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

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4DH
4th Generation District Heating
Technologies and Systems

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

1) Source: Statistik Austria. "Energetischer Endverbrauch 1993 Bis 2013 Nach Energieträgern Und Nutzenergiekategorien Für Wien (Detailinformation)," December 12, 2014
2) Statistik Austria. "Gebäude 2011 Nach Dem Errichtungsjahr (Bauperiode) Des Gebäudes Und Politischen Bezirken," April 12, 2013.

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

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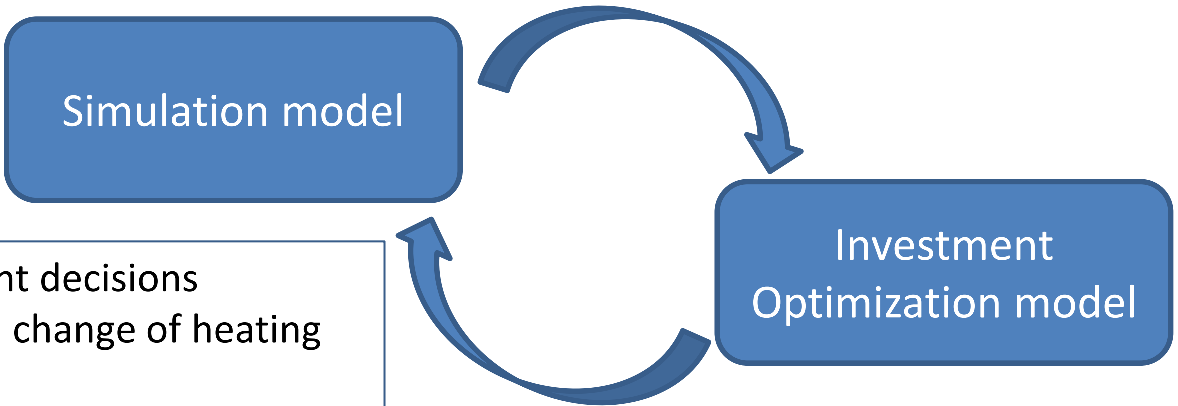
- Integrated analysis of the development of the buildings heat demand and the supply of it with district heating



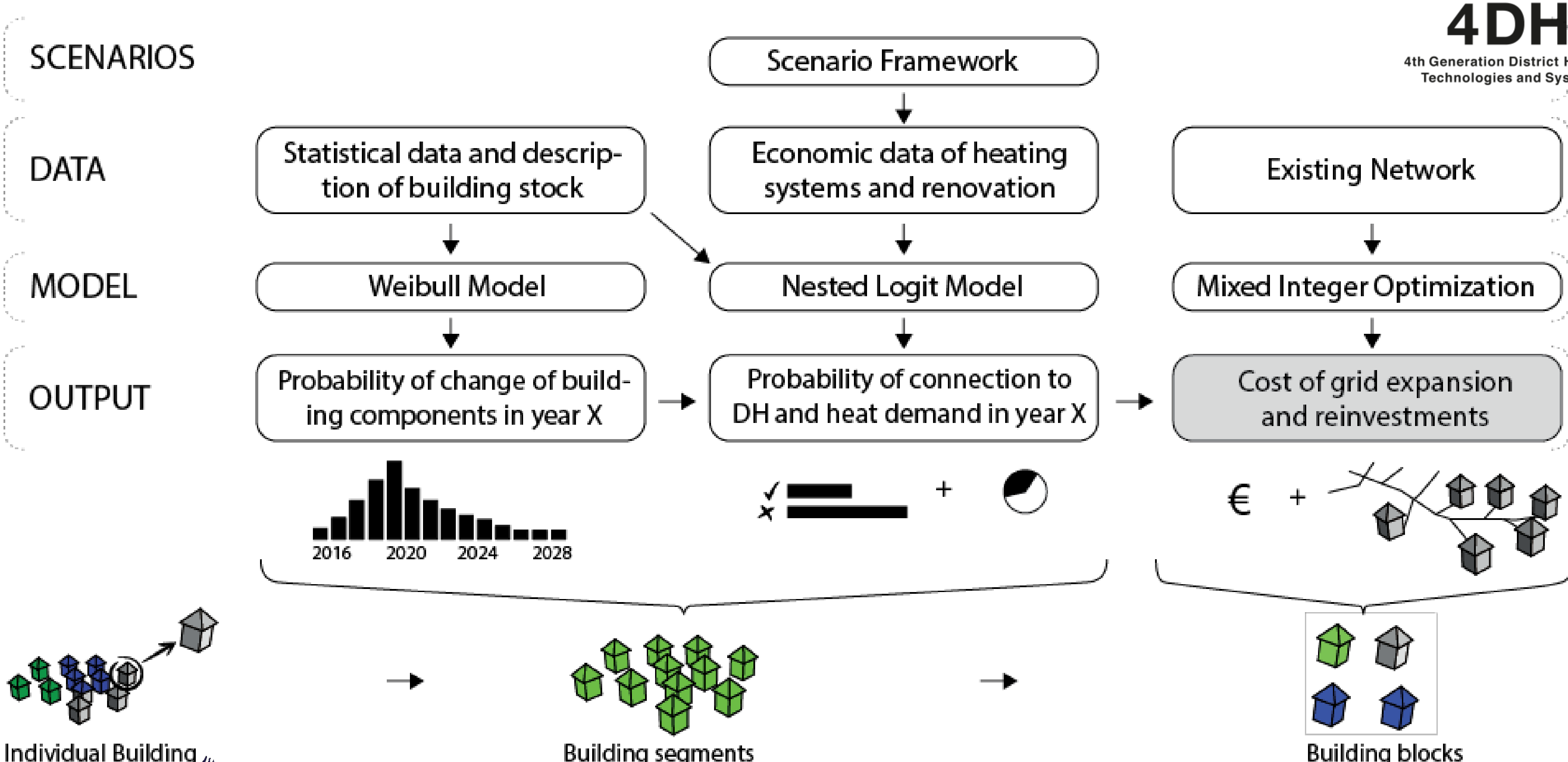
- Building owners investment decisions regarding renovations and change of heating systems
  - Buildings heat demand
  - Share of energy carriers on heat demand

Implemented in Python 2.7

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

Implemented in Matlab R2014a

Methodology



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Methodology: Investment Optimization

Investment period T_{Inv}

Payback period T_a

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

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

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

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 ... disount 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

1) Source: Statistik Austria. "Registerzählung 2011: Ergebnisse Im Überblick: Gebäude 1971 Bis 2011," April 12, 2013.
2) Source: http://www.nachhaltigkeit.wienerstadtwerke.at/oekologie/energieerzeugung-bereitstellung/fernwaerme.html.
3) Source: own assignment based on Information of „Wiener Stadtwerke" (public utilities company in Vienna)
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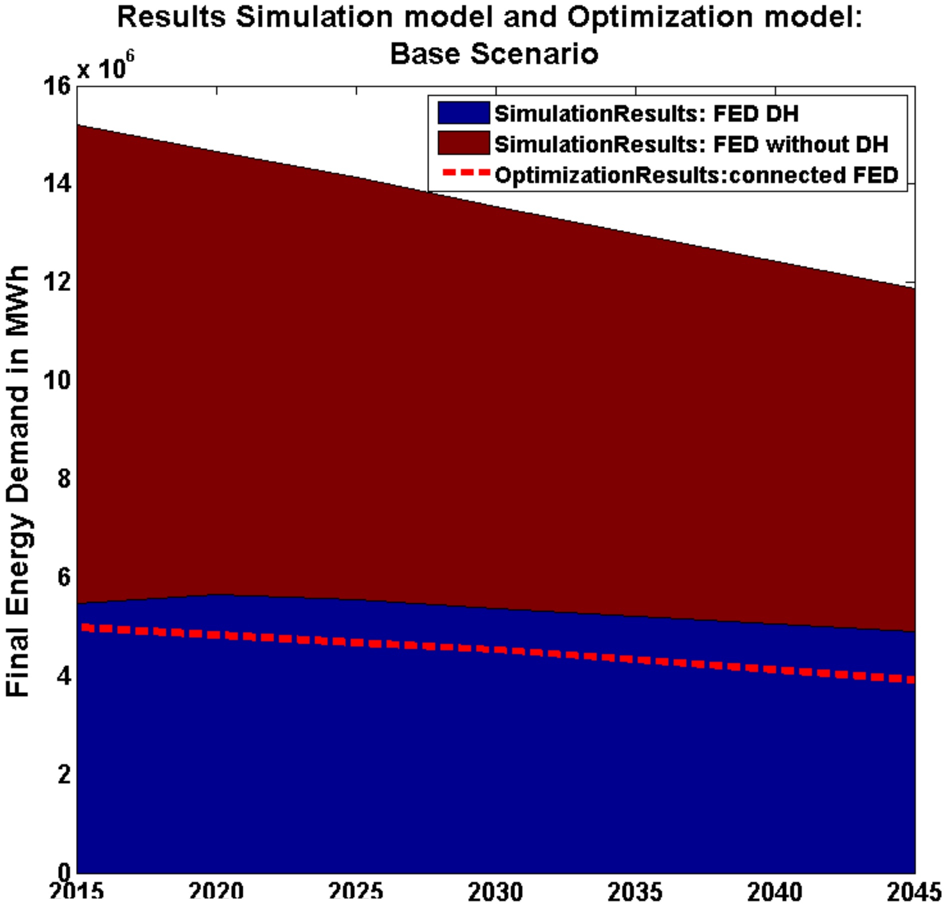
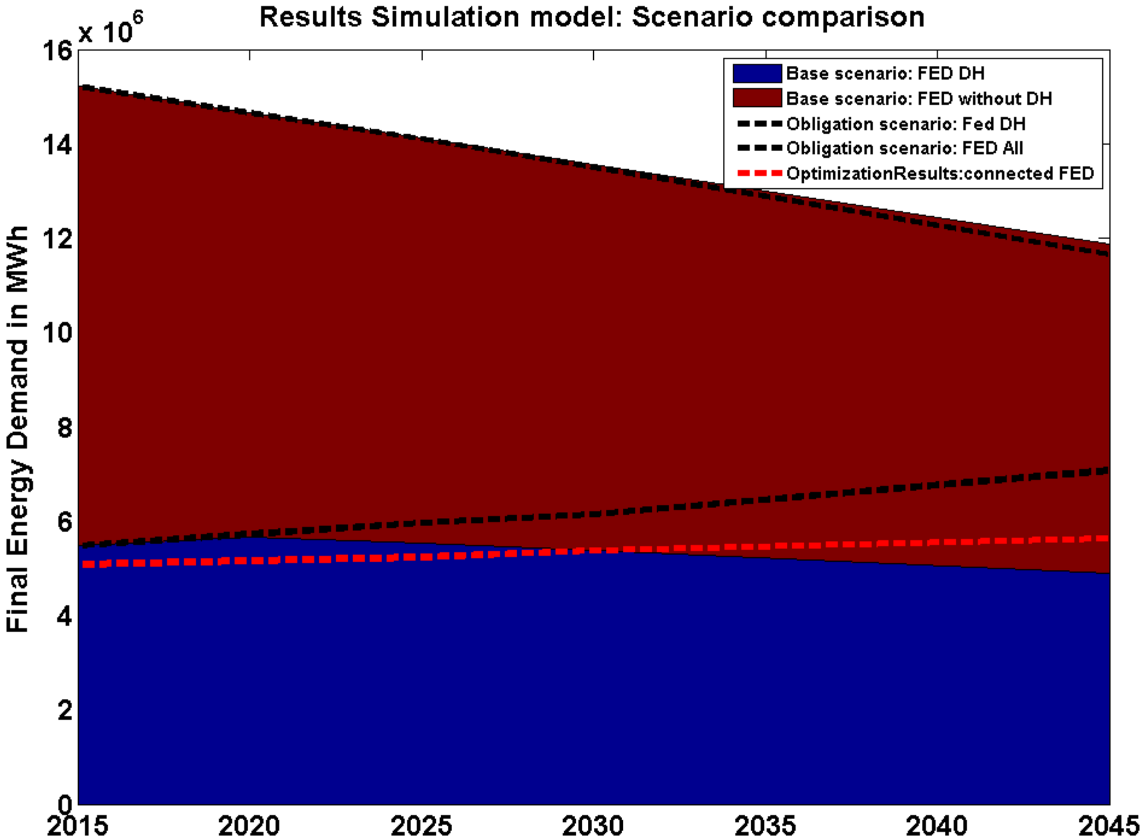
(preliminary) Results



- 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

(preliminary) Results



- 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

(preliminary) Results

District heating Operator

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

Building sector

$$\frac{\text{Costs}_{\text{obligations}}}{\text{Costs}_{\text{Base}}} = 1.02$$

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 CO_2 – Emissions for obligations scenario: Up to **4.88 %** in 2045[1]

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1) Assuming CO_2-Emission factor District heating: 0.221 kg/kWh

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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 CO_2-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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