The impact of policies in the building sector influence the economic feasibility of district heating

Presenter: Sara Fritz
Agenda

• Motivation
• Research Question
• Methodology
• Case Study
• Conclusion
Motivation

- **37.7 %** of the final energy consumption rises from space heating and air conditioning\(^1\)
- **47.4 %** of Vienna’s building stock is older than 50 years\(^2\)
  - Higher renovation rates and change of heating systems can contribute to reach European 20/20/20 targets

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1) Source: Statistik Austria. “Energetischer Endverbrauch 1993 Bis 2013 Nach Energieträgern Und Nutzenergiekategorien Für Wien (Detailinformation),” December 12, 2014

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International Conference on Smart Energy Systems and 4th Generation District Heating, Copenhagen, 25-26 August 2015
Research Question

- Building owners decide about investments for renovation and change of heating systems
- District heating can provide an ecological and economic way to supply heat demand

- How do policies change the buildings heat demand for space heating and domestic hot water up to 2045?
- What are the consequences for the economic feasibility of the existing district heating network?
Methodology

• Integrated analysis of the development of the buildings heat demand and the supply of it with district heating

Simulation model

• Building owners investment decisions regarding renovations and change of heating systems
  • Buildings heat demand
  • Share of energy carriers on heat demand

Investment Optimization model

• Dynamic model with several investment periods
• Extension and expansion planning of existing district heating networks
• Economic evaluation

Implemented in Python 2.7

Implemented in Matlab R2014a

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Methodology

**SCENARIOS**

**DATA**
- Statistical data and description of building stock

**MODEL**
- Weibull Model
- Nested Logit Model

**OUTPUT**
- Probability of change of building components in year X
- Probability of connection to DH and heat demand in year X

**Scenario Framework**

**Existing Network**
- Mixed Integer Optimization
- Cost of grid expansion and reinvestments

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Individual Building

Aalborg University
DENMARK

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Methodology: Investment Optimization

Investment period $T_{Inv}$

$$\max \Pi = \sum_{t=1}^{T_{Inv}} \frac{R_{tot,t} - c_{tot,t}}{(1 + r)^t} + \sum_{t=T_{Inv}+1}^{T_a} \frac{R_{tot,t} - c_{ReInv,t} - c_{op,t} - c_{g,t}}{(1 + r)^t}$$

Payback period $T_a$

Total Revenues $R_{tot,t}$:
- demand charge per MWh $p_{dc,t}$
- base price per MW $p_b,t$

$$R_{tot,t} = \sum_{b \in B} (p_b,t \cdot P_b + p_{dc,t} \cdot D_{b,t}) \cdot x_{b,t}$$

Total Costs $c_{tot}$:
- Investment costs grid $c_{Inv,t}$
- Costs for Heat generation $c_{g,t}$
- Operation Costs $c_{op,t}$
- Reinvestment Costs $c_{ReInv,t}$

$x_{b,t} = \begin{cases} 1, & \text{if block } b \text{ is connected in period } t \\ 0, & \text{else} \end{cases}$

$D_{b,t}$... Demand of building $b$ at time $t$

$r$ ... discount rate
Case Study

• Policy analysis in the building sector
  – Subsidies for renovation can increase renovation rate and decrease heat demand up to 2045
  – **Obligations to connect to district heating network can increase share of district heating on total heat demand** (obligations scenario)
    • If change of heating system is necessary, building owners has to invest in district heating
    • District heating network operator can decide, if connection is economic viable
Case Study

Vienna:

• 165 000 Buildings / 150 000 residential buildings in 2011\(^1\)
• 1 192 km District heating network in 2013\(^2\), market share 35 %\(^2\)
  – 3300 connected blocks\(^3\) (Total: 9400 blocks)

Installed capacities heat generation\(^4\):

• 242 MW incineration plants
• 37 MW biomass CHP
• 173 MW waste heat from industry
• 1370 MW fossil fuel power generation (CHP)
• 1464 MW fossil fuel sites

Current installed capacities are maintained over whole simulation horizon

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3) Source: own assignment based on Information of „Wiener Stadtwerke“ (public utilities company in Vienna)
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Results

Results Simulation model and Optimization model:
Base Scenario

- Final Energy Demand (FED) for District Heating (DH) decrease not as fast as overall FED
  - Reason: Change of heating system for building stock and new buildings
  - 85.91% of FED DH actually connected in 2045 by district heating operator
• Reduction of FED by 2.66 % in comparison to base scenario
• Increase of FED for District heating up to 2045: 55.03 %
  – But: Just 79.59 % instead of 85.91 % of the possible FED DH are connected by district heating operator
Results

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\frac{\text{Profit}_{\text{obligations}}}{\text{Profit}_{\text{Base}}} = 1.18
\]

\[
\frac{\text{Costs}_{\text{obligations}}}{\text{Costs}_{\text{Base}}} = 1.02
\]

Profit includes:
- Revenues (+)
- Costs heat generation
- Costs (Re-) investments
- Costs operation

Costs include:
- Investments heating systems
- Investments renovations
- Operation costs heating systems
- Energy costs
- Construction costs new buildings

Absolute: Building sector: 5.524*10^6 € higher Costs
Absolute: DH Operator: 2.057 *10^6 € higher Revenues

Additional reduction of CO₂ – Emissions for obligations scenario:
Up to 4.88 % in 2045\(^1\)

1) Assuming CO₂-Emission factor District heating: 0.221 kg/kWh
Conclusion

• Obligations to connect to district heating network, if investments in heating systems are necessary, can increase the economic potential of DH by **43.63%**
  – **But:** market share district heating still just **53.64%**

• Additional reduction of CO₂-emissions possible (4.88%)

• Problem: The costs, considering the demand side and supply with district heating are 2.5 higher.
  – Subsidies for building owners are necessary to contribute to an affordable heat supply
Thank you for your attention!

Questions / Discussion

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