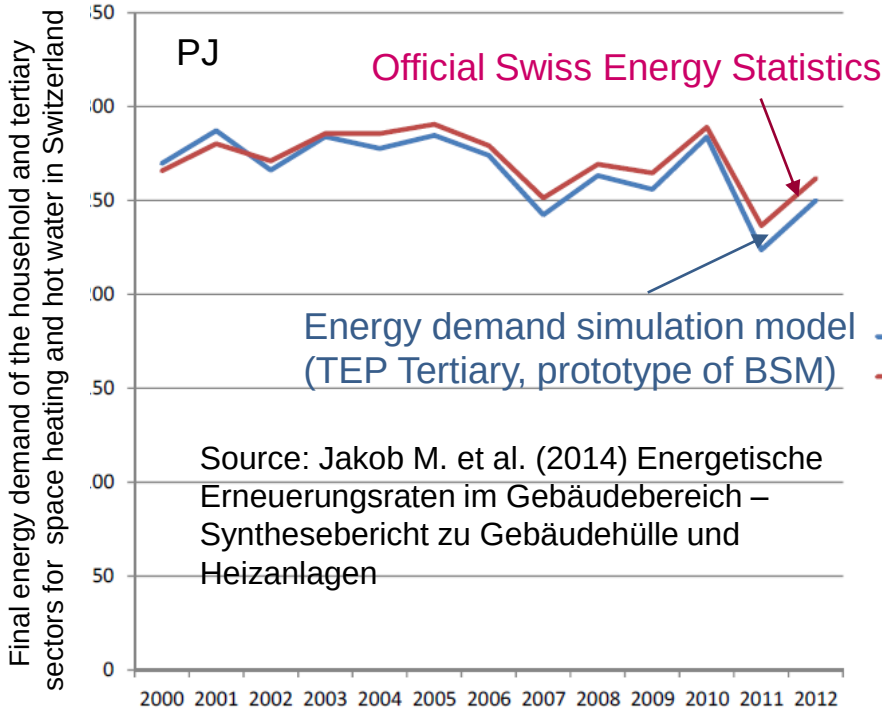
Source: Jakob et al. 2015), Jakob, Unterhollenberg et al. (2015).

- Data from two building owner surveys
- Periodic update would be needed to establish monitoring
- What are the drivers of retrofits? Role of policy instruments?

Problem setting and research questions
Building stock

Performance gap 2: Does yield of retrofit activities meet expectation (e.g. obtained from building stock modelling)?

- Many drivers to be considered, each of them having uncertainties
  - Construction, demolition and retrofit activity
  - State of buildings, use of buildings and user behaviour
  - Resulting useful energy of new, existing and retrofitted buildings
  - Heating system retrofit activity and substitution effects and η
- Implication, bottom-line
  - **Increasing difficulty to relate reasonable model input to aggregate energy statistics**

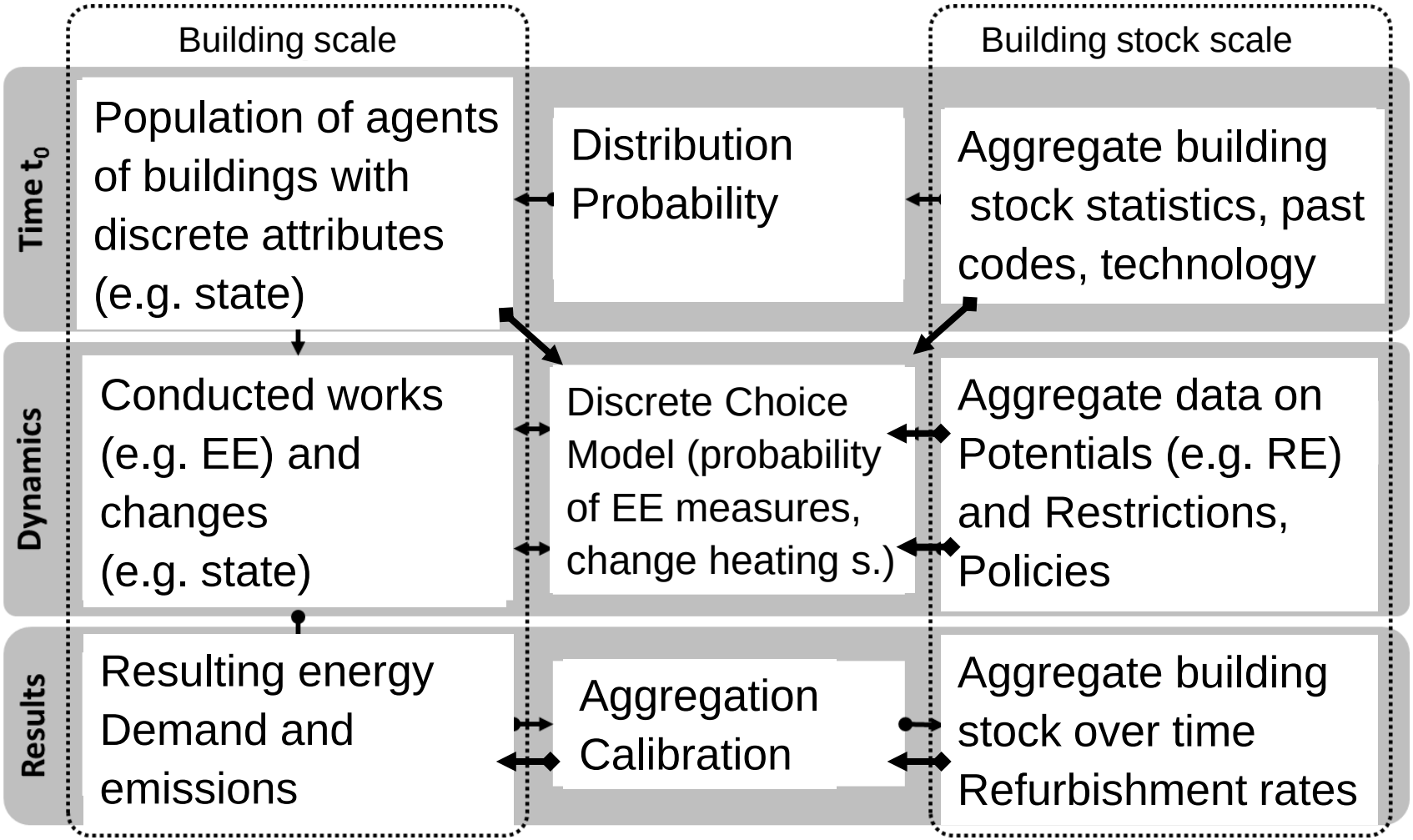


Bring together individual and stock data
Issues

Implementation ongoing within several ongoing Swiss and international projects

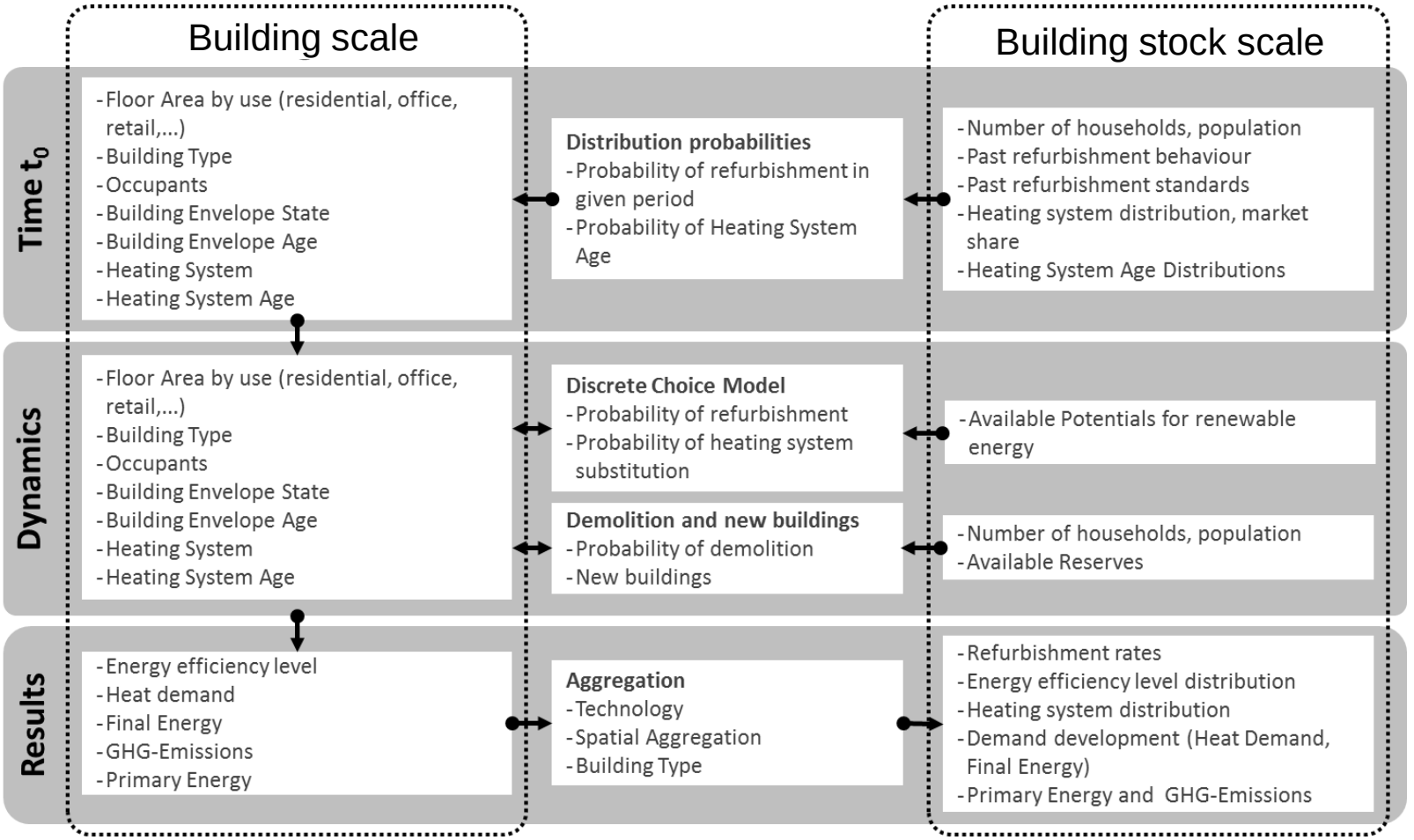
- Increasing the level of detail
  → from building cohorts to individual buildings
- Adding more building types:
  → from residential buildings to the complete building stock
- Use of buildings, use of energy
  → economic sub-sectors, end use categories
- Spatial differentiation
  → from graphs for aggregates to maps
- Advanced Calibration
  → from building stock calibration to individual buildings
- Decision modelling and economics
  → from assumptions at aggregates scale to discrete choice modelling
- Adding material consumption
  → from building use phase to the complete lifecycle

Bring together individual and stock data
Approach



Source: Nägel 2014, Nägeli, Jakob et al. 2015

Bring together individual and stock data
Approach



Source: Nägel 2014, Nägeli, Jakob et al. 2015

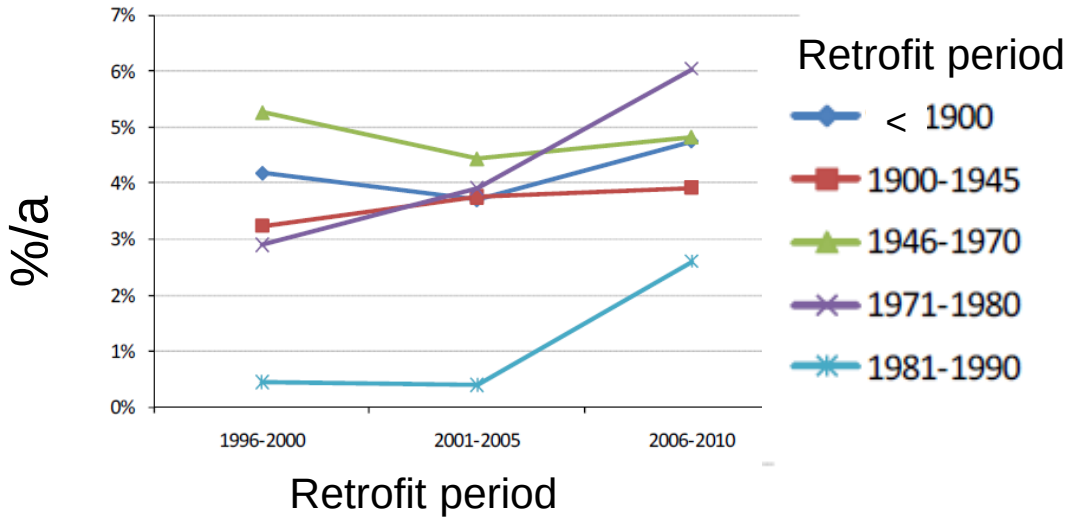
Enhanced building stock modeling

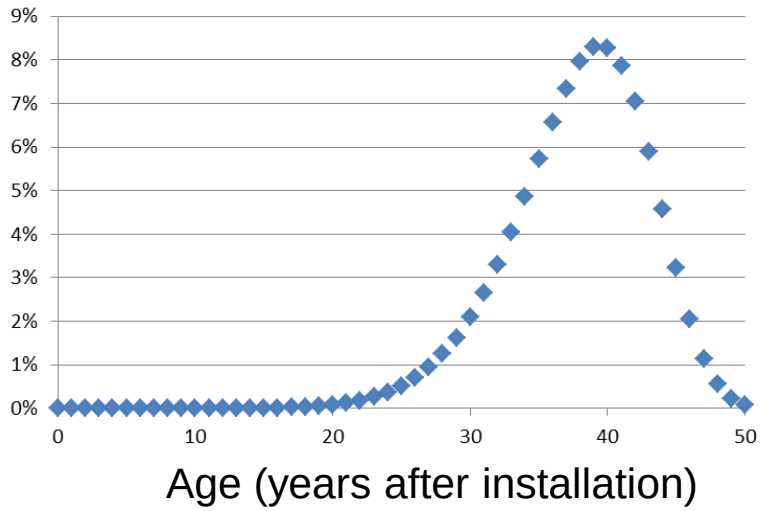
Bring empirical data to building stock model

Example: Derive retrofit probability from retrofit activity

Retrofit rate (empirical) of window replacement

Retrofit probability (model) of window replacement



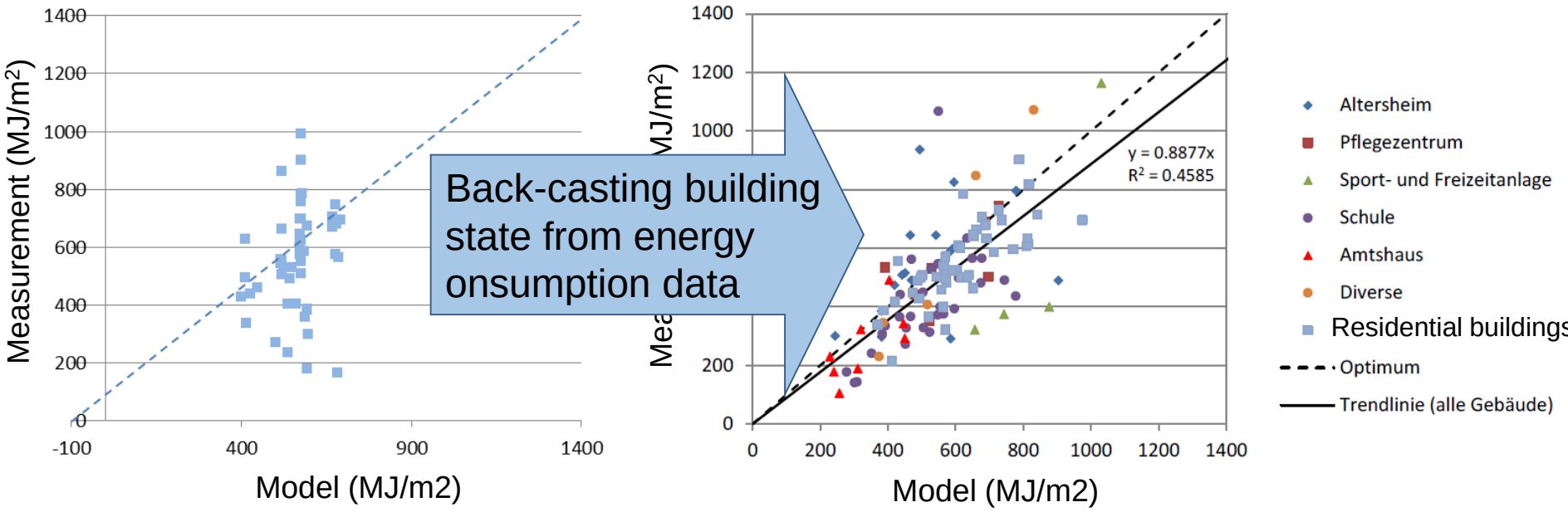


Source: Jakkob et al. (2014), Jakob, Unterhollenberg et al. (2015).

Enhanced performance of individual building stock model

Simplified (traditional)
energy bottom-up model
at scale of aggr. cohorts/archetypes

Advanced (novel)
building stock model at
scale of individual buildings



Source: Die städtischen Gebäude der Stadt Zürich bis 2050

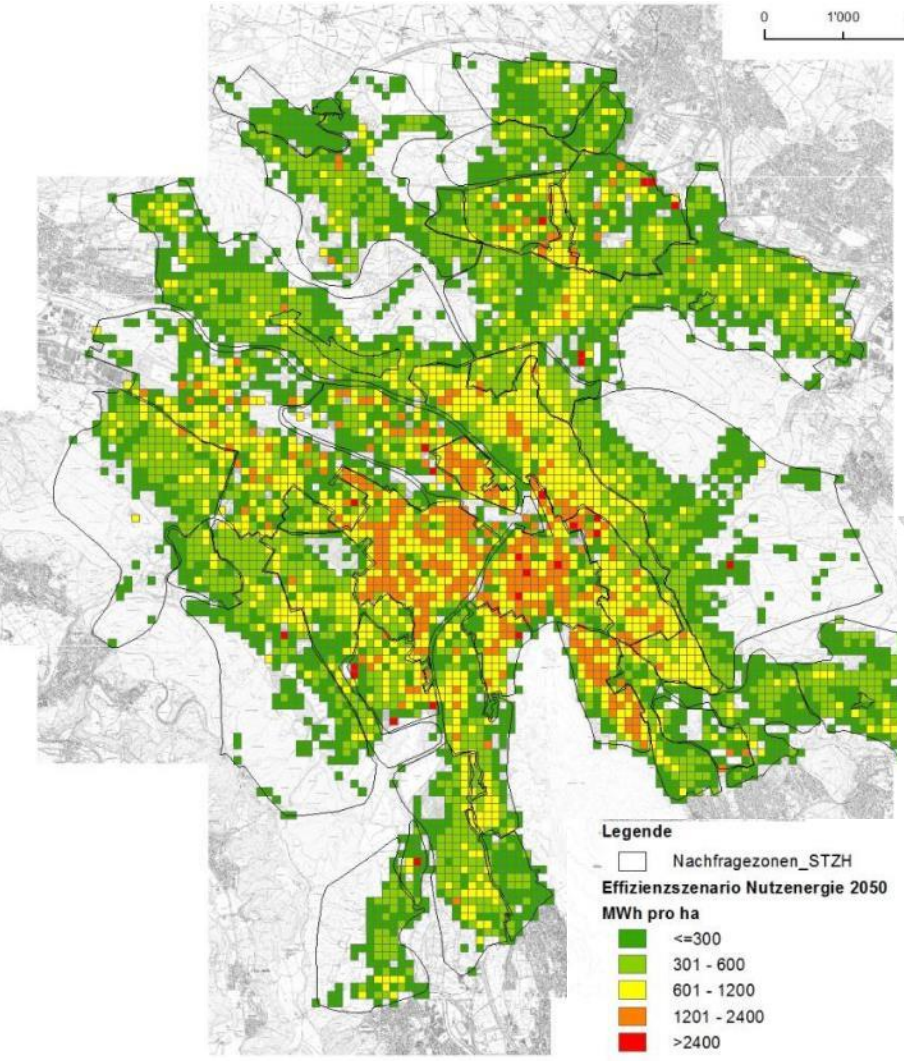
Integrated and scalable approach
Advantage

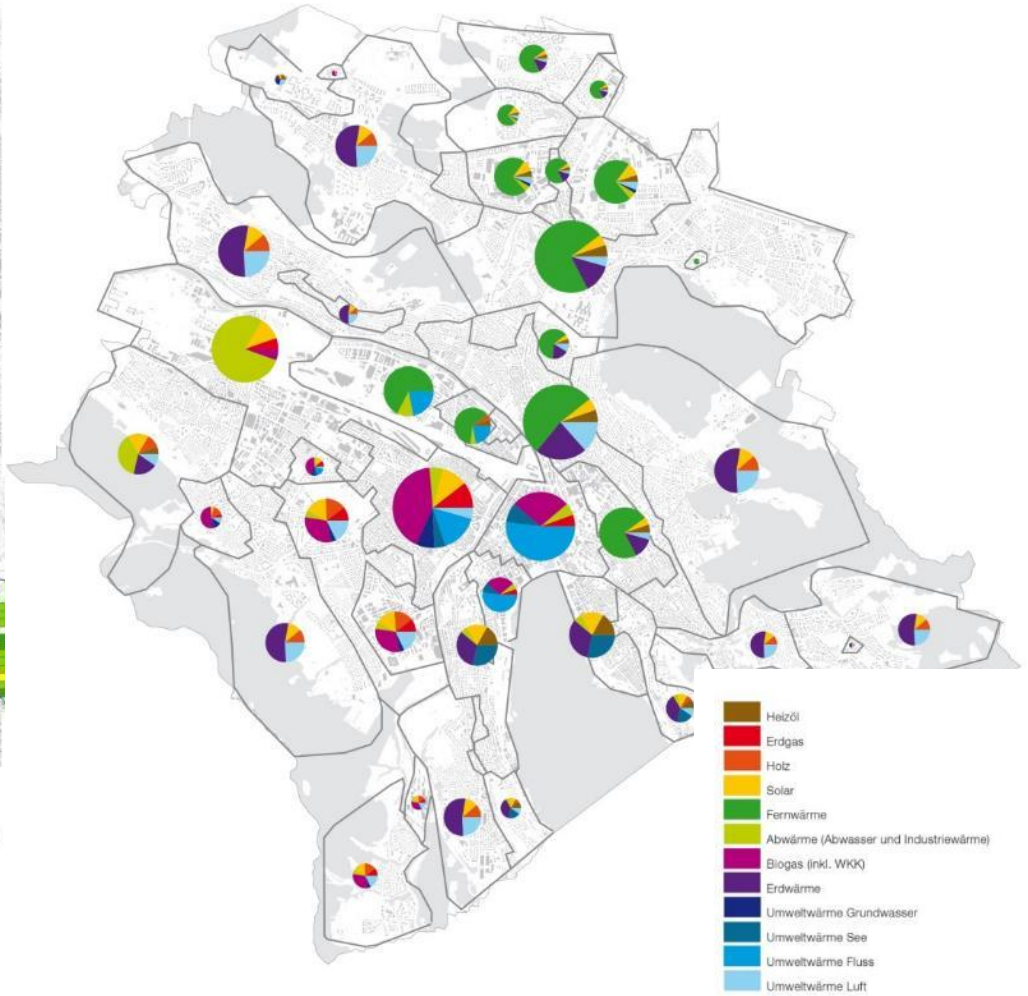
- Many types of data from different sources and scale is incorporated: building state, owner type, individual/aggregate consumption
- More empirical data improves modelling (rather than create contradiction), missing data may be imputed by stochastic approaches (distributions)
- Links individual decisions (micro) to aggregated observables (macro): more realistic representation (average of individuals <> individual average)
- Links several disciplines: economics, policy analysis, building physics, technology and engineering
- Model approach and output may be adjusted according to specific need
  - Distribution instead of average
  - Coherent representation of past (ex-post verification) and future (ex-ante estimation)
  - Energy, Load, Emissions, Material flows, Costs and benefits, Technology markets, Policy impact

Better to relate reasonable model input to aggregate energy statistics

Building stock model (city of Zurich)

Useful and final energy demand, Efficiency scenario 2050





Literature and links

- www.tep-energy.ch
- www.forecast-model.ch
- Jakob M. et al. (2014) Energetische Erneuerungsraten im Gebäudebereich – Synthesebericht zu Gebäudehülle und Heizanlagen
- Jakob M., Fürst M., Martius G. (2013). Die städtischen Gebäude der Stadt Zürich bis 2050 – Eine ergänzende Abschätzung auf Grundlage des Gebäudeparkmodells mit Bezug zum Energieversorgungskonzept 2050. TEP Energy im Auftrag des Amts für Hochbauten der Stadt Zürich
- Nägeli, Jakob et al. (2015). A BUILDING SPECIFIC, ECONOMIC BUILDING STOCK MODEL TO EVALUATE ENERGY EFFICIENCY AND RENEWABLE ENERGY. In: Proceedings of CISBAT Conference.