Power, space heat and refurbishment: Tools and methods to include energy in urban planning

Thomas Hamacher

Problem Statement
New developments

Urban planning

City operation

Smaller scale units in the infrastructure gain more control

Big Data

Urban Planning
Urban planning and energy

Two steps in urban planning

Spatial planning

Zonal planning

Regional planning
Energy utilisation plan as new vector in spatial planning

New tools for the energy utilisation plan
Energy Use Plan Ingolstadt
Wind potential

Die Ergebnisse wurden im Rahmen eines Forschungsprojektes ermittelt. Ohne Gewähr auf Richtigkeit.

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Source: Wagner et al.

Energy Use Plan Ingolstadt
Photovoltaic potential

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Source: Wagner et al.
Energy Use Plan Ingolstadt
Geothermal potential

The results were determined as part of a research project. Without guarantee of accuracy.

Source: Wagner et al.

Energy Use Plan Ingolstadt
Heat map

The results were determined as part of a research project. Without guarantee of accuracy.

Source: Wagner et al.
Energy Use Plan Ingolstadt
Potential of refurbishment

The results were determined within the framework of a research project. No guarantee of accuracy.

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Source: Wagner et al.

Energy Use Plan Ingolstadt
Potential combined heat and power

The results were determined within the framework of a research project. No guarantee of accuracy.

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Source: Wagner et al.
Energy Use Plan Ingolstadt
Potential heat pumps (collectors)

Die Ergebnisse wurden im Rahmen eines Forschungsprojektes ermittelt. Ohne Gewähr auf Richtigkeit.

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Source: Wagner et al.

Energy Use Plan Ingolstadt
Summary

Die Ergebnisse wurden im Rahmen eines Forschungsprojektes ermittelt. Ohne Gewähr auf Richtigkeit.

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Source: Wagner et al.
Tools and methods to plan energy infrastructures and concepts

Numerous energy models exist on national and international level, how can they be modified to be adequate for the urban scale?

<table>
<thead>
<tr>
<th>Simulation</th>
<th>Optimisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Model (Insel, Transys, DigSilent, …)</td>
<td>„least-cost“ (New-Urbs)</td>
</tr>
<tr>
<td>Multi-agent models (SESAM,…)</td>
<td>Partial Equilibrium Model (TIMES, MESSAGE, …)</td>
</tr>
</tbody>
</table>

Combination supply and demand

Supply Side (DH-Network, …)  Demand Side (Building stock)
City and heat supply

Technische Universität München

Lehrstuhl für Energiewirtschaft und Anwendungstechnik
Prof. Dr.-Ing. U. Wagner, Prof. Dr. rer. nat. Th. Hamacher

City and heat supply

Technische Universität München

Lehrstuhl für Energiewirtschaft und Anwendungstechnik
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100 % = Startwert 2008 = 1.582 GWh/a
Darstellung: Daniel Reiter, Salzburg AG
City and heat supply
City and heat supply
City and heat supply

Eine Darstellung zeigt die Zunahme von Solar- und Holzenergie sowie die Abnahme von Heizöl und Erdgas. Darstellung: Daniel Reiter, Salzburg AG

Rückgang der Ölheizungssysteme und Trägheit leitungsgebundener Versorgung

Lehrstuhl für Energiewirtschaft und Anwendungstechnik
Prof. Dr.-Ing. U. Wagner, Prof. Dr. rer. nat. Th. Hamacher
### Combination supply and demand

- **Heat** (DH-Network)
- **Gas**
- **Electricity**

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### Interdisciplinary planning of target networks for electricity, gas and heat

- **Objective:** Investigation of effects on energy infrastructures in cities caused by energy policies in Germany (“Energiewende”)
- **Methods:**
  - Definition of scenarios for load and generation
  - Optimization of networks considering synergies
  - Variants calculation
  - Special focus: Interdisciplinary planning of networks for electricity, gas and district heating

Source: Schönsteiner et al.
Exemplary optimization of a district heating network in Frankfurt

- Result: Optimized heat flow for different scenarios
- Example:

  ![Heat flow map of Frankfurt](image)

- Conclusions: Identification of areas with long-term potential for district heating networks

Source: Schönsteiner et al.

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Definition of scenarios for load and generation

<table>
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<tr>
<th>Optimization of networks considering synergies</th>
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</thead>
<tbody>
<tr>
<td>Electricity</td>
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<tr>
<td>Target network</td>
</tr>
</tbody>
</table>

Source: Schönsteiner et al.
Combination supply and demand

Heat (DH-Network)

Electricity

Coupling heat and electricity sector

Source: Heilek
Combination supply and demand

Flexible demand

Electricity

Football heat map: guess who played?

Quelle: http://www.laola1.at/
Time budgets micro view

Sleep — Breakfast — Drive to work — Work — Go to cinema — Go shopping — Drive home — Dinner — Watch TV — Sleep

Monte-Carlo Simulation of the Demand of Electric Energy - four Persons Household -

Source: Hermann
Summary

• Building design, construction, refurbishment and maintenance can optimally only been planned in the context of the whole urban system and partially beyond

• Area and zonal planning needs to include energy right from the beginning, new methods and tools need to be developed and more urgently be implemented in daily processes

• Planning the energy infrastructure becomes more complex with the advent of new possibilities like power-to-heat, flexible demand and area wide refurbishment

• New actors are necessary to catalyse the planning and manage the complex projects including private and public actors
Further presentations

Toolchain zur Bewertung von Regelstrategien im Gebäudebereich (Florian Sänger, Klaus Klimke, Johannes Jungwirth)

SIMULATION DER ABWÄRMENUTZUNG EINES HOCHTEMPERATUR BRENnstoffzellen-Systems in EINEM EINFAMILIENHAUS (M. Windeknecht, P. Tzscheutschler)

CO-SIMULATION OF A SMART HOME MODEL BASED ON A MICRO ELECTRICITY MARKET (W. El-Baz, and P. Tzscheutschler)

SMART HOME MODEL BASED ON AN INTERACT IVE DSM DEVICES WITHIN A MICRO ELECTRICITY MARKET (P. Tzscheutschler, W. El-Baz)