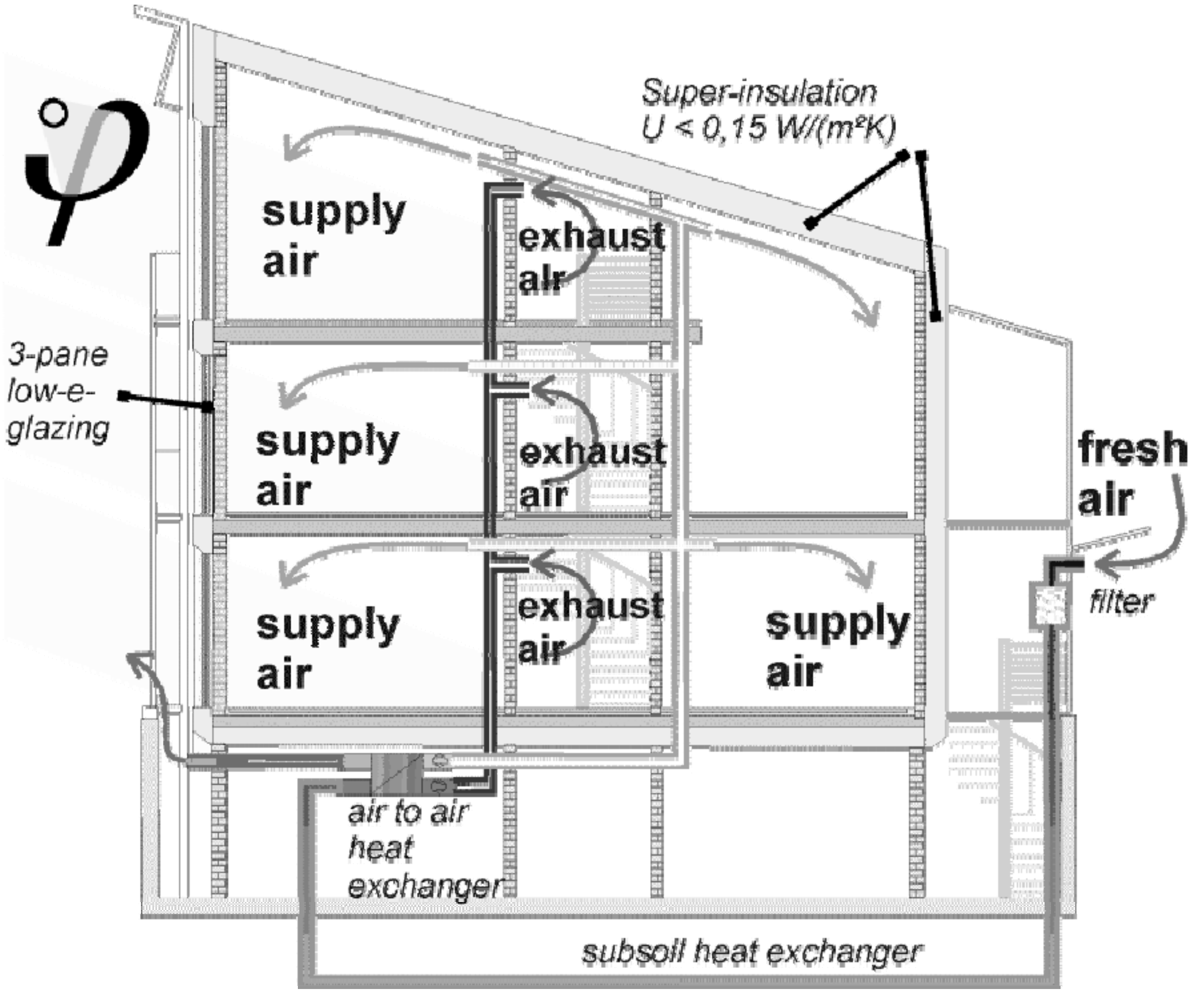
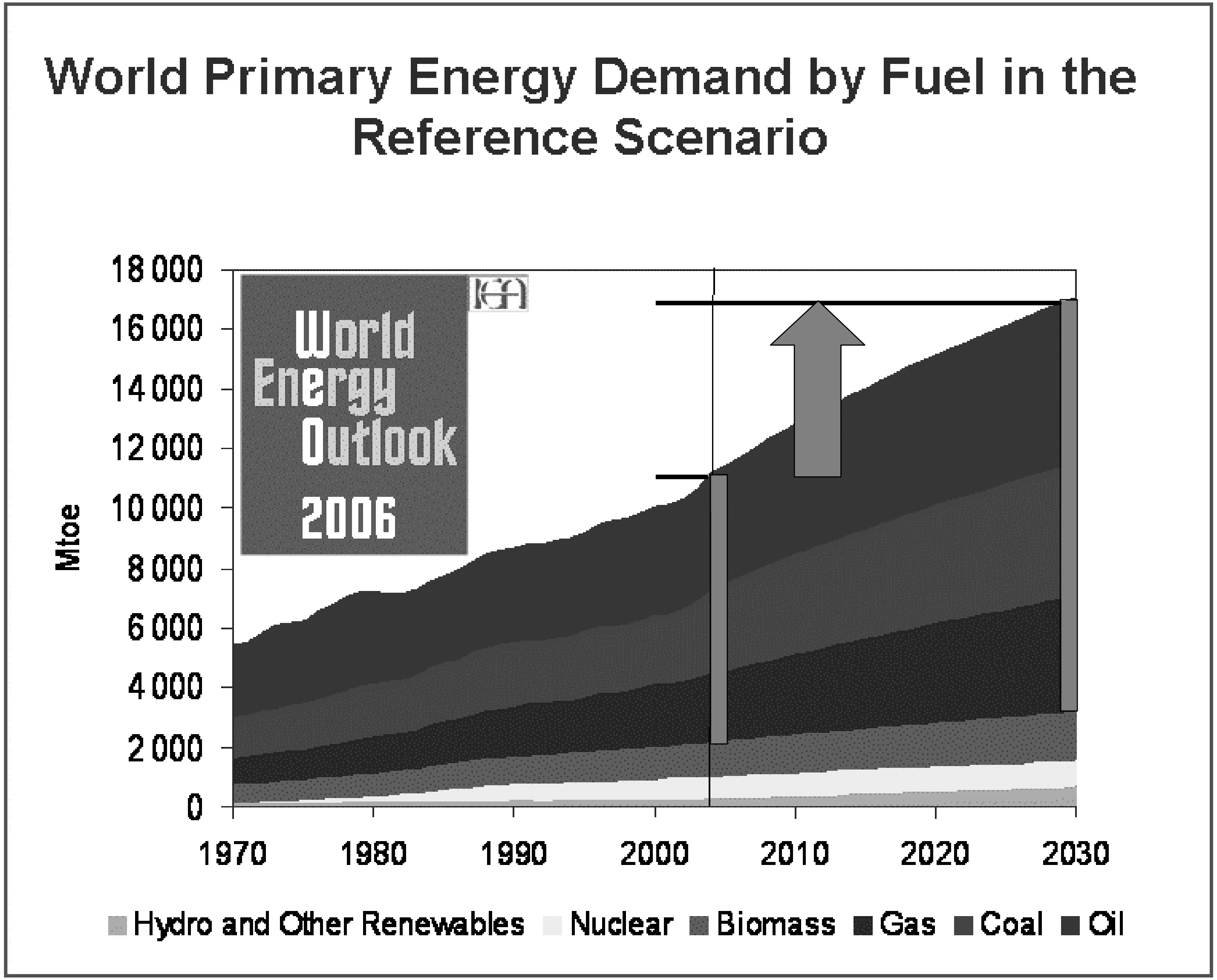
Energy Efficiency - a Key to Sustainable Housing



Jürgen Schnieders
Passivhaus Institut
Darmstadt

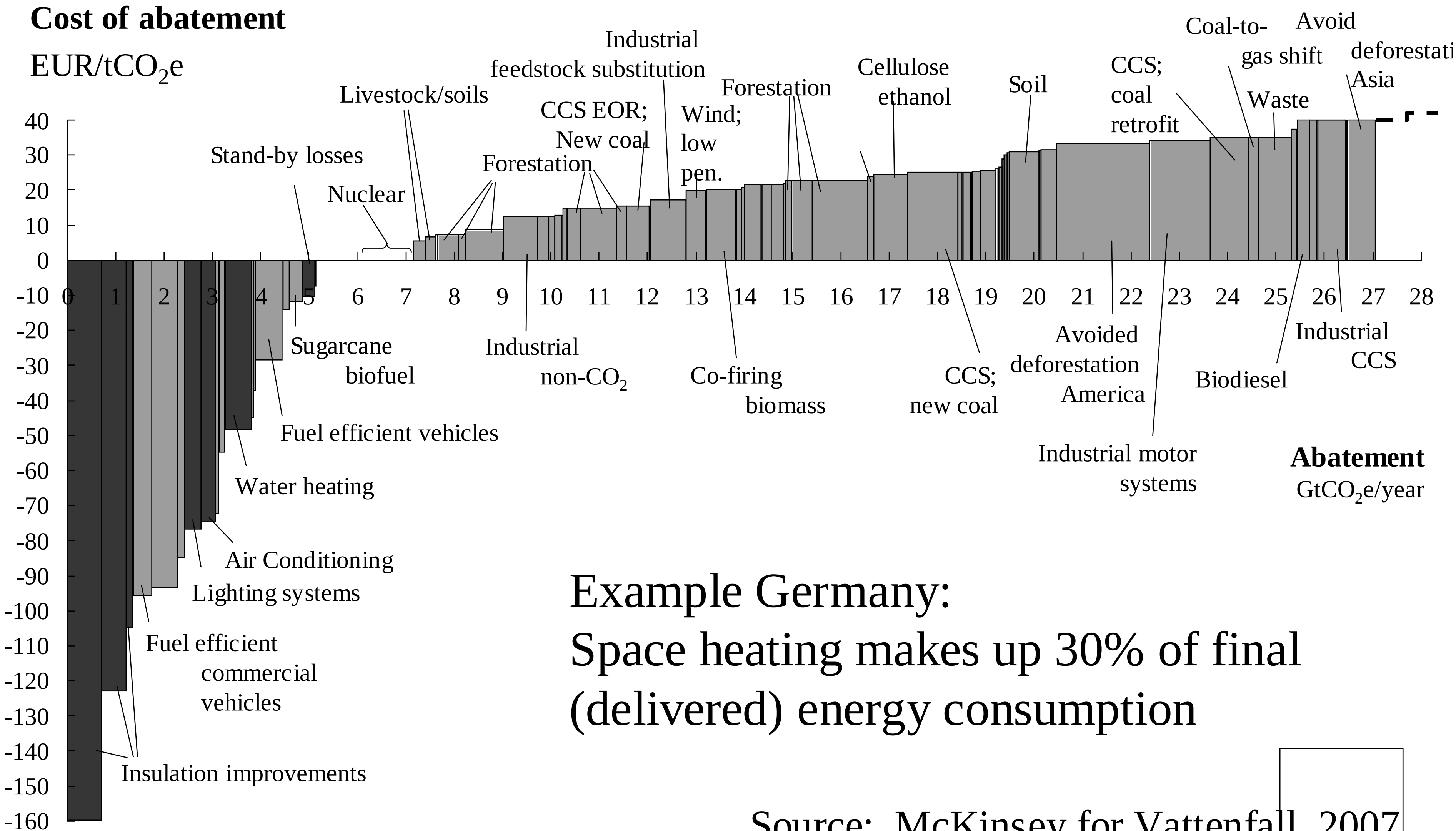
IEA world energy outlook 2006 Reference-Scenario

Fossil
+50%



Efficiency/Conservation in the global cost curve of GHG abatement

2030



Example Germany:
Space heating makes up 30% of final (delivered) energy consumption

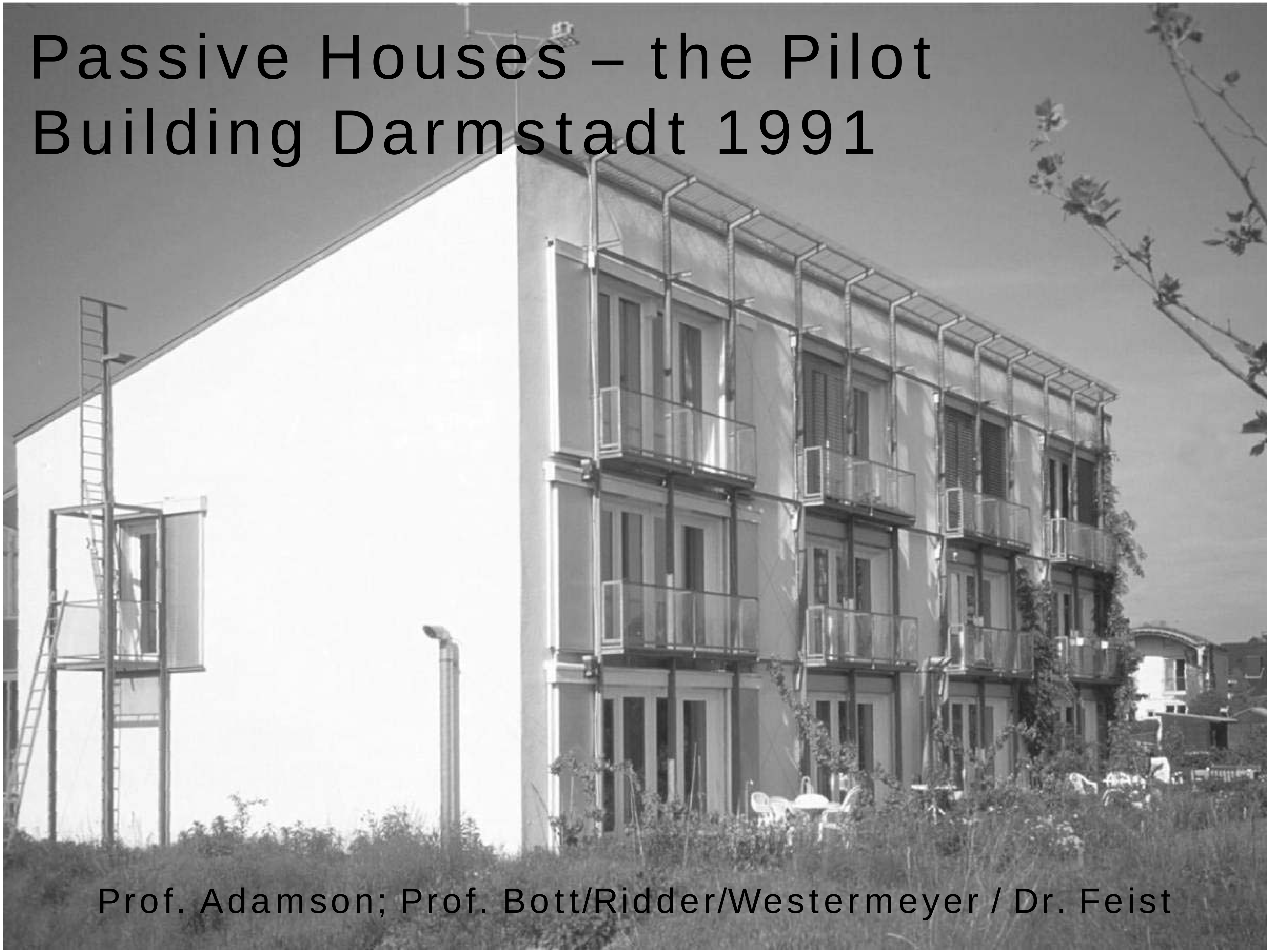
Source: McKinsey for Vattenfall, 2007

„1974 Helga Henriksson, 72 years old and a retired needlework teacher, wanted to be a pioneer by building a house which could be a model for people who were building other new homes. This example would have a composting toilet and solar roof instead of an oak kitchen and Jacuzzi - bath. EFEM architects and myself designed the house with 42 square meters of solar collectors, a heat storage of 50 cubic meters, a heat pump in order to make domestic hot water and 24 automatic valves to manage the air-flow."

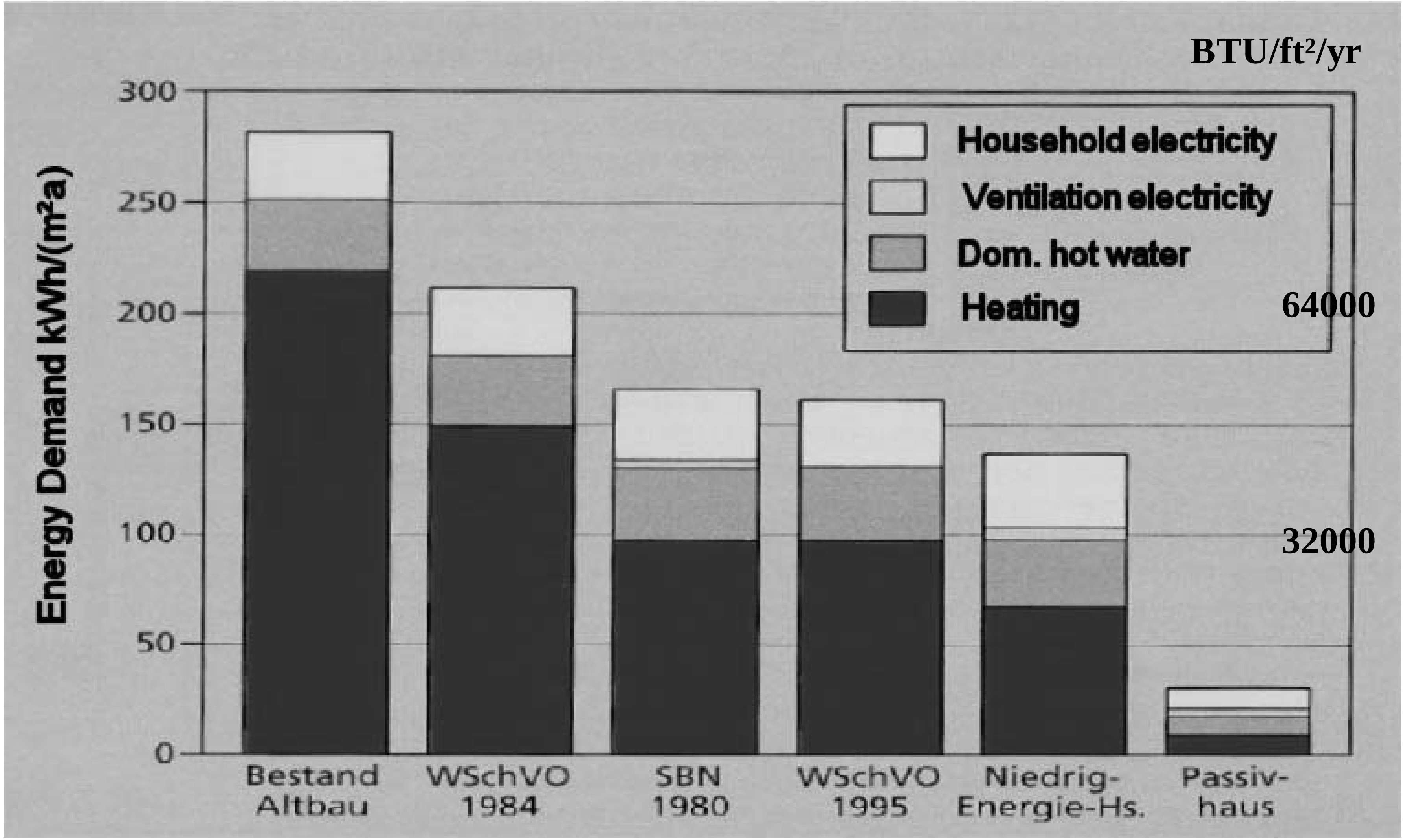
Hans Eek, Göteborg

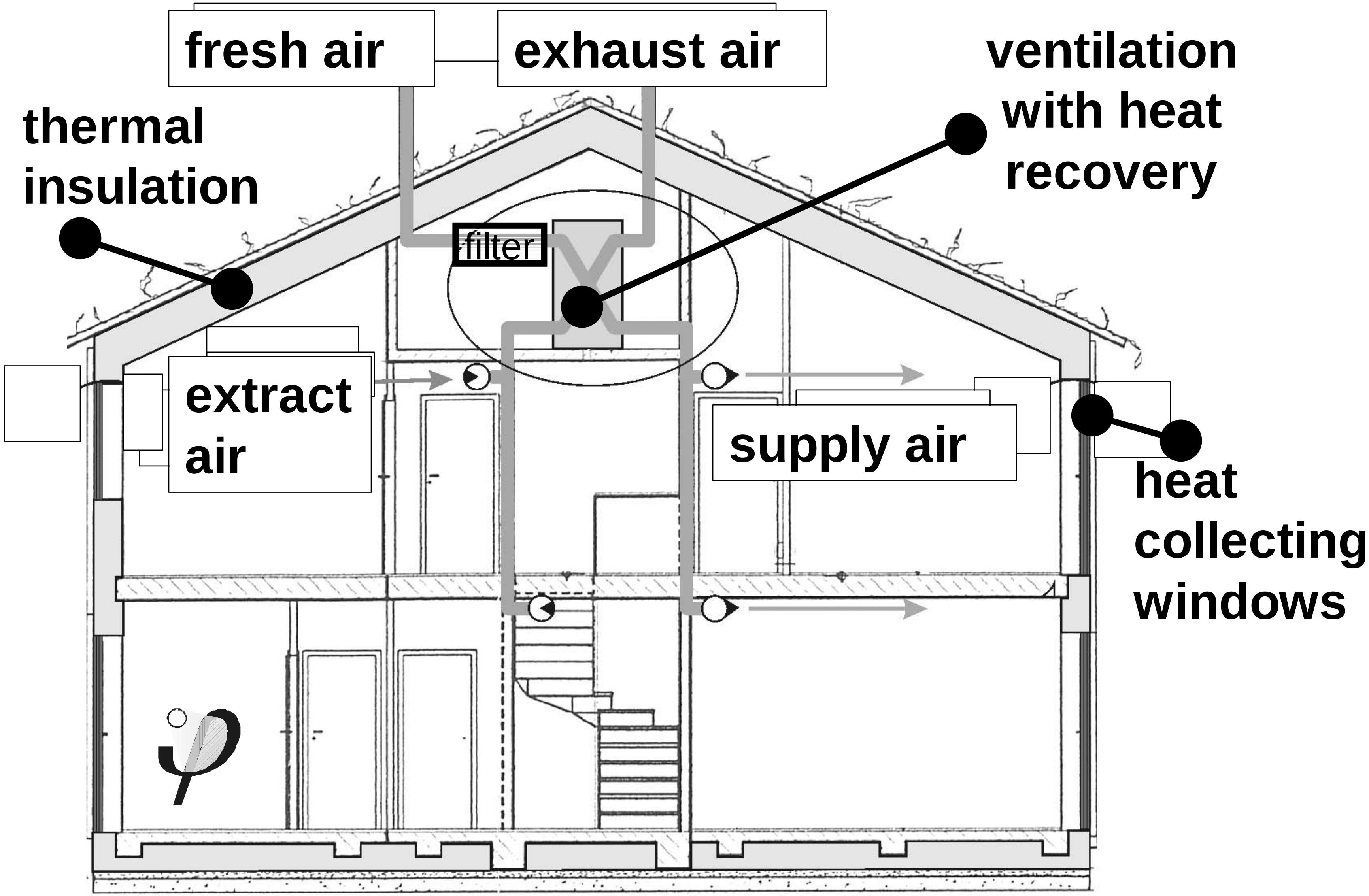
„The house did not work at all. It was a Christmas tree for engineers."

Passive Houses – the Pilot Building Darmstadt 1991

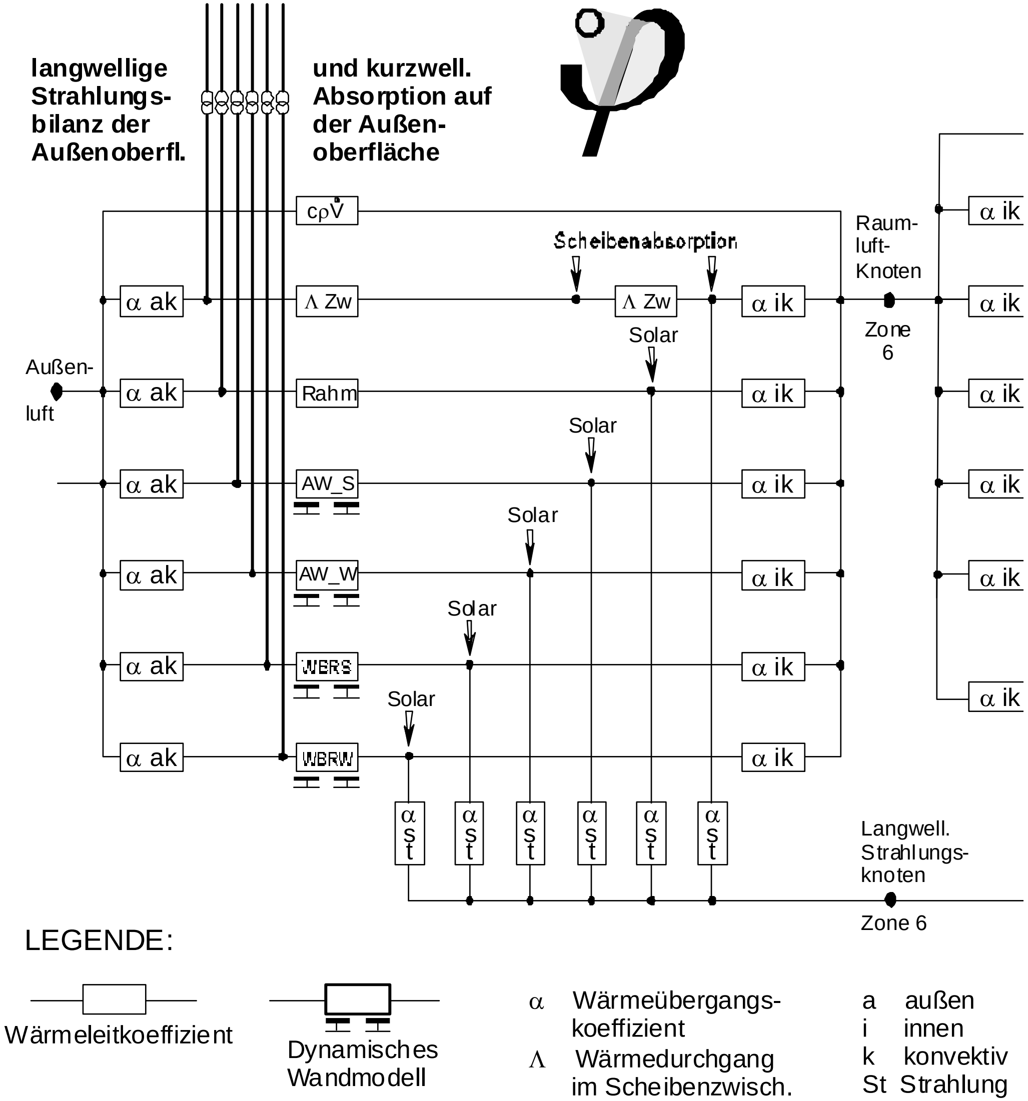


Prof. Adamson; Prof. Bott/Ridder/Westermeyer / Dr. Feist

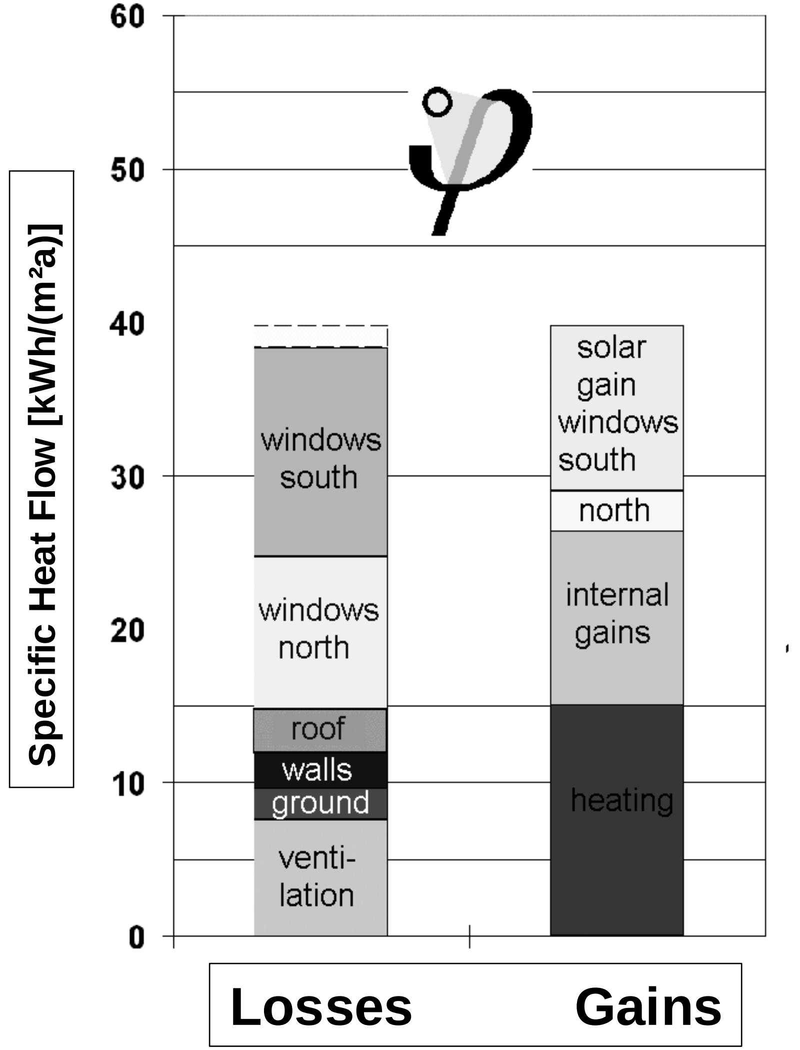

BTU/ft²/yr
300
250
200
150
100
50
0
Energy Demand kWh/(m²a)
Household electricity
Ventilation electricity
Dom. hot water
Heating
64000
32000
Bestand Altbau
WSchVO 1984
SBN 1980
WSchVO 1995
Niedrig-Energie-Hs.
Passiv-haus


fresh air
exhaust air
ventilation with heat recovery
thermal insulation
filter
extract air
supply air
heat collecting windows

Design by dynamic thermal simulation



Energy balance method



Dynamische Wandmodelle sind in 4 bis 8 Schichten mit Kapazitäten und

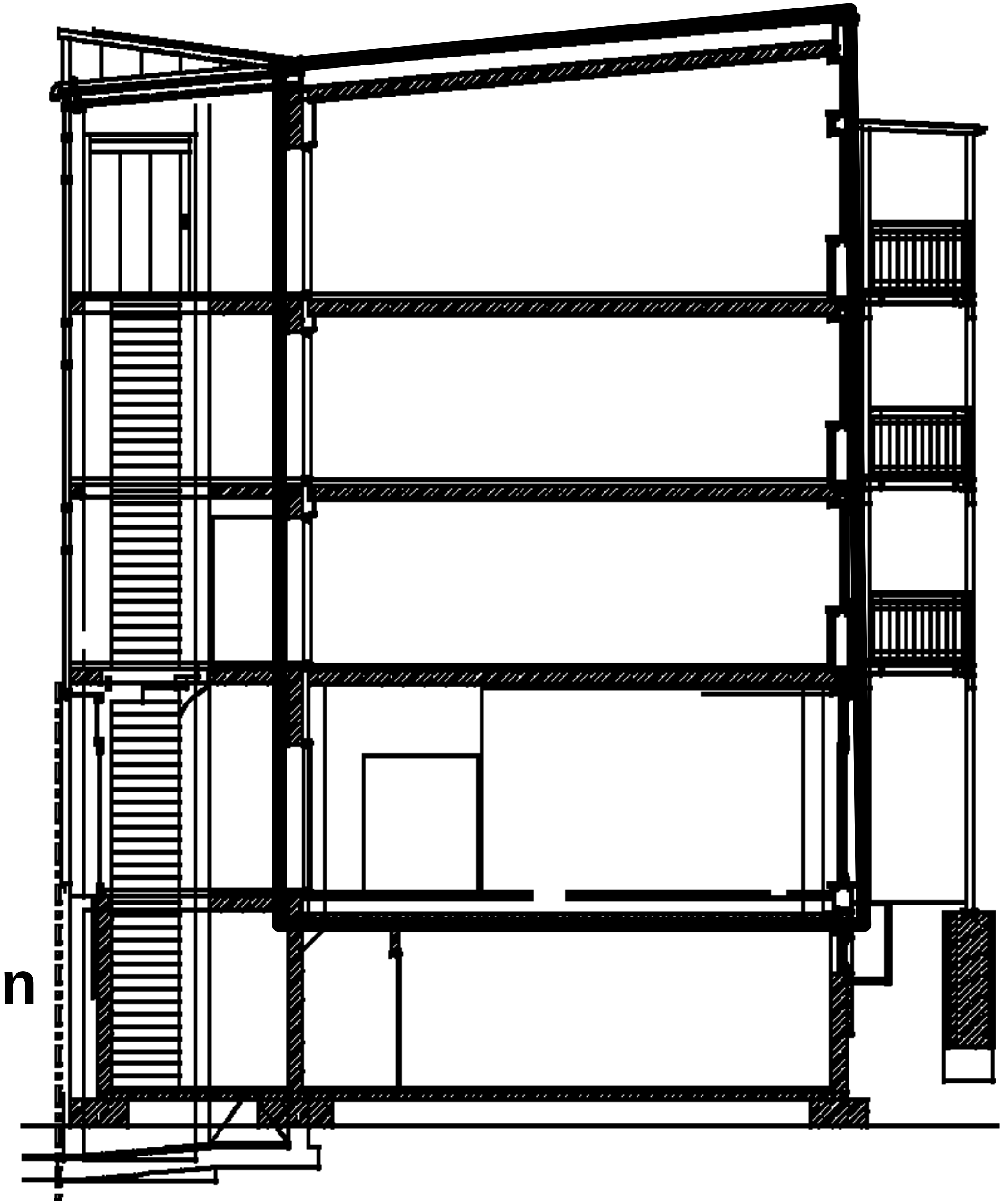
Energy balance requires system boundary

thermal envelope

= boundary of the energy balance

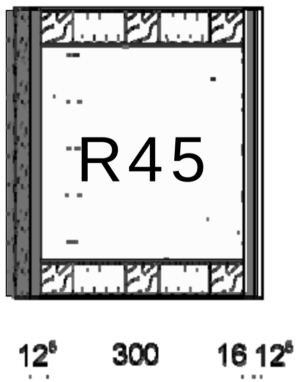
= layer of insulation

= layer of consideration



Details of Passive Houses

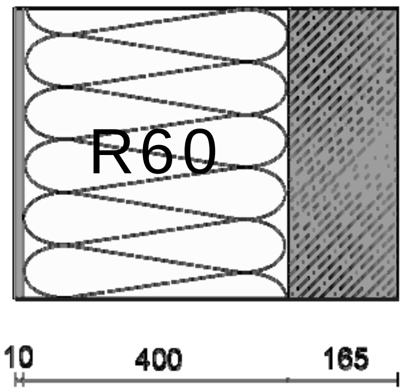
Outer wall (south and north facade)



Prefabri-cated lightweight wood element

U = 0,126 W/(m²K)

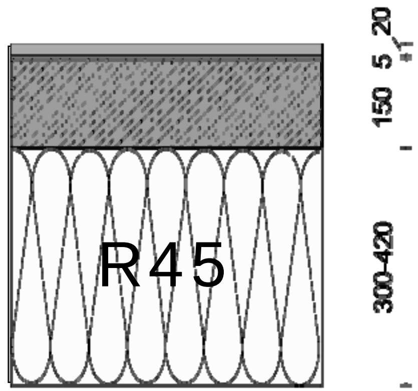
Outer wall (gable side)



Concrete with ETHICS

U = 0,097 W/(m²K)

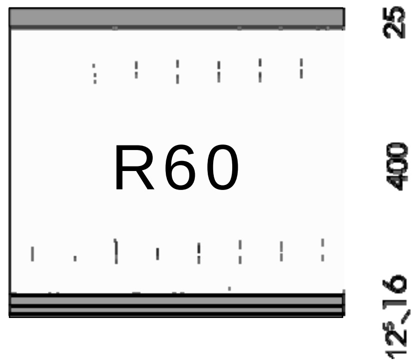
floor slab



Concrete with insulation

U_m=0,125
U_e=0,091
W/(m²K)

roof

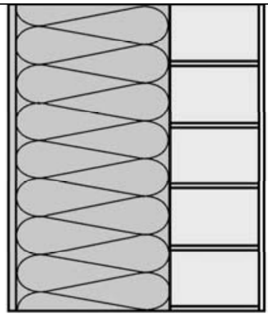


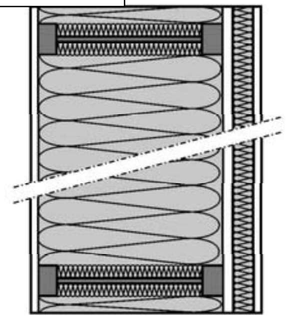
Lightweight with I-studs

U_r=0,095 W/(m²K)

Insulated Building Envelope

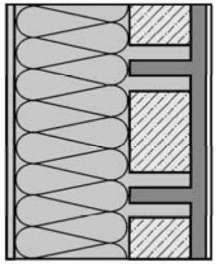
U = 0.13 W/(m²K) (R 40)

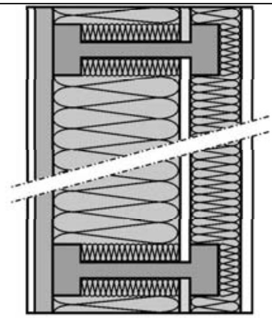




Ethics:
external thermal insulation

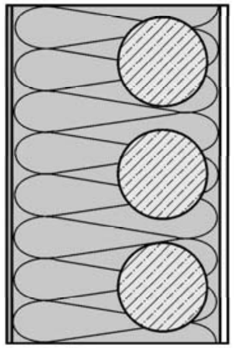
timber frame construction

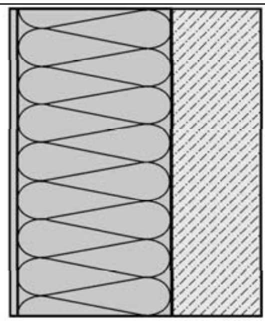




Insulating concrete form

timber frame using special studs

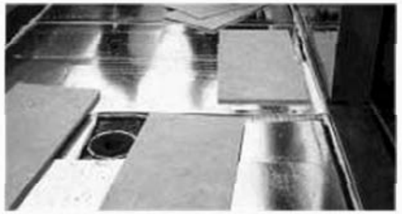




prefabricated wall I

prefabricated wall II

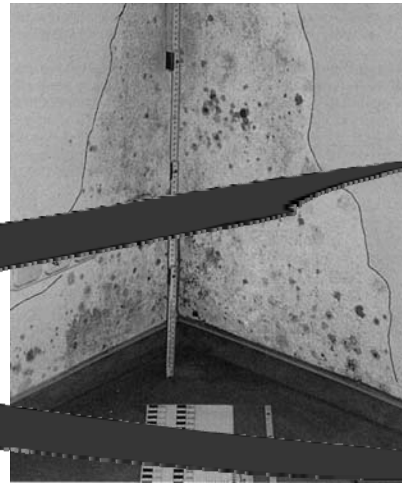
in future vacuum insulation



type I during construction at Wolfurt

type II stainless steel. At the passive house Zwingenberg

Thermal bridge free design - not a dogma, but makes live easier



Thermal bridges with s[illegible]e temper[illegible]es below dew point

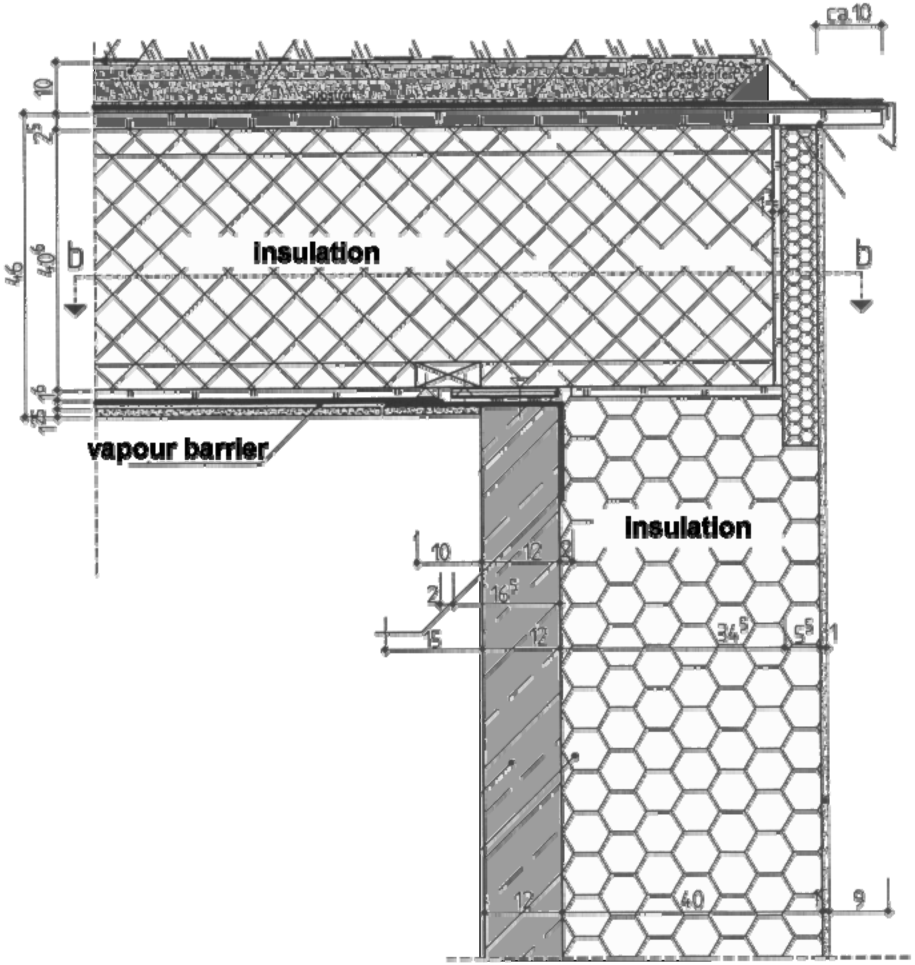
... do not exist in a Passive House

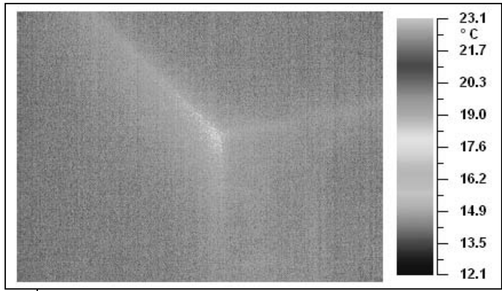
Thermal bridge free design: calculation with thermal bridges neglected is conservative

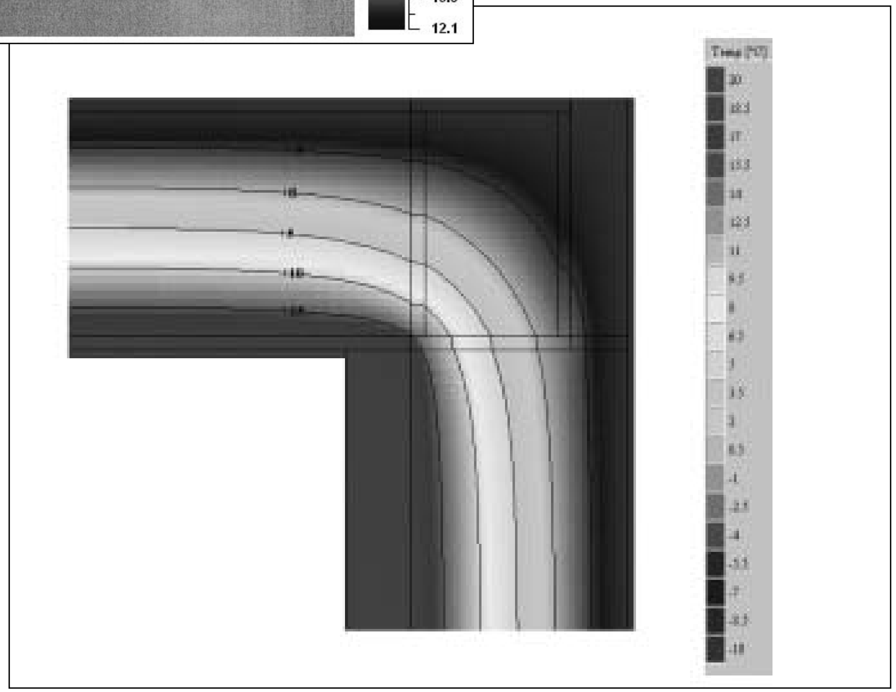
If not: Calculate! Take into acount! Compensate !

Junctions without Thermal Bridges in the Passive House

roof / end of the row / verge

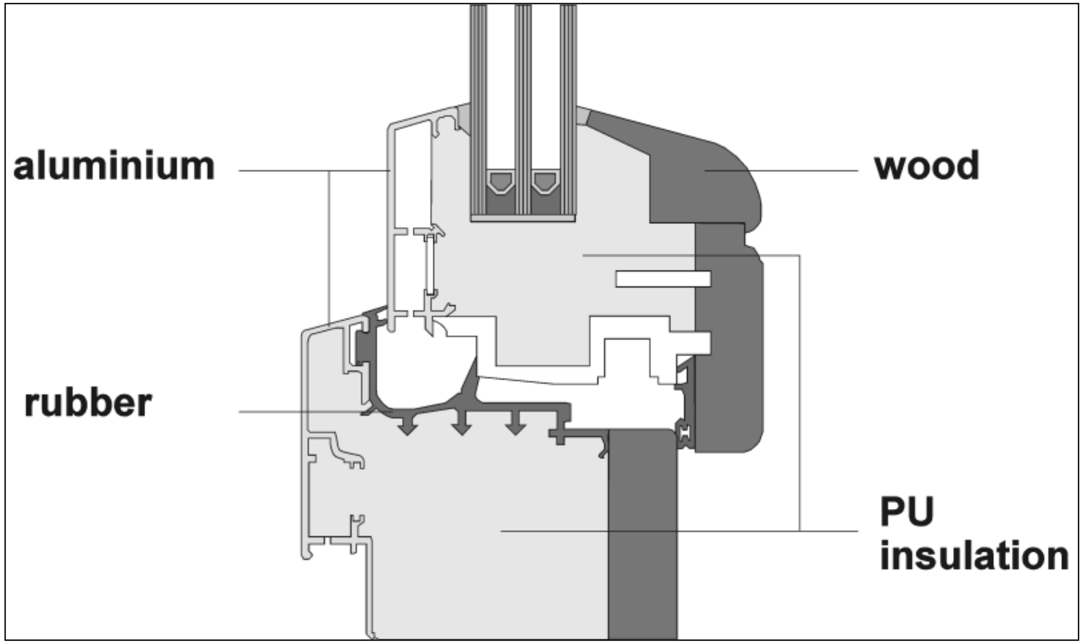






Ψ = -0.055 W/(mK)

Details Window: Passive House



glasing: U_g = 0,75 W/(m²K)
g=60%

spacer: Ψ_g = 0,03 W/(mK)

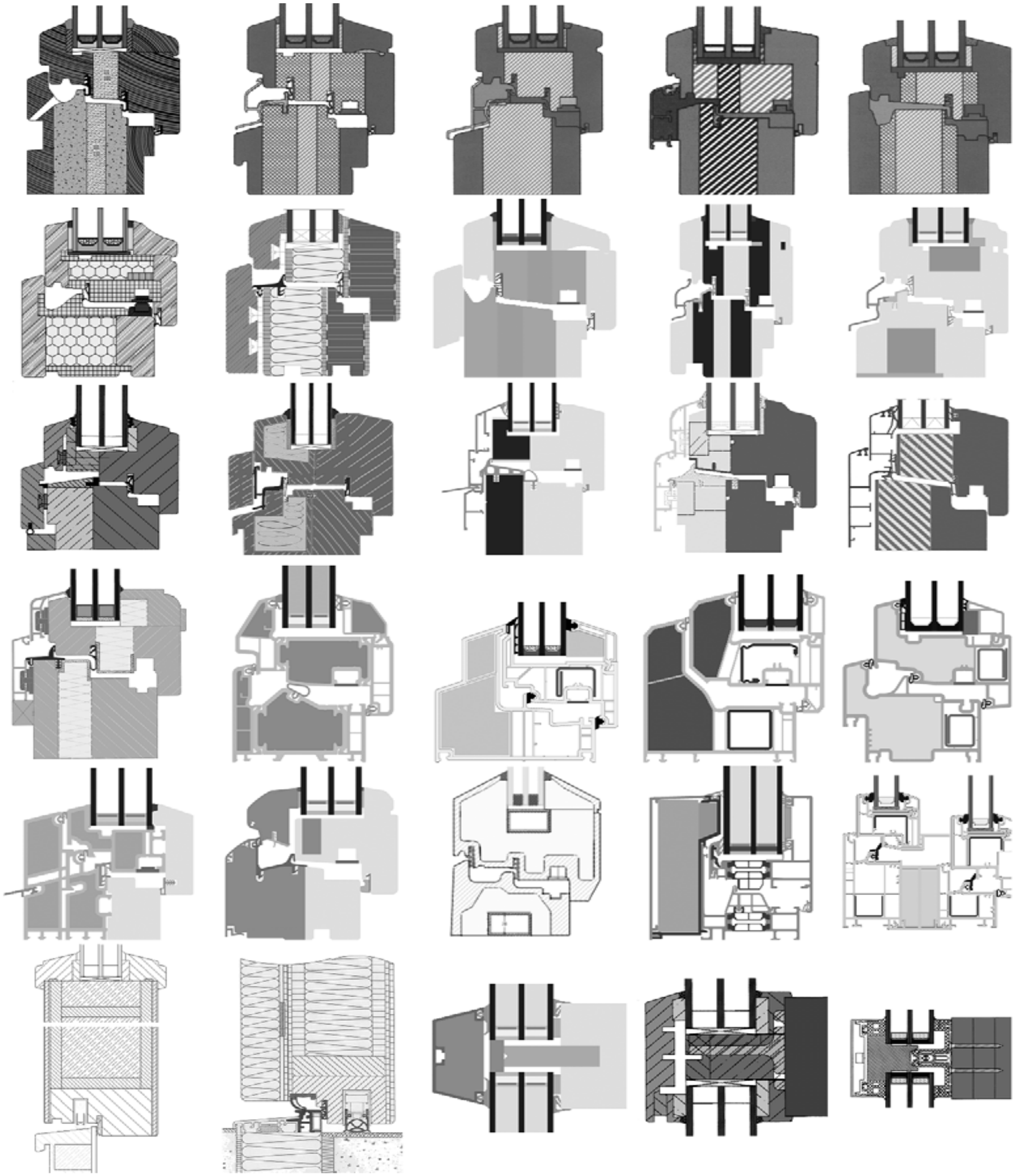
frame: U_f = 0,57 W/(m²K)

junction: Ψ_j = 0,03 W/(mK)

USA: R7

Window EN 10077 overall: U_w = 0,83 W/(m²K)

Superinsulated Windows: More than glazing



U_w not higher than

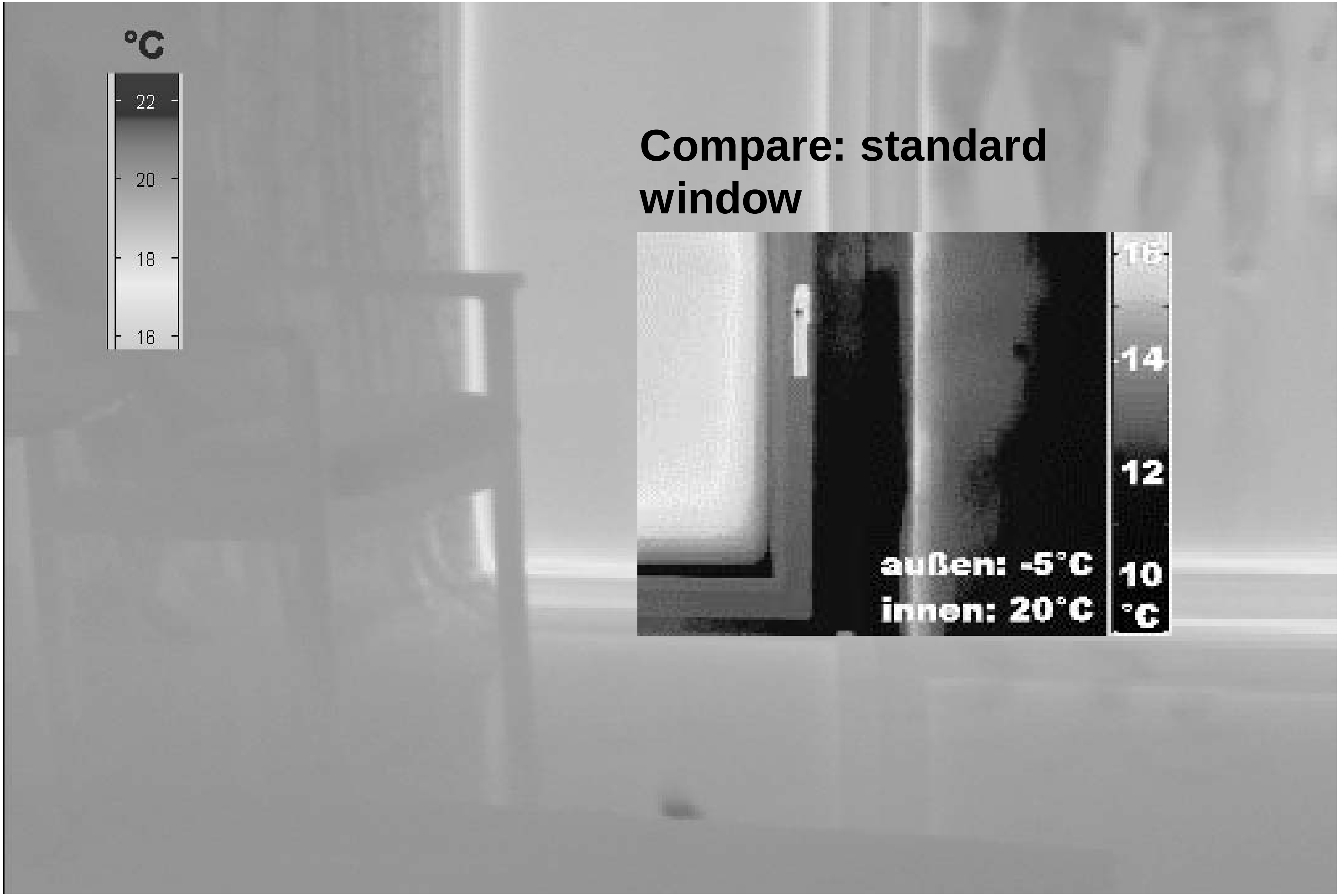
0.8 W/(m²K)

(R-7)

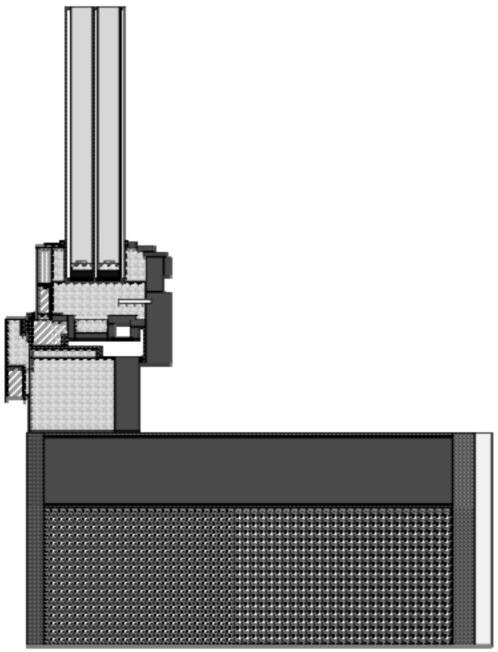
Innovative Products:

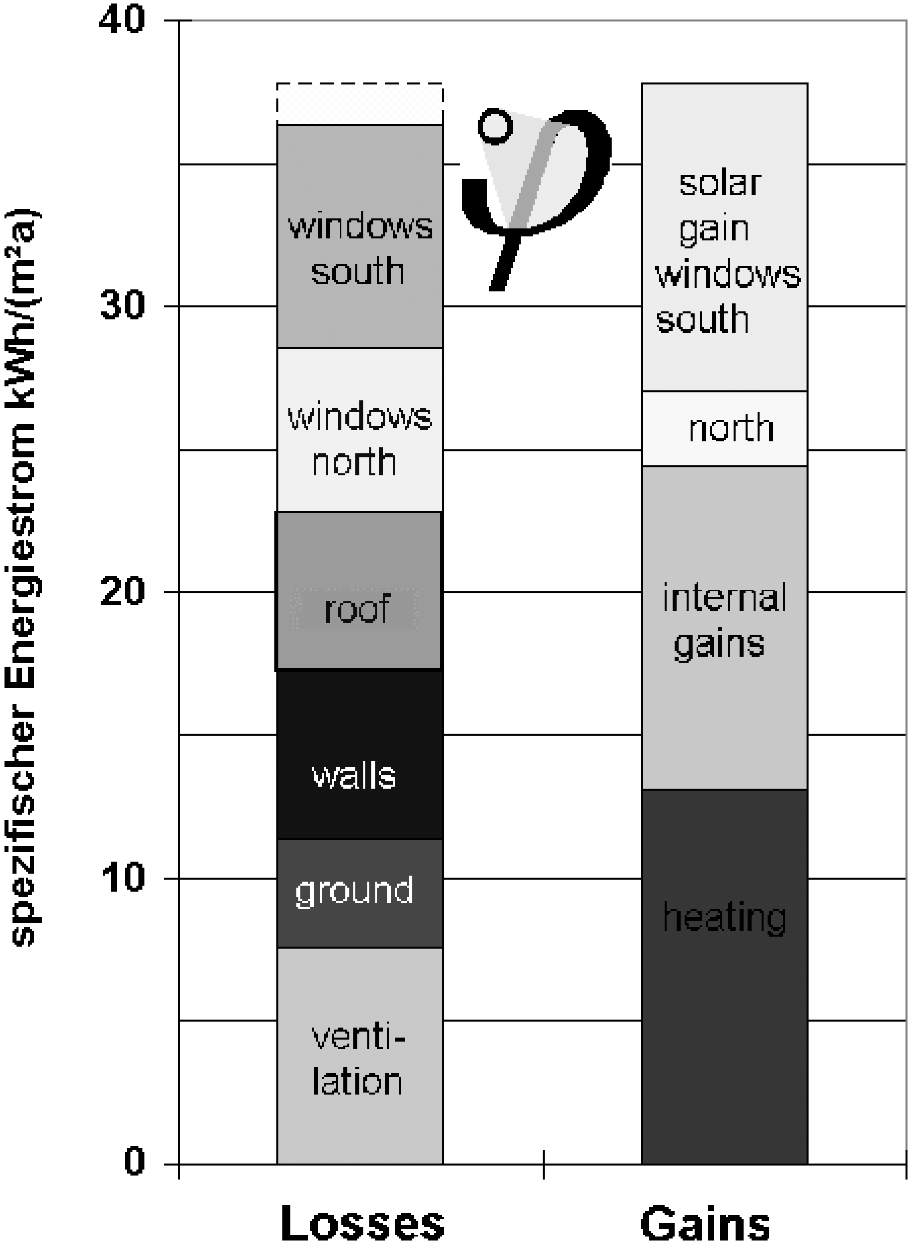
- **CO_2 mitigation**
- **improved comfort**
- **job creation in small and medium enterprises**

PH-Windows - Thermal Comfort Included



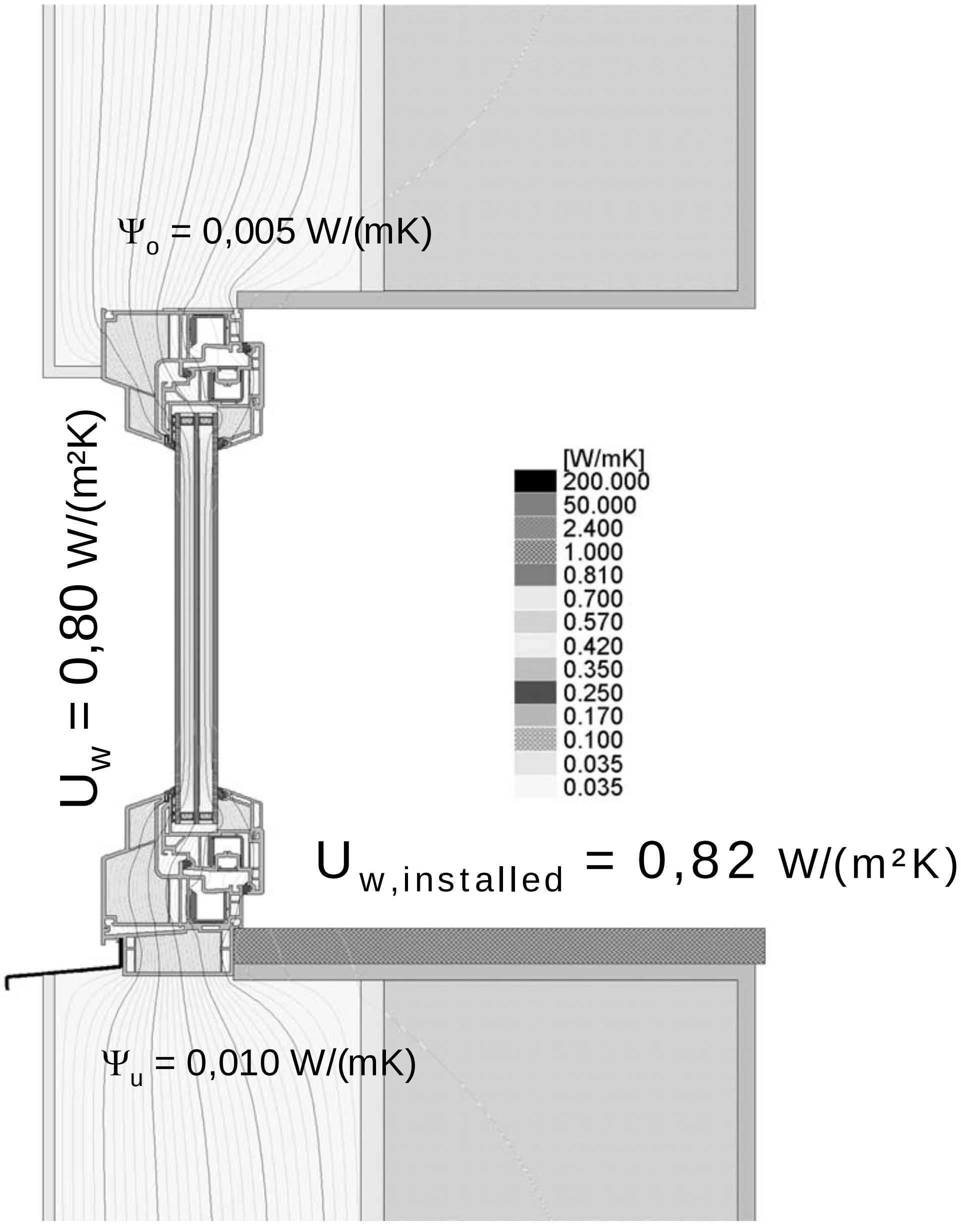
Designing Passive Houses:
Mind the details

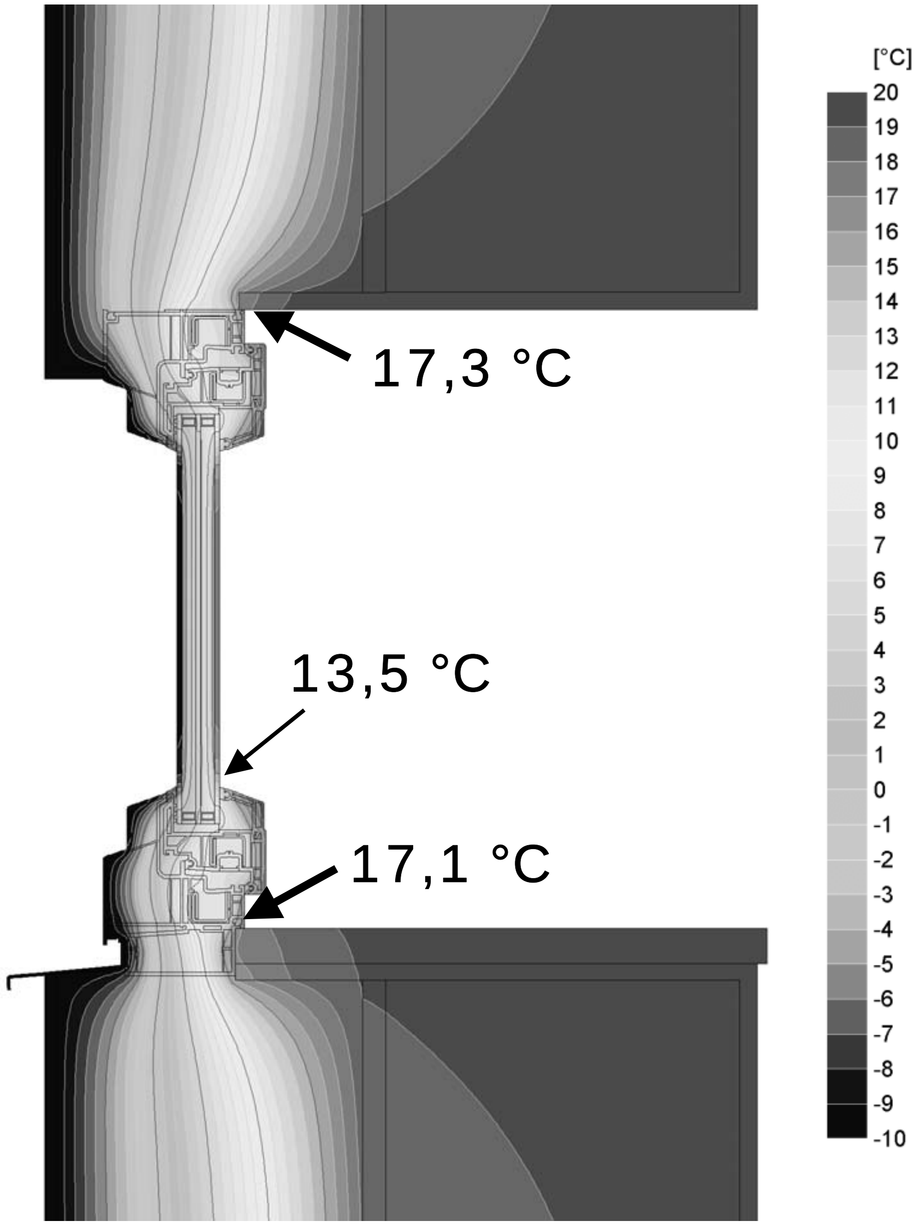




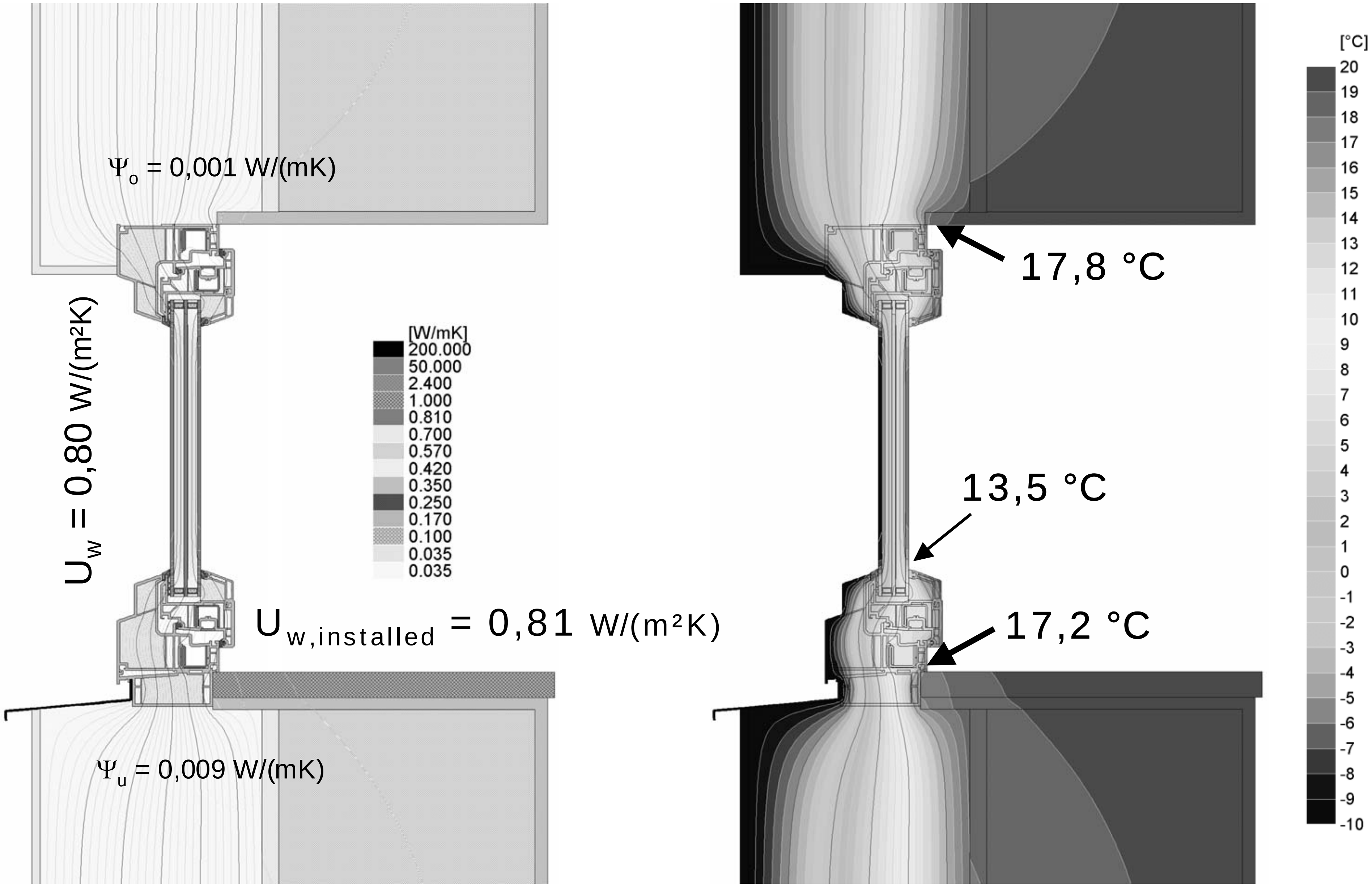
window frame edge external aligned

Installation - outside

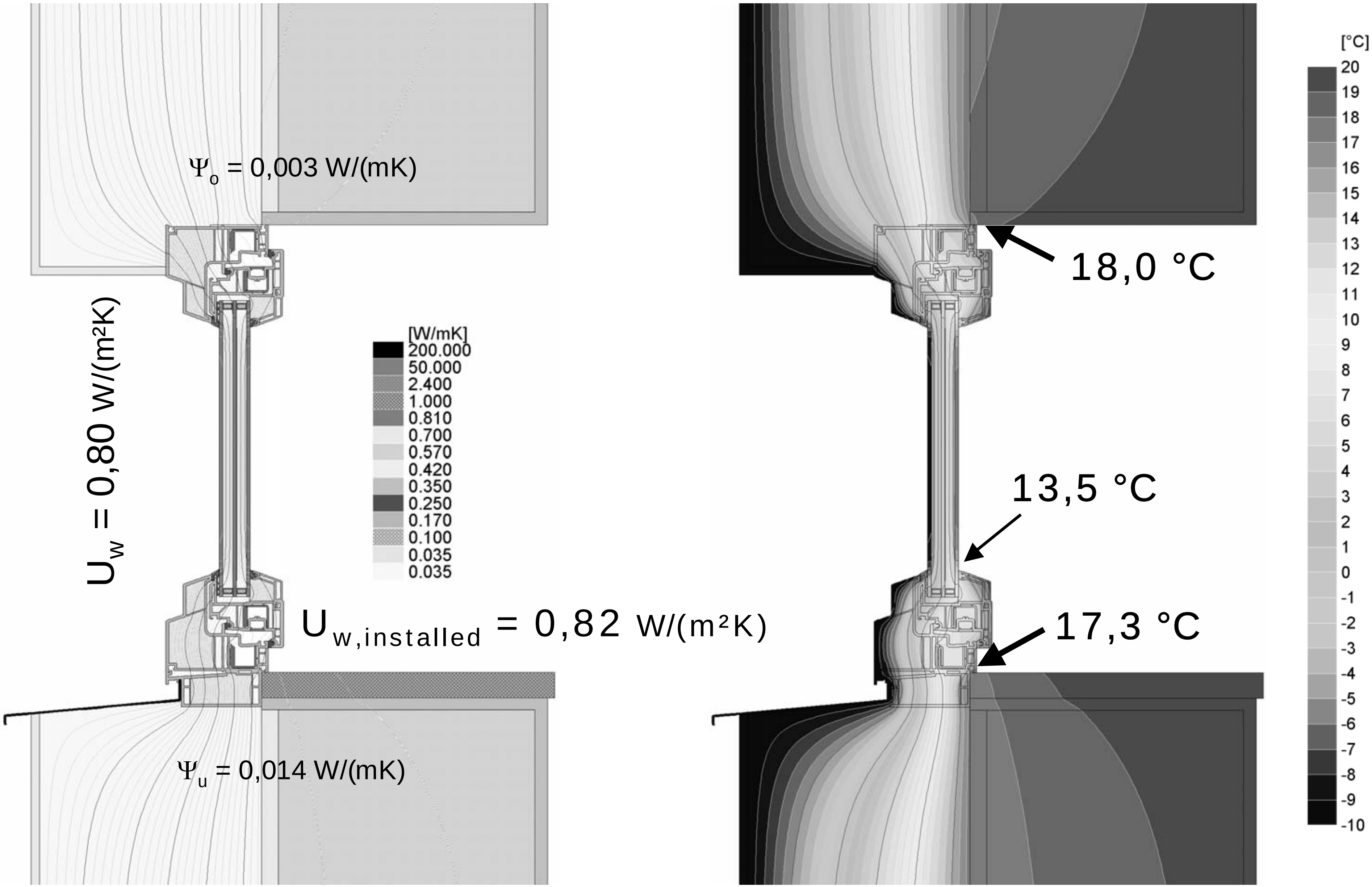




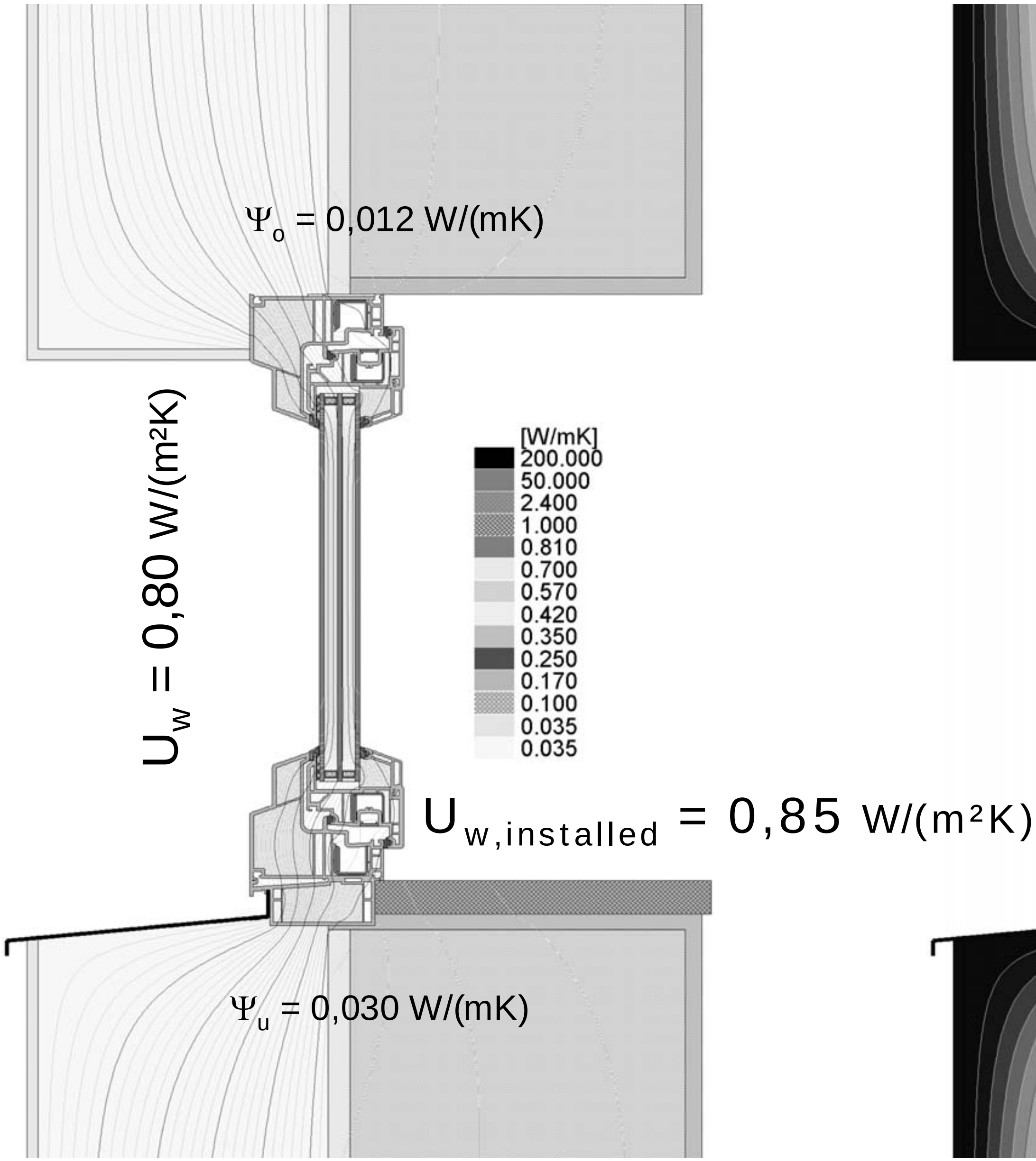
Installation - center

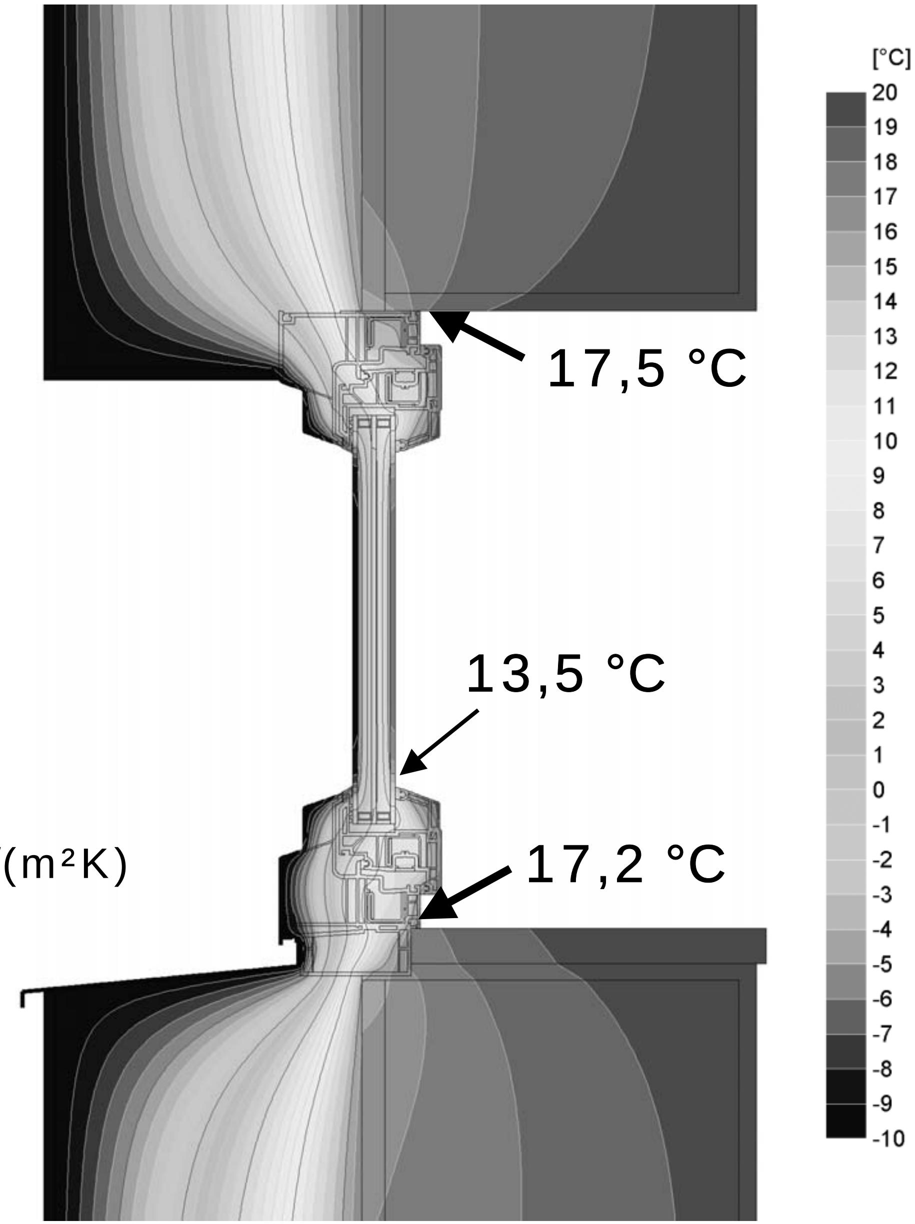


Installation - outside masonry

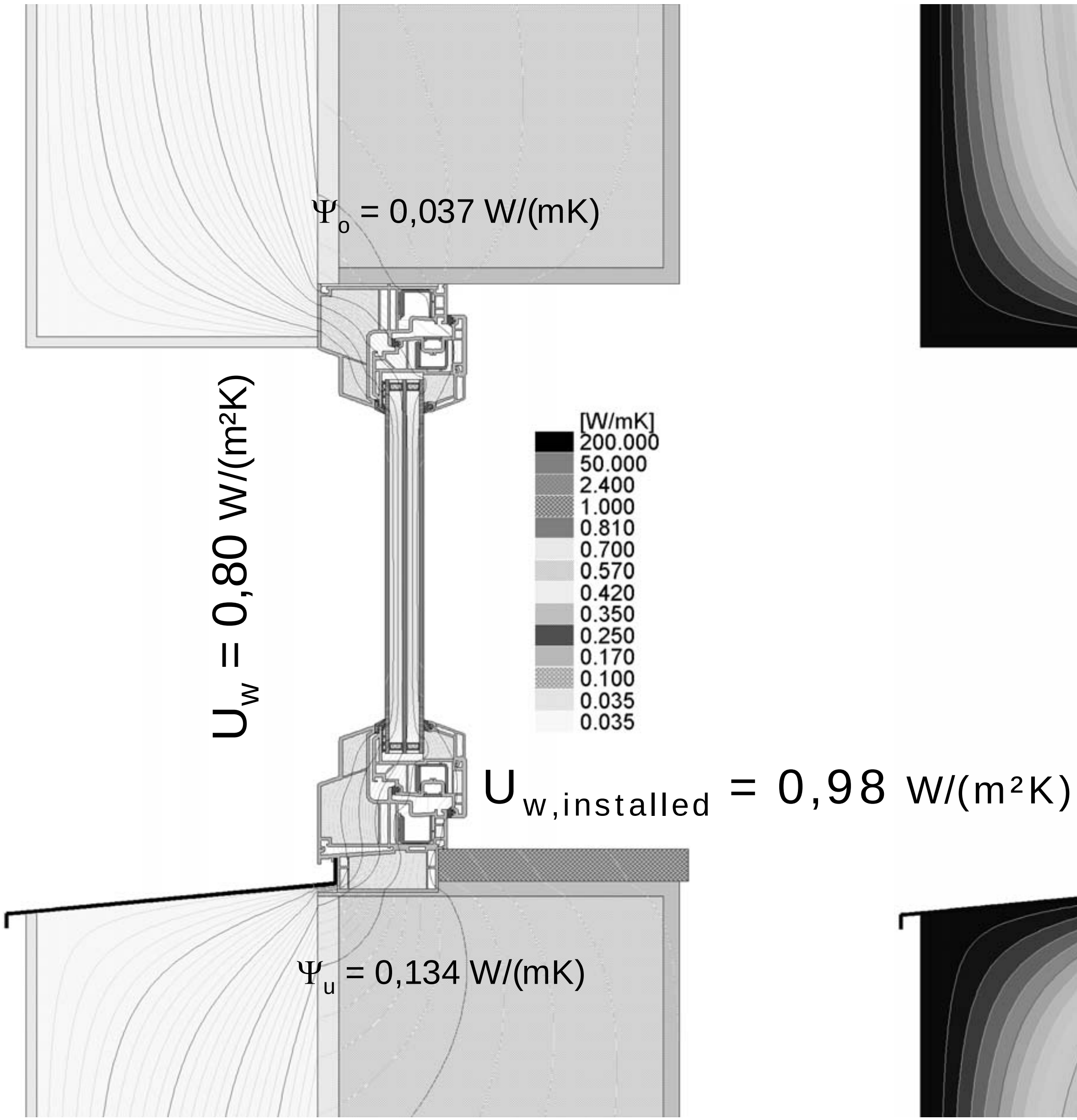


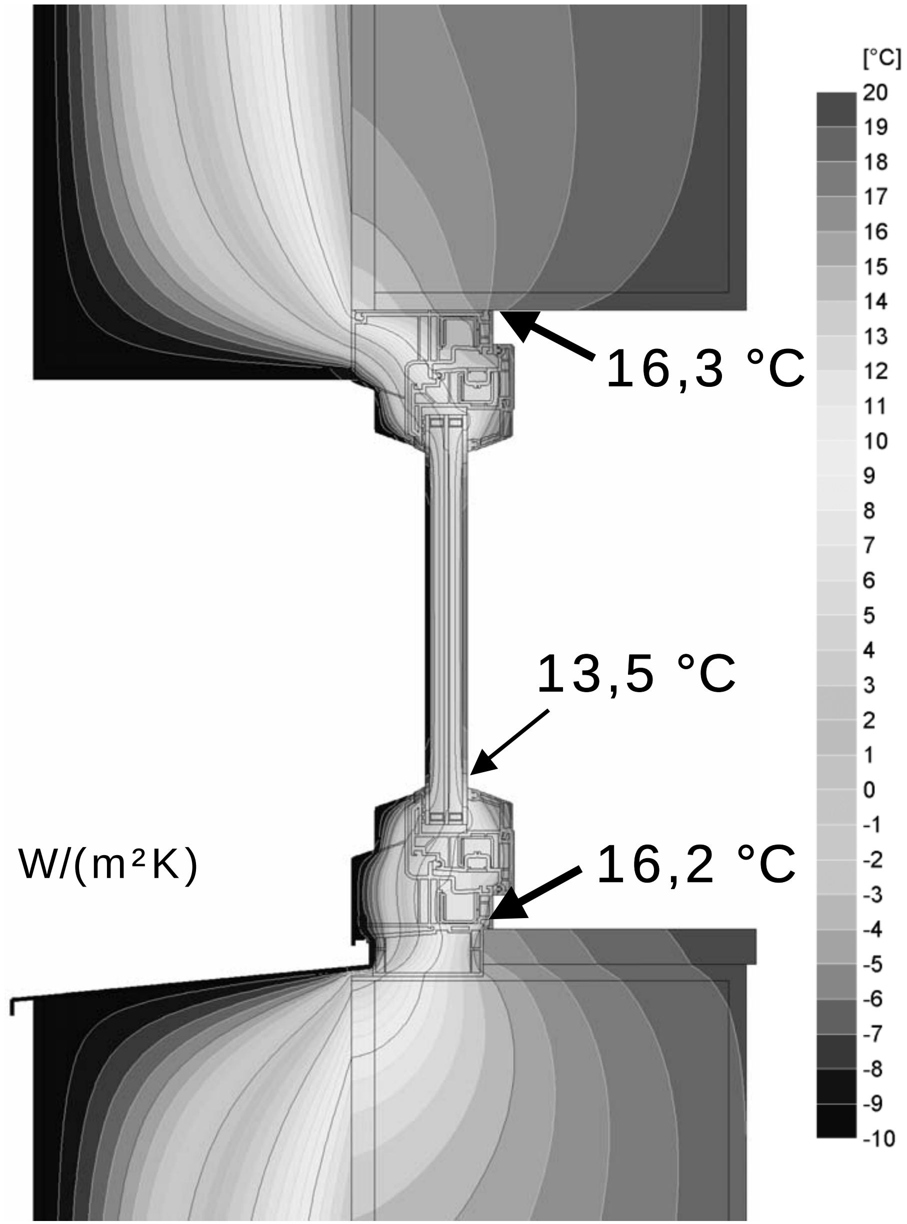
Installation - 50/50



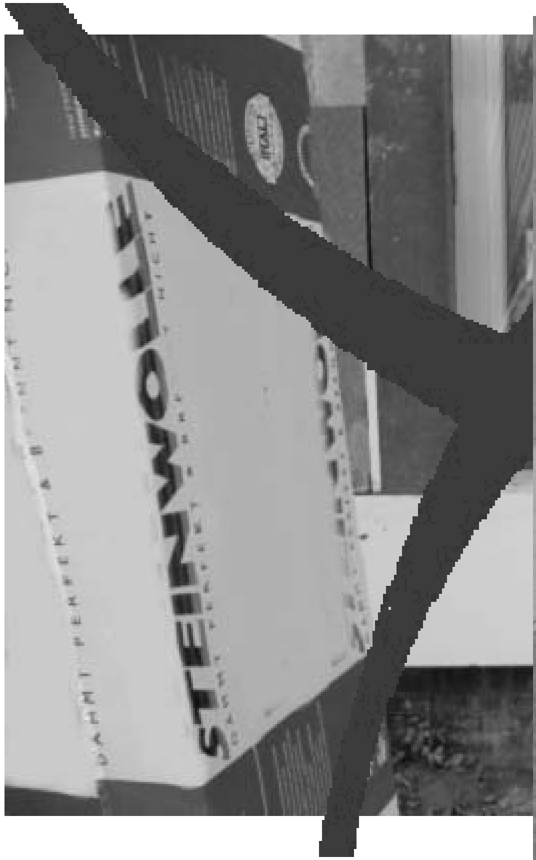


Installation - in masonry layer





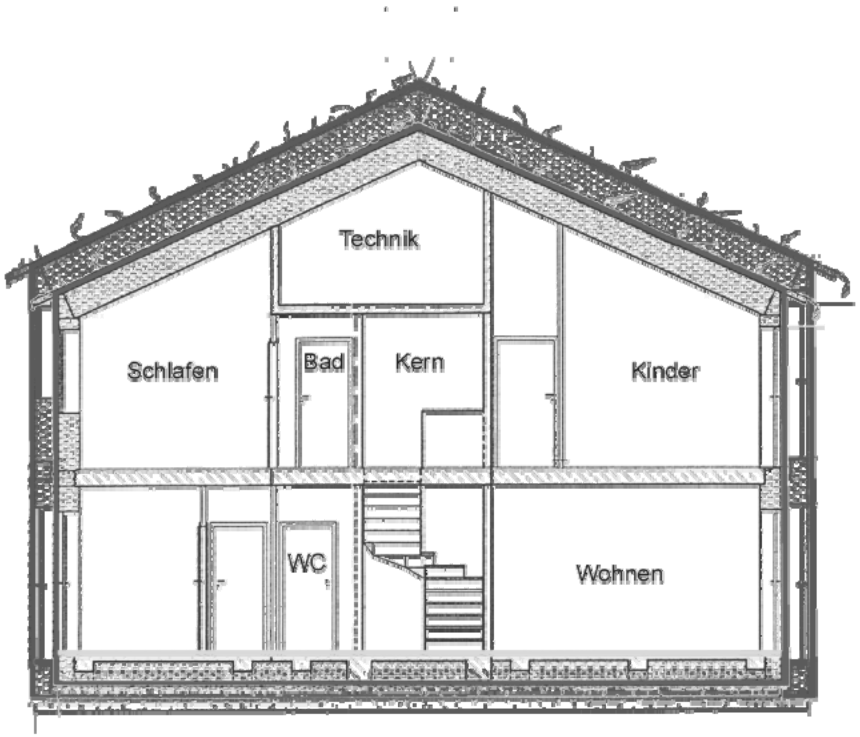
Most frequent failures and problems

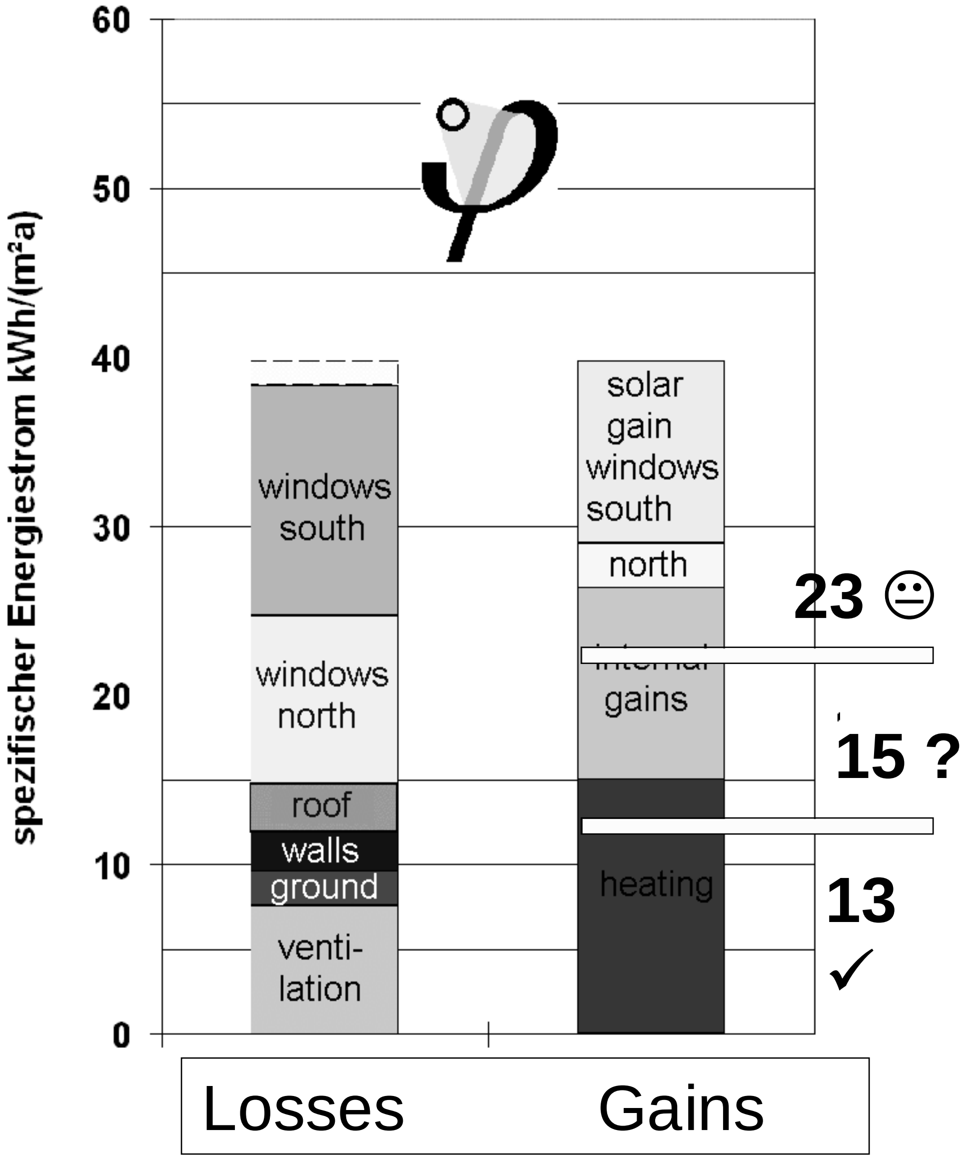


Window frame should be covered by insulation

MFH Hamburg, Wernst Immobilien

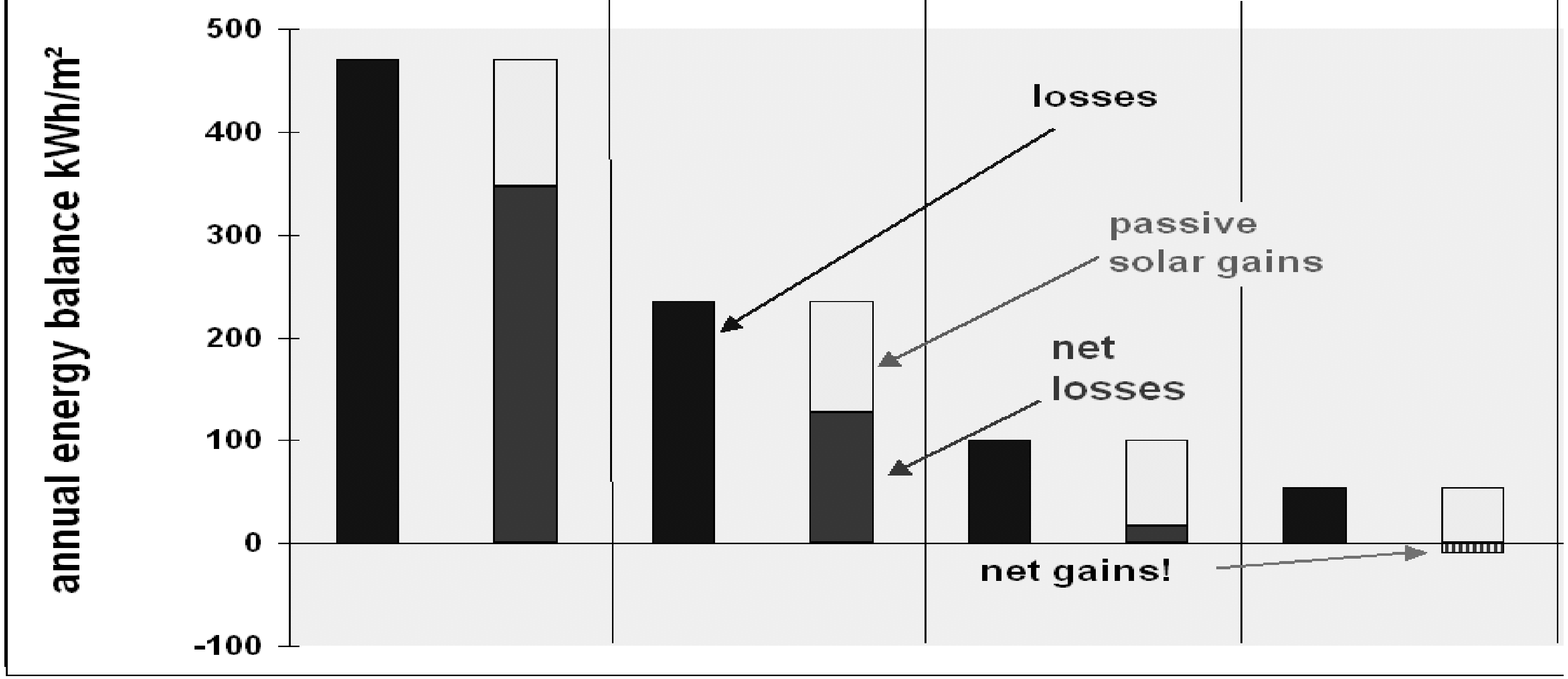
Save money on one component and compensate the effects elsewhere
- but be reasonable!



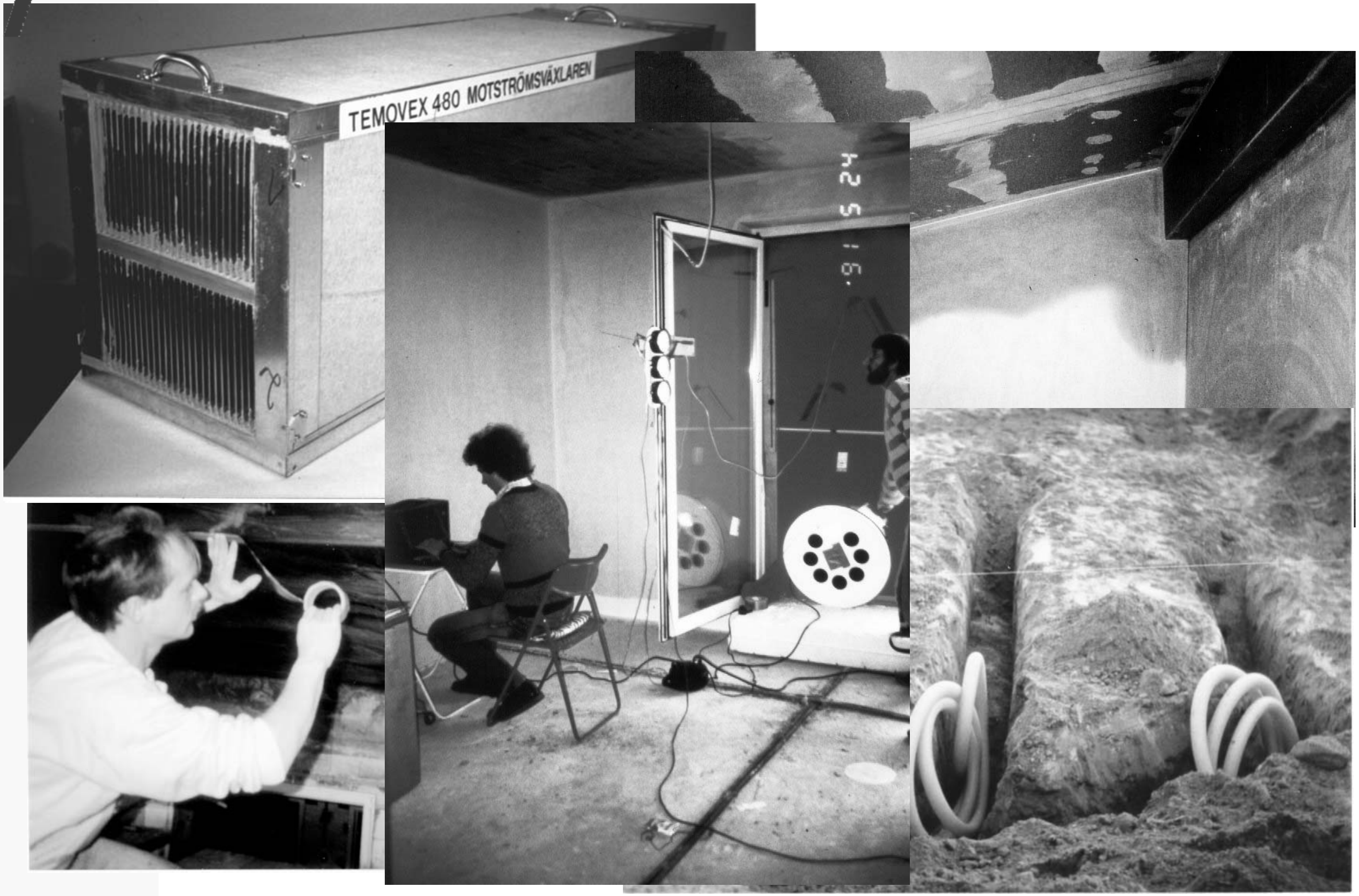


Superwindows

	R1	R2	R4	R8
Type	single	double	double low-e, Ar	triple low-e, Ar
U_g- value (W/(m²K))	5.60	2.80	1.20	0.65
Surface temperature	-1.8 °C	9.1 °C	15.3 °C	17.5 °C
solar transmittance	0.92	0.80	0.62	0.48

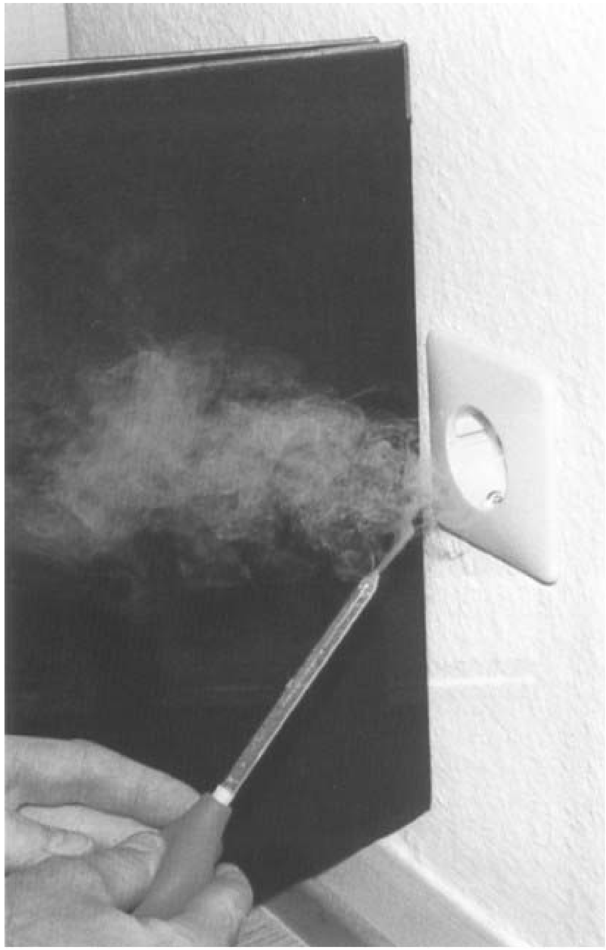


Airtightness and Ventilation

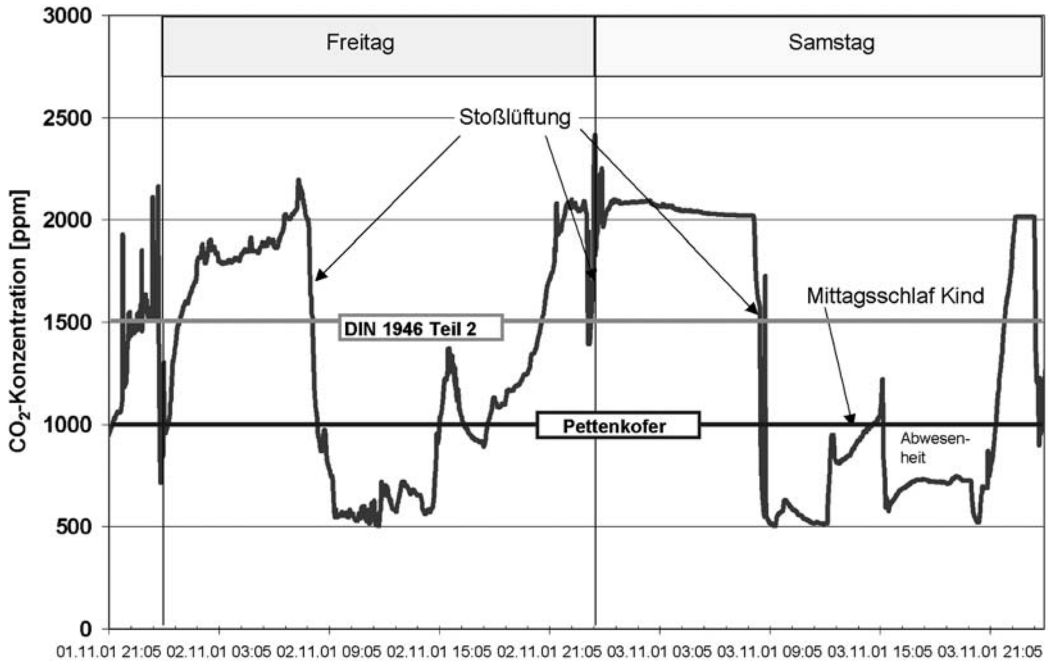


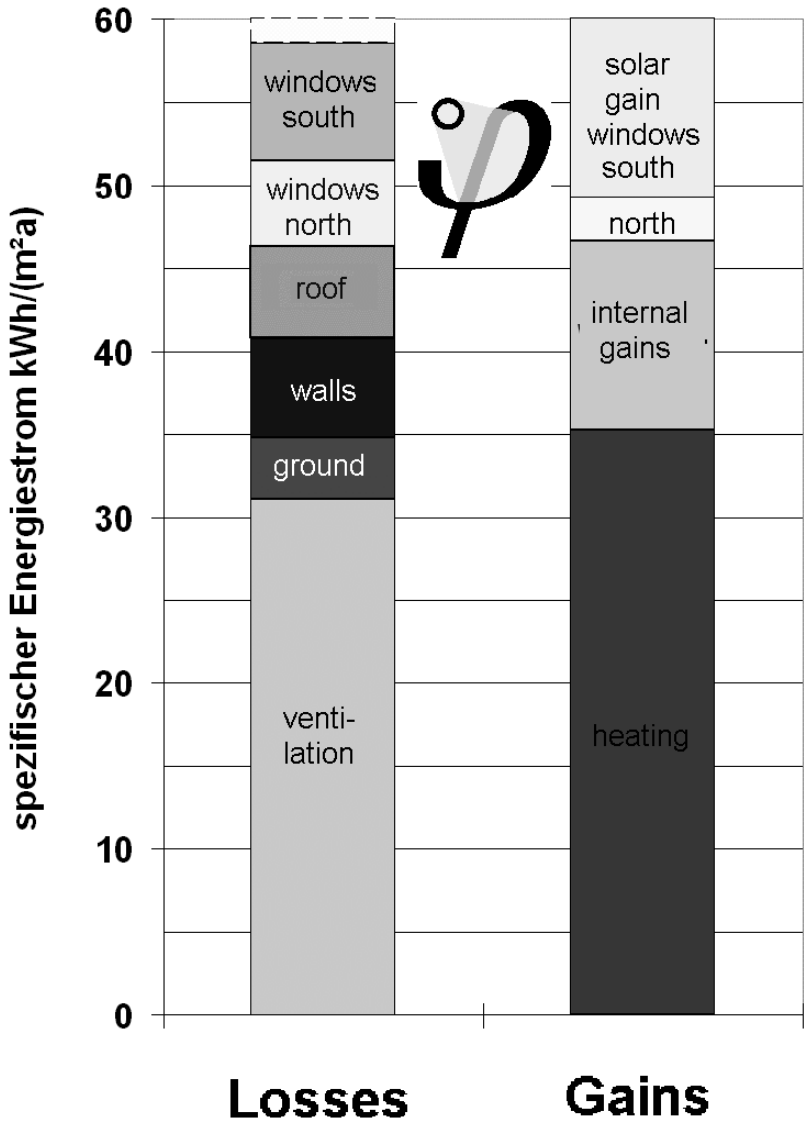
Air tightness - conditio sine qua non

- ➔ preservation of structure :
  Leakage --> damage
- ➔ thermal comfort:
  ISO 7730 draft risk
- ➔ thermal comfort:
  thermal stratification
- ➔ heating load
- ➔ sound insulation
- ➔ ventilation effectiveness

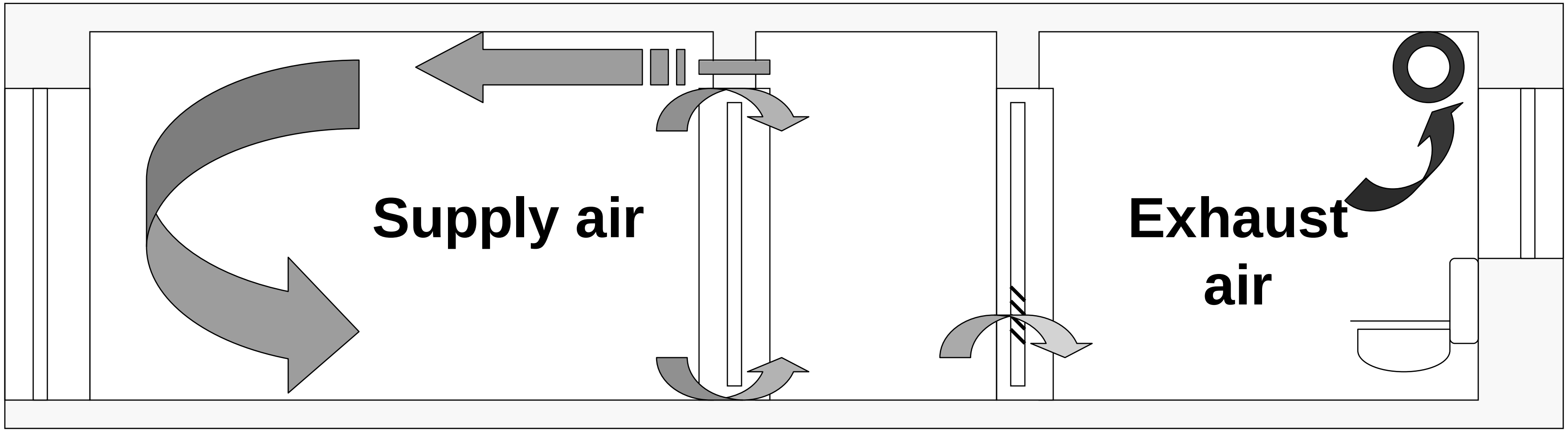


Ventilation system is essential





Ventilation

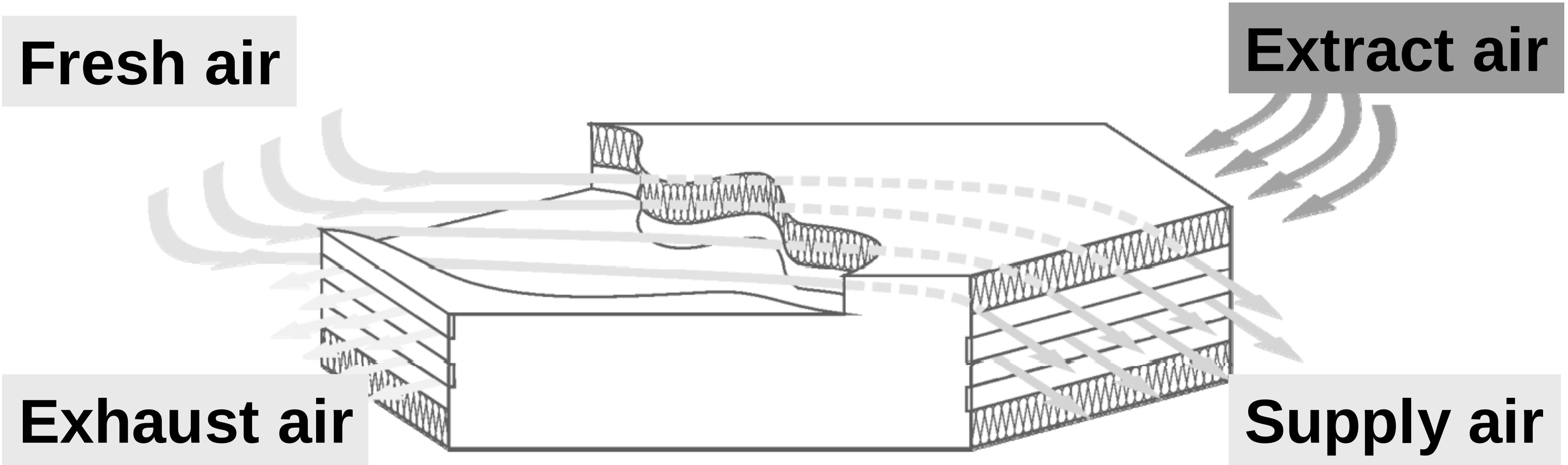


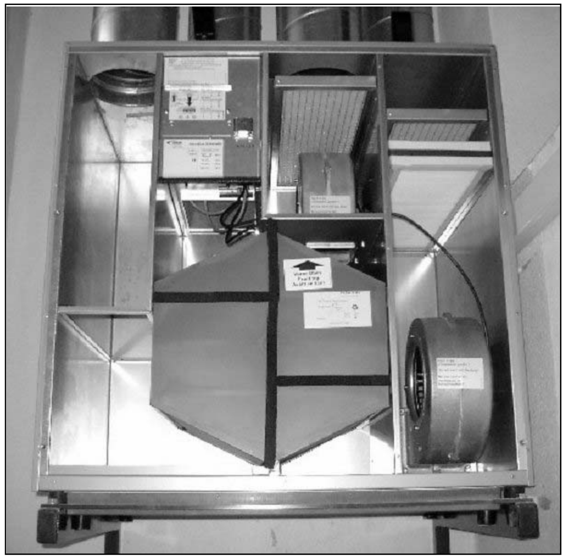
Supply air requirement
30 m³/h/Person (DIN 1946)
Typical home: 120 m³/h

Exhaust air requirement

Kitchen : 60 m³/h
Bathroom: 40 m³/h
Toilet : 20 m³/h

Heat Recovery Ventilation:
More than 80% recovered





Efficiency according to German standard test procedures

$$\eta'_w = \frac{(\dot{H}_{Zu} - \dot{H}_{Au})}{(\dot{H}^*_{Zu} - \dot{H}_{Au})} = \frac{\vartheta_{Zu} - \vartheta_{Au}}{\vartheta_{Ab} - \vartheta_{Au}}$$

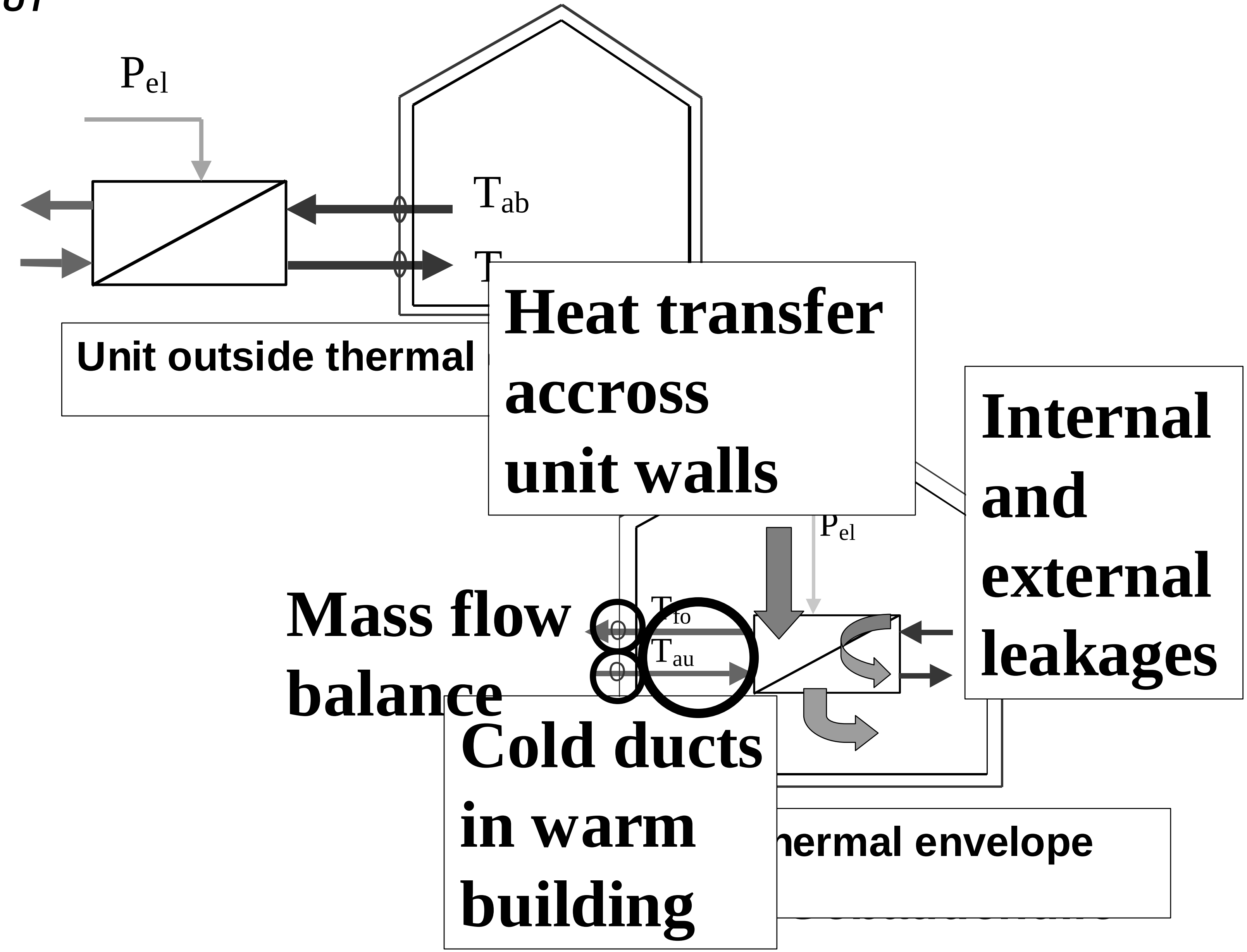
where $\dot{H}^*_{Zu} = \dot{H}(\vartheta_{Ab}; x_{Au})$

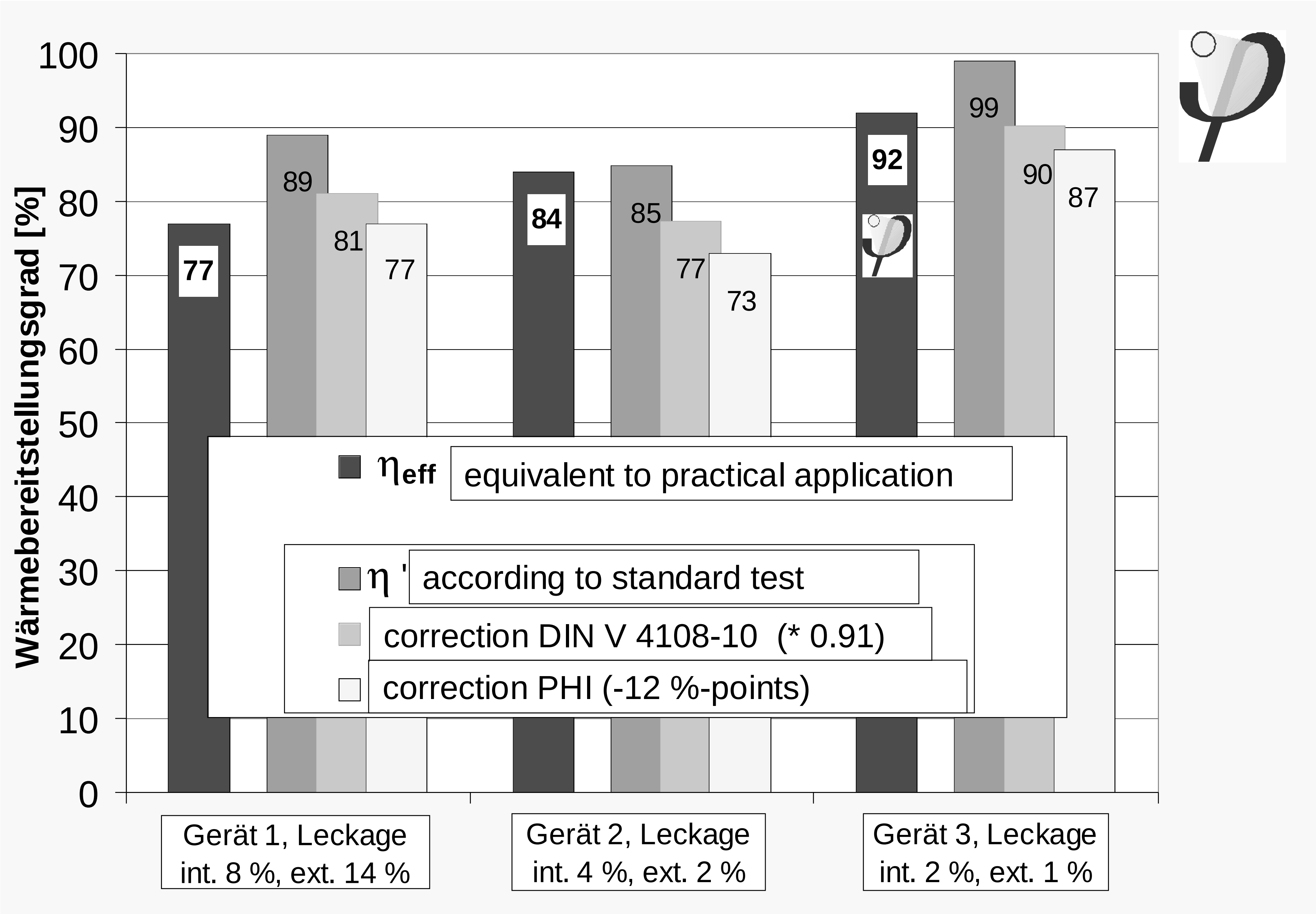
Zu: Supply into room
Ab: Extract from room
Fo: Exhaust to ambient
Au: Ambient

PASSIV HAUS INSTITUT

Energy balance boundaries

according to PHPP / EN 832





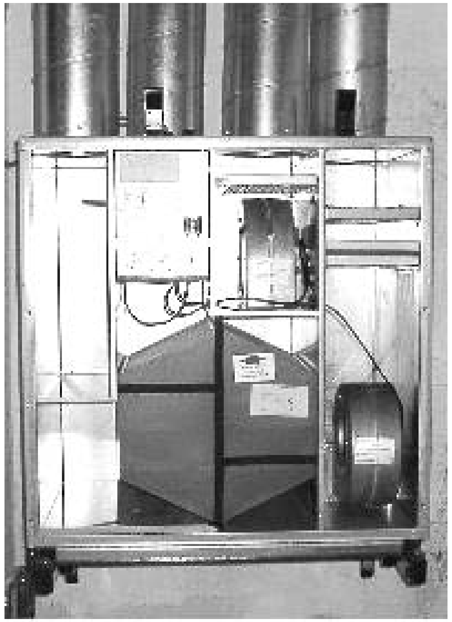
100
90
80
70
60
50
40
30
20
10
0
Wärmebereitstellungsgrad [%]
77
89
81
77
84
85
77
73
92
99
90
87
η_{eff} equivalent to practical application
η ' according to standard test
correction DIN V 4108-10 (* 0.91)
correction PHI (-12 %-points)
Gerät 1, Leckage int. 8 %, ext. 14 %
Gerät 2, Leckage int. 4 %, ext. 2 %
Gerät 3, Leckage int. 2 %, ext. 1 %

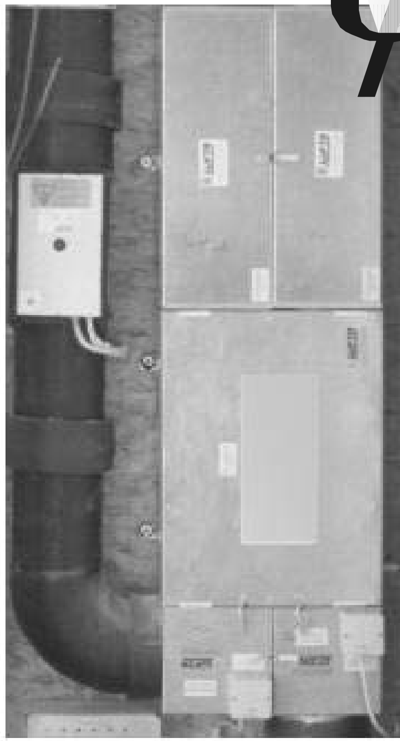
Ventilation

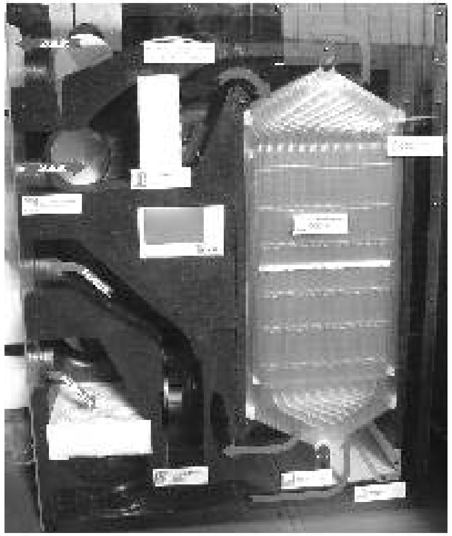
➔ ***simple technology***

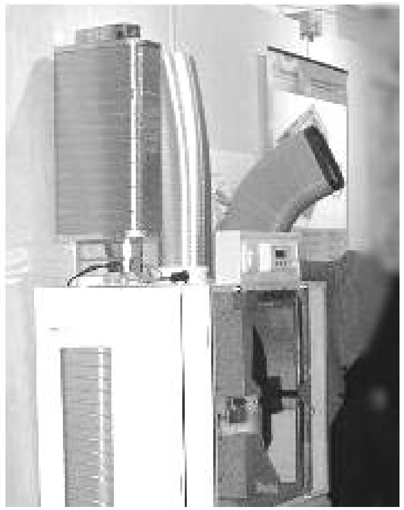
➔ ***small and efficient***

➔ ***improved indoor air quality***





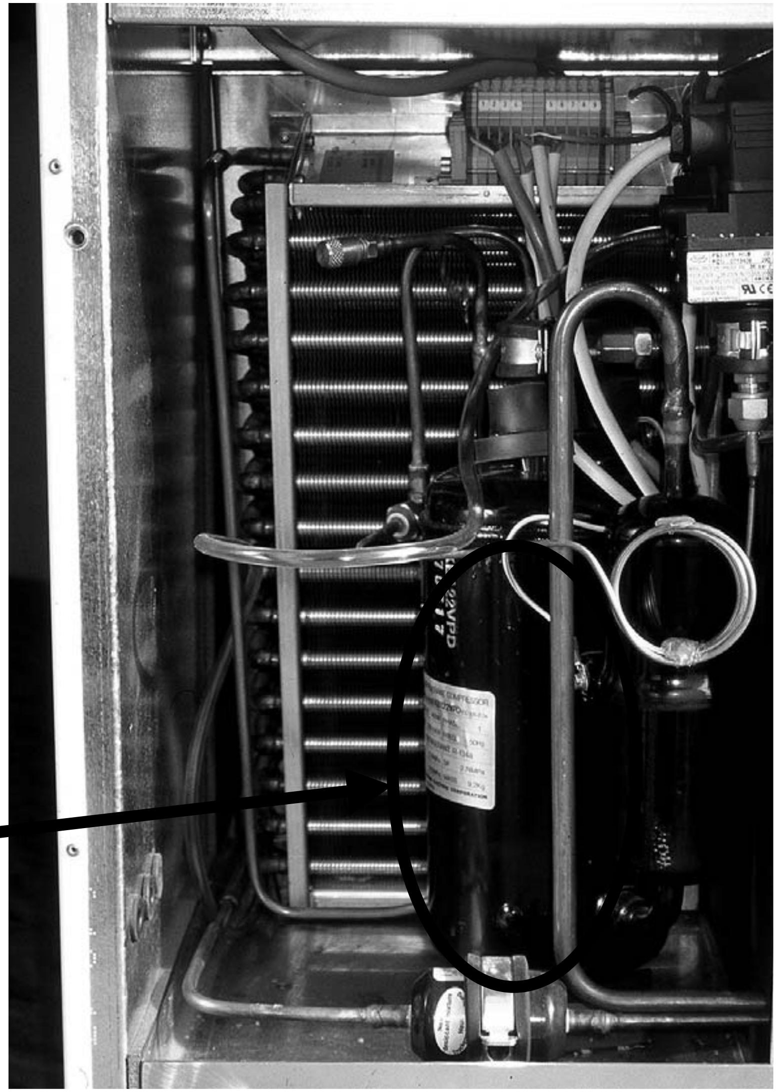




Compact building services system, *developed by C. Drexel.*

Heating, domestic hot water and ventilation in one system.

The small heat pump in the compact system.

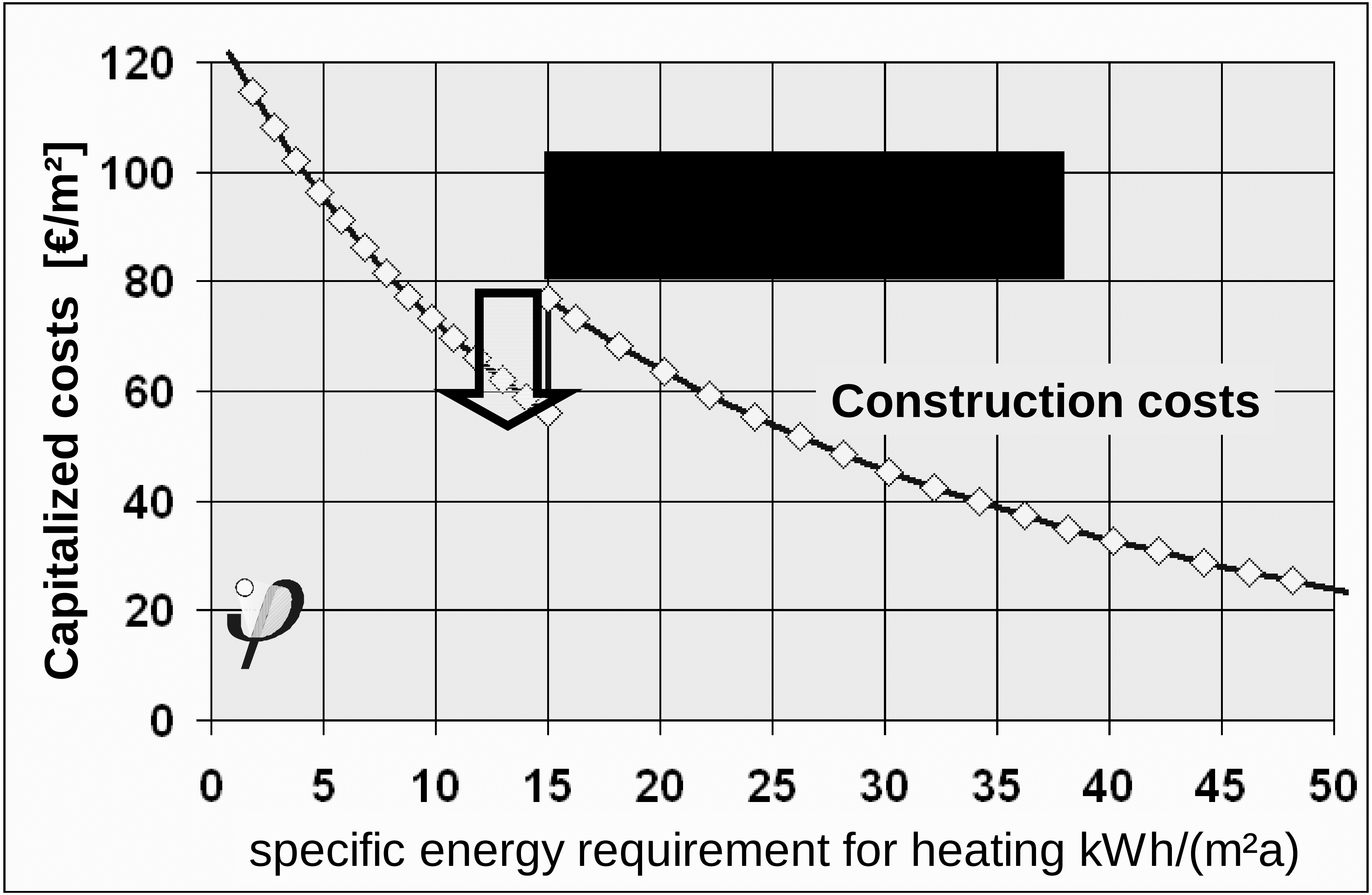


Compact Systems for Passive Houses

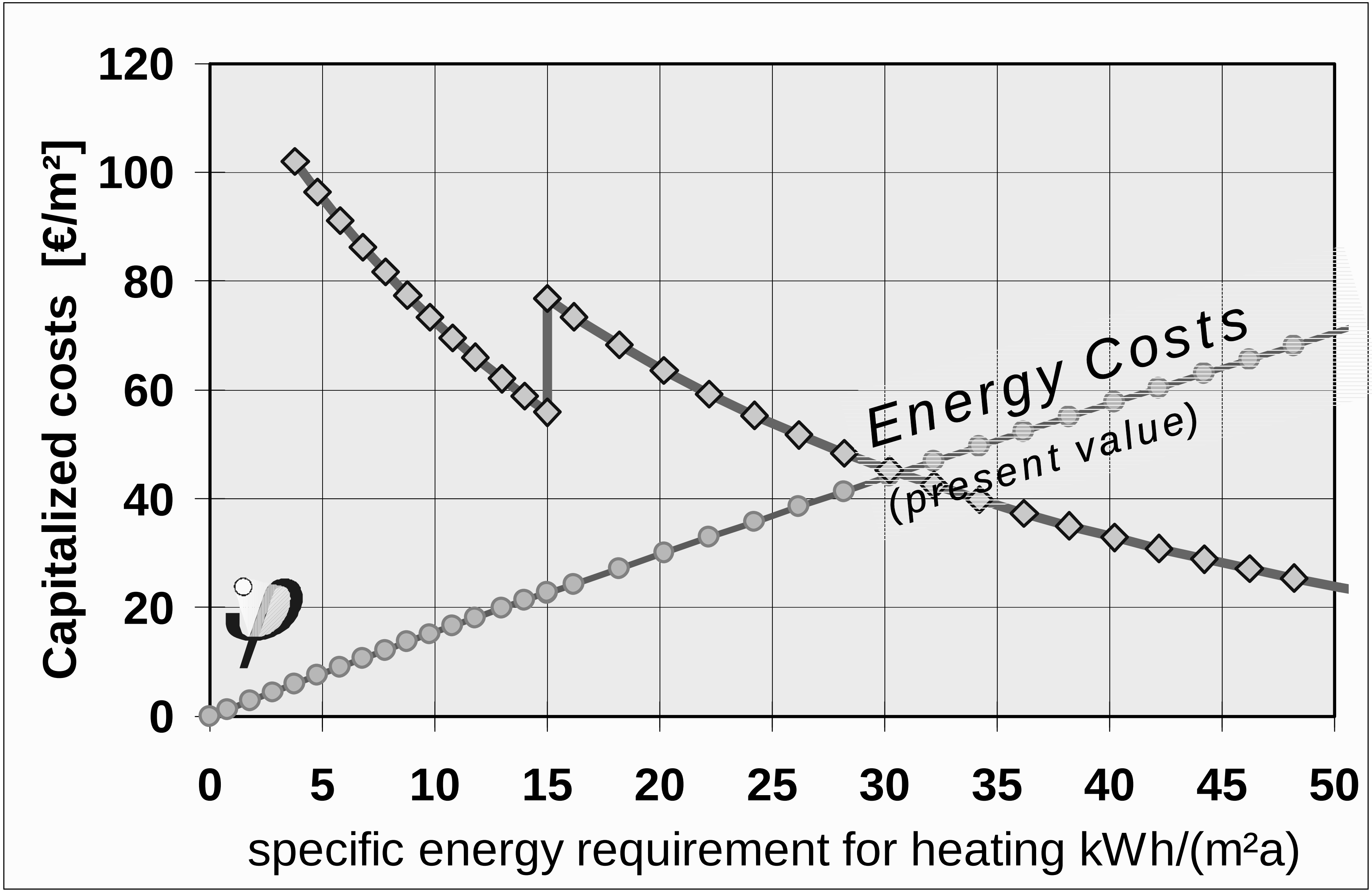
One unit does it altogether:

Heating, Ventilation, Cooling and Domestic Hot Water

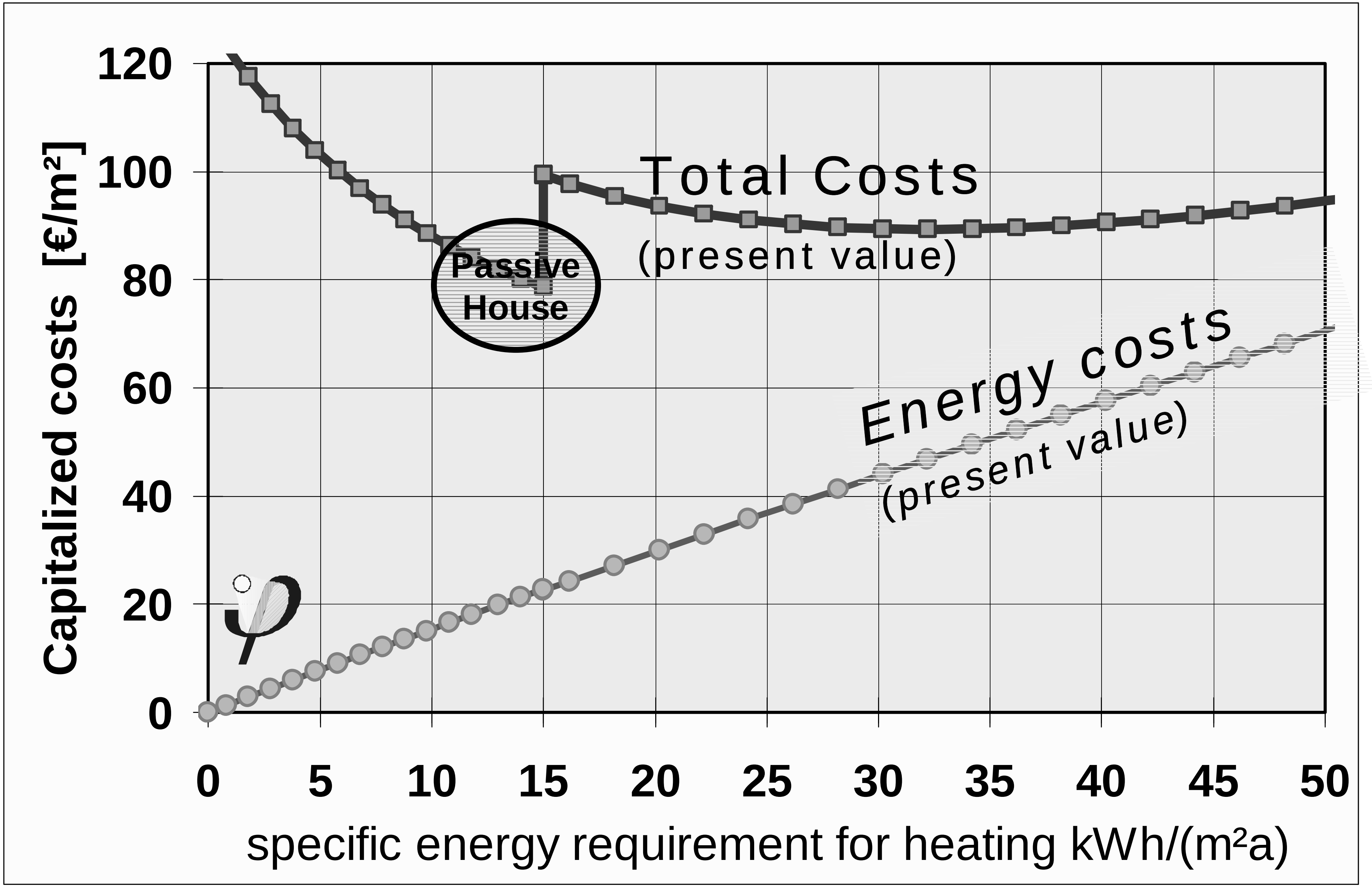
1995: Concept
1997: Prototype
2004: six products available on the market



Capitalized costs [€/m²]
120
100
80
60
40
20
0
[redacted]
Construction costs
0
5
10
15
20
25
30
35
40
45
50
specific energy requirement for heating kWh/(m²a)



Capitalized costs [€/m²]
120
100
80
60
40
20
0
0
5
10
15
20
25
30
35
40
45
50
specific energy requirement for heating kWh/(m²a)
Energy Costs
(present value)



Total Costs
(present value)
Passive House
Energy costs
(present value)
Capitalized costs [€/m²]
120
100
80
60
40
20
0
0
5
10
15
20
25
30
35
40
45
50
specific energy requirement for heating kWh/(m²a)

"The passive houses in Göteborg-Lindås are consequently designed according to the PH principle: first of all the heat loss should be reduced - a sophisticated heating system will be obsolete.
The occupants feel very comfortable and Mrs. Helga Henriksson would be very happy if she could see that her original objective was eventually achieved."

Hans Eek,
Göteborg

Passive Housing Estate in Göteborg