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# Advances in Housing Renovation

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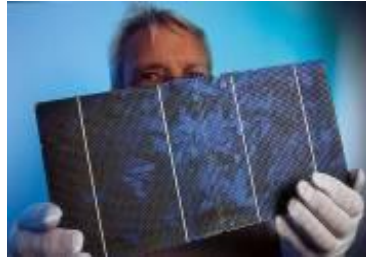
**Sebastian Herkel**, Hans-Martin Henning

Fraunhofer-Institut für  
Solare Energiesysteme ISE

FINAL TASK 37 SEMINAR

San Francisco, 21<sup>st</sup> June 2010

# 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 3<sup>rd</sup> 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

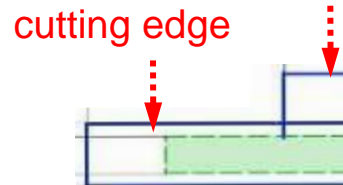
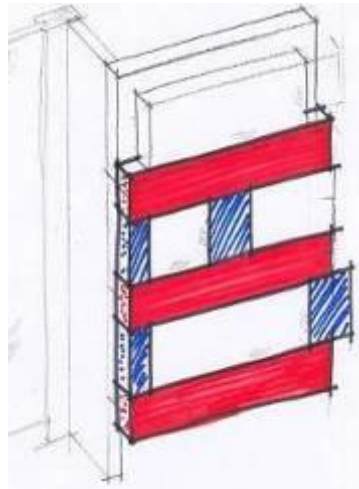
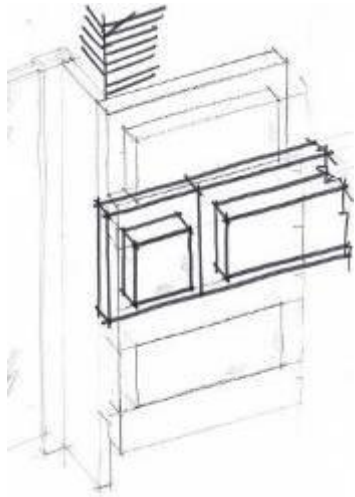
# Outline

- 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



source: Fraunhofer ISE, D

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

# Spray insulation system

## New Insulation technologies



source: TU Graz, Austria

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

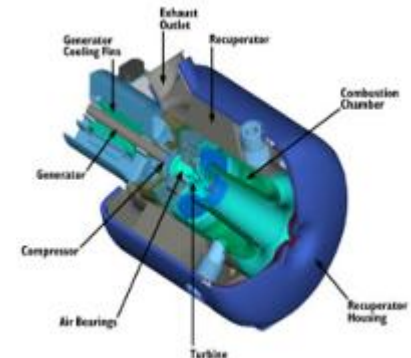


# Efficient energy transformation

## Trends

Use the exergy content of energy:

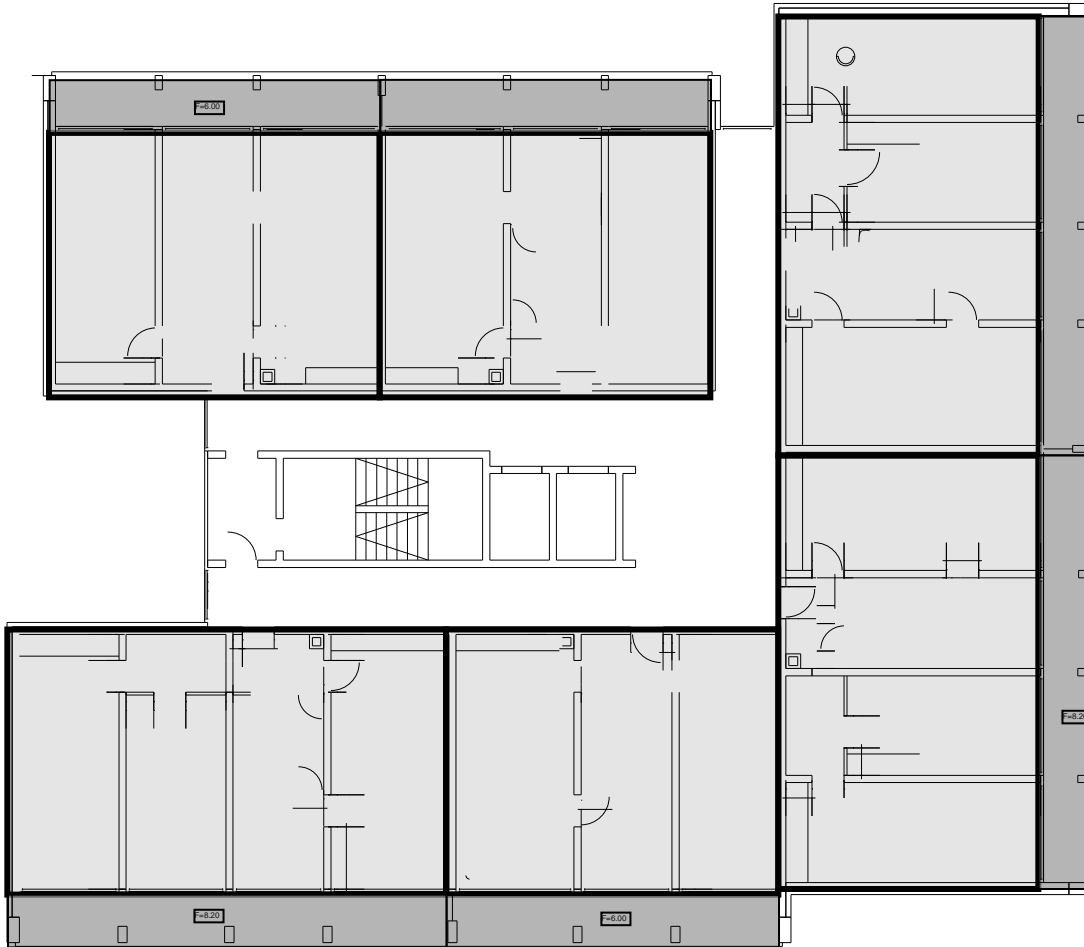
- Combined heat and power (CHP) for any type of fuel (fossil, biomass)
- Heat pumps for use of electricity for heating application
- Minimized temperature differences between room and heat transfer fluid (heating, cooling) → low-exergy heating and cooling (LowEx)



- Technologies
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# Restructuring of Floor Plans

## Existing floor plan



**Example: Buggingerstr. 50, Freiburg, D**

# Restructuring of Floor Plans

## Increased areas, smaller flats



# Prepared In all Aspects for Future The PIAF Methodology

(developed by ECN, the Netherlands)

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

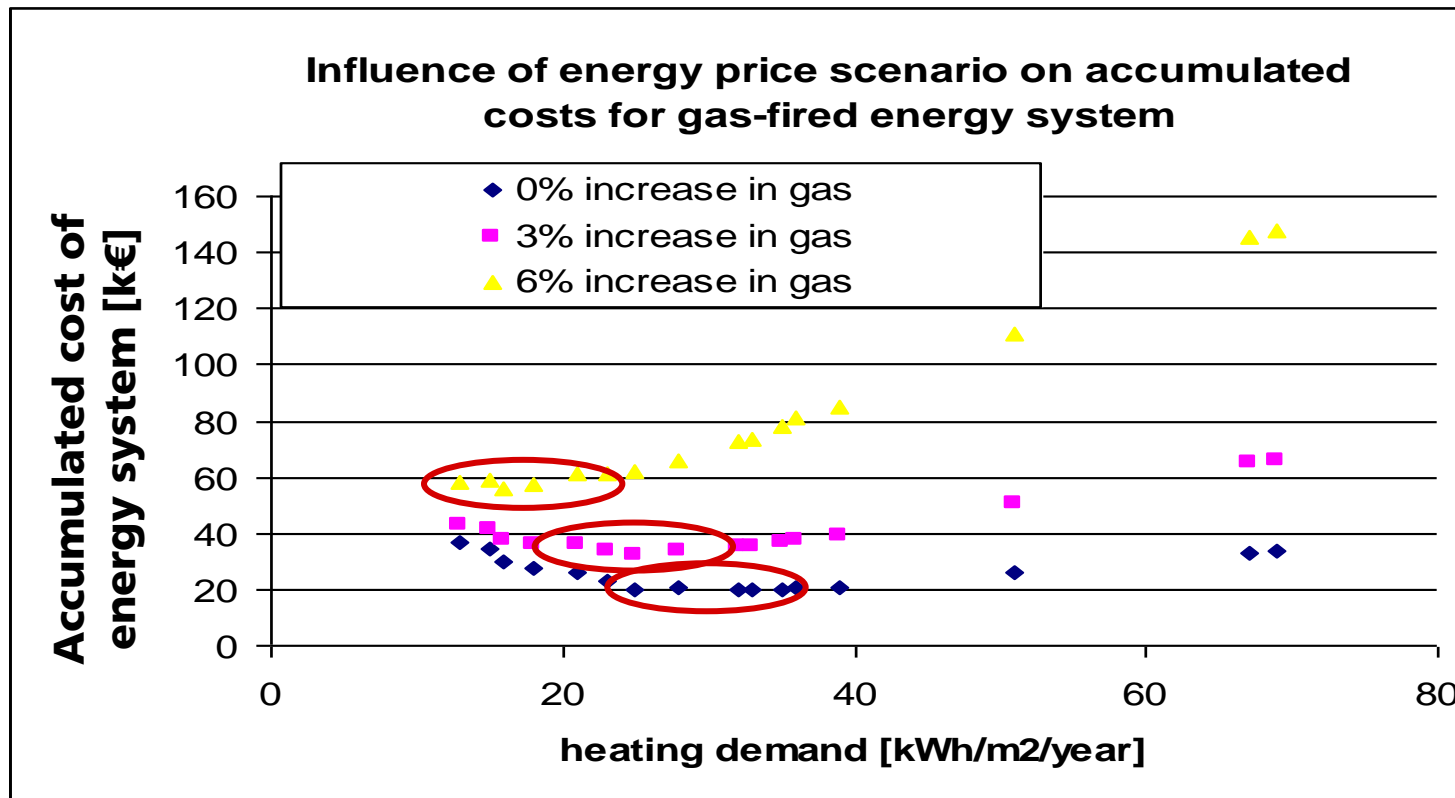
(developed by ECN, the Netherlands)

- 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

# Prepared In all Aspects for Future The PIAF Methodology

(developed by ECN, the Netherlands)

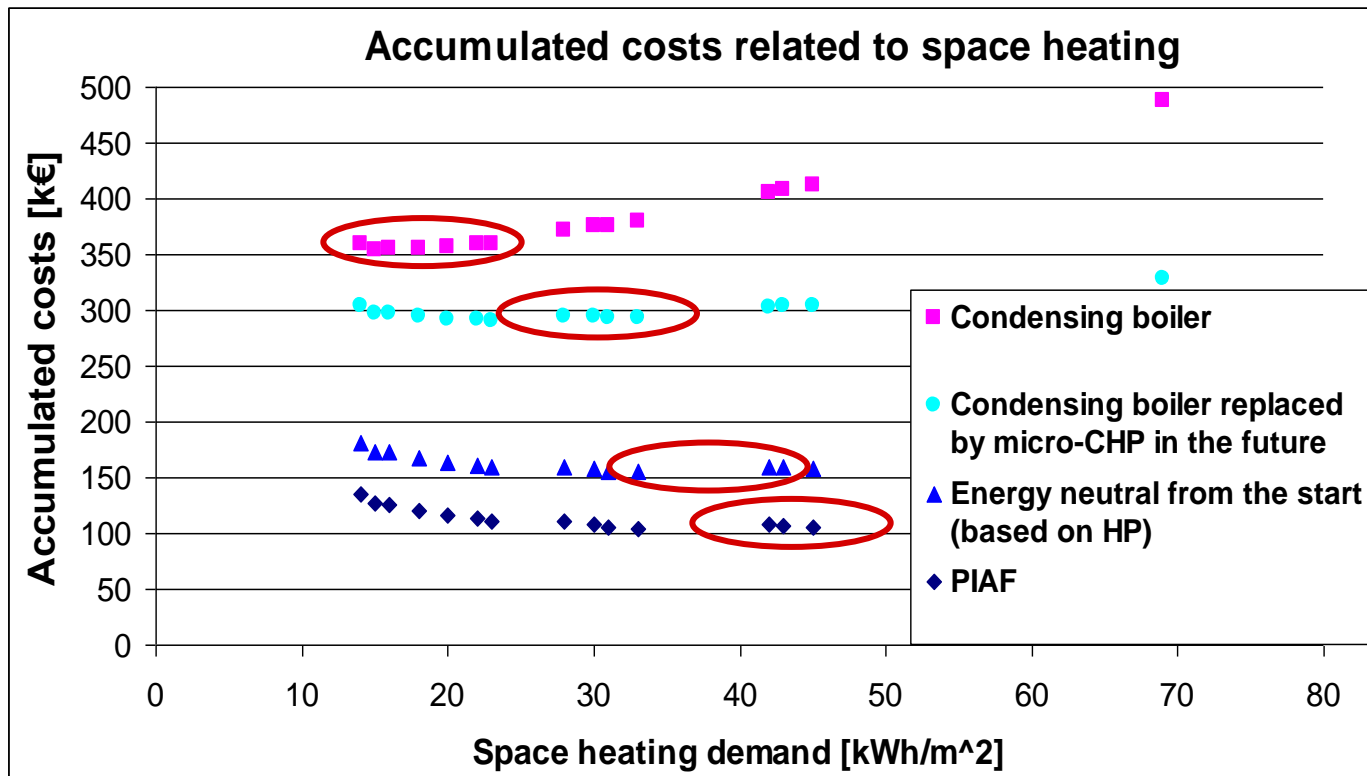
Example: Energy supply for a single family house



# Prepared In all Aspects for Future The PIAF Methodology

(developed by ECN, the Netherlands)

Example: Energy supply for a single family house



# 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
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- Building retrofit examples: *Rislerstraße* and *Blaue Heimat*

# Retrofit Projects I

## IEA SHC Task 37



**protected  
façade**

### **Roter Block, Freiburg**

Owner: Freiburger Stadtbau GmbH  
Architecture: Huller, Banzhaf + Partner  
BT / Energy Concept: Fischer / Stahl + Weiß



**passivhouse  
renovation**

### **Tevesstrasse, Frankfurt**

Owner: AGB Frankfurt  
Architecture: Grenz / Rasch  
BT / Energy Concept: Baumgartner / PHI



**passivhouse  
renovation**

### **Hoheloochstrasse, Ludwigshafen**

Owner: GAG Ludwigshafen  
BT / Energy Concept : PHI



**Vacuum-  
insulation**

### **Guter Hirte, Ulm**

Owner: Kath. Gemeinde Bofingen  
Energy Concept : IBP

# Retrofit Projects II

## IEA SHC Task 37



**„KfW40“  
„KfW60“**

### **Rislerstrasse, Freiburg**

Owner : Freiburger Stadtbau GmbH

Architecture: B. Thoma – G. Henninger-Thoma

BT / Energy Concept : Lenz / Stahl + Weiß



**„Zero“-  
House**

### **Blaue Heimat, Heidelberg**

Owner : GGH- Heidelberg

Architecture: J. Gerstner, Heidelberg

BT / Energy Concept : solares bauen GmbH



**3L- House**

### **Freyastrasse, Mannheim**

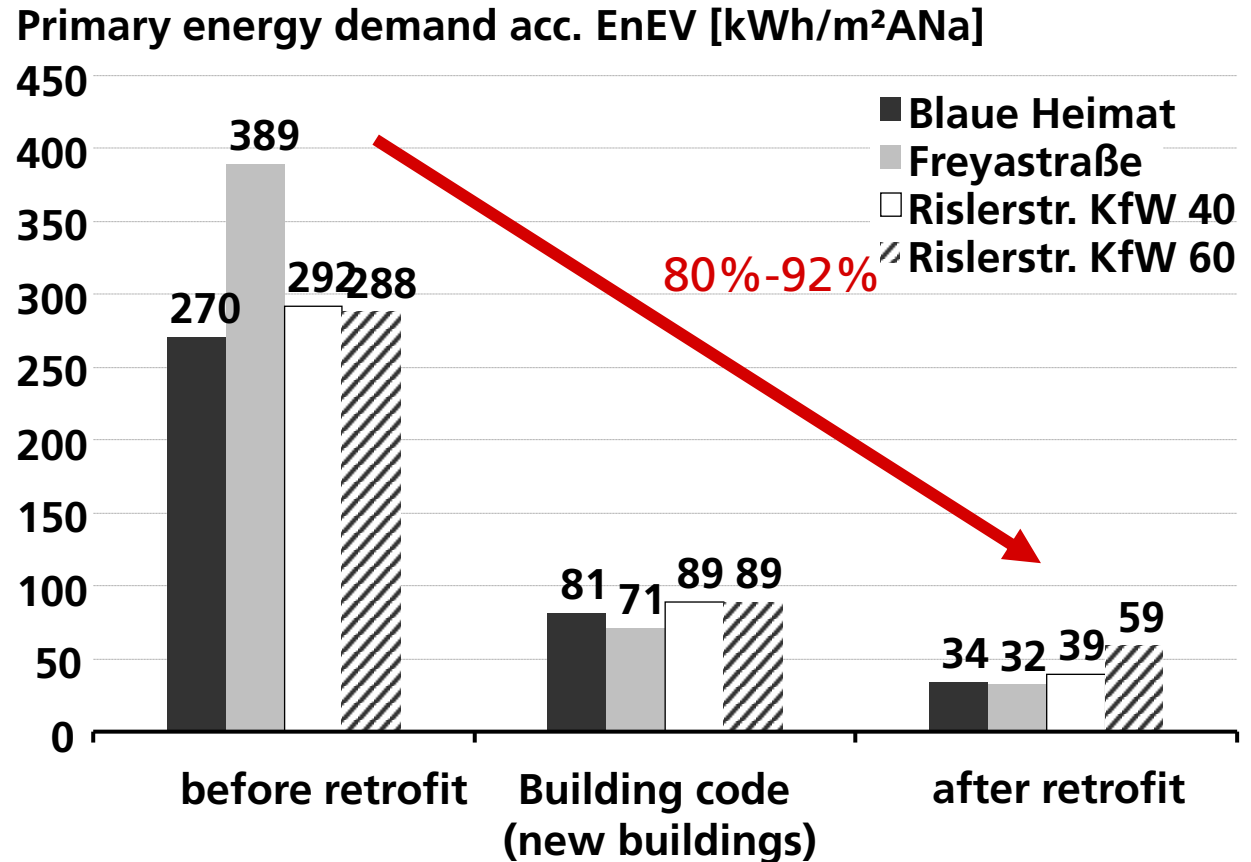
Owner : GBG – Mannheimer

Wohnungsbaugesellschaft mbH

Energy Concept: IBP / IGE

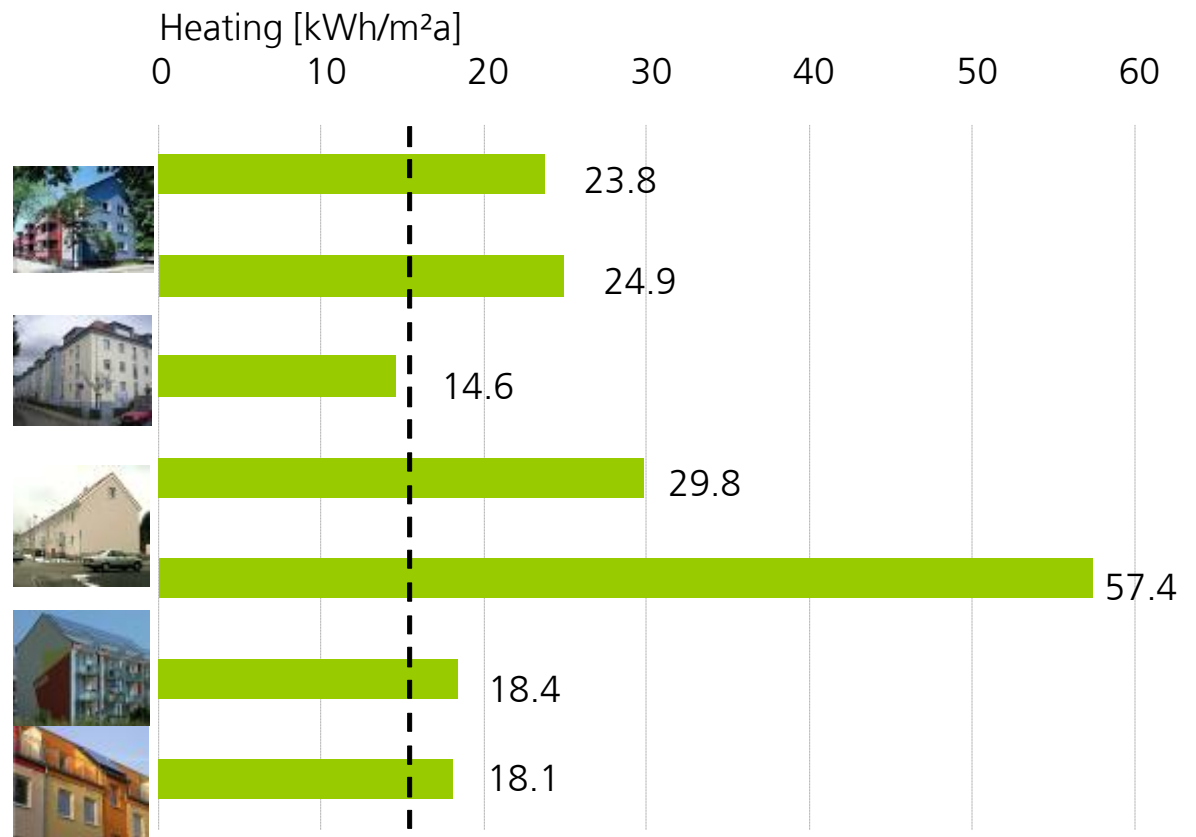
# Key Data - Energy Design

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



# Cross Analysis: measured heating energy [kWh/m<sup>2</sup>year]

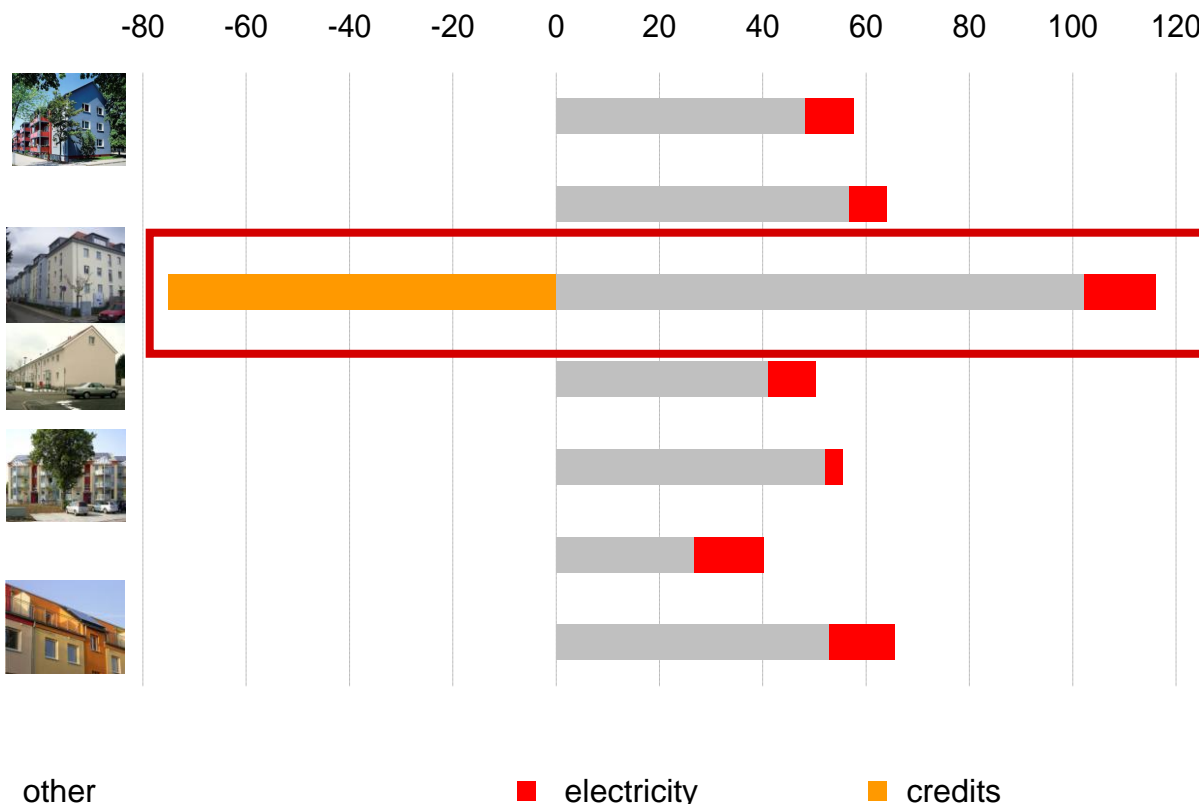
- Heating energy below 30 kWh/m<sup>2</sup>a for "KfW –Houses"
- Blaue Heimat < 15 kWh/m<sup>2</sup>a
- Large variations in attached houses Freyastrasse 11 – 60 kWh/m<sup>2</sup>a
- Passivhouse in renovation (Ludwigshafen, Frankfurt) 18 kWh



Data: ISE, IBP, IGE, PHI

# Measured primary Energy Consumption [kWh/m<sup>2</sup>a]

- Rislerstrasse KfW 40:  
57.7 kWh/m<sup>2</sup>a
- Rislerstrasse KfW 60:  
64.0 kWh/m<sup>2</sup>a
- Blaue Heimat (incl.  
CHP credits):  
39.9 kWh/m<sup>2</sup>a
- Freyastrasse:  
50.2 kWh/m<sup>2</sup>a
- Hoheloogstr:  
40.2 kWh/m<sup>2</sup>a
- Tevesstr.:  
65.6 kWh/m<sup>2</sup>a



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

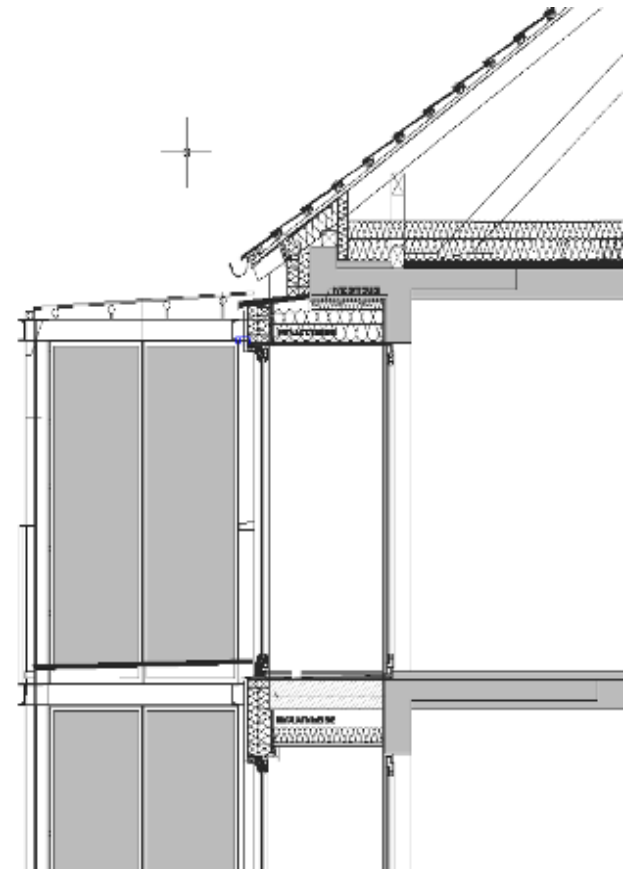
# Rislerstrasse, Freiburg

- Built in 1961
- Retrofit 2005
- Two energy standards:  
KfW40 resp. KfW60
- Net Heated Floor Area:  
1230m<sup>2</sup> resp. 1640m<sup>2</sup>
- 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:  $HT' = 0,27 \text{ W/m}^2\text{K}$   
KfW60:  $HT' = 0,35 \text{ W/m}^2\text{K}$
- Distribution in ceiling's insulation



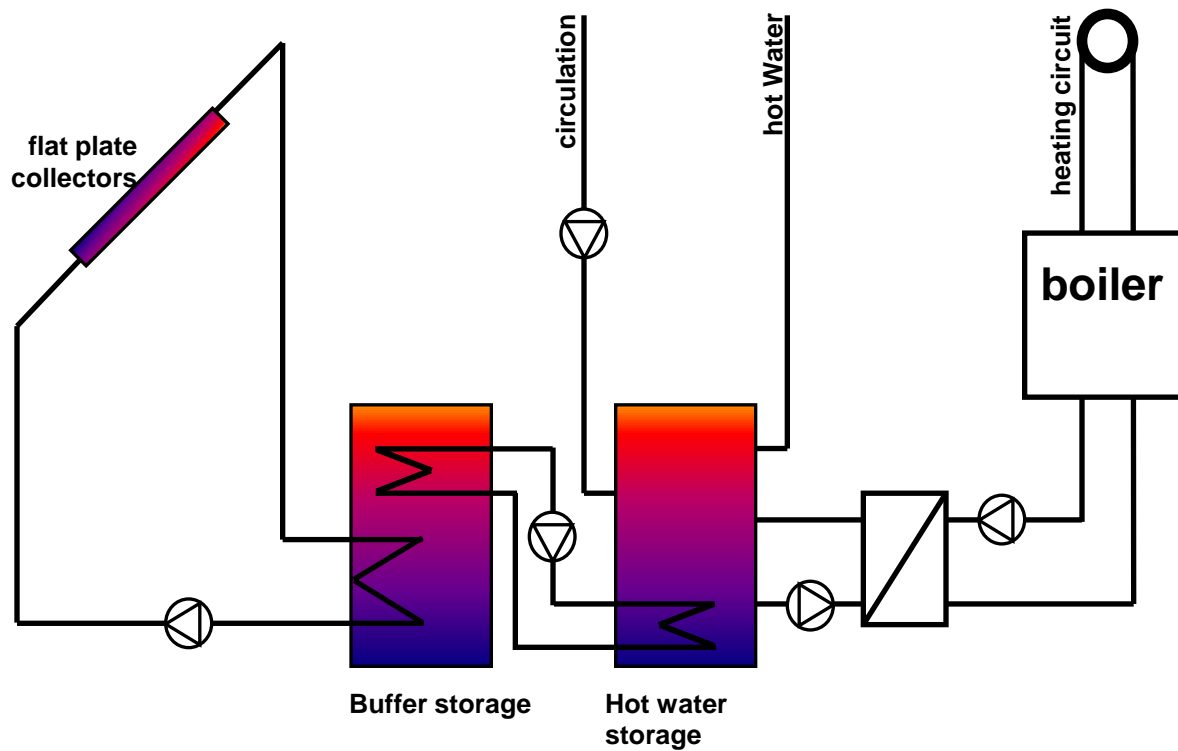
# Concept – supply

- Gas condensing boiler 60kW each
- Heating system low temperature radiators
- Solar thermal collector for DHW
  - KfW 40: 24 m<sup>2</sup>
  - KfW 60: 29 m<sup>2</sup>
- Buffer storage 750 l, DHW storage 500 l
- Ventilation
  - KfW 40: balanced vent., heat recovery 85%
  - KfW 60: Exhaust ventilation



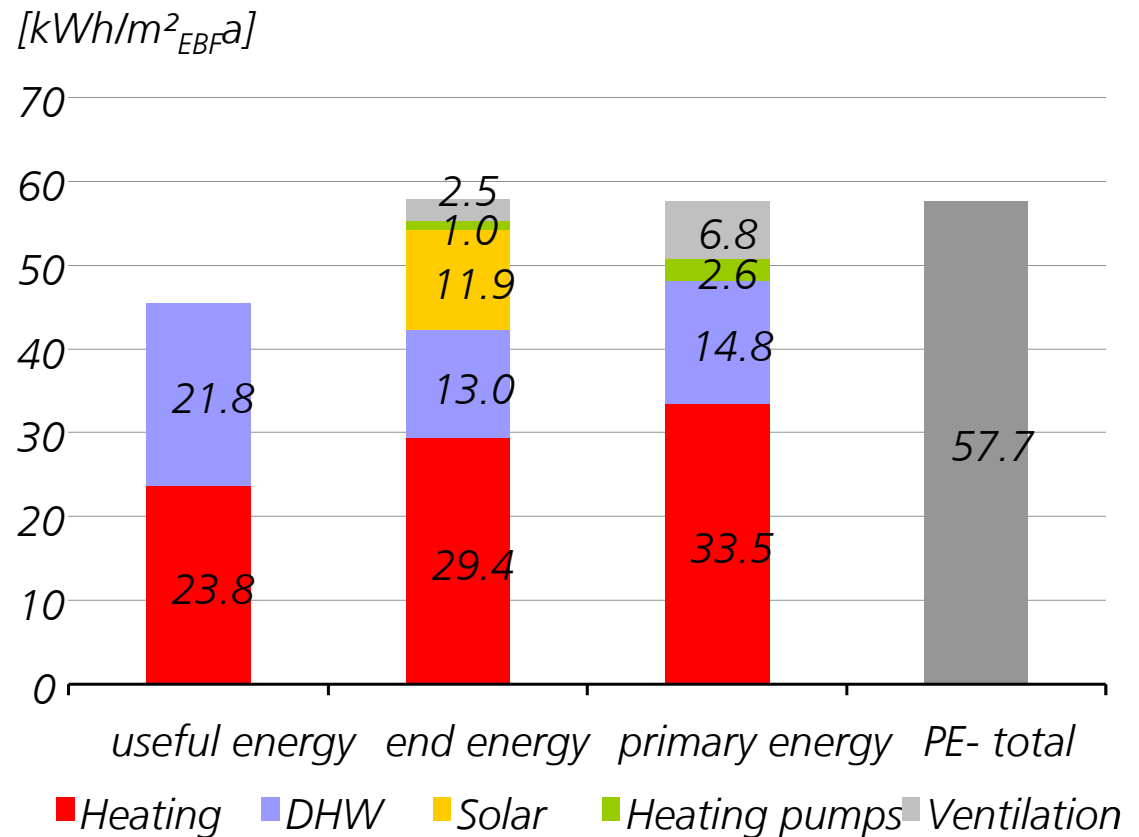
# Supply scheme

## Rieslerstrasse



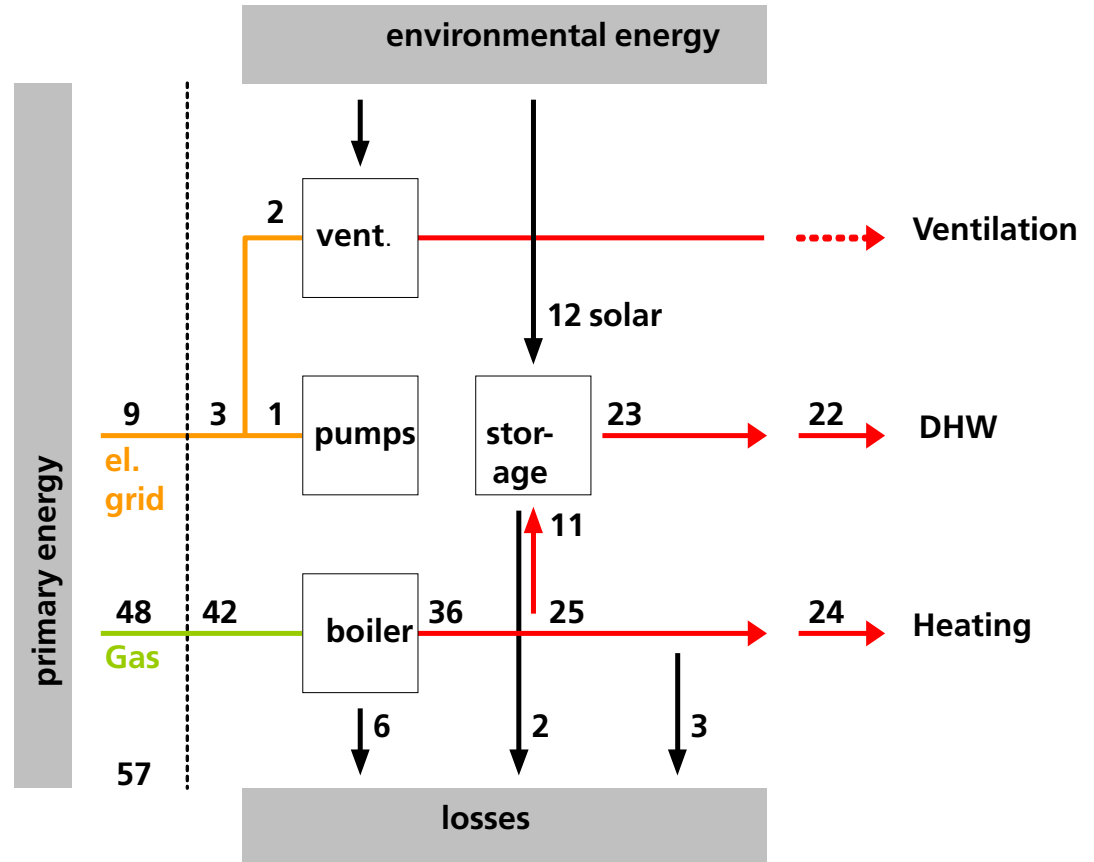
# Energy consumption KfW 40

- 01/07 – 12/07
- PE- consumption (NFA)  
58 kWh/m<sup>2</sup>a  
(planned: 54 kWh/m<sup>2</sup>a)
- end energy / primary energy
  - electricity  
2.7 kWh<sub>PE</sub>/kWh<sub>EE</sub>
  - natural gas  
1.1 kWh<sub>PE</sub>/kWh<sub>EE</sub>
  - solar thermal  
0 kWh<sub>PE</sub>/kWh<sub>EE</sub>



# Energy flow - KfW 40

- Almost same demand for DHW and heating
- Solar contribution ~ 12 kWh/m<sup>2</sup>a
- Overall losses ~ 11 kWh/m<sup>2</sup>a
- Hot water consumption underestimated following ENEV



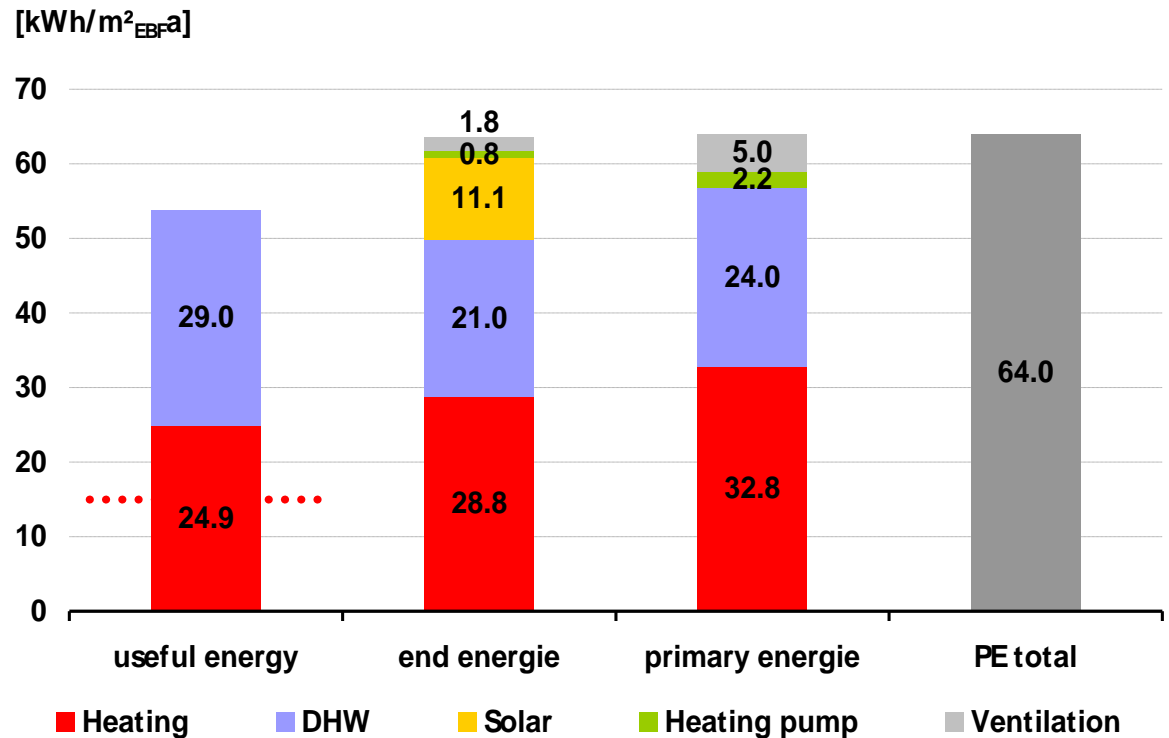
# Energy consumption KfW 60

Measurement period 01/07 – 12/07

Specific PE-consumption:

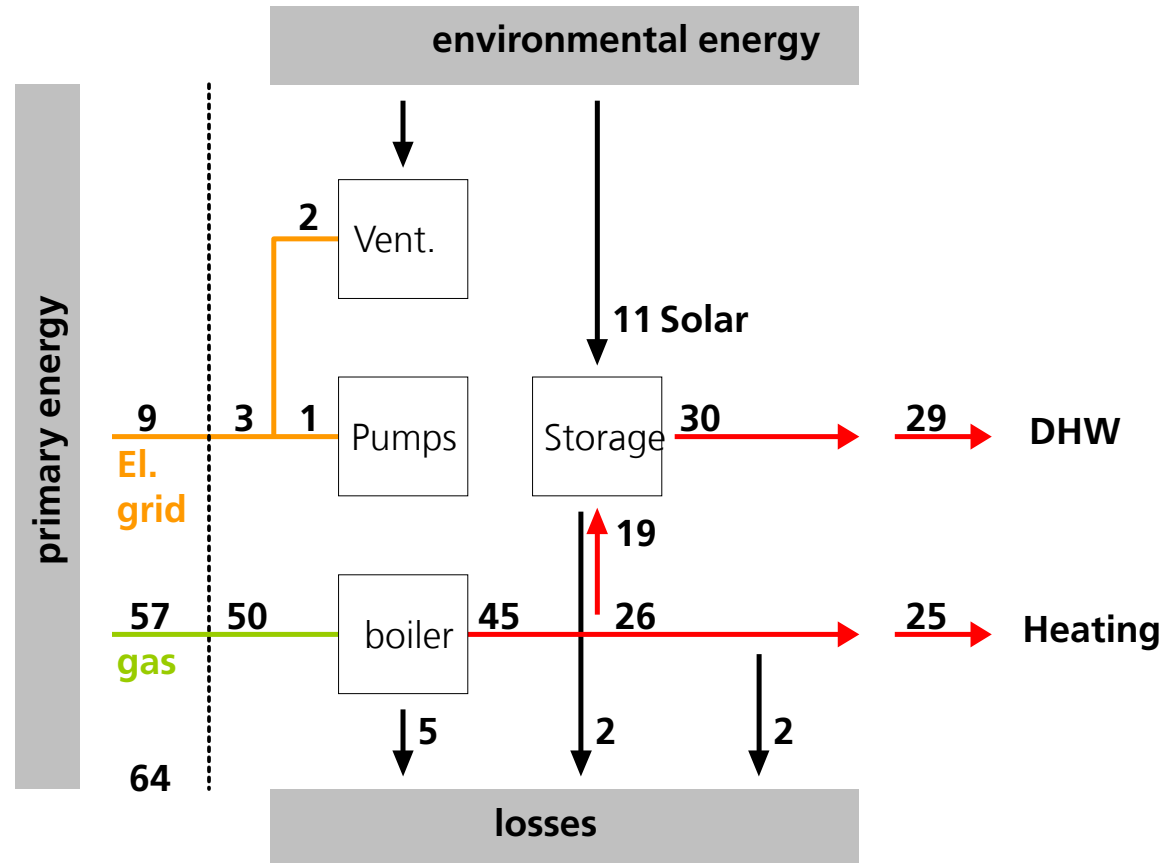
■ 64 kWh/m<sup>2</sup>y

■ (planned: 80 kWh/m<sup>2</sup>y)



# Energy flow – KfW 60

- Appr. same part DHW and Heating
- Solar contribution ~ 11 kWh/m<sup>2</sup>a
- Overall losses ~ 10 kWh/m<sup>2</sup>a
- Hot water consumption underestimated 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: 3375m<sup>2</sup>

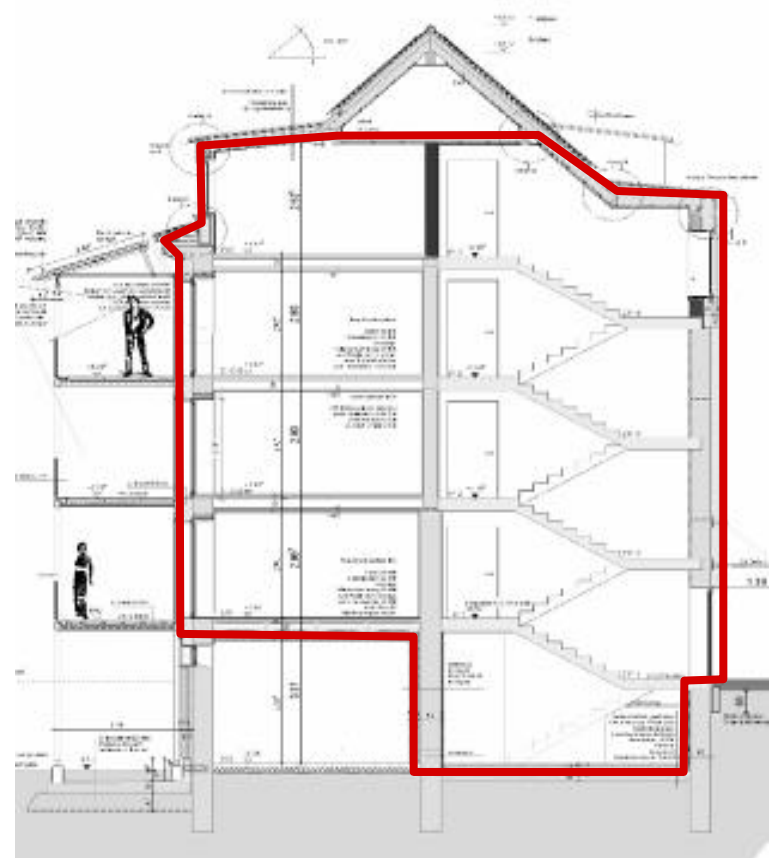
No. of flats : 40



# Concept – building envelope

## Blaue Heimat

- Insulation of external wall, roof and floor to basement
- Windows: triple - glazing
- Transmission losses  
 $HT' = 0,31 \text{ W/m}^2\text{K}$
- 200% insulation of distribution pipes:  
reduced losses compared to building code



# Concept – energy supply

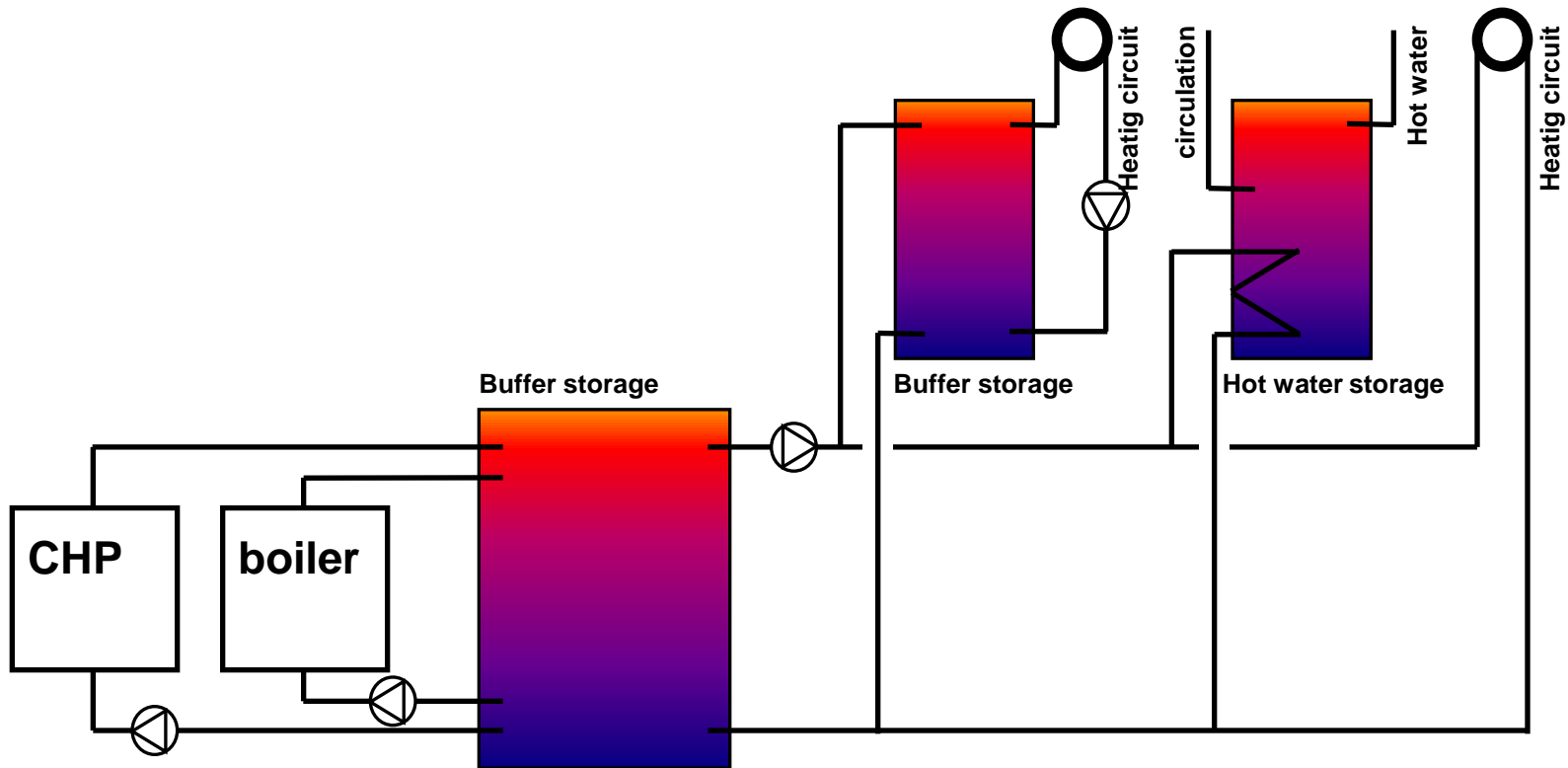
## Blaue Heimat

- Natural gas-based CHP 50 kW<sub>el</sub> / 80 kW<sub>th</sub>
- 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



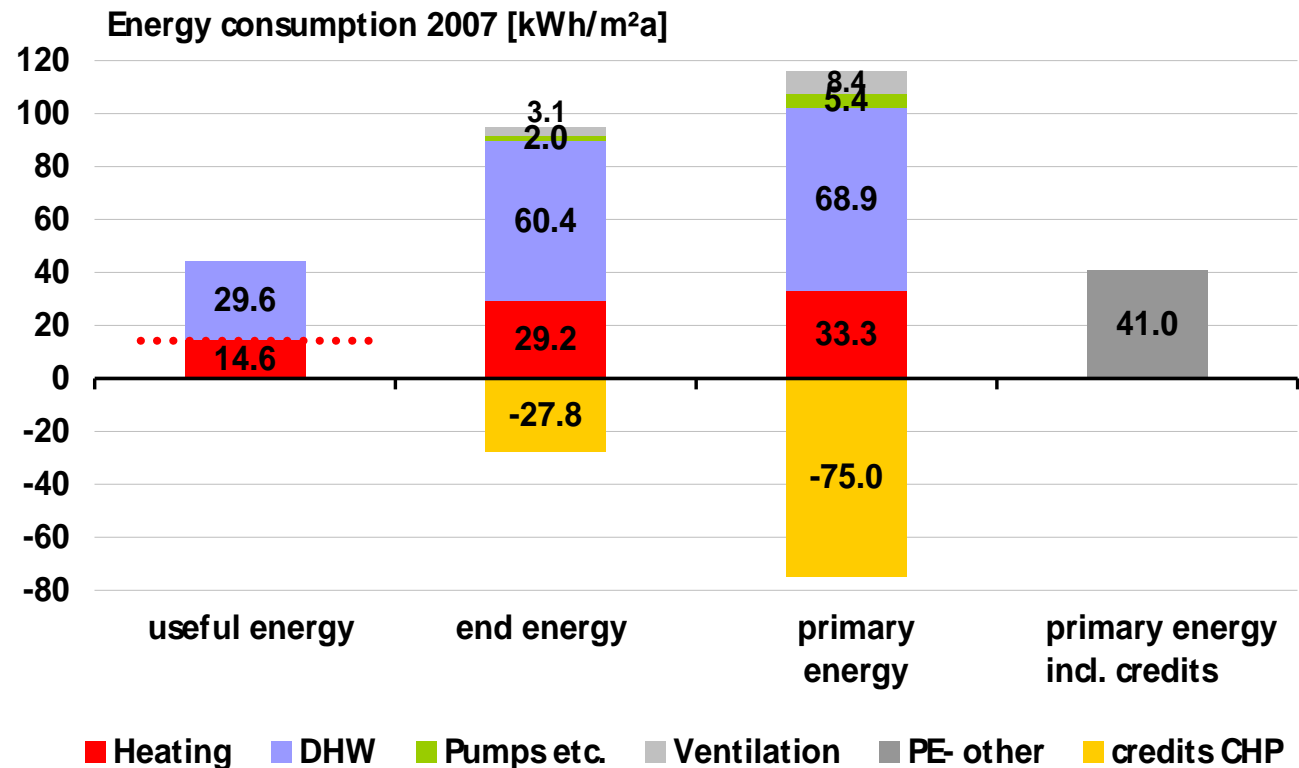
# Supply scheme

## Blaue Heimat



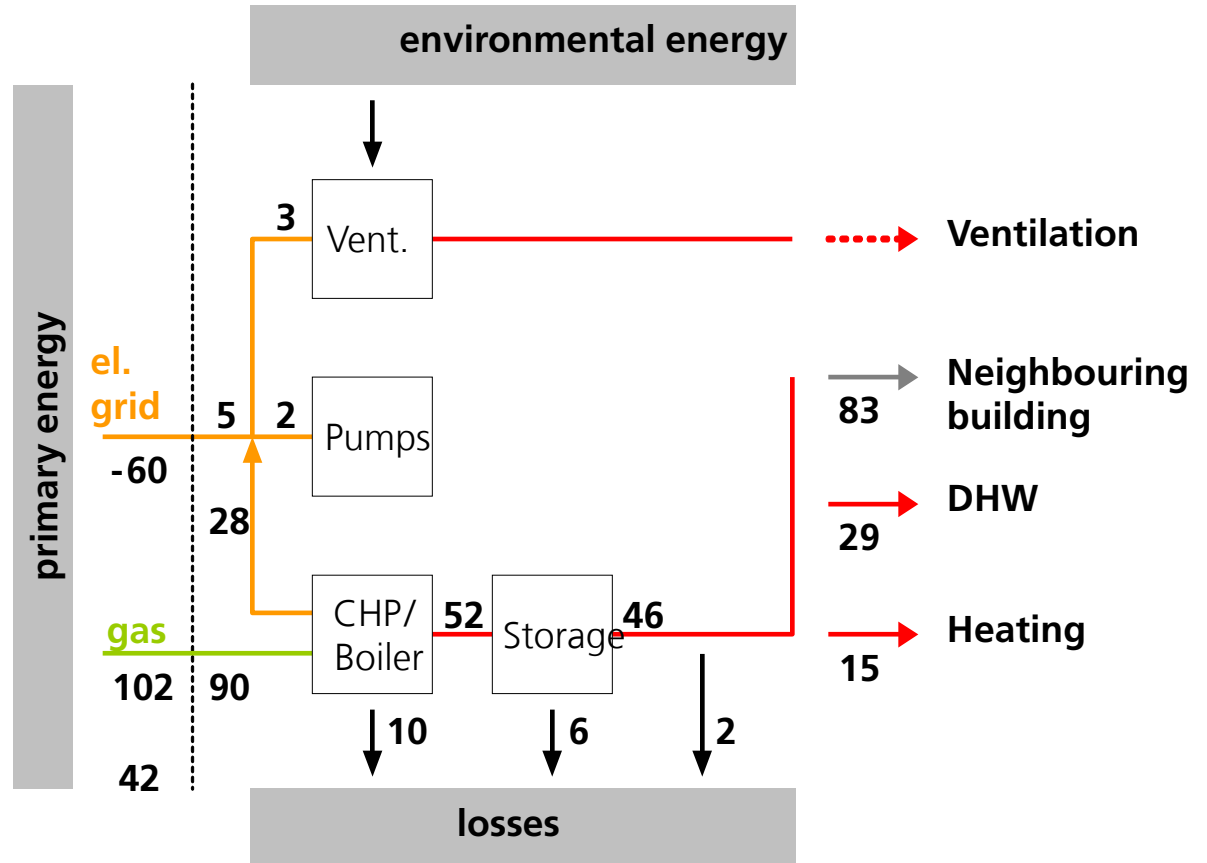
# Energy consumption Blaue Heimat

- 1/07 – 12/07
- Heating energy consumption achieves almost passive house standard
- CHP- credits: 75 kWh/m<sup>2</sup>a
- Net zero energy house not completely achieved



# 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)

[www.ise.fraunhofer.de](http://www.ise.fraunhofer.de)

[www.iea-task37.org](http://www.iea-task37.org)

# Thank you for your attention...



## Fraunhofer Institute for Solar Energy Systems ISE

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