Advances in Housing Renovation

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Fraunhofer Institute for Solar Energy Systems ISE

- Located in Freiburg/Germany
- Main areas of business
  - Photovoltaics
  - Energy efficiency and renewable energy use in buildings
  - Solar thermal energy use
- Total staff 950 (~100 PhD-students, ~100 master students, ~350 regular staff)
- Budget ~ € 55 million (2009)
- Financing mainly based on 3rd party contracts (industry, public)
Subtask C: Analysis and Concepts

Objectives

- Evaluate the performance of advanced housing renovation projects, using performance characterization methods developed in SHC Task 28
- Assess the adaptability of new energy supply systems, including renewable energy systems, as part of comprehensive renovation packages
- Analyze new products and concepts for advanced housing renovations and provide manufacturers feedback to optimize products
- Develop and publicize optimized renovation concept packages
Outline

- Technologies
- Design Concepts & Process
- Analysis of building renovation projects
- Building retrofit examples: Rislerstraße and Blaue Heimat
Technologies

Design Concepts & Process

Analysis of building renovation projects

Building retrofit examples: *Rislerstraße* and *Blaue Heimat*
Vacuum insulation system
New Insulation technologies

- New development with industrial partner (Maxit; Maxit LockPlate®)
- Required insulation thickness reduced by a factor of 3
- Recently introduced into the market

source: Fraunhofer ISE, D
Spray insulation system
New Insulation technologies

- Internal insulation for historic building
- Based on recycled materials
- Relatively low water vapour diffusion resistance factor (µ) of 6 [ - ]
- Capillary-active and open-diffusion internal insulation system

source: TU Graz, Austria
Development of a heat bridge catalogue for retrofit specific issues

- Window integration
- Balconies
- Combination of unheated basement and heated ground floor
- Published in Final Report of Subtask C

source: Gütermann, CH, PHI D
Efficient energy transformation

Trends

Use the exergy content of energy:

- Combined heat and power (CHP) for any type of fuel (fossil, biomass)
- Heat pumps for use of electricity for heating application
- Minimized temperature differences between room and heat transfer fluid (heating, cooling) → low-exergy heating and cooling (LowEx)
- Technologies
- Design Concepts & Process
- Analysis of building renovation projects
- Building retrofit examples: *Rislerstraße* and *Blaue Heimat*
Restructuring of Floor Plans
Existing floor plan

Example: Buggingerstr. 50, Freiburg, D
Restructuring of Floor Plans
Increased areas, smaller flats
The developments that are considered in this methodology are:

- Developments with implications on security of supply of energy
- Price developments of energy
- Technological developments (either resulting in new technologies and/or improved existing technologies) and cost development
Prepared In all Aspects for Future

The PIAF Methodology

(developed by ECN, the Netherlands)

- Four step procedure:
- Set an energy target for the building, to be reached at the next natural renovation cycle, i.e. the replacement of the HVAC system.
- Determine the optimal HVAC system to put in place at that moment in time, composed from the best available technology (in terms of cost-performance ratio, taking into account the effect of energy price developments).
- Determine the optimal building skin (in terms of cost-performance ratio, taking into account the effect of energy price developments) associated with the HVAC system resulting from 2.
- Determine the optimal HVAC system (in terms of cost-performance ratio, taking into account the effect of energy price developments and impact of necessary alterations to the system of step 2 in the future) for the time until the next natural renovation cycle.
The PIAF Methodology (developed by ECN, the Netherlands)

Example: Energy supply for a single family house

Influence of energy price scenario on accumulated costs for gas-fired energy system

- 0% increase in gas
- 3% increase in gas
- 6% increase in gas

Accumulated cost of energy system [k€]

heating demand [kWh/m²/year]

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Example: Energy supply for a single family house

Accumulated costs related to space heating

- Condensing boiler
- Condensing boiler replaced by micro-CHP in the future
- Energy neutral from the start (based on HP)
- PIAF
Users participation
Examples from Austria

- Participation of users in various phases of the design process is an important success factor for advanced housing renovation.
Technologies

Design Concepts & Process

Analysis of building renovation projects

Building retrofit examples: Rislerstraße and Blaue Heimat
### Retrofit Projects I
**IEA SHC Task 37**

<table>
<thead>
<tr>
<th>Protected Façade</th>
<th>Roter Block, Freiburg</th>
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<tbody>
<tr>
<td>Owner: Freiburger Stadtbau GmbH</td>
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<tr>
<td>Architecture: Huller, Banzhaf + Partner</td>
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<td>BT / Energy Concept: Fischer / Stahl + Weiß</td>
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<th>Passivhouse Renovation</th>
<th>Tevesstrasse, Frankfurt</th>
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<tr>
<td>Owner: AGB Frankfurt</td>
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<td>Architecture: Grenz / Rasch</td>
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<td>Energy Concept: IBP</td>
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<td>Project Name</td>
<td>Location</td>
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<tr>
<td>„Zero“-House</td>
<td>Blaue Heimat, Heidelberg</td>
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<td>3L- House</td>
<td>Freyastrasse, Mannheim</td>
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Key Data - Energy Design

- **Blaue Heimat**: Reduction 84% (KfW 40/“Zero”)
- **Freyastrasse**: Reduction 92%
- **Rislerstrasse 1-5**: Reduction 87% (KfW 40)
- **Rislerstrasse 7-13**: Reduction 80% (KfW 60)

Primary energy demand acc. EnEV [kWh/m²ANa]

- **Before retrofit**
  - Blaue Heimat: 389
  - Freyastrasse: 292
  - Rislerstrasse KfW 40: 228
  - Rislerstrasse KfW 60: 110

- **Building code (new buildings)**
  - Blaue Heimat: 81
  - Freyastrasse: 71
  - Rislerstrasse KfW 40: 89
  - Rislerstrasse KfW 60: 89

- **After retrofit**
  - Blaue Heimat: 34
  - Freyastrasse: 32
  - Rislerstrasse KfW 40: 39
  - Rislerstrasse KfW 60: 59

Reduction range: 80% - 92%
Cross Analysis: measured heating energy [kWh/m²\text{year}]

- **Heating energy below 30 kWh/m²a for “KfW – Houses”**
  - Blaue Heimat < 15 kWh/m²a
  - Large variations in attached houses Freyastrasse 11 – 60 kWh/m²a
  - Passivhouse in renovation (Ludwigshafen, Frankfurt) 18 kWh

<table>
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<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
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<tr>
<td>Blaue Heimat</td>
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<td>23.8</td>
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<td>Large variations</td>
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Data: ISE, IBP, IGE, PHI
Measured primary Energy Consumption [kWh/m²a]

- Rislerstrasse KfW 40: 57.7 kWh/m²a
- Rislerstrasse KfW 60: 64.0 kWh/m²a
- Blaue Heimat (incl. CHP credits): 39.9 kWh/m²a
- Freyastrasse: 50.2 kWh/m²a
- Hoheloogstr: 40.2 kWh/m²a
- Tevesstr.: 65.6 kWh/m²a
■ Technologies
■ Design Concepts & Processes
■ Analysis of building renovation projects
■ Building retrofit examples: *Rislerstraße* and *Blaue Heimat*
Rislerstrasse, Freiburg

- Built in 1961
- Retrofit 2005
- Two energy standards: KfW40 resp. KfW60
- Net Heated Floor Area: 1230m² resp. 1640m²
- No. of flats: 18 resp. 24
Concept – building envelope

- Insulation of external wall, roof and floor to basement
- Windows:
  - KfW40: triple - glazing
  - KfW60: double - glazing
- Transmission losses
  - KfW40: HT’=0,27 W/m²K
  - KfW60: HT’=0,35 W/m²K
- Distribution in ceiling’s insulation
Concept – supply

- Gas condensing boiler 60kW each
- Heating system low temperature radiators
- Solar thermal collector for DHW
  KfW 40: 24 m²
  KfW 60: 29 m²
- Buffer storage 750 l, DHW storage 500 l
- Ventilation
  KfW 40: balanced vent., heat recovery 85%
  KfW 60: Exhaust ventilation
Supply scheme
Rieslerstrasse

Diagram:
- Flat plate collectors
- Circulation
- Hot water storage
- Buffer storage
- Hot water
- Heating circuit
- Boiler
Energy consumption KfW 40

- 01/07 – 12/07
- PE- consumption (NFA) 58 kWh/m²a (planned: 54 kWh/m²a)
- end energy / primary energy
  - electricity 2.7 kWh\textsubscript{PE}/kWh\textsubscript{EE}
  - natural gas 1.1 kWh\textsubscript{PE}/kWh\textsubscript{EE}
  - solar thermal 0 kWh\textsubscript{PE}/kWh\textsubscript{EE}
Energy flow - KfW 40

- Almost same demand for DHW and heating
- Solar contribution ~ 12 kWh/m²a
- Overall losses ~ 11 kWh/m²a
- Hot water consumption underestimated following ENEV
Energy consumption KfW 60

Measurement period 01/07 – 12/07

Specific PE-consumption:
- 64 kWh/m²y
- (planned: 80 kWh/m²y)
Energy flow – KfW 60

- Appr. same part DHW and Heating
- Solar contribution ~ 11 kWh/m²a
- Overall losses ~ 10 kWh/m²a
- Hot water consumption under-estimated following ENEV
Summary Rislerstrasse

- Technologies applied (high level insulation, gas condensing boiler in combination with solar thermal) can be stated as “state of the art”
- Energy demand for DHW and heating in same level
- Efficiency of boiler as expected
- Significant contribution of solar thermal to energy demand
  - Although solar thermal system was designed for DHW only
  - Potential for enhanced solar contribution visible
- Open questions regarding user behaviour with respect to ventilation: small advantage of ventilation with heat exchanger compared to exhaust ventilation
Blaue Heimat, Heidelberg

Built in 1951
Retrofit in 2005
NHFA: 3375m²
No. of flats : 40
Concept – building envelope
Blaue Heimat

- Insulation of external wall, roof and floor to basement
- Windows: triple-glazing
- Transmission losses
  HT’=0.31 W/m²K
- 200% insulation of distribution pipes: reduced losses compared to building code
Concept – energy supply
Blaue Heimat

- Natural gas-based CHP 50 kW_{el} / 80 kW_{th}
- 3 x 1,000 l buffer storage
- 2 peak load boilers 184 kW
- Balanced ventilation with heat recovery (>85 %), 3-level control in the flats
- „Zero“- Concept: Net Zero Energy house
Supply scheme

Blaue Heimat

Diagram showing a supply scheme with a CHP, boiler, buffer storage, and hot water storage connected by heat circuits and circulation lines.
Energy consumption Blaue Heimat

- 1/07 – 12/07
- Heating energy consumption achieves almost passive house standard
- CHP- credits: 75 kWh/m²a
- Net zero energy house not completely achieved

Energy consumption 2007 [kWh/m²a]

- Useful energy
- End energy
- Primary energy
- Primary energy incl. credits

Heating DHW Pumps etc. Ventilation PE- other credits CHP
Energy flow

- Dominated by DHW demand
- Storage and distribution losses in same order of magnitude as heating demand
Summary – Blaue Heimat

- Advanced housing retrofit possible
- DHW becomes most important
- Increased influence of user behaviour (Ventilation, DHW)
- Distribution losses and energy for ventilation and heating pumps become more important
- CHP could play a role in net zero multi-family houses
- Solution where high level insulation becomes difficult
Conclusion

- Advanced housing retrofit even to the level of passive houses becomes state of the art
- Energy standards like the net zero energy balance possible even with specific issues in retrofit (ventilation, heat bridges, air tightness)
- DHW becomes as important as heating
- Increasing influence of user behaviour (desired room temperature, ventilation, hot water demand)
- Specific solutions have to be adapted to particular conditions (e.g. centralized vs. de-centralized, direct supply vs. storage, separated supply for DHW and heating)

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www.iea-task37.org
Thank you for your attention…

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