How to decarbonize Munich's heat supply?

Forecasting the space heating demand of Munich

Andreas Müller, Maik Günther, Benedikt Baus

7th International Conference on Smart Energy Systems

21-22 September 2021, Copenhagen

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Comparing calculated and measured delivered energy for space heating and domestic hot water production

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Stadtwerke München's (SWM) district heating vision 2040 and the *Modell München*

Goal for Munich's district heating

- Carbon neutral by 2040ies

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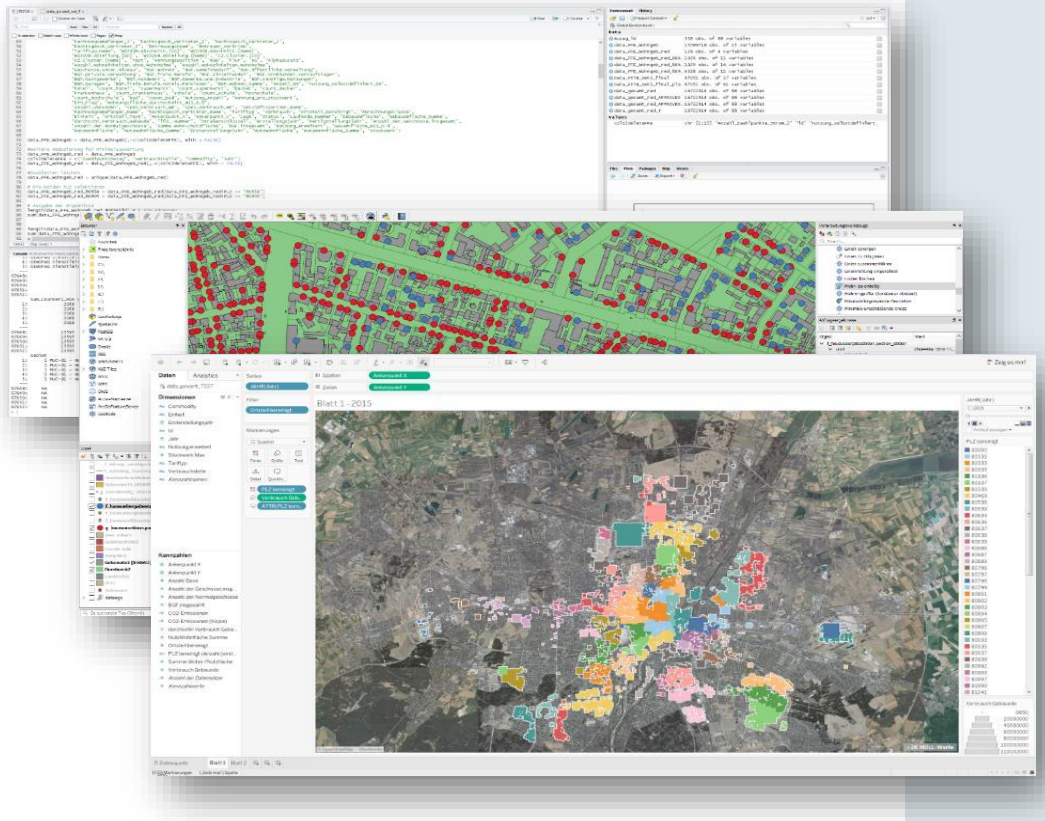
Modell München

- Co-developed by SWM, e-think and TU Wien using the Invert/EE-Lab model
- Highly disaggregated projections (Energy performance standards, heat supply technologies, …)
- Quantify and visualize impact for infrastructure development
- Current status:
  - Current situation analysed, data update until end of 2021
  - Currently working on demand projections on the level of individual buildings



Challenging Data Preparation

- Multiple (partly inconsistent) data sources: Munich's building stock database, address lists, OSM data, SWMs grid infrastructure data base, …
- Missing data, false data, inconsistent years of survey data, etc.
- Almost 300.000 buildings, more than 160.000 addresses

➢ **Consistent dataset of more than 180 tds. Buildings:**
  - Shape file (foot print)
  - Energy carrier (partly including sold energy)
  - Number of floors
  - Construction period, building type (utilization)

Challenging Data Preparation

- **Complementing energy relevant data**
  - Filter for (most probably) unheated objects
  - Calculated building height based on number of floors
  - Calculate the surface area of buildings
  - Estimate glazed surface area
  - Estimate average u-Values of building components and efficiency of heating systems

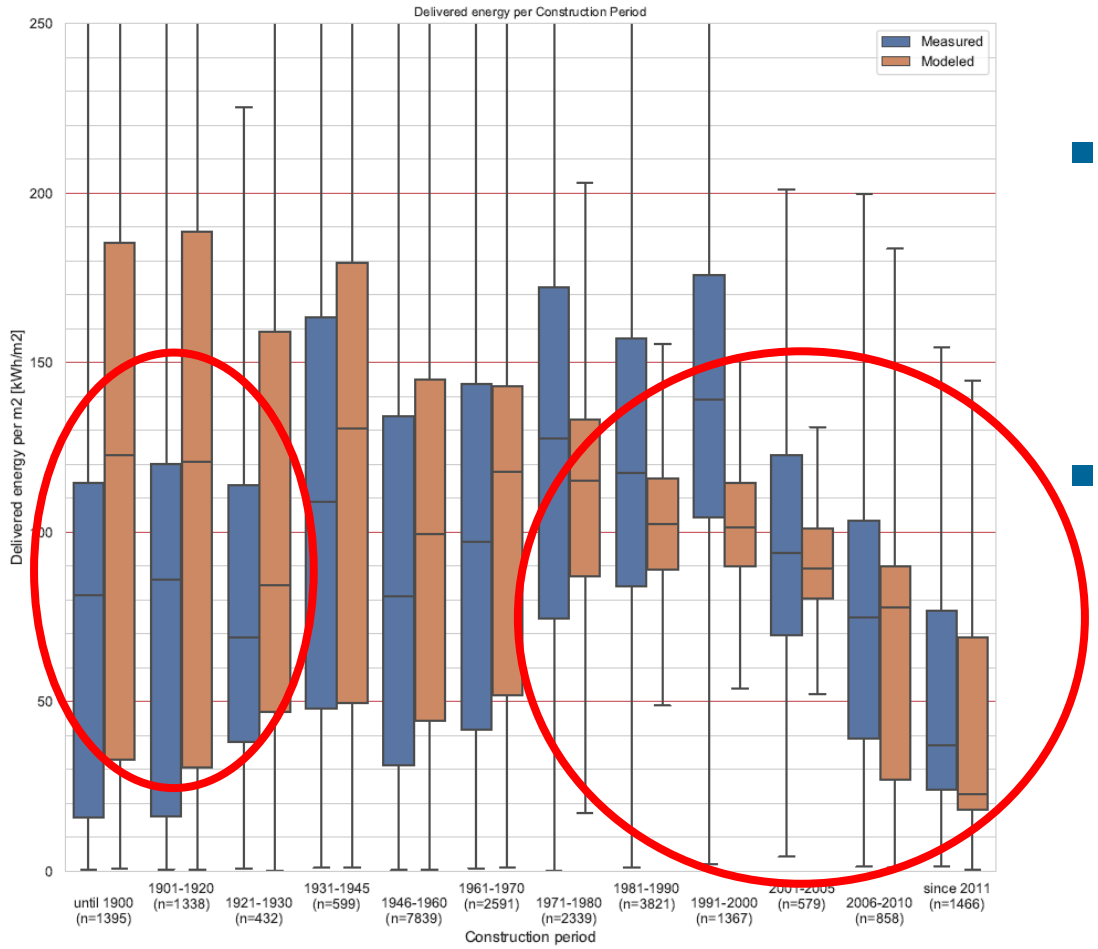
- **Calculate the delivered energy per building and compare data with measured data (sold energy by SWM)**

Comparison von calculated and measured delivered energy on individual building level

- A comparison on individual buildings is challenging, since many buildings share a district heat or gas meter and it is not know, which buildings share the gas or district heating meter with other buildings
- However: Energy deliveries between buildings separated by public streets is most probably rare.

- Therefore such an analysis has been done for those blocks, where energy delivery by a certain energy carrier is measured for all (or most) (residential) buildings.
- This is the case for about half of the blocks (~4500) and 15 % of the buildings (~26 tds. Buildings)

Comparison von calculated and measured delivered energy on individual building level



- Our assumptions overestimate the demand in buildings constr. before 1970 with largest deviation for buildings constructed until 1920
- Underestimate demand in buildings constructed since the 1970ies

Measured delivered energy on individual building level: Impact of users?

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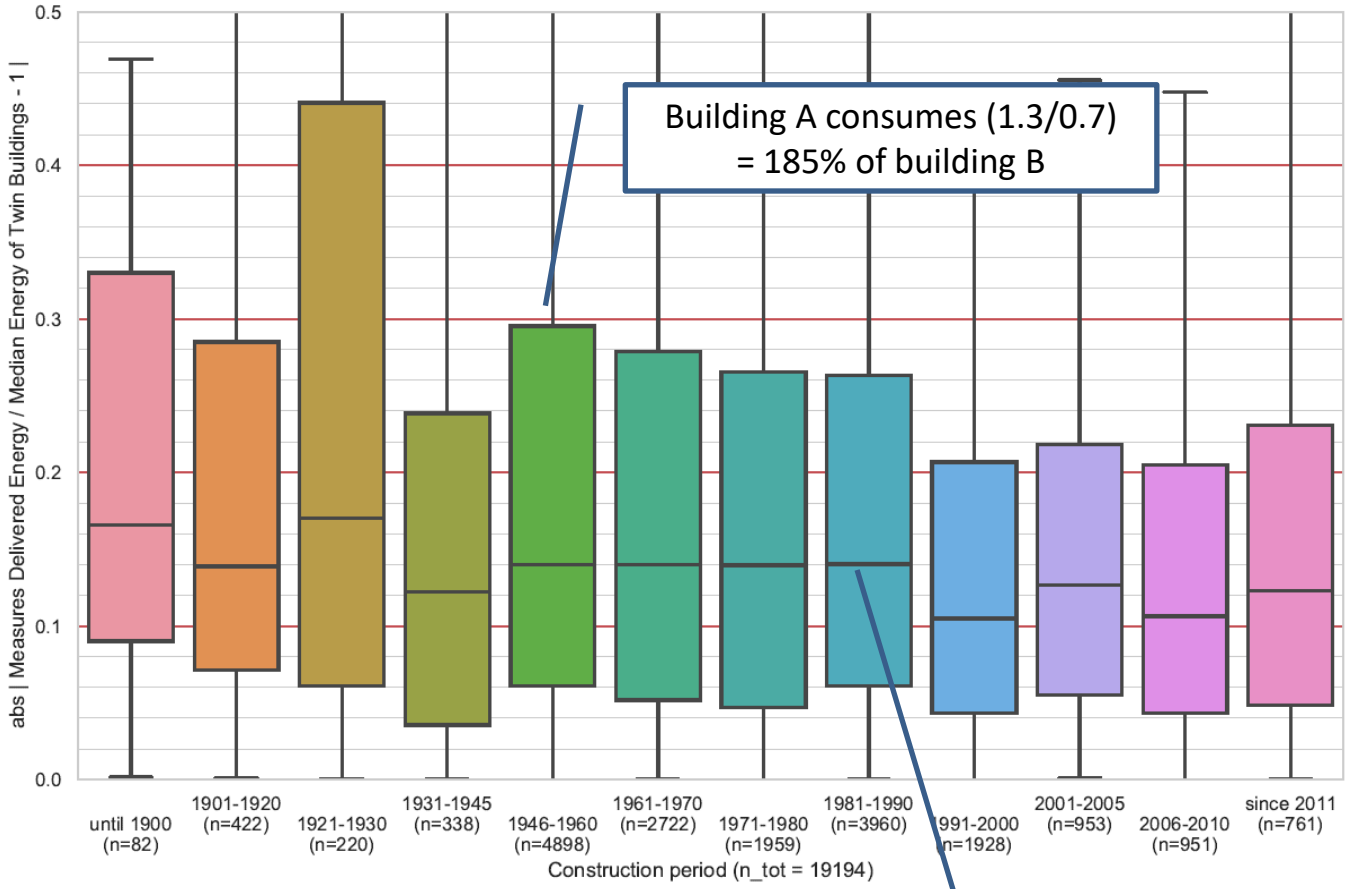
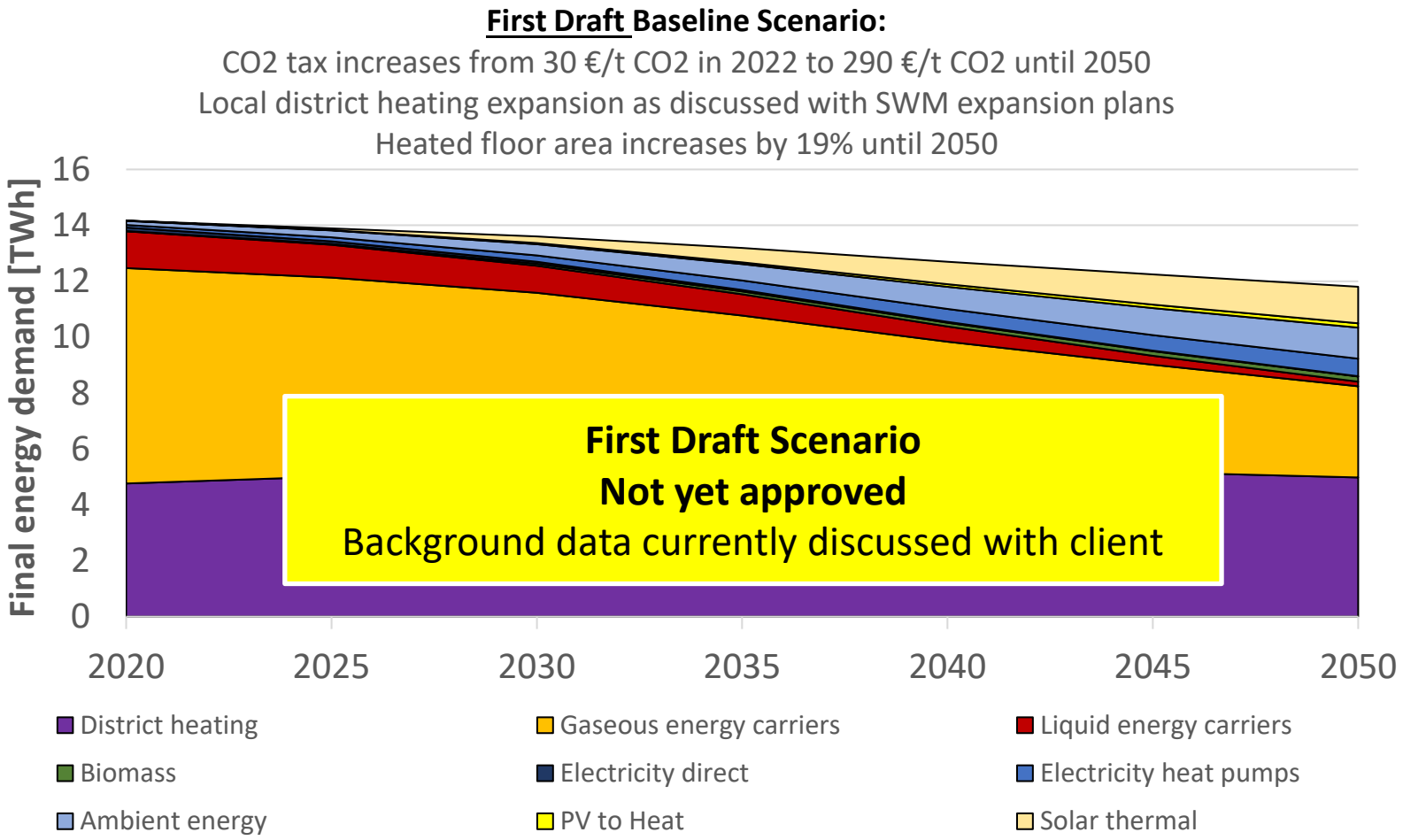


- Median level for deviation in delivered energy between twin buildings is ~33%.

Projections of future energy demand and delivered energy: First concept-of-proof results for Munich



Outlook and Conclusions

- Discussion of scenario background data with SWM
  - e.g. Cost and prices, renovation options
- Data update until end of 2021
  - Building stock data (geometries, utilization, etc.)
  - Currently used energy carriers
  - Improved calibration of our energy model
- New scenarios
  - What is the implication for the renovation potential and our scenarios, if recently constructed buildings might not consume significantly less energy than old buildings?

Contact data

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Validation of energy demand calculation

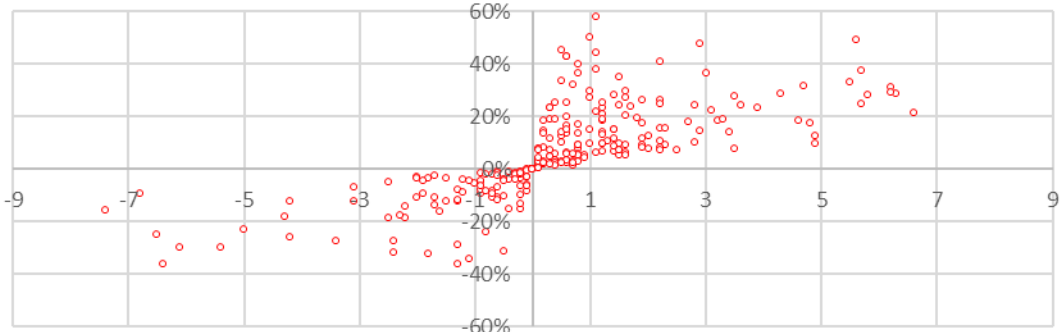
- **Manual comparison and adoption in regions with large deviations**
  - Munich uses a 4-level regional classification: DISTRICT.XX.YY. ZZ
  - 23 districts, 474 3rd level regions, >9000 4th level regions (street blocks)
  - 3rd-level regions with a high deviation were investigated and adopted manually. Large deviations mostly due to:
    - Process energy (Industry, hospitals, spa‘s with outdoor pools, etc.)
    - Partly unheated large ware houses, industrial sites etc.
    - Residential buildings belonging to the architectural style of brutalism

- On the 3rd regional level (474 regions), the deviations between calculated and measured consumption are below +/- 20% for 80% of the regions.

Comparison von calculated and measured delivered energy on local level

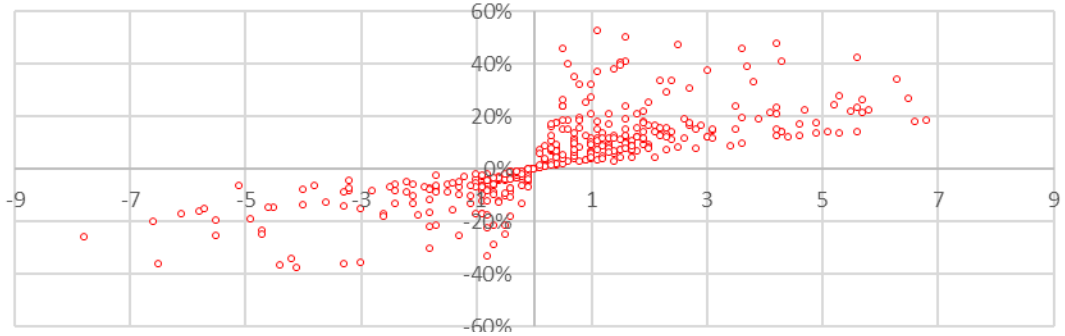
- On the 3rd regional level, the deviations between calculated and measured consumption are below +/- 20% for 80% of the regions.

Deviation: District heating demand: SWM vs Invert
Building block code: District.X.X
(Only regions with >500 GWh demand, 279 (out of 474) regions)



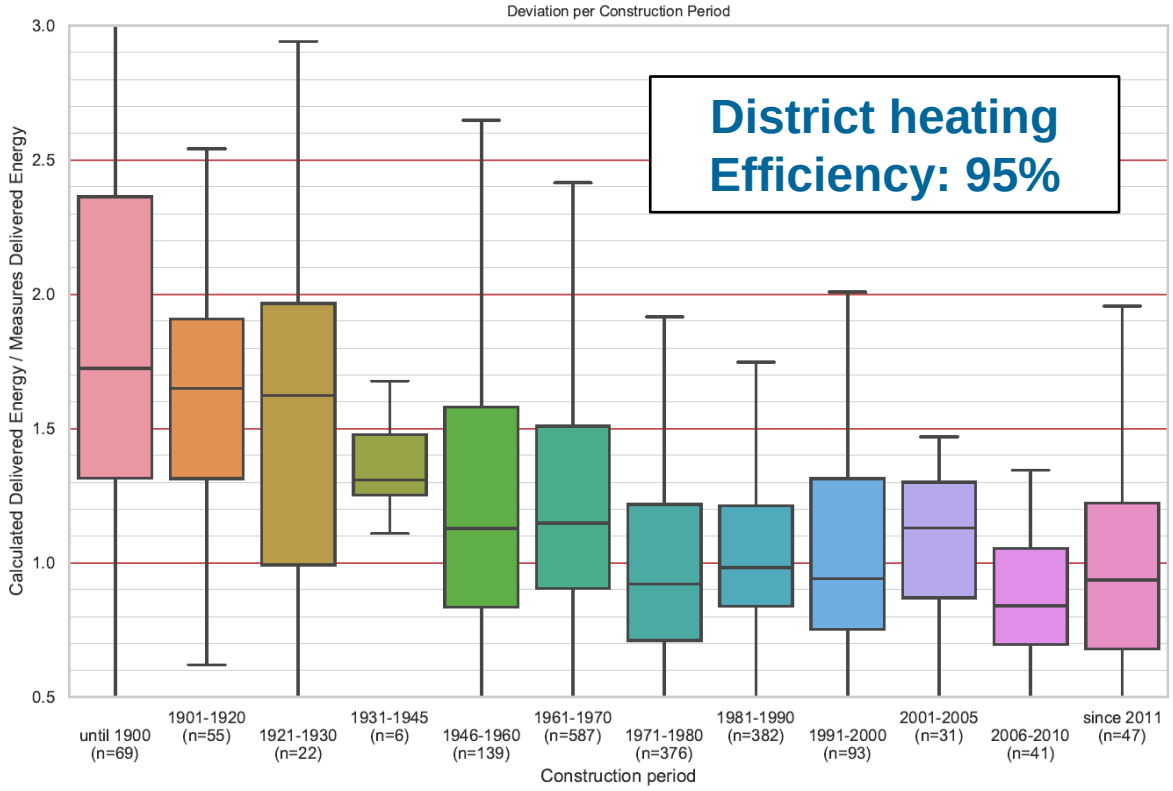
Y-axis: relative deviation, X-axis: absolute deviation in GWh

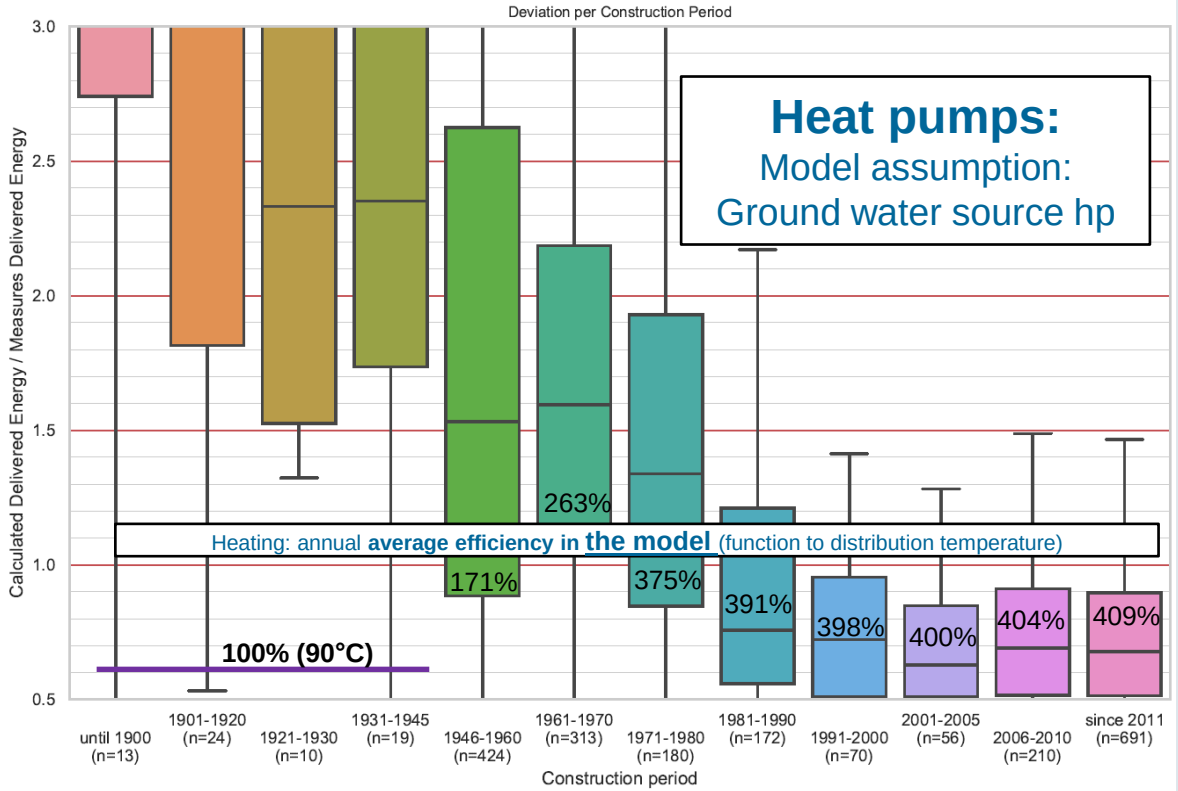
Deviation: gas demand: SWM vs Invert
Building block code: District.X.X
(Only regions with >500 GWh demand, 423 (out of 474) regions)



Y-axis: relative deviation, X-axis: absolute deviation in GWh

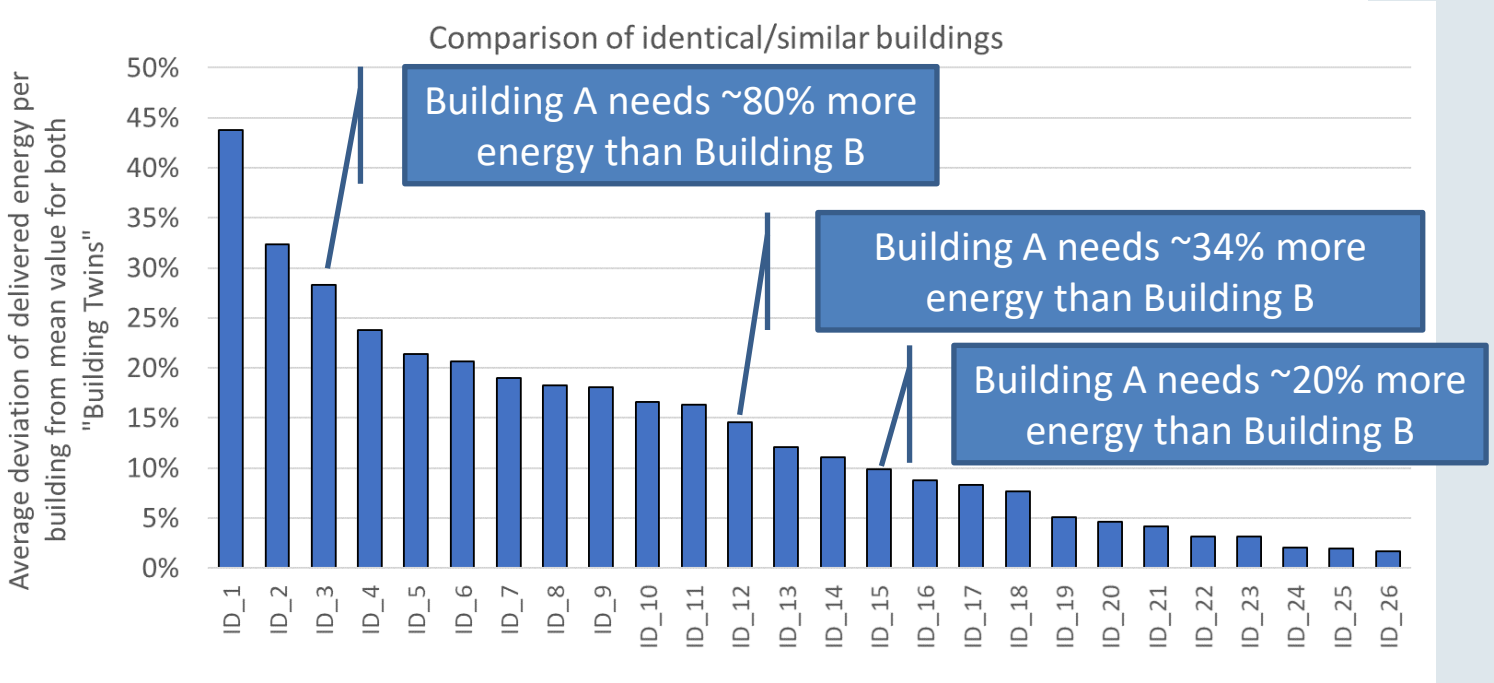
Comparison von calculated and measured delivered energy on individual building level





- Heat pumps: Delivered energy in newer buildings is underestimated. **IF** we get the energy needs correct, the average annual achieved efficiency for heating is about 290%.

Measured delivered energy on individual building level: Impact of users?



- In 12 out of 26 „twin building“ cases (2x26 buildings) in this area, the delivered energy of one building exceeds that of the second by more than 1/3 (with a median value of 25%).

Projections of future energy demand and delivered energy on the level of individual buildings

Heat demand scenarios using the Invert/EE-Lab

- **Multiagent model → For each building an investment agent takes decisions**
- Buildings components are aging → Decision to demolish building or replace existing components choosing from different option
- Integrated building simulation model, endogenously considers indoor and outdoor temperatures, insulation thickness, external surface areas, transparent area, external and internal gains, …)
- **As results the model delivers a probability distribution of different states (including the associated costs, investments, energy consumption, etc.) per building**