Institut für Wärmetechnik

TU Graz

Low Energy Buildings and Renewable Energy Use

Czech-Austrian Winter/Summer School

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Whole life optimised building

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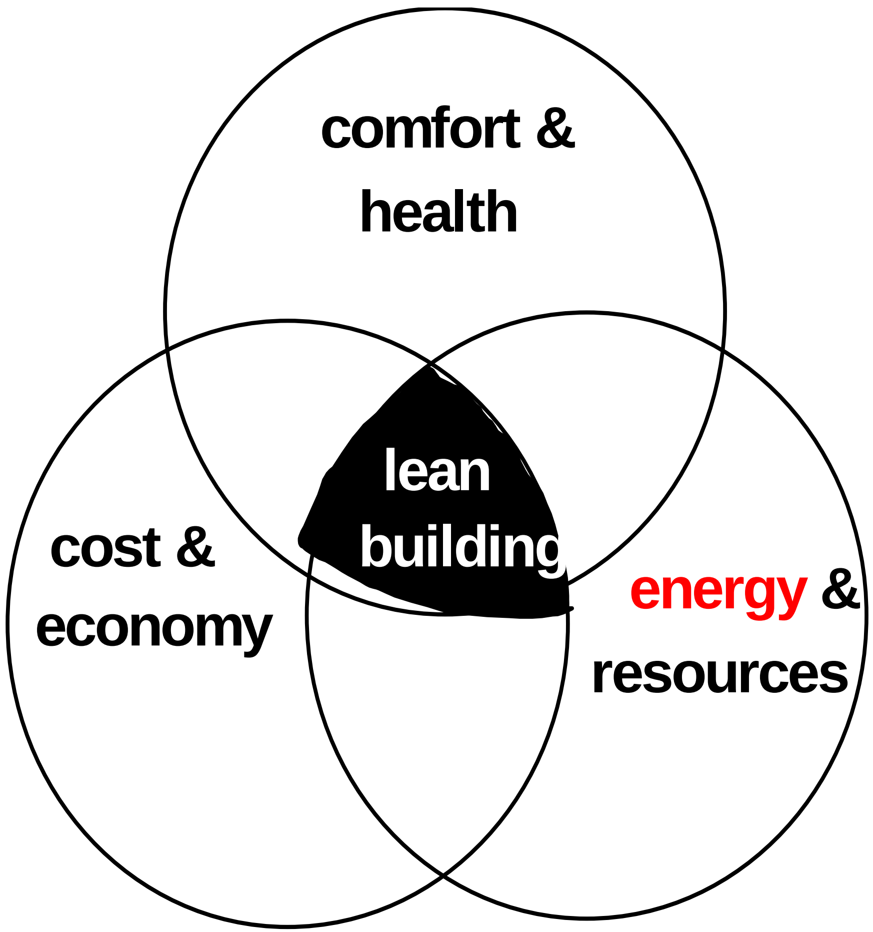


Gebäudebestand in Österreich

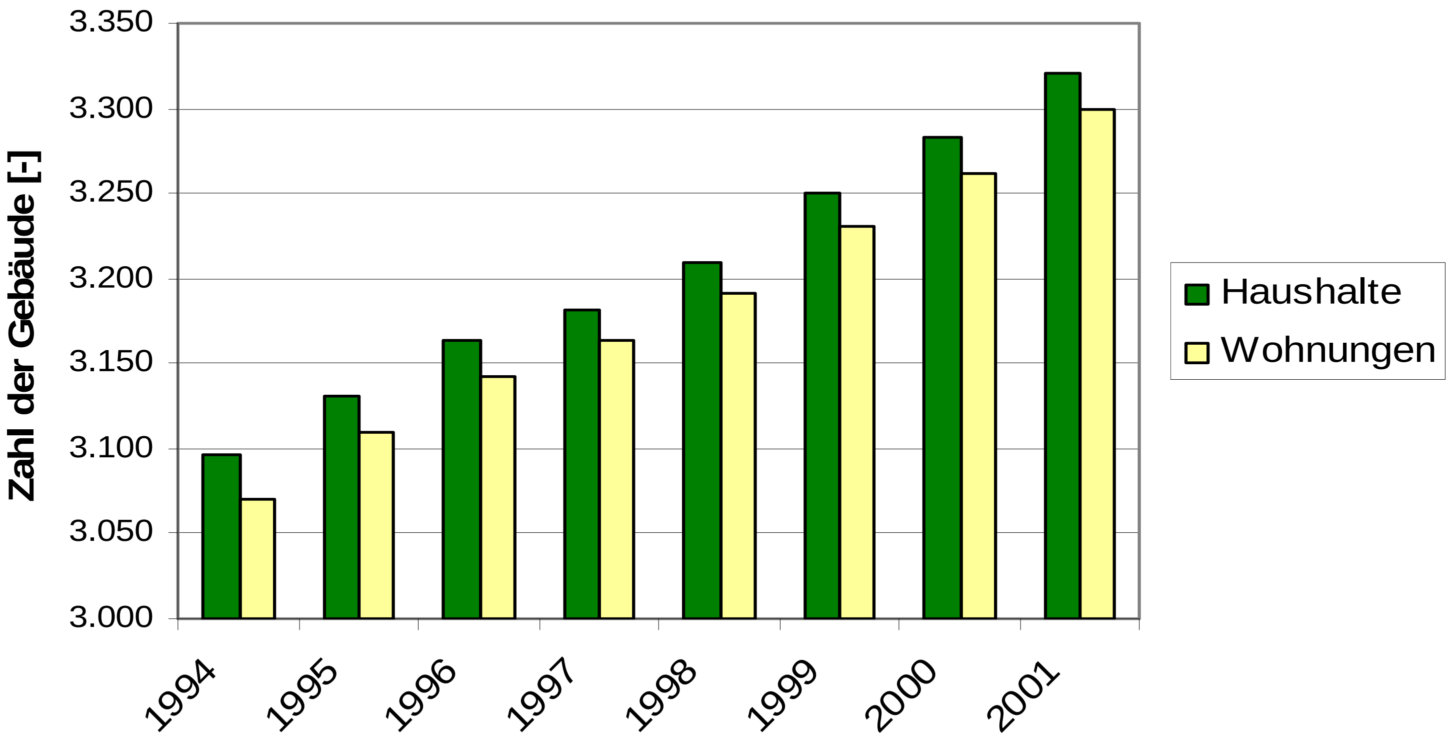
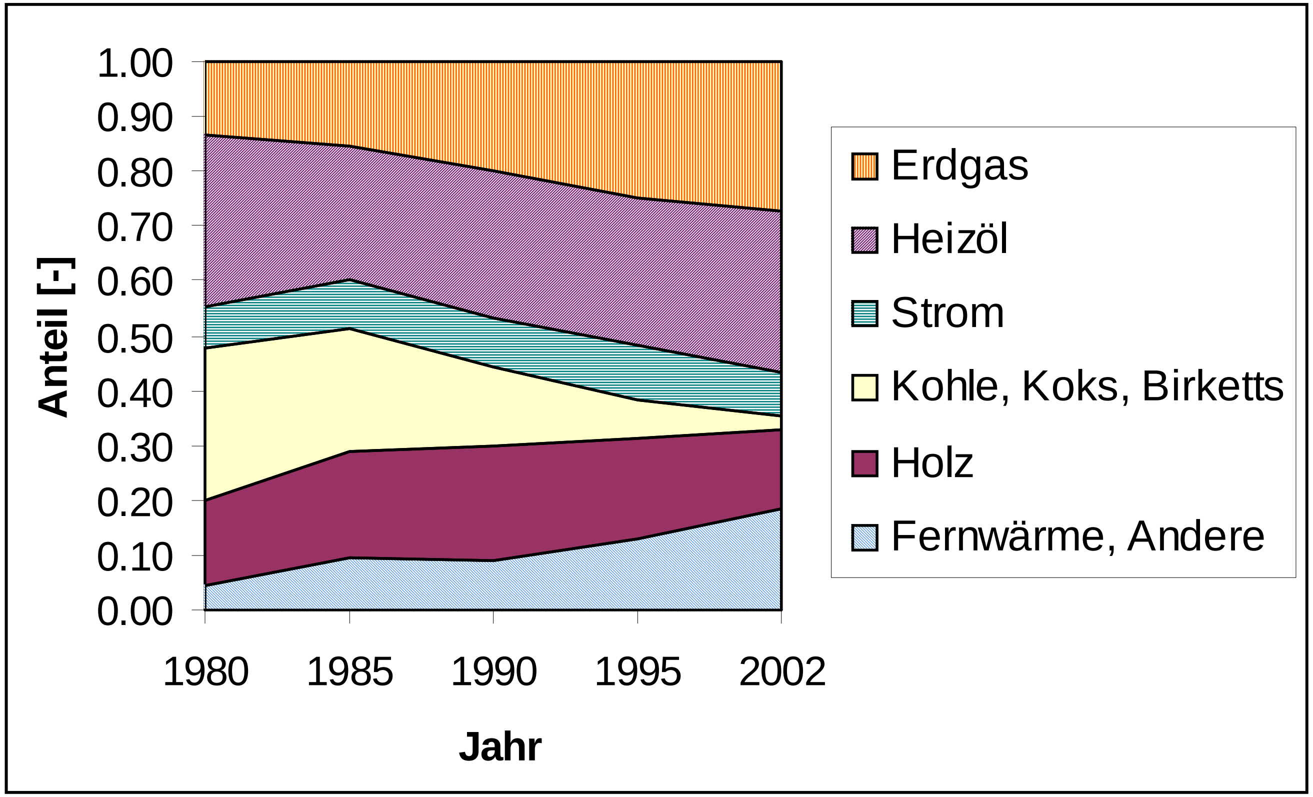


Abbildung: Entwicklung des Gebäudebestandes in Österreich, Quelle: www.statistik.austria.at, 15.03.2005

Quelle: Statistik Austria, (2004)

Energy carriers in Austrian households



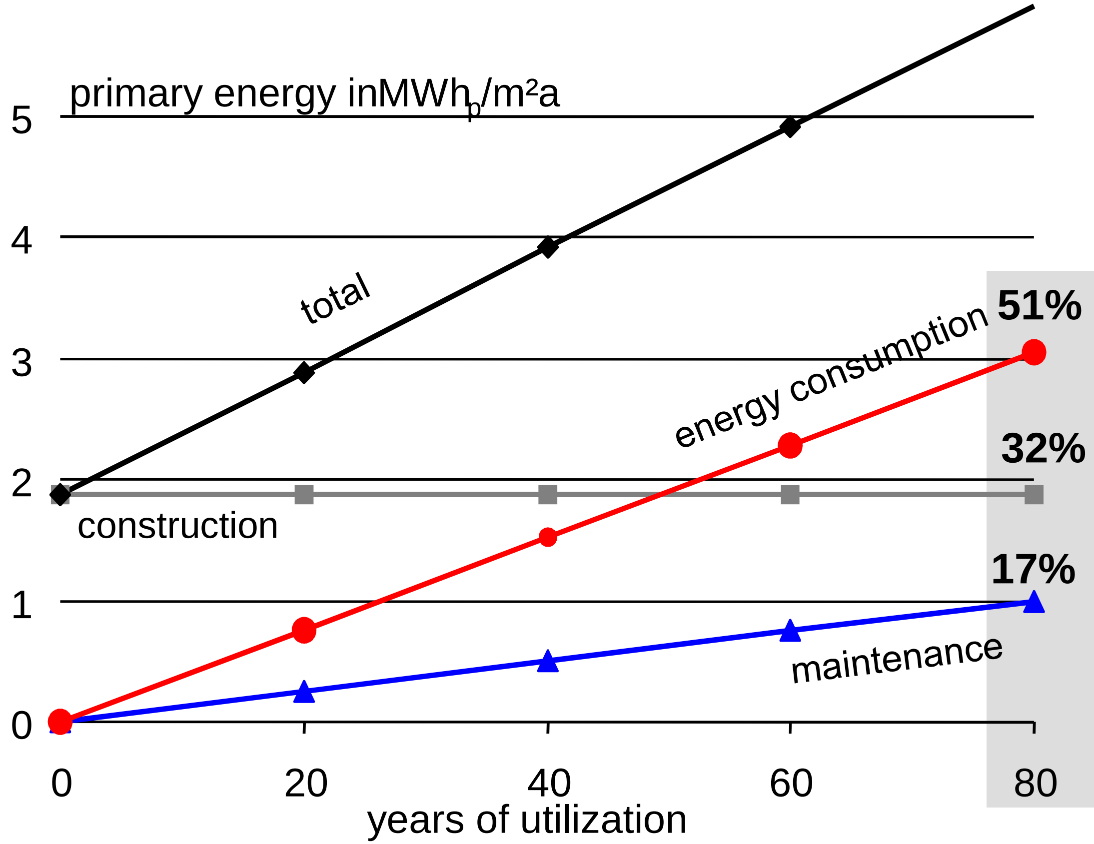
Quelle: Statistik Austria, (2005)

Heating values and specific CO_2-emissions of fossil fuels

Energy carrier	Lower heating value	CO_2-emissions (related to lower heating value)
Hard coal	8,14 kWh/kg	0,350 kg/kWh
Lignite	2,68 kWh/kg	0,410 kg/kWh
Ignite briquetts	5,35 kWh/kg	0,380 kg/kWh
Coke	7,50 kWh/kg	0,420 kg/kWh
Heavy duty oil	10,61 kWh/l	0,290 kg/kWh
Oil „extra light“	10,08 kWh/l	0,270 kg/kWh
Natural gas	10,00 kWh/m3	0,200 kg/kWh

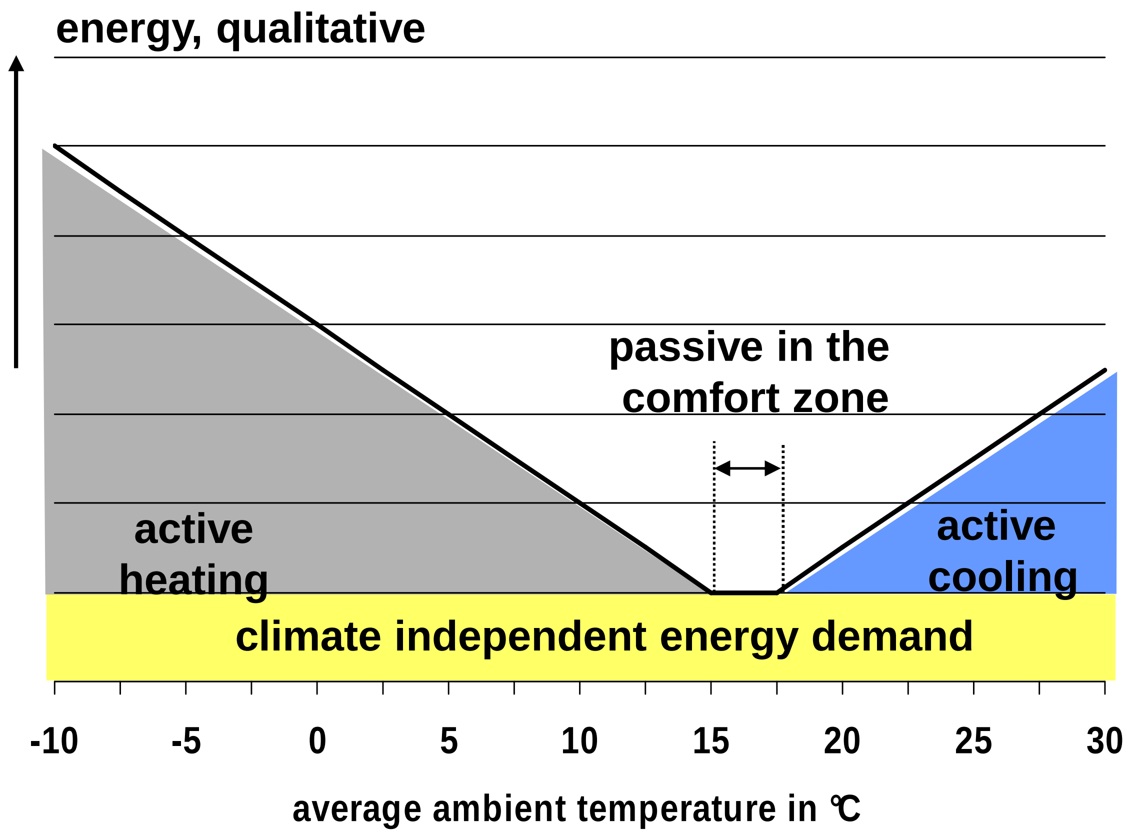
Life Cycle Energy

embodied energy 1,9 MWh/m²



Current Buildings

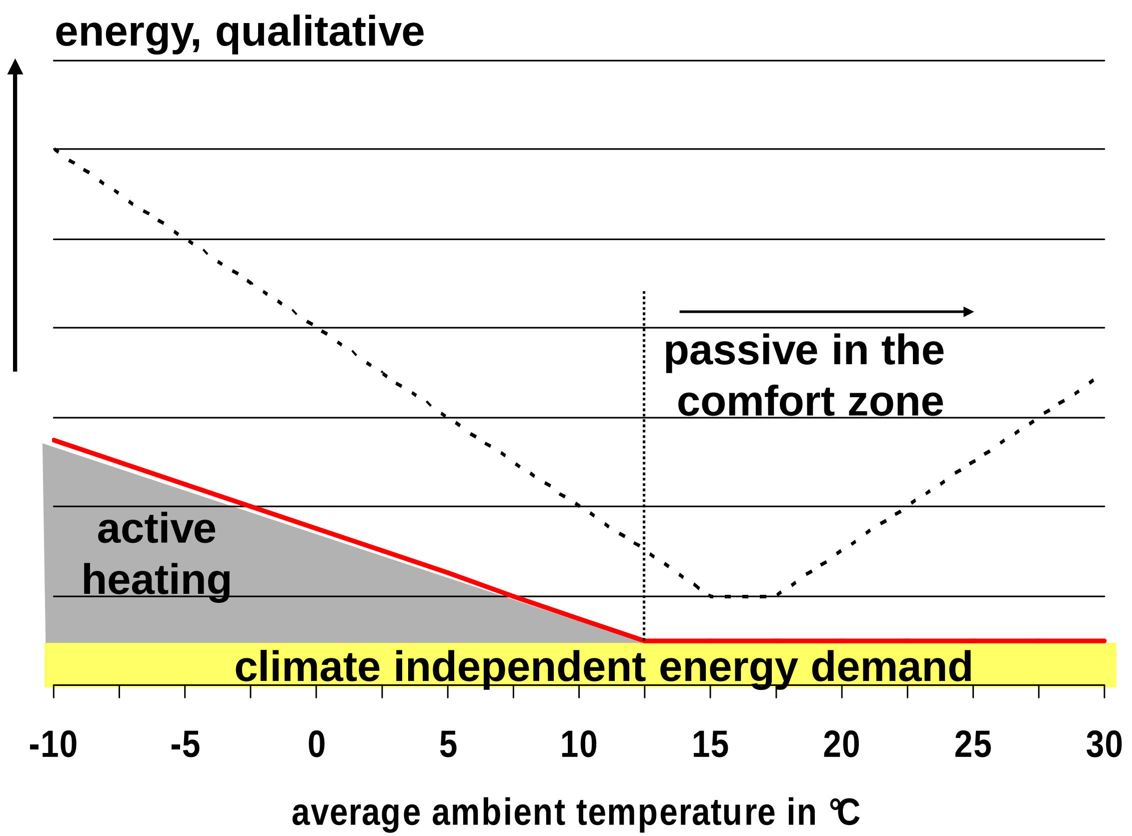
Energy for:
- heating
- cooling
- ventilation
- lighting
- utilization



Example: Mid European climate

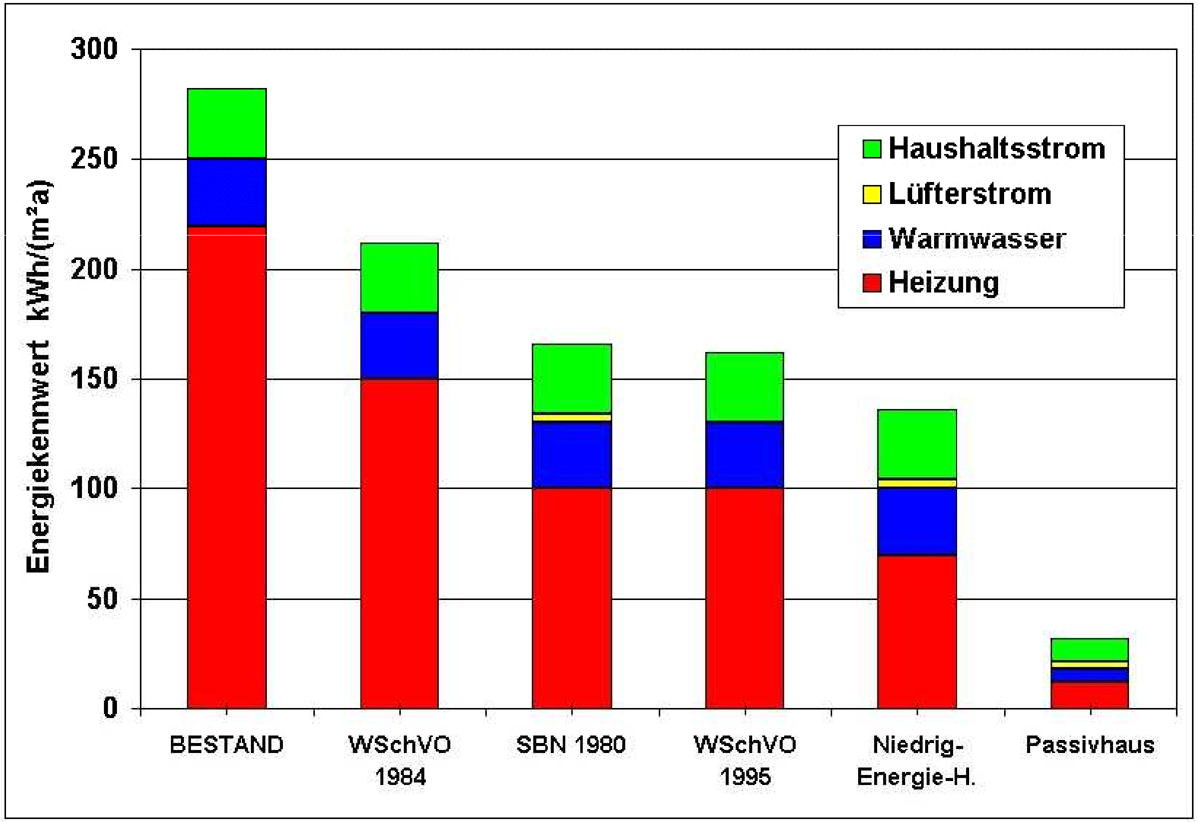
Lean Buildings

Energy for:
- heating
- cooling
- ventilation
- lighting
- utilization



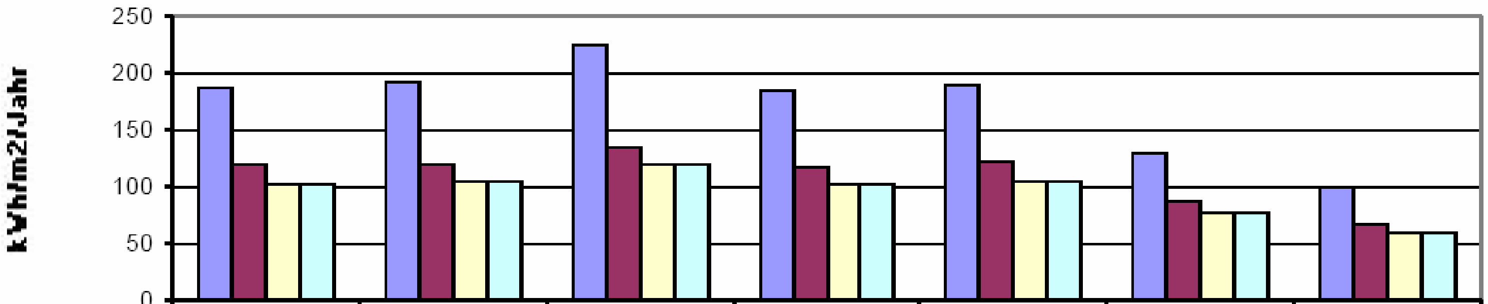
Example: Mid European climate

Energy demand of buildings



Specific space heating energy demand of single (SFH) and multi family buildings (MFH-K : small, MFH-G big) in decpendenc of year of errection in Austria

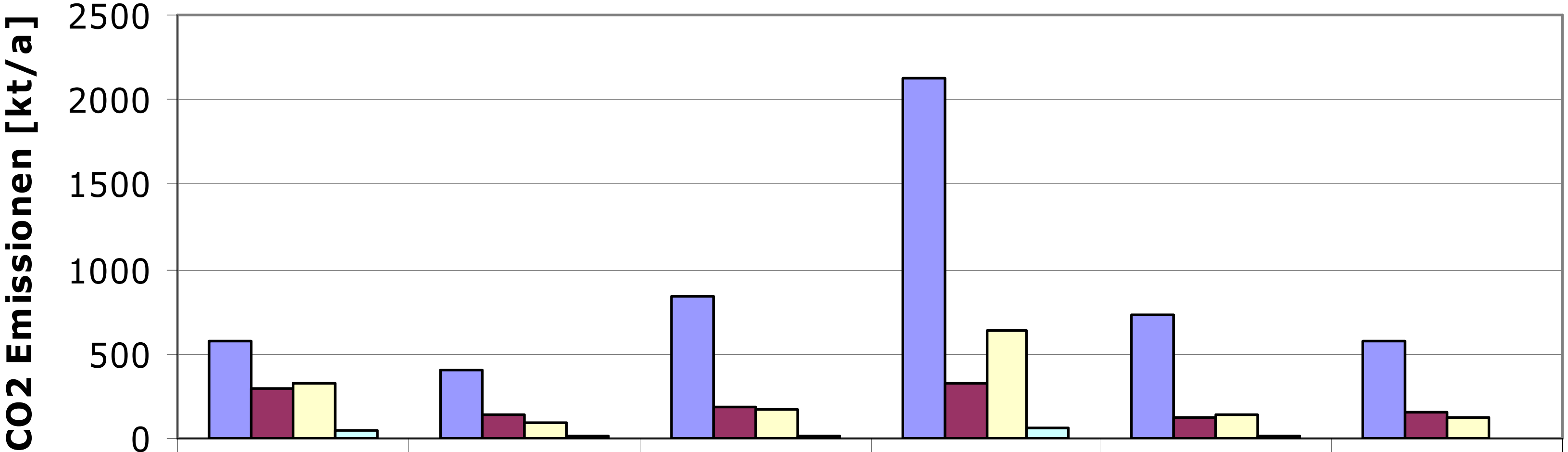
Raumheizungskennzahlen nach Baualtersklassen und Haustypen (nutzenergiebezogen)



	vor 1919	1919 - 1945	1945 - 1960	1961 - 1970	1971 - 1980	1981 - 1990	ab 1991
EFH	188	193	226	186	191	130	99
MFH-K	121	121	136	118	122	88	67
MFH-G	103	106	120	103	104	78	60
NWG	103	106	120	103	104	78	60

Quelle: Jungmeier, et al. (1996)

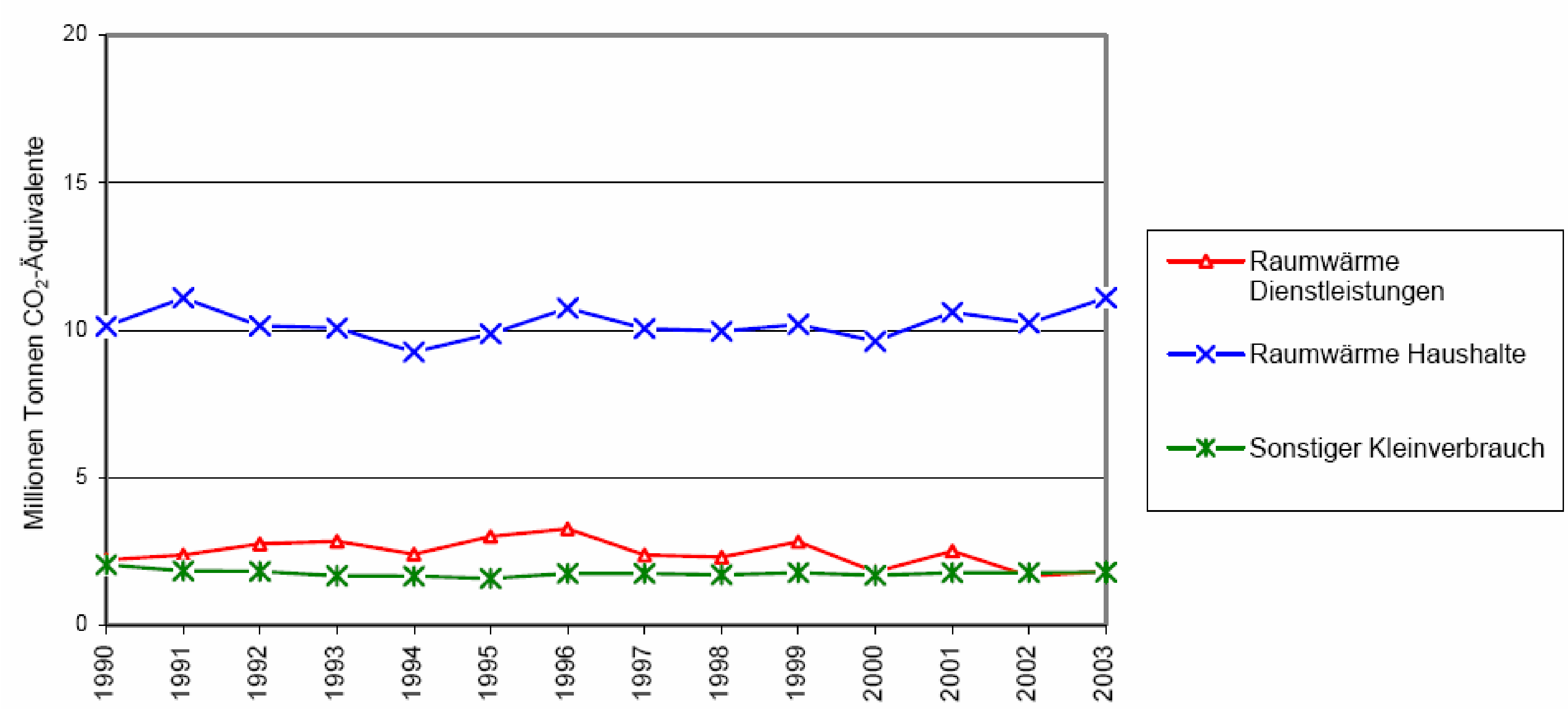
CO_2-emissions from space heating of appartements in Austria



	vor 1919	1919 - 1945	1945 - 1960	1961 - 1980	1981 - 1990	ab 1991
EFH	580	408	841	2 134	732	575
MFH-K	293	144	179	333	128	148
MFH-G	321	94	177	636	140	118
NWG	49	11	22	55	16	7

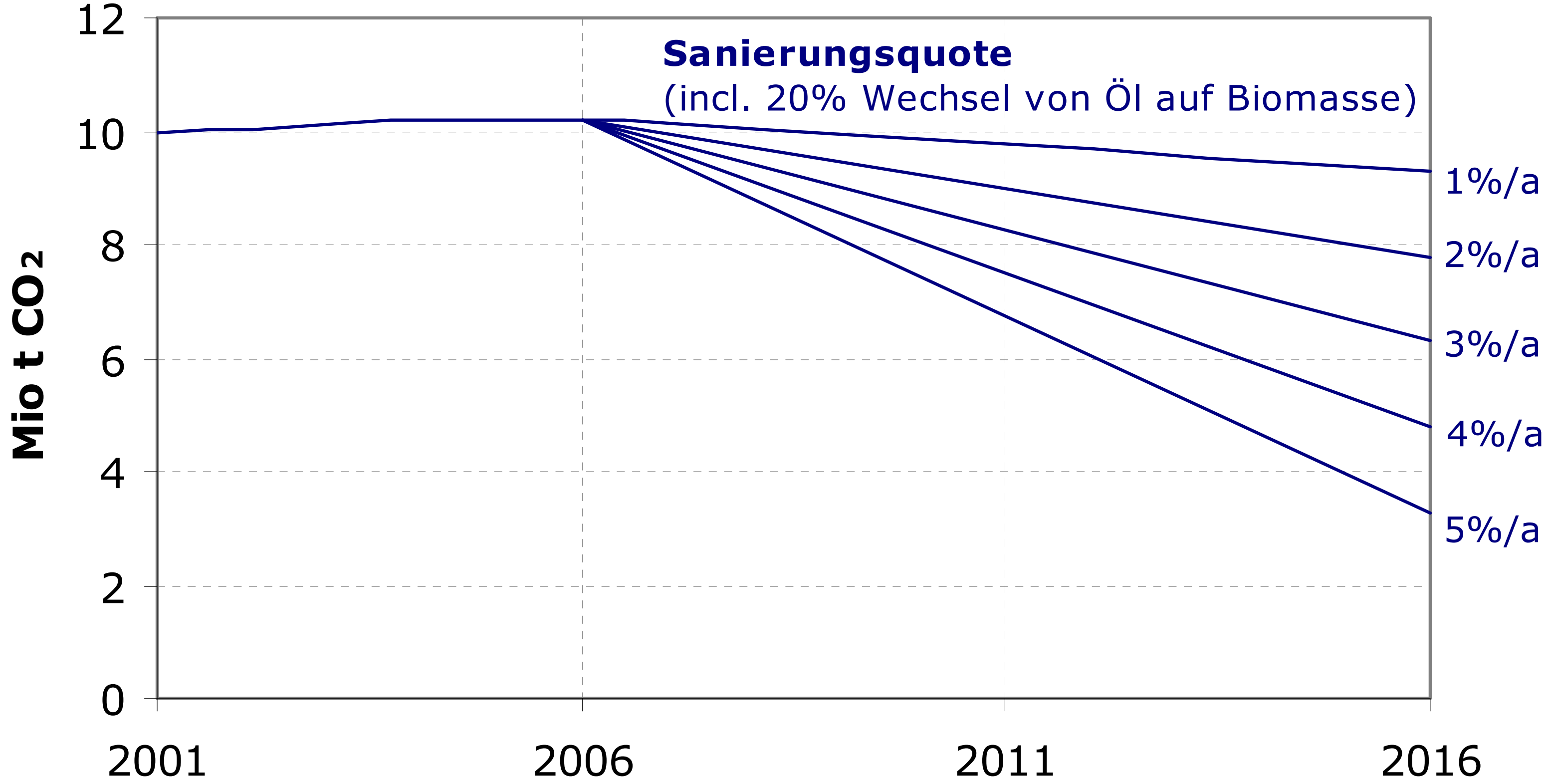
Quelle: eigene Berechnung

CO_2-equivalent emissions from the residential sector (Raumwärme Haushalte) and other small



Quelle: BMLFUW (2005)

Trendscenario of thermal renovation and fuel switch of all Austrian dwellings (basic data from Statistik Austria, 2001)



Quelle: eigene Berechnung

Steps of integrated building design für low energy demand

Boundary conditions
(Size, orientation, number of persons, climatic indoor conditions,
Costs (errection and operation), etc.)

↓

Energetical optimization of the building itself
(measures at the building)

↓

Simple and efficient heating, ventilation, cooling system

↓

Ecologically benign heat and cold production
(renewable energy carriers)

Energetical System Building

Building behaviour

- Active thermal mass
- Passive solar energy use

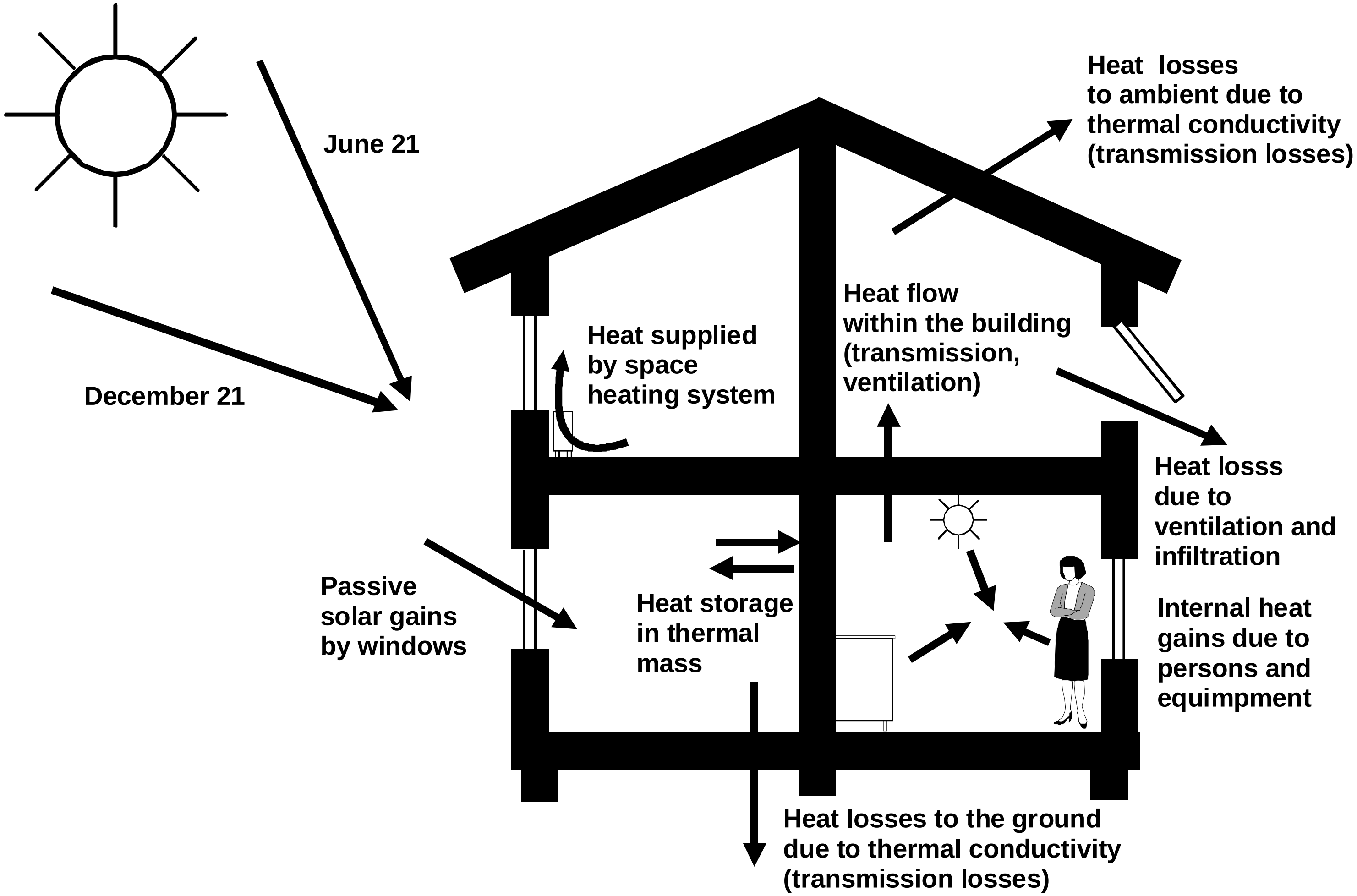
User behaviour

- Ventilation
- Internal Heat gains
- Indoor air set temperature
- Shading

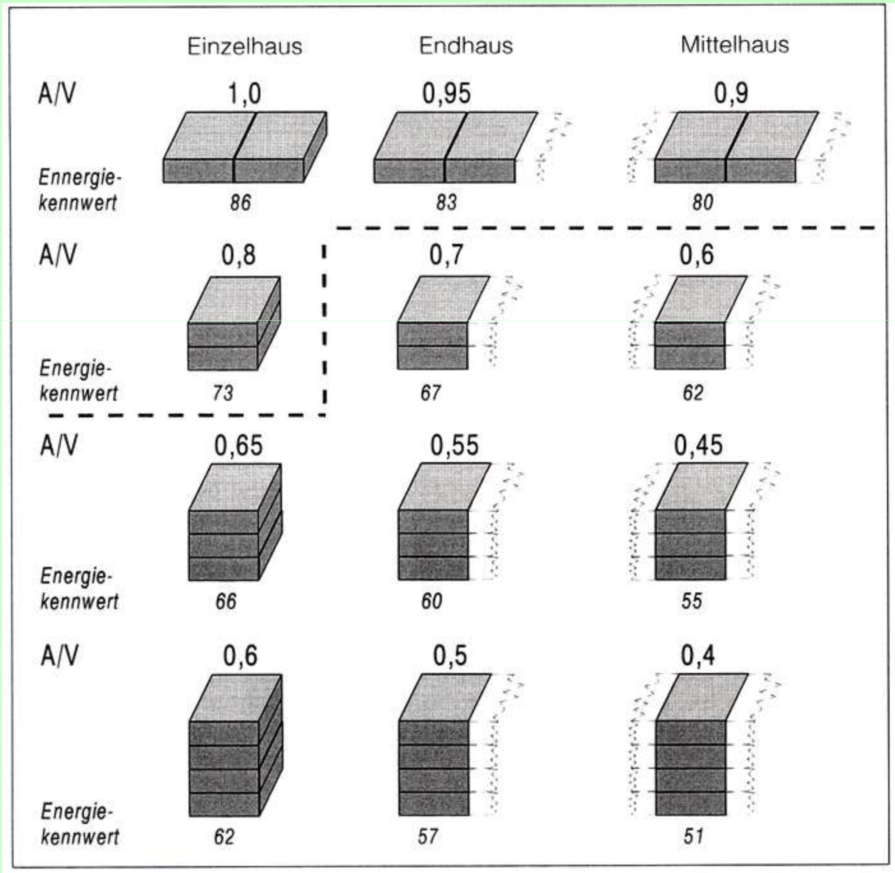
Control

- Indoor air temperature controlled (centralized, decentralized)
- Outdoor air temperature dependend (centralized)
- Analog - digital
- Irradiation controlled
- Positioning of sensors

Energetical System Building



Building Shape: Ratio of A/V for differetn shapes



Quelle: Feist, W., 1998, Das Niedrigenergiehaus

Heat transfer coefficient for transmission heat losses

$$U = \frac{\dot{Q}}{A \cdot \Delta T} (= k) \qquad [W/(m^2K)]$$

mit A... Heat transfer surface $[m^2]$

$\dot{Q}$... Transferred heat [W]

ΔT... Forcing temperature difference [K]

$$\dot{q} = \frac{\dot{Q}}{A} = U \cdot \Delta T \quad \text{.... specific heat flow} \quad [W/m^2]$$

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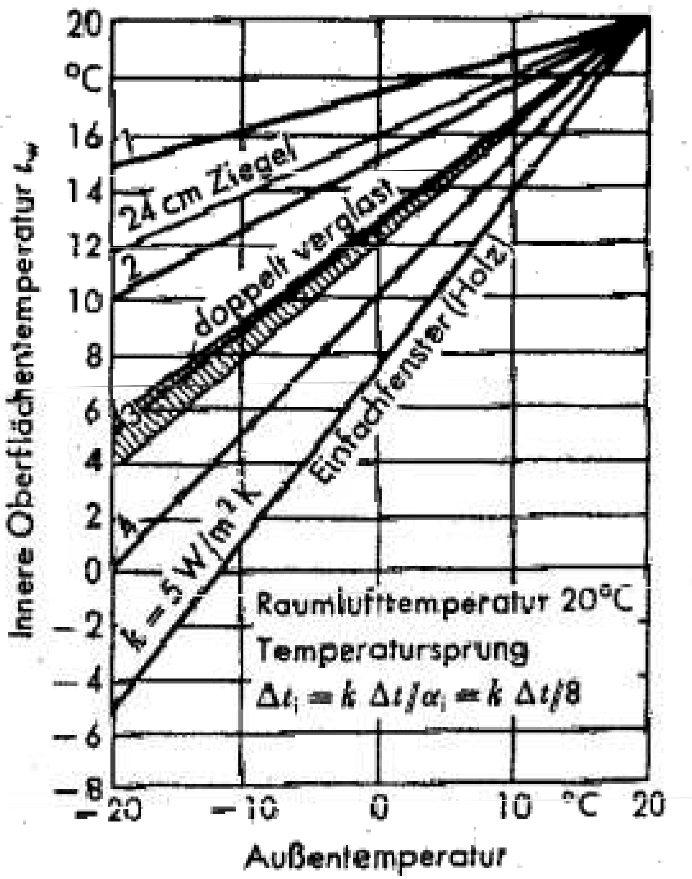
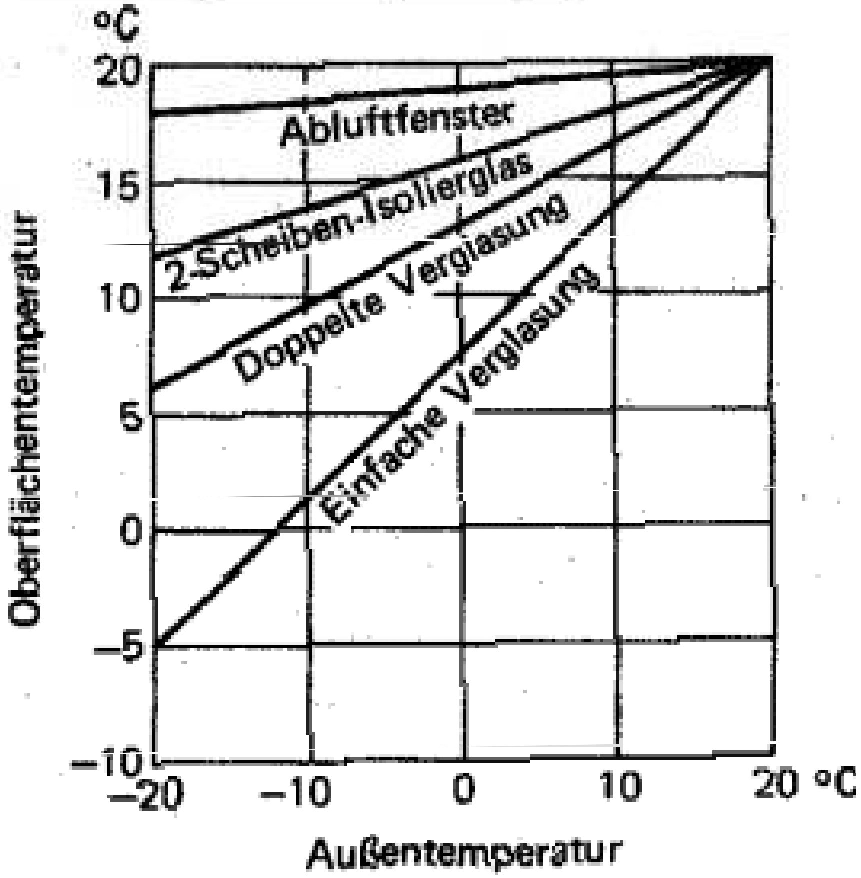
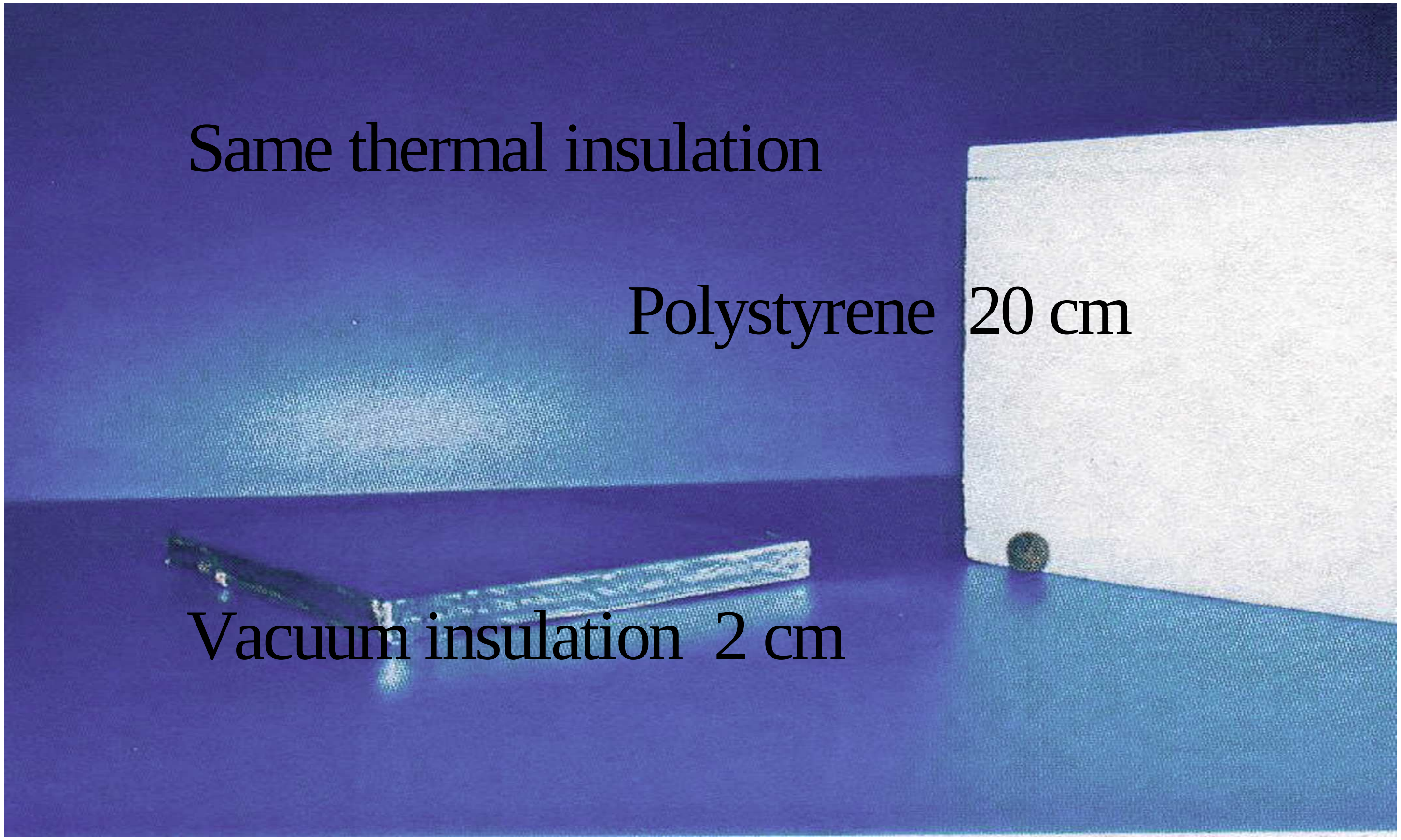
Maximum U-values (W/m²K) Austria (2007)

Bauteil	U-Wert [W/m²K]
WÄNDE gegen Außenluft	0,35
Kleinflächige WÄNDE gegen Außenluft (z.B. bei Gaupen), die 2% der Wände des gesamten Gebäudes gegen Außenluft nicht überschreiten, sofern die ÖNORM B 8110-2 (Kondensatfreiheit) eingehalten wird.	0,70
TRENNWÄNDE zwischen Wohn- oder Betriebseinheiten	0,90
WÄNDE gegen unbeheizte, frostfrei zu haltende Gebäudeteile (ausgenommen Dachräume)	0,60
WÄNDE gegen unbeheizte oder nicht ausgebaute Dachräume	0,35
WÄNDE gegen andere Bauwerke an Grundstücks- bzw. Bauplatzgrenzen	0,50
ERDBERÜHRTE WÄNDE UND FUSSBÖDEN	0,40
FENSTER, FENSTERTÜREN, VERGLASTE oder UNVERGLASTE TÜREN (bezogen auf Prüfnormmaß) und sonstige vertikale TRANSPARENTE BAUTEILE gegen unbeheizte Gebäudeteile	2,50
FENSTER und FENSTERTÜREN in Wohngebäuden gegen Außenluft (bezogen auf Prüfnormmaß)	1,40
Sonstige FENSTER, FENSTERTÜREN und vertikale TRANSPARENTE BAUTEILE gegen Außenluft, VERGLASTE oder UNVERGLASTE AUSSENTÜREN (bezogen auf Prüfnormmaß)	1,70
DACHFLÄCHENFENSTER gegen Außenluft	1,70
Sonstige TRANSPARENTE BAUTEILE horizontal oder in Schrägen gegen Außenluft	2,00
DECKEN gegen Außenluft, gegen Dachräume (durchlüftet oder ungedämmt) und über Durchfahrten sowie DACHSCHRÄGEN gegen Außenluft	0,20
INNENDECKEN gegen unbeheizte Gebäudeteile	0,40
INNENDECKEN gegen getrennte Wohn- und Betriebseinheiten	0,90

Room air temperature – temperature of surrounding surfaces ⇔ thermal comfort



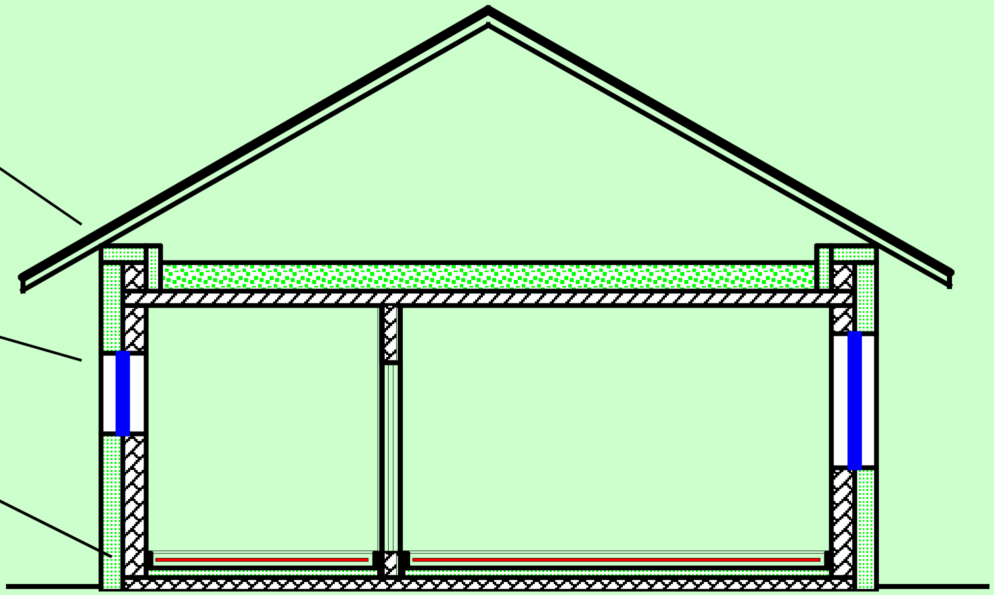



Same thermal insulation
Polystyrene 20 cm
Vacuum insulation 2 cm

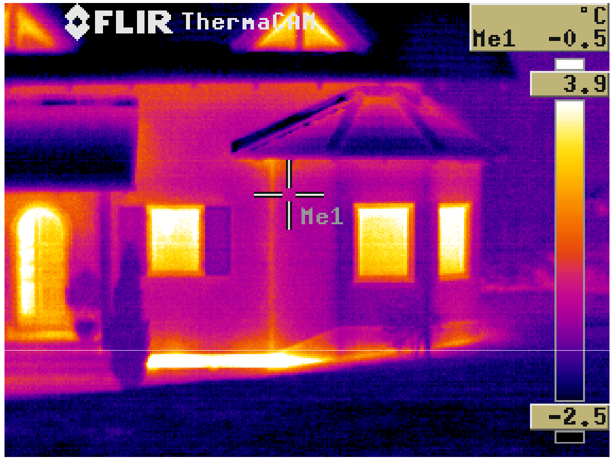
Avoiding thermal bridges

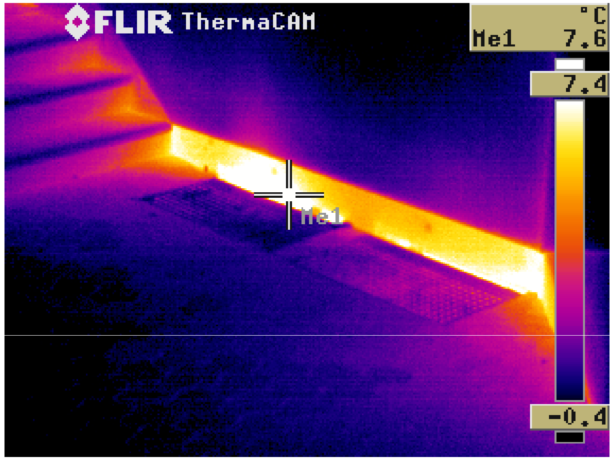
Problematic zones:

- **Connection of roof**
- **Windows**
- **Floor e.g. cellar ceiling**
- **Balkonies**

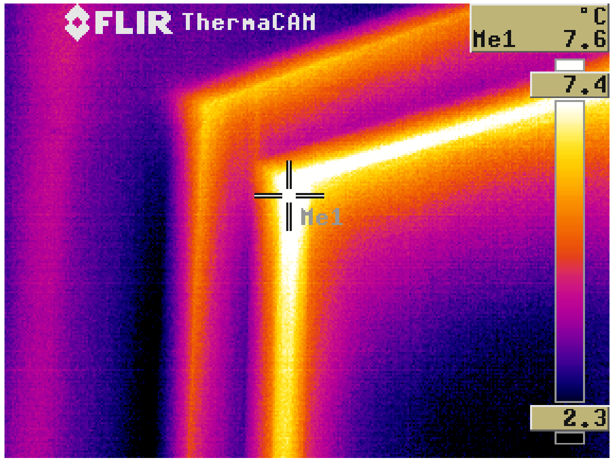


Thermal bridges, Thermographie



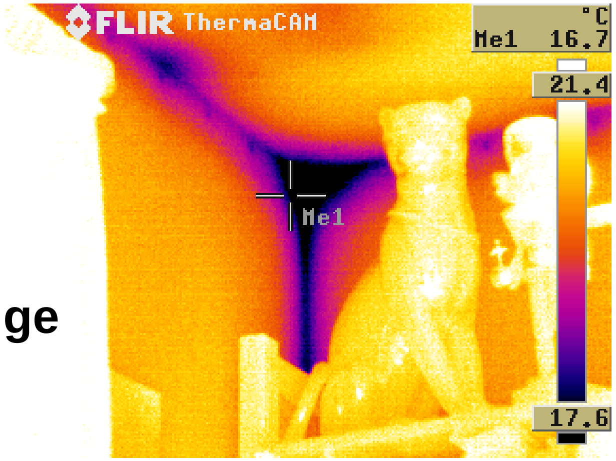


Ground floor to cellar,

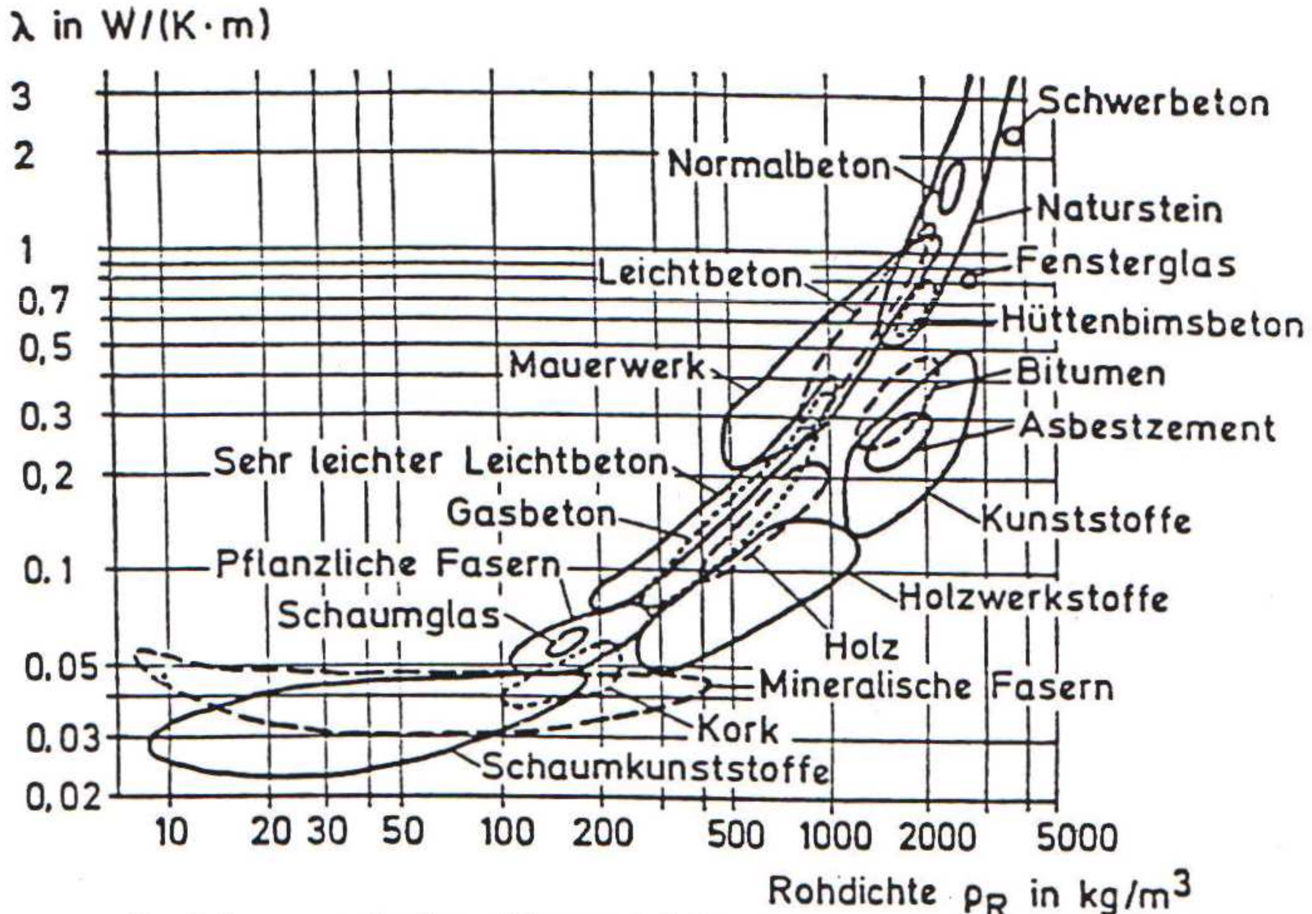


Window

interior edge



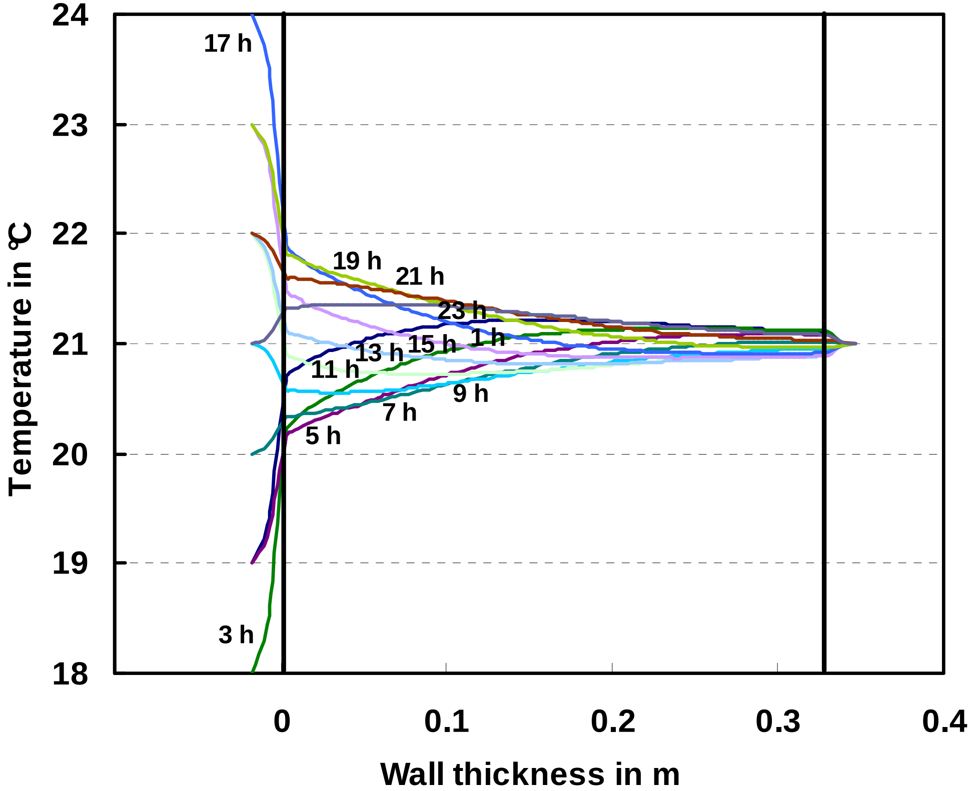
Material: Thermal conductivity λ and density ρ



Beziehung zwischen Wärmeleitfähigkeit λ und Rohdichte ϱ_R

Principal of active thermal mass

$$\dot{q} = -\lambda \frac{\partial T}{\partial x} \qquad \frac{\partial \dot{q}}{\partial x} = -\lambda \frac{\partial^2 T}{\partial x^2} = \rho_{Sp}\, c_p \frac{\partial T}{dt}$$



Needs room air temperature shifts

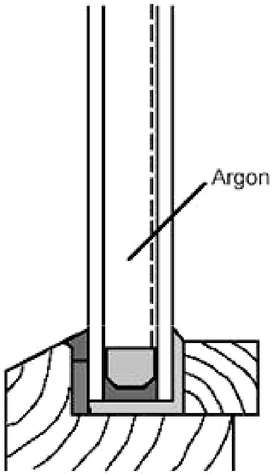
Stored and released heat : 0.076 kWh/(m² d).

Significant temperature change up to a depth of ca. 10 cm (concrete wall)

It is not useful to make this wall thicker

Thermal mass means AREA not DEPTH

Energy transmitttance through windows



k_V = 1,3 W/(m² K)

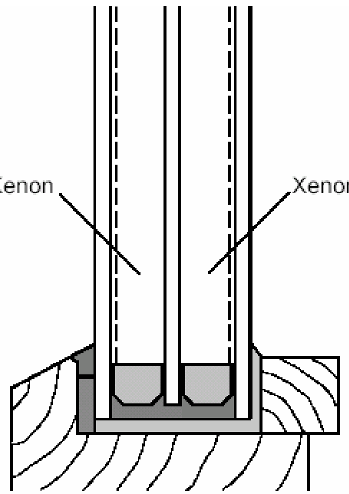
k_F = 1,4 W/(m² K)

g_F = 0,62

$k_{eq,F,Nord}$ = 0,81 W/(m² K)

$k_{eq,F,Ost/West}$ = 0,38 W/(m² K)

$k_{eq,F,Süd}$ = -0,09 W/(m² K)



k_V = 0,40 W/(m² K)

k_F = 0,67 W/(m² K)

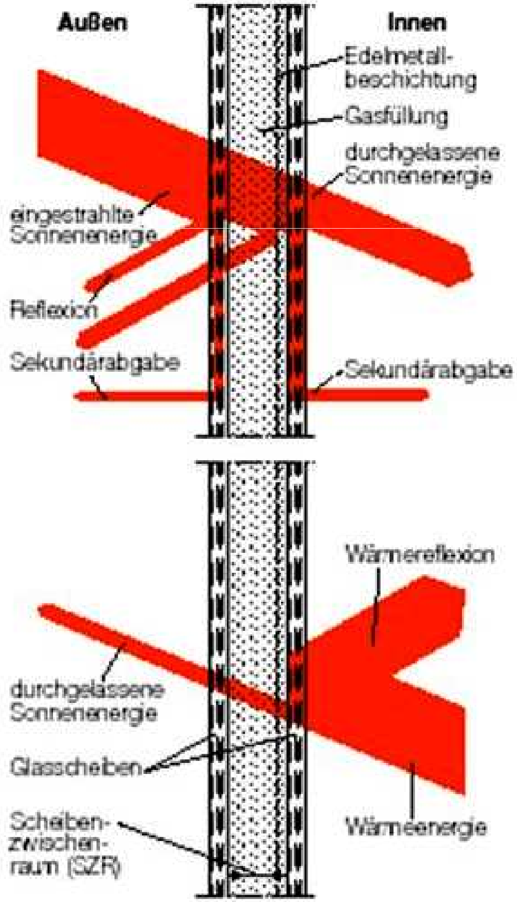
g_F = 0,42

$k_{eq,F,Nord}$ = 0,27 W/(m² K)

$k_{eq,F,Ost/West}$ = -0,02 W/(m² K)

$k_{eq,F,Süd}$ = -0,34 W/(m² K)

Bild 3.7: Wärmedurchgang durch ein Fenster mit Wärmeschutzglas (schematische Darstellung)



Energy transmittance (g) and heat transfer coefficient (U) for different glazings

	Diffuse *g*-value	*U*-value glazing in W/(m² K)
Insulating glazing (4 + 16 + 4 mm, air)	0.65	3.00
Thermal insulation double-glazing (4 + 14 + 4 mm, argon)	0.60	1.30
Thermal insulation double-glazing (4 + 14 + 4 mm, xenon)	0.58	0.90
Thermal insulation triple-glazing with argon filling	0.44	0.80
Thermal insulation triple-glazing with krypton filling	0.44	0.70
Thermal insulation triple-glazing with xenon filling	0.42	0.40
10 cm plastic capillaries, one cover pane	0.67	0.90
10 cm plastic honeycombs, one cover pane	0.71	0.90
10 cm glass capillaries, two panes	0.65	0.97
2.4 cm granular aerogel, two panes filled with air	0.50	0.90
2 cm evacuated (100 mbar) aerogel plate, two panes	0.60	0.50

The diffuse *g*-values were measured for a poor in iron 4 mm front pane, whereas for the *U-value*s an average sample temperature of 10 °C has been assumed.

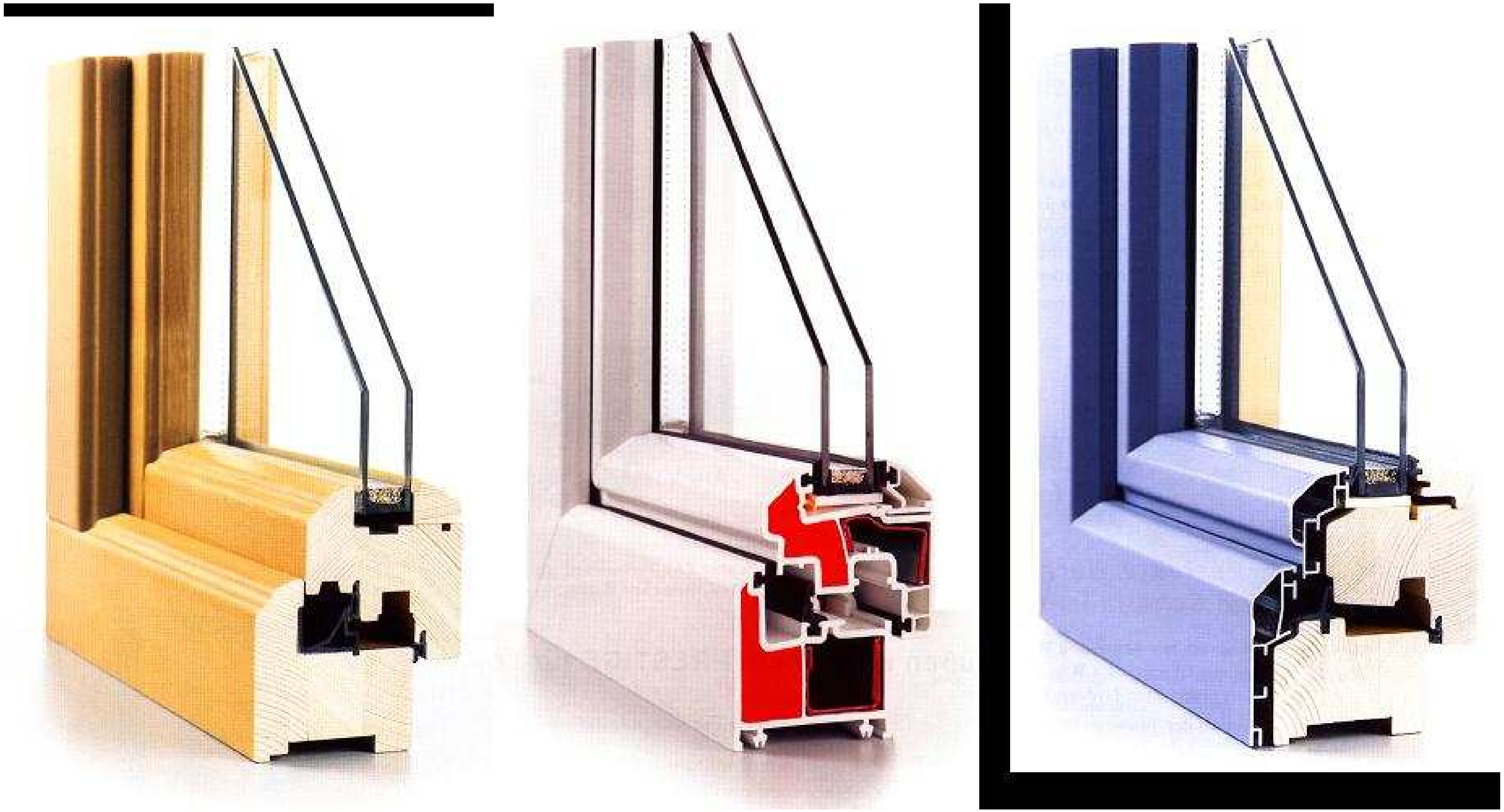
$$U_{eq} = U_W - S_F\, g$$

S_F = 0,95 north, 1,65 east/west, 2,4 south

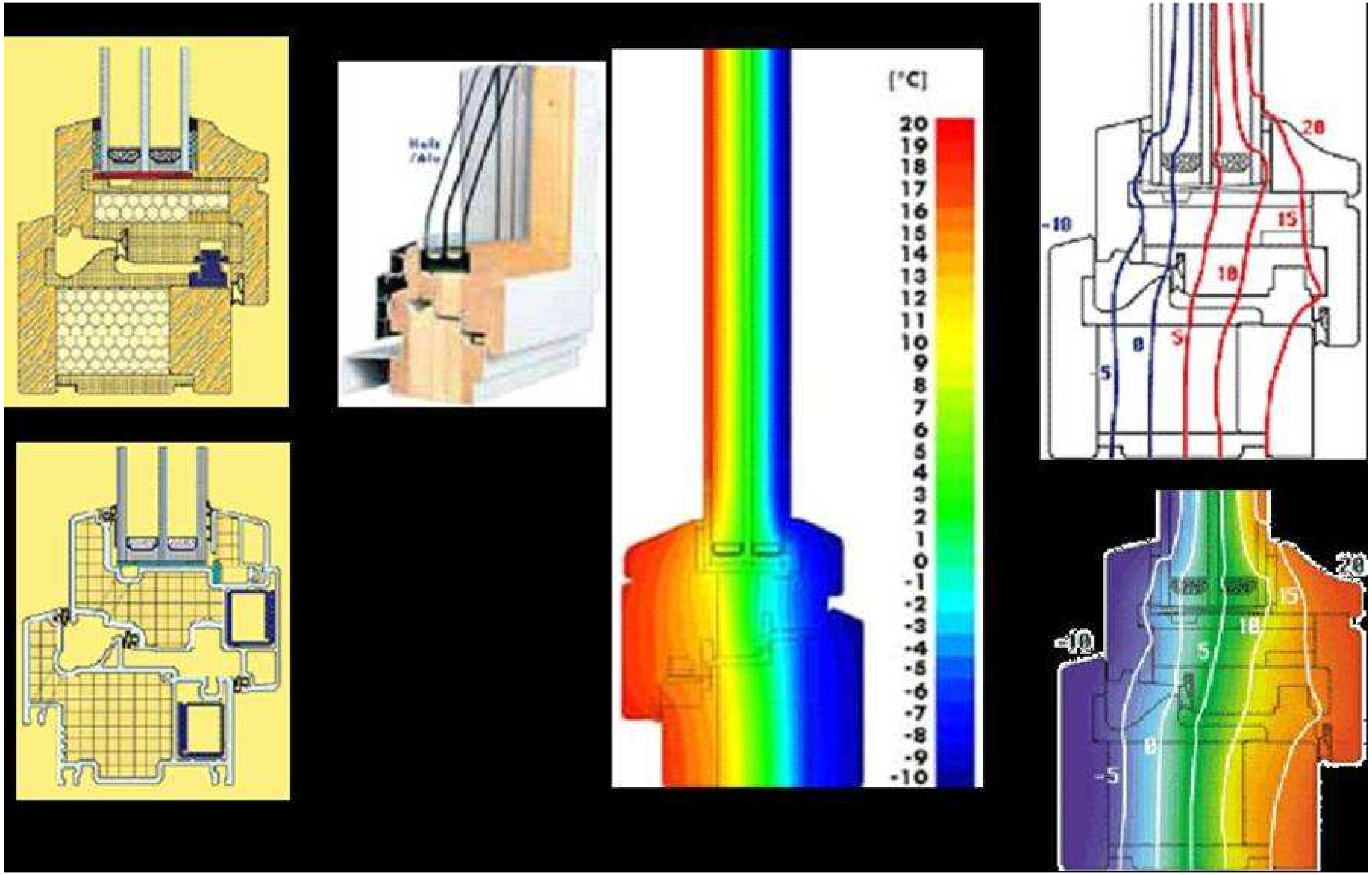
Diffuse g-value ($g_{diffuse}$), U-value of the window (U_w) and equivalent U-values (U_{eq}) corresponding to different glazing types (see /3-5/)

	$g_{diffuse}$	U_w	U_{eq} (south) in W/(m² K)	U_{eq} (east/west)	U_{eq} (north)
Simple glazing	0.87	5.8	3.7	4.4	5.0
Double-glazing (air 4 + 12 + 4 mm)	0.78	2.9	1.0	1.6	2.2
Double-glazing with thermal insulation and argon filling (6 + 15 + 6 mm)	0.60	1.5	0.1	0.5	0.9
Triple-glazing with thermal insulation and krypton filling (4 + 8 + 4 + 8 + 4 mm)	0.48	0.9	-0.3	0.1	0.4
Triple-glazing with thermal insulation and xenon filling (4 + 16 + 4 + 16 + 4 mm)	0.46	0.6	-0.5	-0.2	0.2

2-panes windows



3-pane low U windows



Factors influencing the solar transmittance of windows

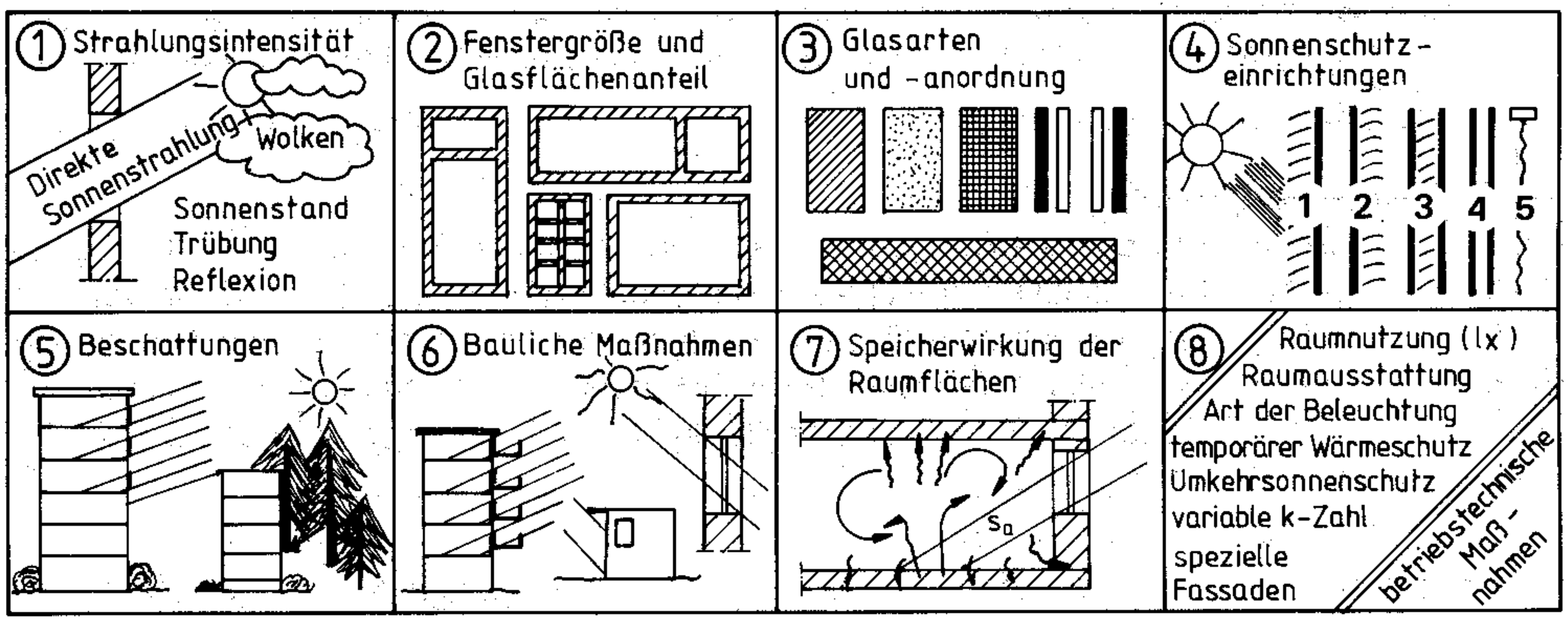
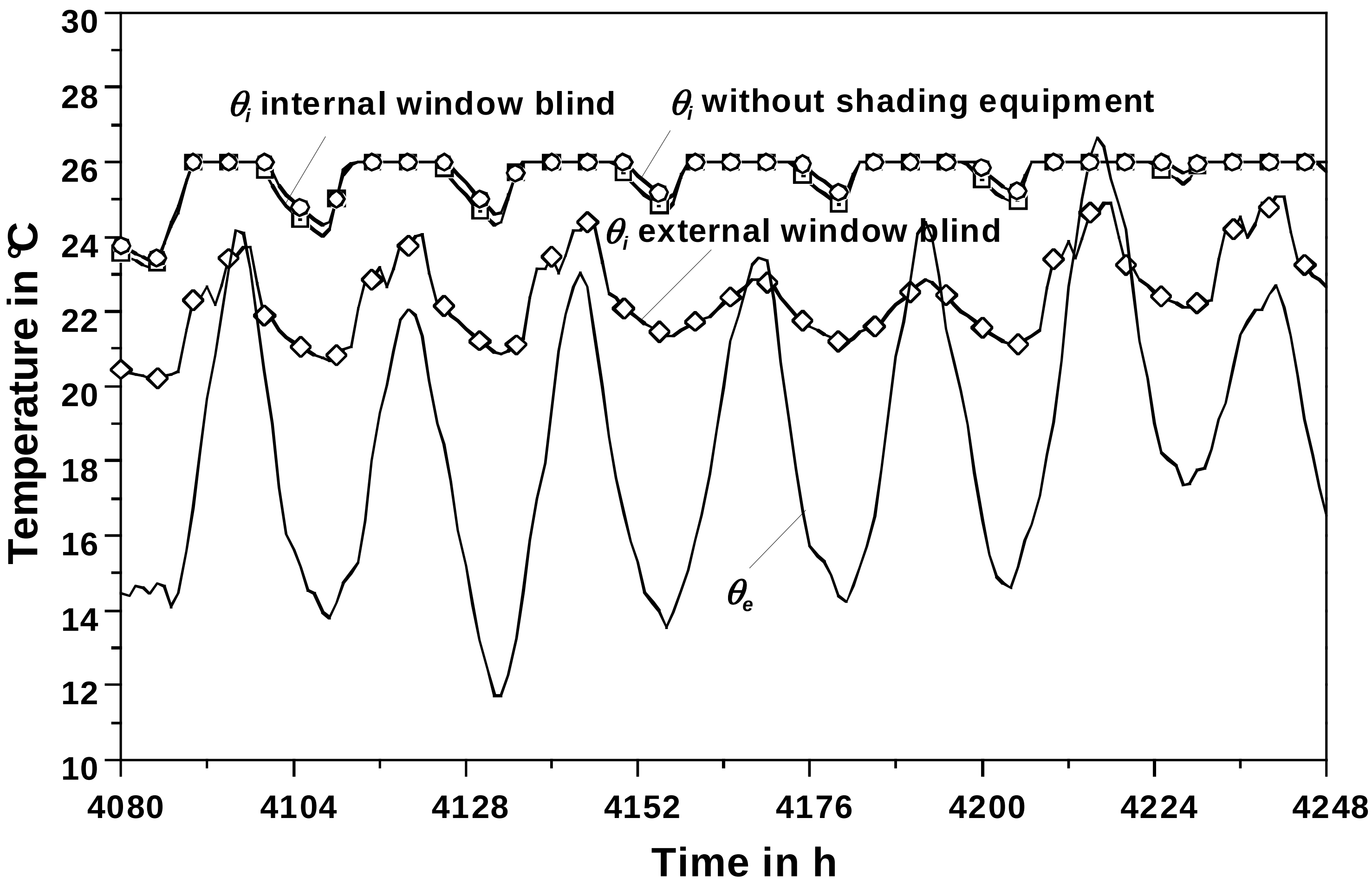
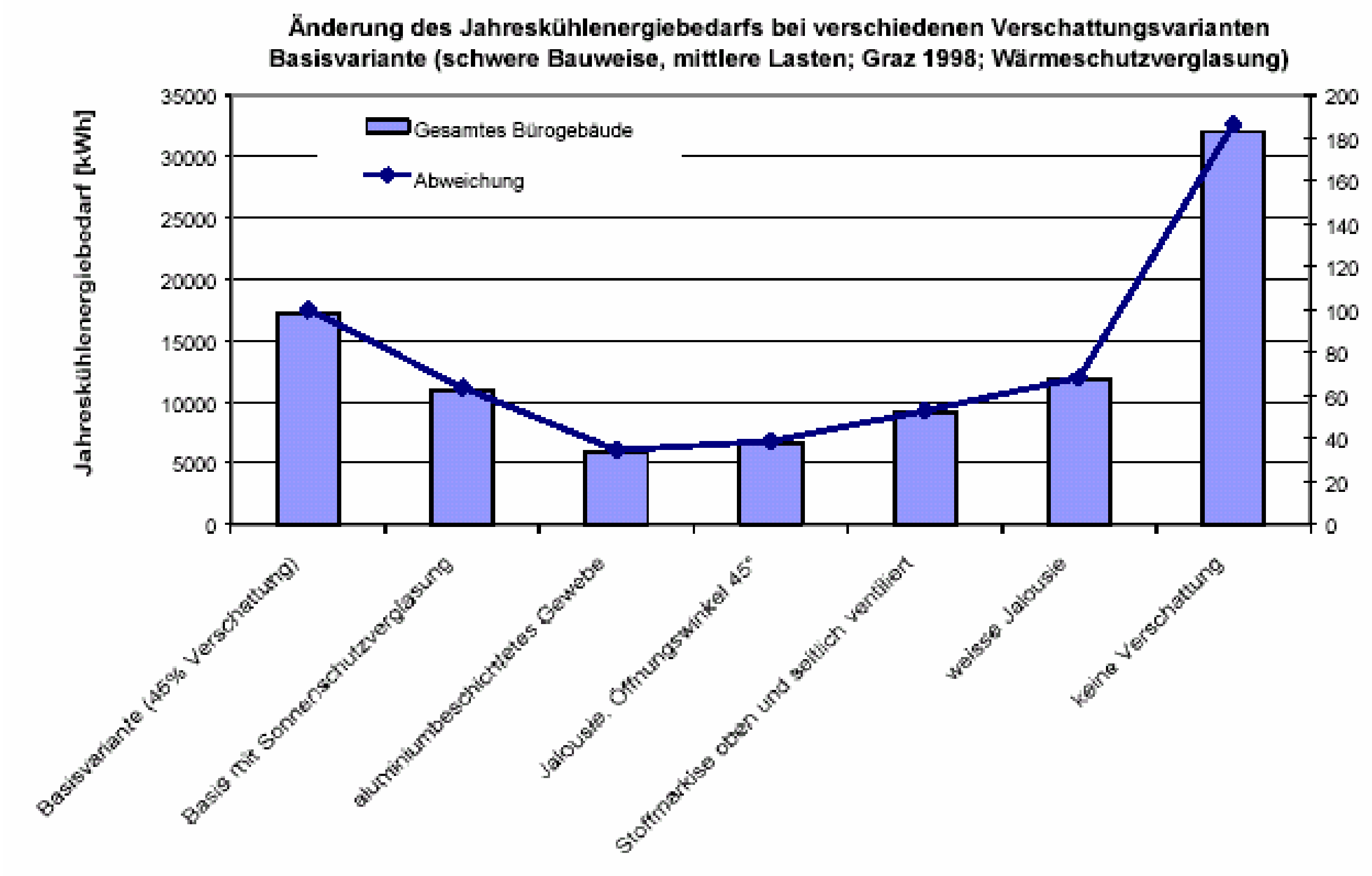


Abb. 7.24 Einflußgrößen auf Sonnenwärme durch Fenster

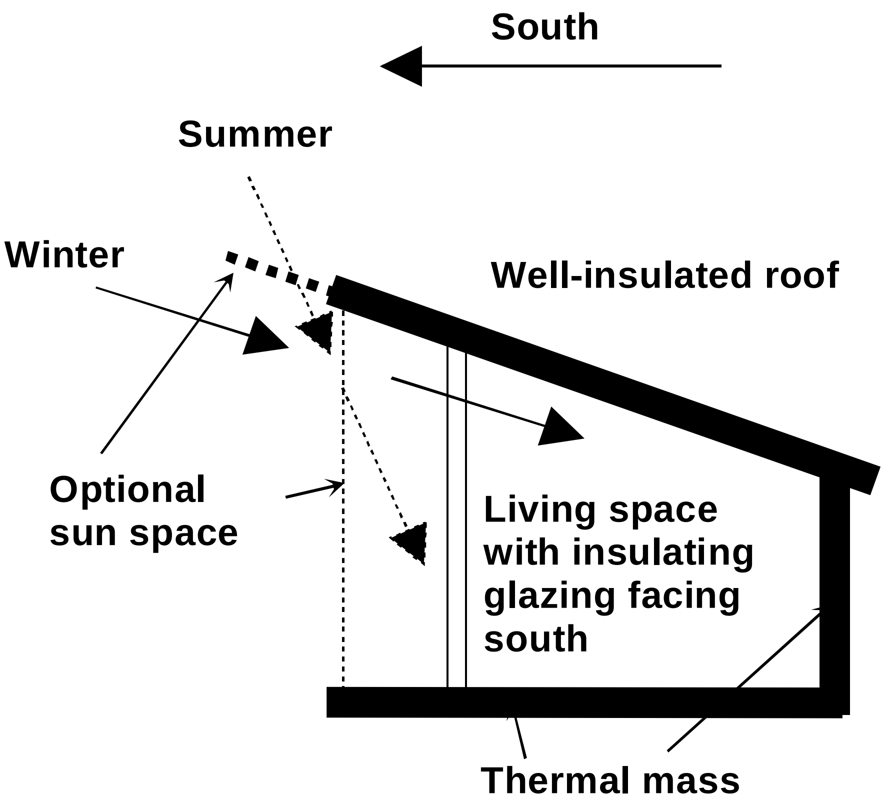
Shading by internal and external window blinds (θ_e ambient temperature, θ_i room temperature)

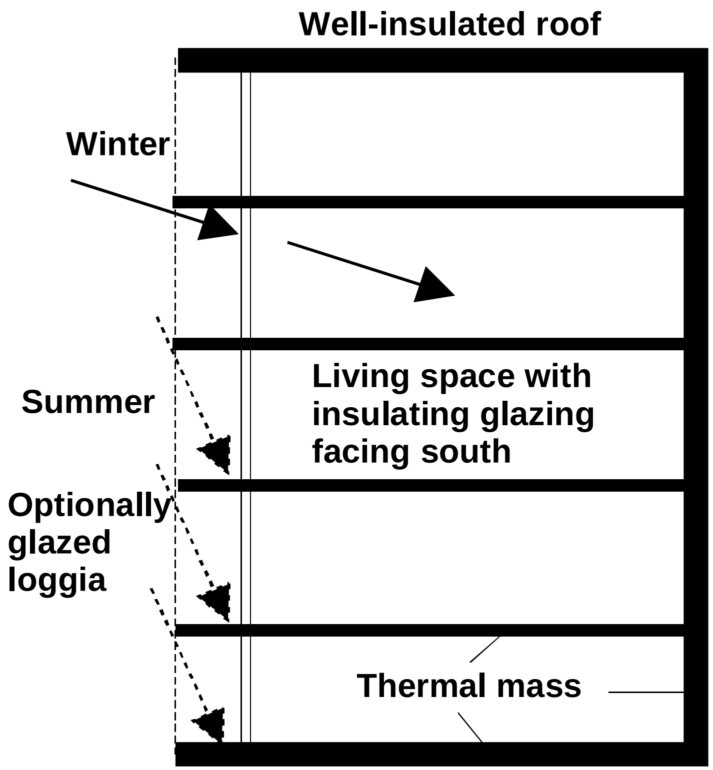


Cooling energy demand for different shading strategies in an office building

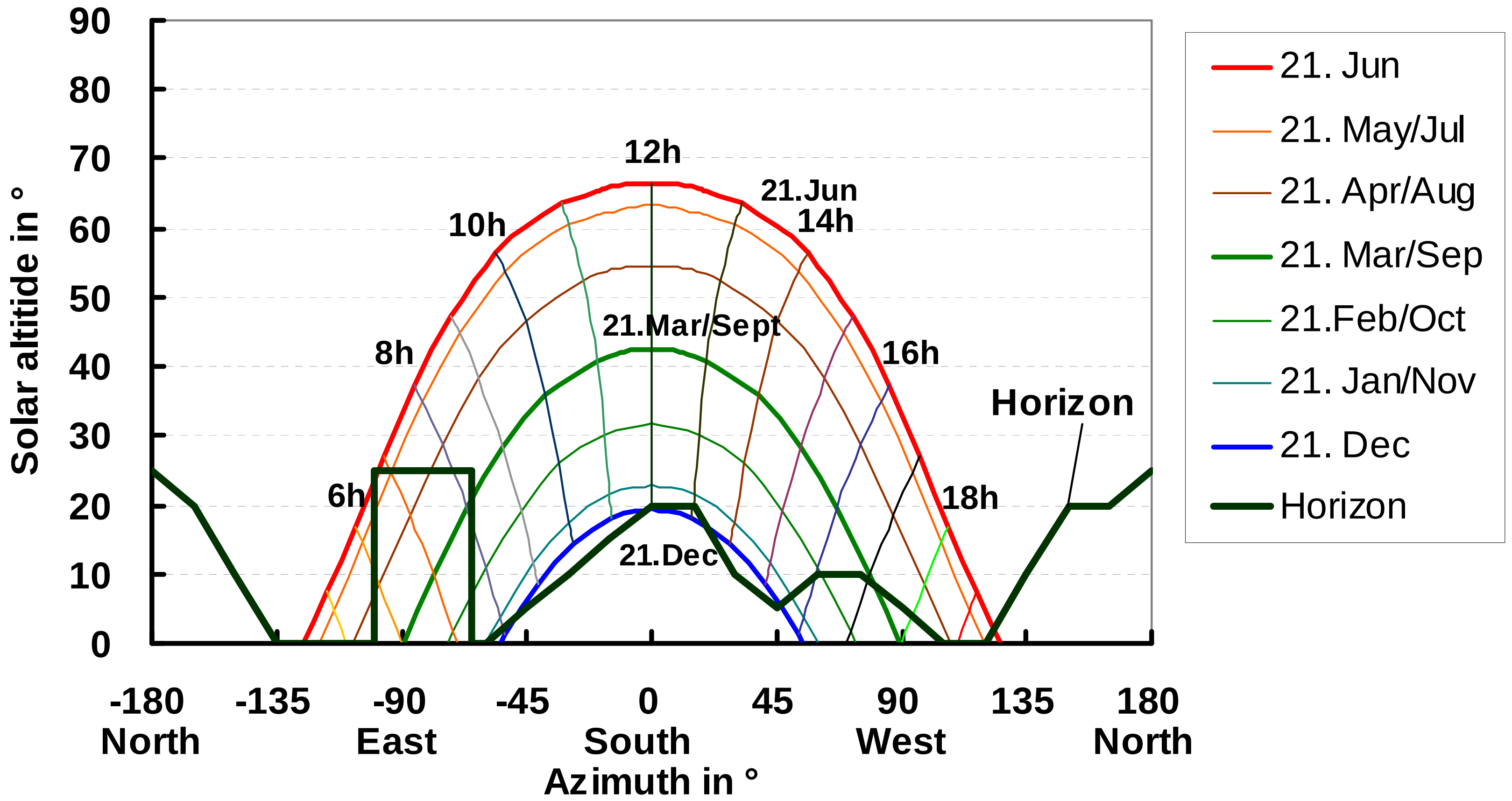


Shading of transparent building surfaces by roof overhangs (left: one family home, right: multiple families home)

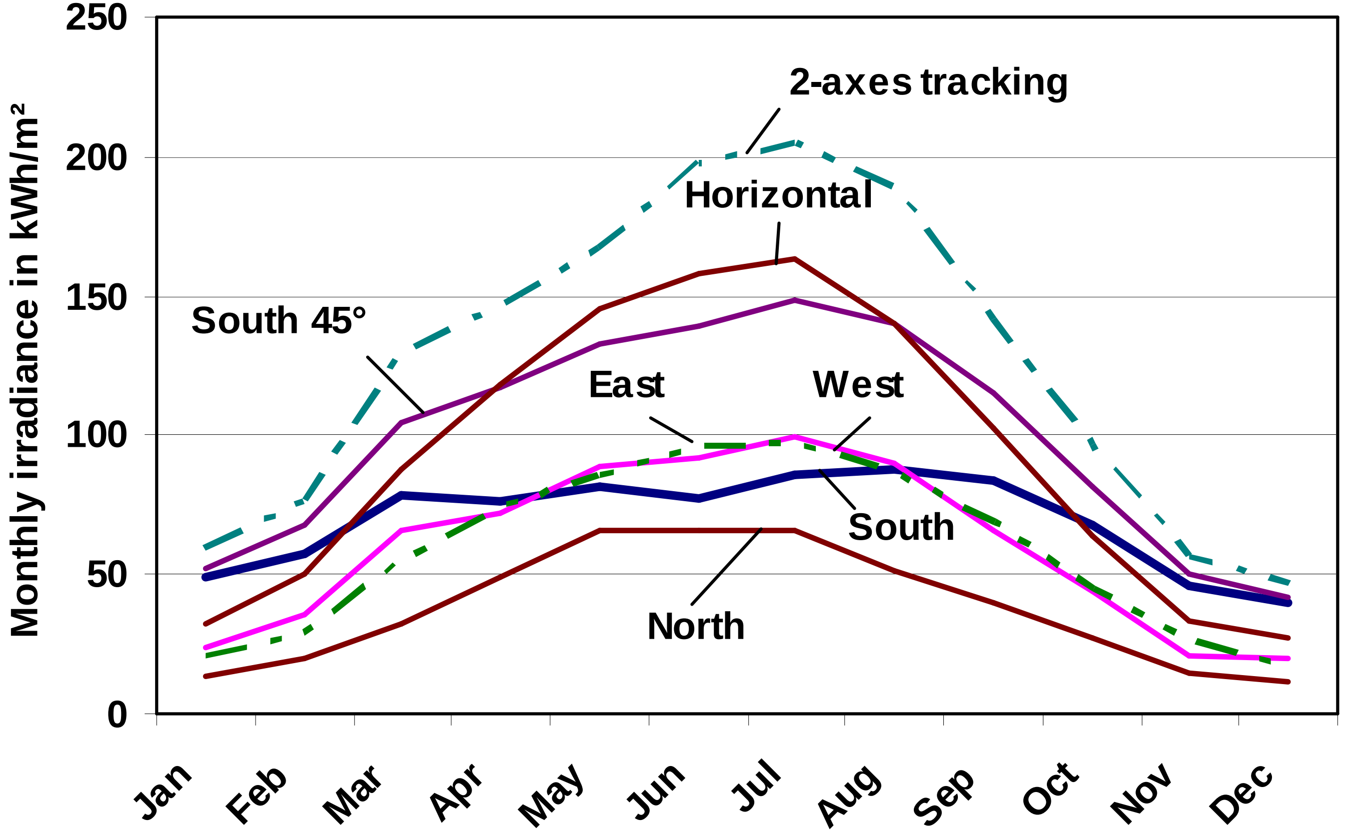




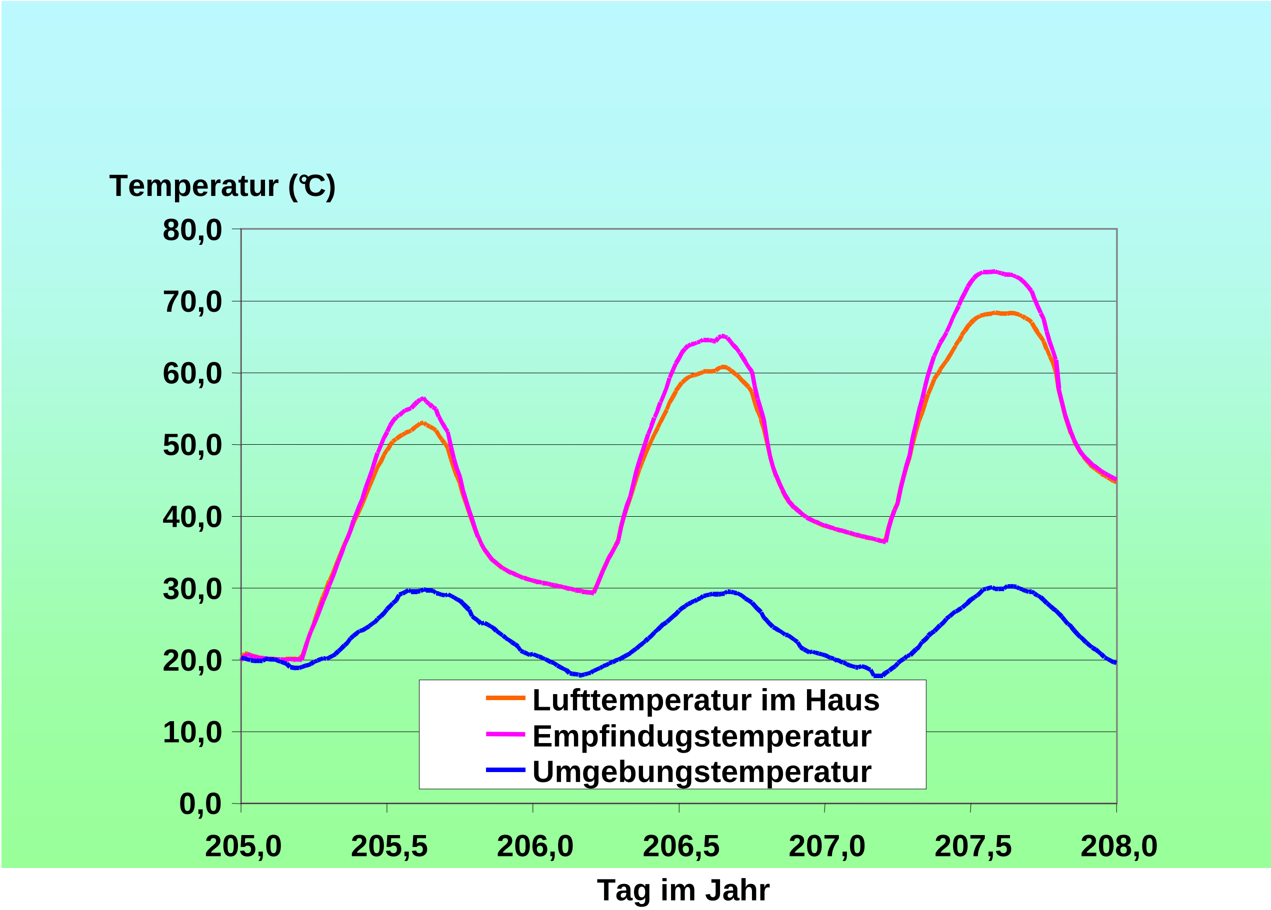
Solar position plot



Global radiation incident on surfaces with various alignments in Central Europe (climate Graz/Austria, 47° latitude)

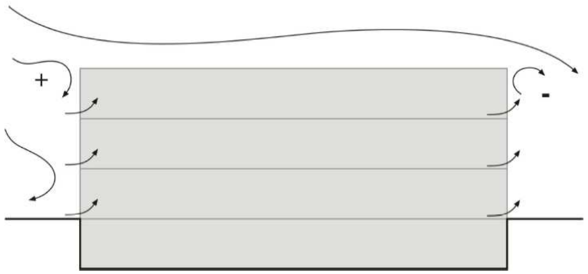


Summer Overheating in an office building (simulated)

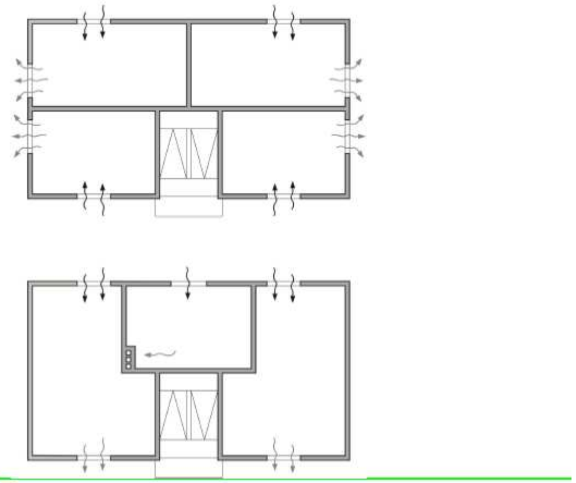


Natural ventilation

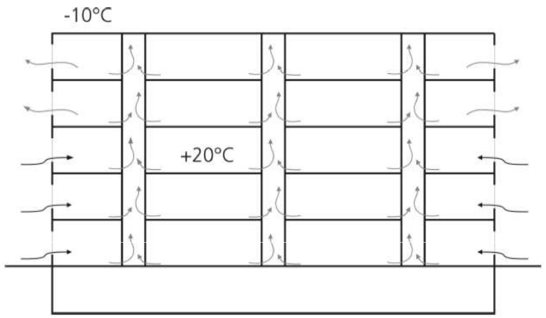
Natürliche Luftströmung durch Gebäude



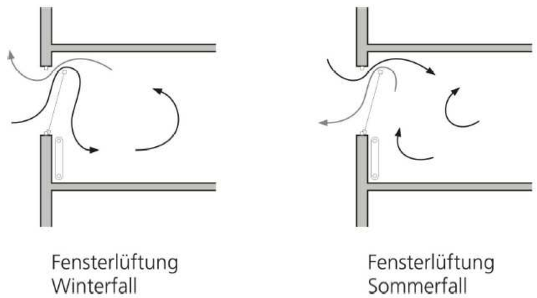
Querlüftung bei natürlicher Lüftung



Schachtwirkung durch thermischen Auftrieb



Natürliche Lüftung Sommer/Winter



Quelle: Bohne, Skript techn. Gebäudeausrüstung, UNI-Hannover

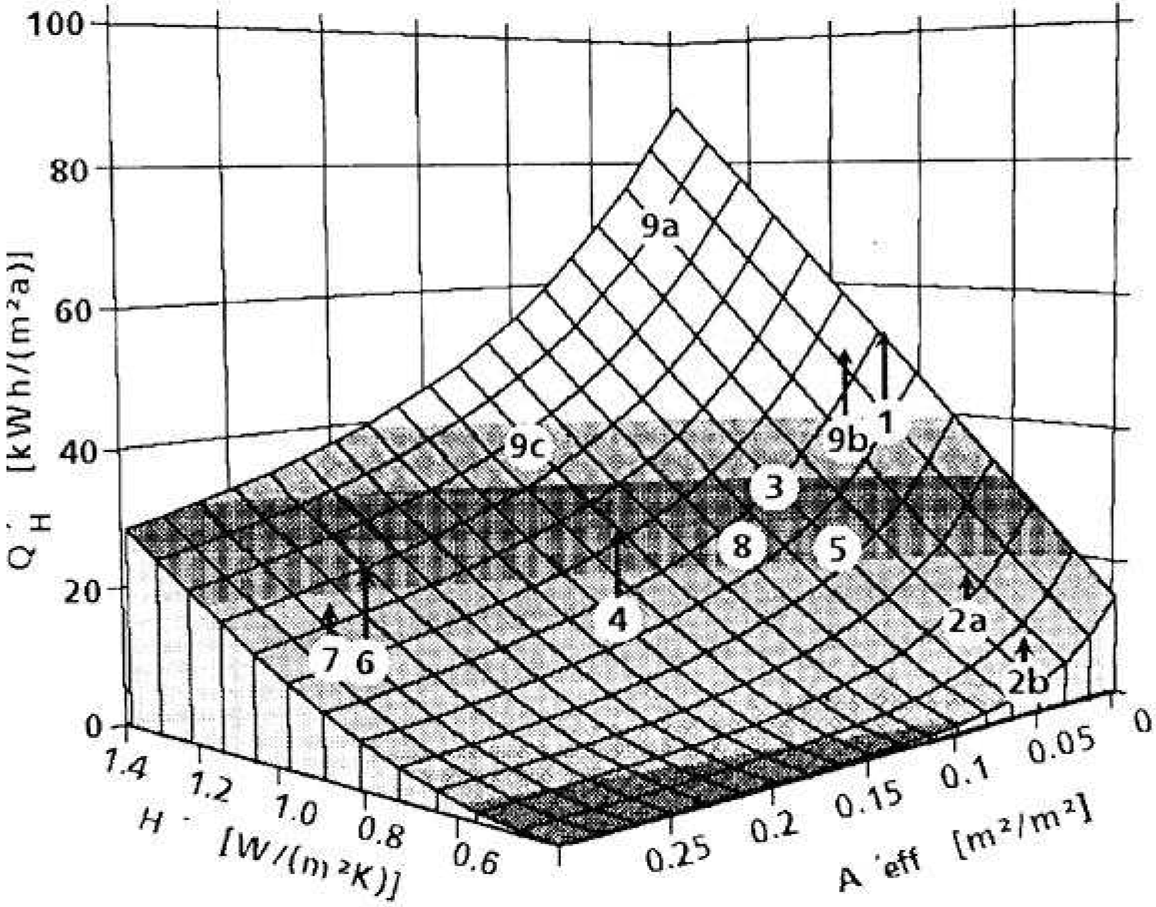
Low-energy lean multi family building

Solar houses

„Passive row houses“

„Solarhouses“ – „Passivhouses“

Gebäudekennfeld für ein Gebäude mittelschwerer Bauart und einigen realisierten Gebäuden: 7: Solarhaus Freiburg, 2: Passivhaus Kranichstein (a: Endhaus, b: Mittelhaus), Q´H: spezifischer Heizenergiebedarf (Voss, 1997)



EU Directive on the overall energy performance of buildings (EPBD) and its effect on the planning of buildings

Directive 2002/91/EG of the European Parliament and the Commission

Motivation for Directive (16.12.2002)

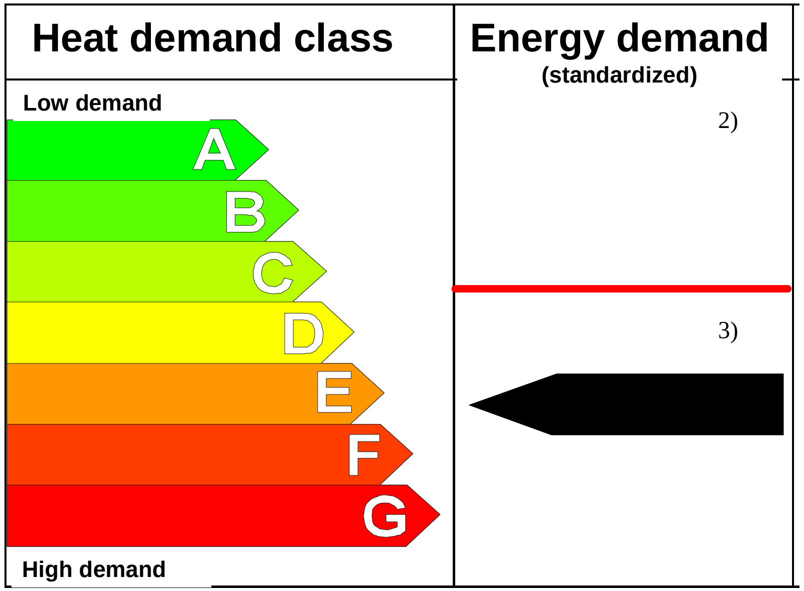
- Reduction of the energy demand and the CO2 emission of buildings (space heating and hot tap water amounts to 40% of the total end-use energy demand in Europe)
- Value of buildings not (only) because of the location but also because of the energy demand and the operating costs
- European harmonization of standards for calculation and evaluation (certificates) of energy demand of buildings
- Reduction of emissions by constant maintenance of boilers and air-conditioning systems

Content of the Directive

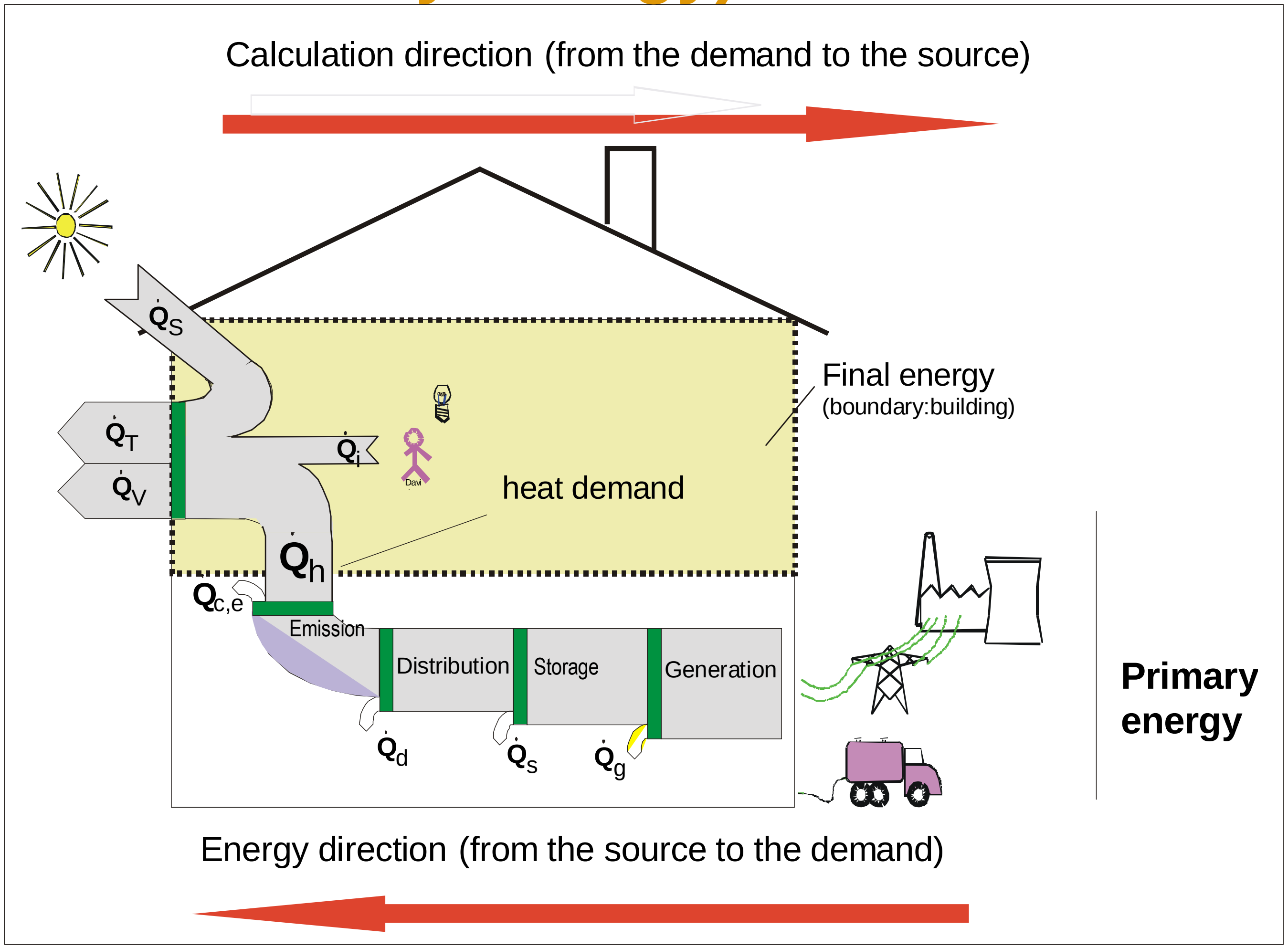
- Development of the calculation method (energy demand of heating (EN 13790), cooling (new), lightning (new) and losses of the production- and distribution systems (new)

- Fixing of average, minimum and maximum energy demand of buildings by the national governments

- Development of energy certificates for buildings



Calculation of Final, End-Use (and Primary Energy) Demand



Possibilities of energetical limits in the building sector

-U-Values of the components in W/m²K

-LEK- Value of the building envelope in [-]

-Useful energie demand in kWh/m²a

-End-use energy demand in kWh/m²a

-primaryenergy demand in kWh/m²a

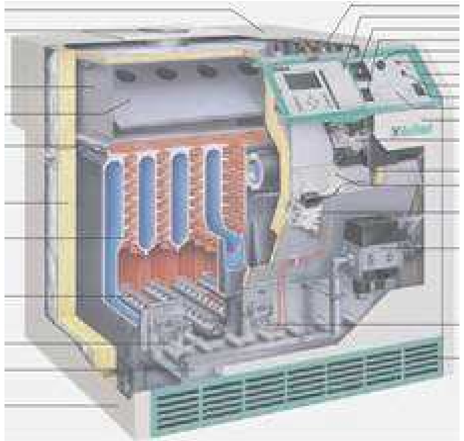
- CO_2 – key figure kgCO_2/m².a

Content of the Directive

- Application for all new and refurbished buildings
  - Private houses: new buildings, (partly)selling, renovation
  - Public buildings: right after the directive comes into force
- Increasing the use of renewable energy sources, combined heat and power plants (CHP) and heat pumps if economically feasible

Content of the Directive

- Regularly inspections of boilers (>100 kW every 2 / 4(gas) years; <20 kW every 15 years)



- Regularly inspection of air-conditioning systems

- Inspection by independent specialists

- Set into force by

!!! January 4th 2006 !!!

Three Levels of Energy-Demand Evaluation

- **Level A**
  Calculation of End-Use Energy demand
  (predefined user behaviourm, Asset Rating)

- **Level B**
  Measurement of End-Use Energy demand
  (actual user behaviour, Operational Rating)

- **Level C**
  Estimation of End-Use Energy demand using statistical values for different types, architectures and ages of buildings

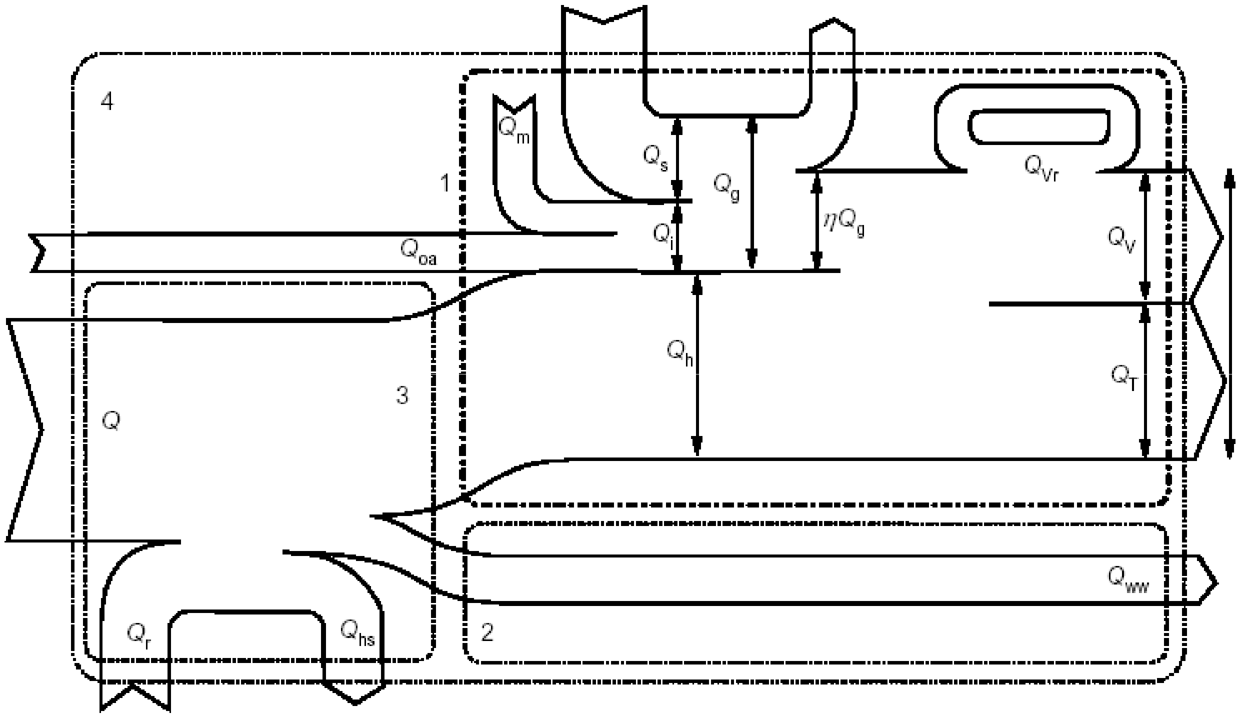
Status of the EPBD development (CEN)

- Mandate to CEN (October 2003) for developing calculation systems

- Affected Technical Committees (TCs)
  - CEN/TC 89 Thermal performance of buildings and building components
  - CEN/TC 156 Ventilation for buildings
  - CEN/TC 169 Light and lighting
  - CEN/TC 228 Heating systems in buildings
  - CEN/TC 247 Building Automation, Controls and Building Management

- Till this time big activities in the standardization bodies

Energy Flow in Buildings by En ISO 13790



Key

Q	energy use for heating
Q_{oa}	heat from other appliances
Q_r	recovered energy
Q_{hs}	losses from the heating system
Q_m	metabolic heat
Q_s	passive solar gains
Q_i	internal gains
Q_g	total gains
$\eta\ Q_g$	useful gains
Q_h	heat use
Q_V	ventilation heat loss
Q_{Vr}	ventilation heat recovery
Q_T	transmission heat loss
Q_{ww}	heat for hot water preparation
Q_L	total heat loss
1	boundary of the heated zone
2	boundary of the hot water system
3	boundary of the heating plant
4	boundary of the building

Energy Certificate Berlaymont Gebäude

Year of errection:	1967 (renovated from 1995 to 2004)
Useful area:	241.515 m²
Persons:	over 3000 Persons per day
Heating:	3 Gas burners with a total capacity of 7.800 [kW]
Cooling:	4 Compression cooling machines with a total cooling capacity of 8.900 [kW]

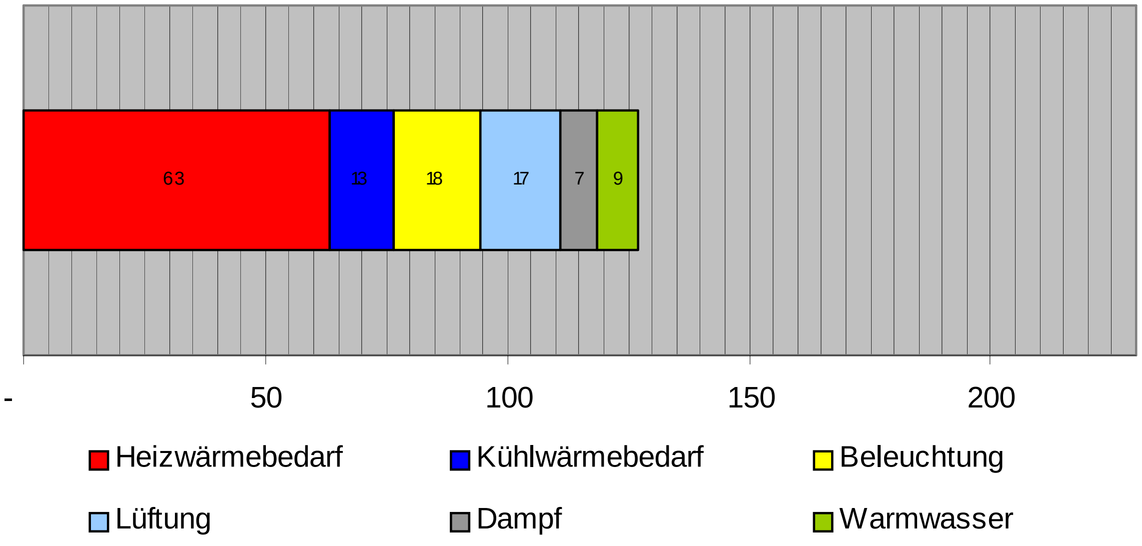
Results useful energy, example Berlaymont, Brüssel

Nutzenergie:

Heizwärmebedarf	63	[kWh/(m².a)]
Kühlwärmebedarf	13	[kWh/(m².a)]
Beleuchtung	18	[kWh/(m².a)]
Luftförderung	17	[kWh/(m².a)]
Dampf	7	[kWh/(m².a)]
Warmwasser	9	[kWh/(m².a)]

Summe	127	[kWh/(m².a)]

spezifischer Nutzenergiebedarf [kWh/(m².a)]



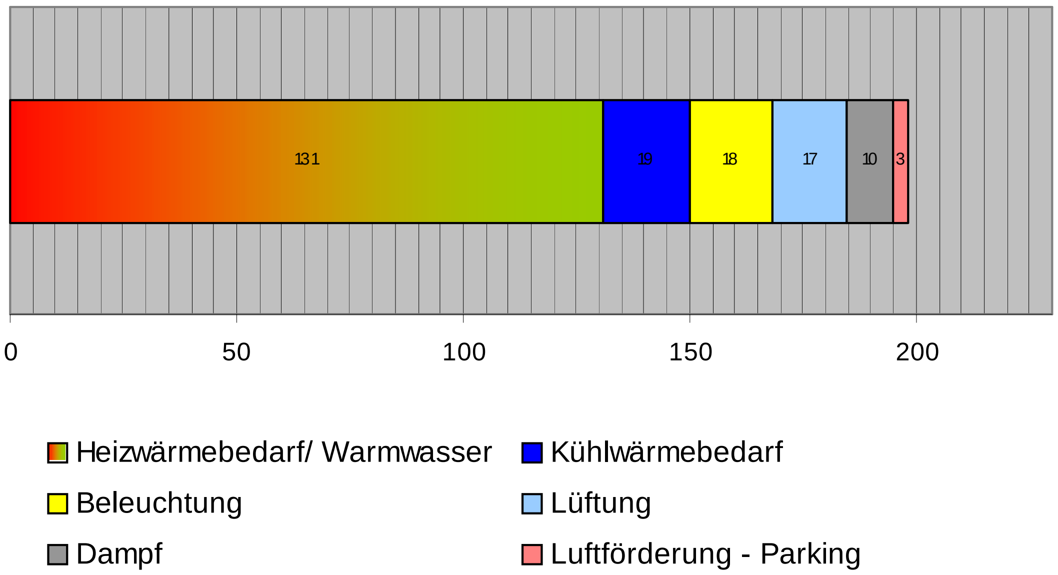
Endenergie:

Heizwärmebedarf und Warmwasser	131	[kWh/(m².a)]
Kühlwärmebedarf	19	[kWh/(m².a)]
Beleuchtung	18	[kWh/(m².a)]
Luftförderung	17	[kWh/(m².a)]
Dampf	10	[kWh/(m².a)]
Luftförderung - Parking	3	[kWh/(m².a)]

Summe	198[kWh/(m².a)]

Results end use energy, example Berlaymont, Brüssel

spezifischer Endenergiebedarf [kWh/(m².a)]



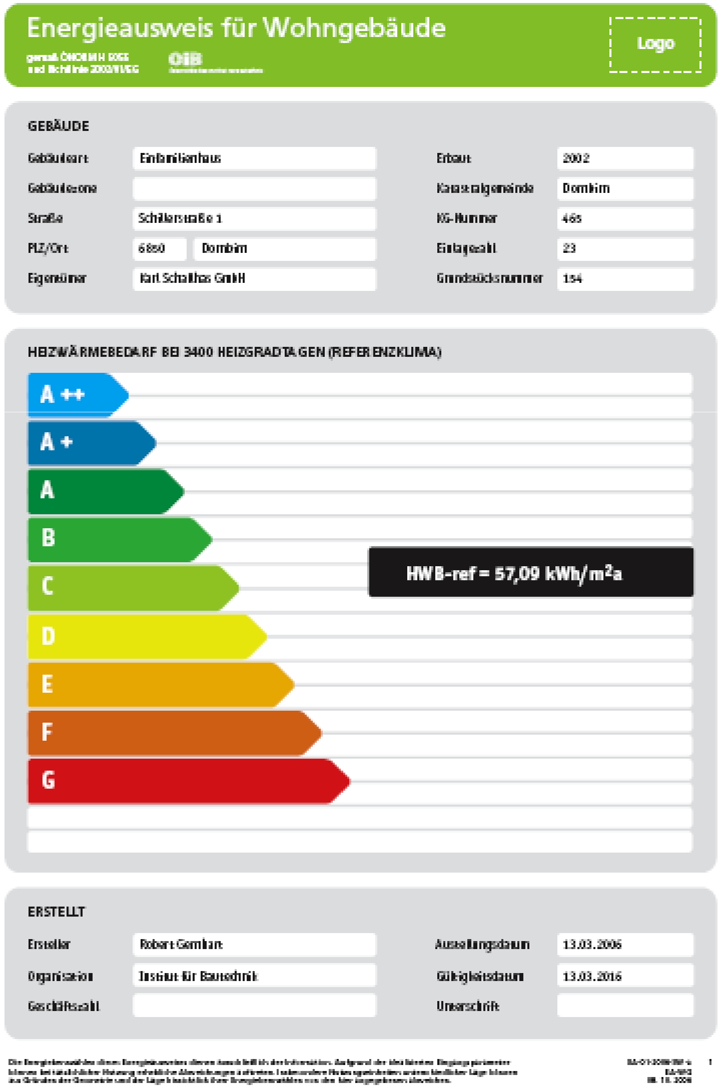
Institut für Wärmetechnik

TU Graz

IWT TU Graz
Institut für Wärmetechnik

TU Graz
Graz University of Technology

Energieausweis Wohngebäude



Energieausweis für Wohngebäude

Logo

GEBÄUDE

Gebäudeart	Einfamilienhaus	Erbaut	2002
Gebäudezone		Katastralgemeinde	Dornbirn
Straße	Schillerstraße 1	KG-Nummer	465
PLZ/Ort	6850 Dornbirn	Einlagezahl	23
Eigentümer	Karl Schallhas GmbH	Grundstücksnummer	154

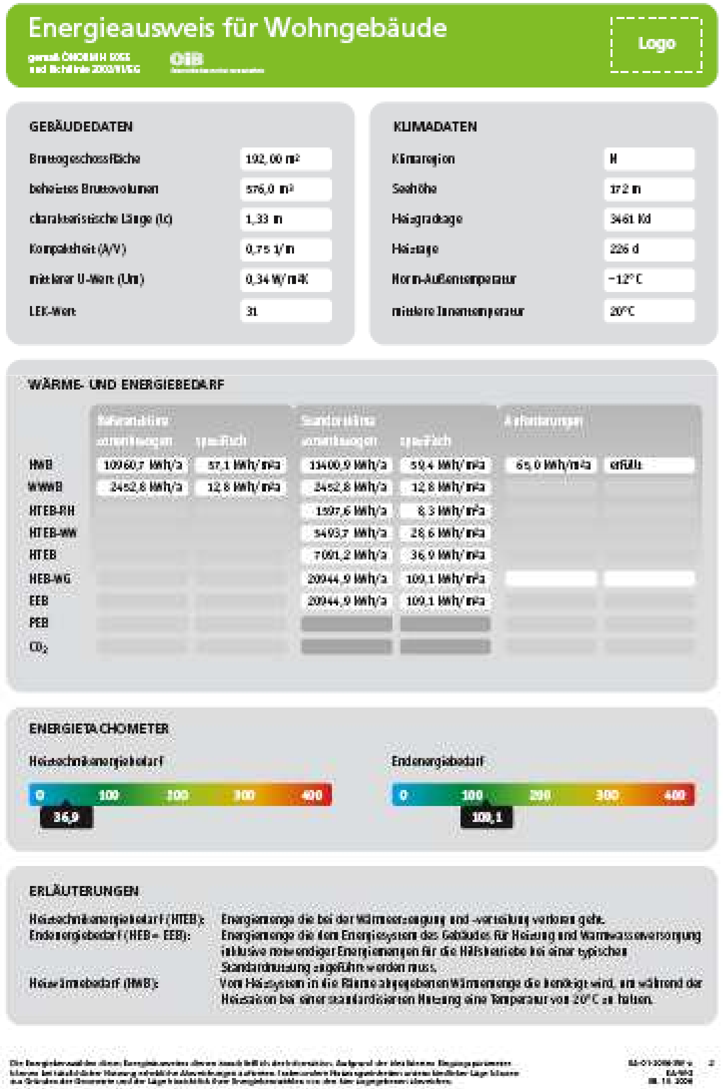
HEIZWÄRMEBEDARF BEI 3400 HEIZGRADTAGEN (REFERENZKLIMA)

A ++
A +
A
B
C
D
E
F
G

HWB-ref = 57,09 kWh/m²a

ERSTELLT

Ersteller	Robert Gernhart	Ausstellungsdatum	13.03.2006
Organisation	Institut für Bautechnik	Gültigkeitsdatum	13.03.2016
Geschäftszahl		Unterschrift	



Energieausweis für Wohngebäude

Logo

GEBÄUDEDATEN

Bruttogeschossfläche	192,00 m²
beheiztes Bruttovolumen	576,0 m³
charakteristische Länge (lc)	1,33 m
Kompaktheit (A/V)	0,75 1/m
mittlerer U-Wert (Um)	0,34 W/m²K
LEK-Wert	31

KLIMADATEN

Klimaregion	N
Seehöhe	172 m
Heizgradtage	3461 Kd
Heiztage	226 d
Norm-Außentemperatur	−12°C
mittlere Innentemperatur	20°C

WÄRME- UND ENERGIEBEDARF

	Referenzklima zonenbezogen	spezifisch	Standortklima zonenbezogen	spezifisch	Anforderungen	
HWB	10960,7 kWh/a	57,1 kWh/m²a	11400,9 kWh/a	59,4 kWh/m²a	65,0 kWh/m²a	erfüllt
WWWB	2452,8 kWh/a	12,8 kWh/m²a	2452,8 kWh/a	12,8 kWh/m²a		
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HTEB-WW			5493,7 kWh/a	28,6 kWh/m²a		
HTEB			7091,2 kWh/a	36,9 kWh/m²a		
HEB-WG			20944,9 kWh/a	109,1 kWh/m²a		
EEB			20944,9 kWh/a	109,1 kWh/m²a		
PEB						
CO_2						

ENERGIETACHOMETER

Heiztechnikenergiebedarf: 0 – 100 – 200 – 300 – 400; 36,9

Endenergiebedarf: 0 – 100 – 200 – 300 – 400; 109,1

ERLÄUTERUNGEN

Heiztechnikenergiebedarf (HTEB): Energiemenge die bei der Wärmeerzeugung und -verteilung verloren geht.

Endenergiebedarf (HEB = EEB): Energiemenge die dem Energiesystem des Gebäudes für Heizung und Warmwasserversorgung inklusive notwendiger Energiemengen für die Hilfsbetriebe bei einer typischen Standardnutzung zugeführt werden muss.

Heizwärmebedarf (HWB): Vom Heizsystem in die Räume abgegebene Wärmemenge die benötigt wird, um während der Heizsaison bei einer standardisierten Nutzung eine Temperatur von 20°C zu halten.

Energieausweis Nichtwohngebäude

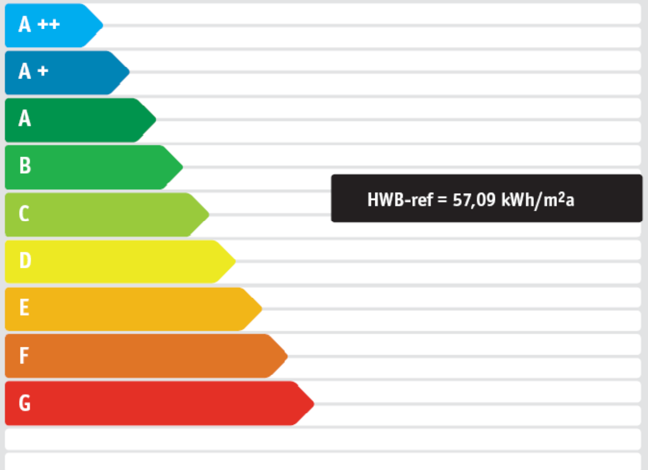
Energieausweis für Nicht-Wohngebäude

gemäß ÖNORM H 5055 und Richtlinie 2002/91/EG — OIB — Logo

GEBÄUDE

Gebäudeart	Einfamilienhaus	Erbaut	2002
Gebäudezone		Katastralgemeinde	Dornbirn
Straße	Schillerstraße 1	KG-Nummer	465
PLZ/Ort	6850 Dornbirn	Einlagezahl	23
Eigentümer	Karl Schallhas GmbH	Grundstücksnummer	154

HEIZWÄRMEBEDARF BEI 3400 HEIZGRADTAGEN (REFERENZKLIMA)



ERSTELLT

Ersteller	Robert Gernhart	Ausstellungsdatum	13.03.2006
Organisation	Institut für Bautechnik	Gültigkeitsdatum	13.03.2016
Geschäftszahl		Unterschrift	

Die Energiekennzahlen dieses Energieausweises dienen ausschließlich der Information. Aufgrund der idealisierten Eingangsparameter können bei tatsächlicher Nutzung erhebliche Abweichungen auftreten. Insbesondere Nutzungseinheiten unterschiedlicher Lage können aus Gründen der Geometrie und der Lage hinsichtlich ihrer Energiekennzahlen von den hier angegebenen abweichen.

EA-01-2006-SW-a 1
EA-NWG
08. 10. 2006

Energieausweis für Nicht-Wohngebäude

gemäß ÖNORM H 5055 und Richtlinie 2002/91/EG — OIB — Logo

GEBÄUDEDATEN

Bruttogeschossfläche	192,00 m²
beheiztes Bruttovolumen	576,0 m³
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WÄRME- UND ENERGIEBEDARF

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HWB-WG	10960,7 kWh/a	57,1 kWh/m²a	11400,9 kWh/a	59,4 kWh/m²a	65,0 kWh/m²a	erfüllt
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HWB-NWG(n)	8200,5 kWh/a	14,2 kWh/m³a	8563,5 kWh/a	14,9 kWh/m³a		
WWWB	2452,8 kWh/a	12,8 kWh/m²a	2452,8 kWh/a	12,8 kWh/m²a		
NERLT-H				0,0 kWh/m²a		
KB						
NERLT-K				0,0 kWh/m²a		
NERLT-D				0,0 kWh/m²a		
NE				0,0 kWh/m²a		
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KTEB						
HEB-WG						
HEB-NWG						
KEB-NWG						
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BelEB-NWG						
EEB						
PEB						
CO_2						

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EA-01-2006-SW-a 2
EA-NWG
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Energieausweis für Wohngebäude

gemäß ÖNORM H 5055
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OIB

Logo

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ENERGIETACHOMETER

Heiztechnikenergiebedarf

Endenergiebedarf

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Energieausweis für Nicht-Wohngebäude

gemäß ÖNORM H 5055
und Richtlinie 2002/91/EG

OIB

Logo

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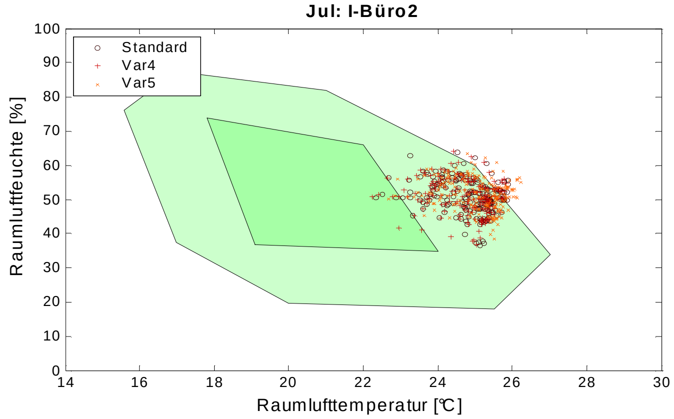
BelEB-NWG						
EEB						
PEB						
CO_2						

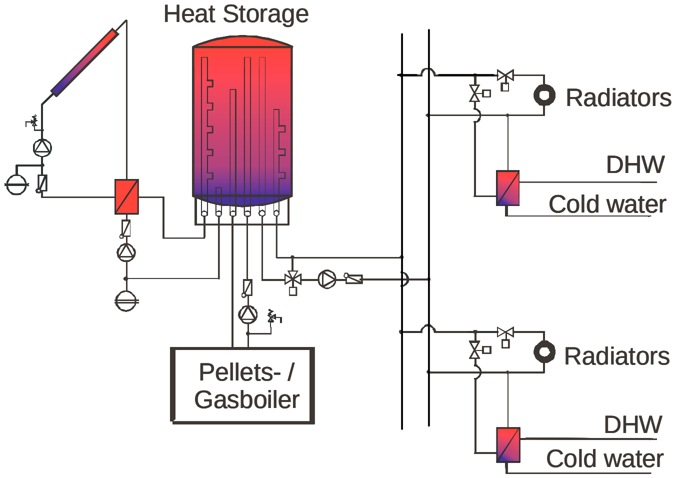
What can‘t be done with the calculation via EPBD

- Heating / cooling load



- Statistic about over-temperature

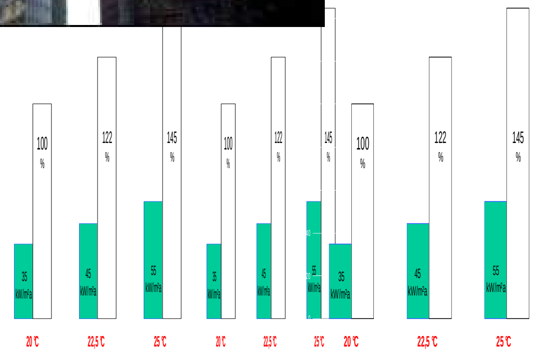
- Detailed effects of complex hydraulics and controls



What can‘t be done with the calculation via EPBD

- Effect of complex calculations (big sunspaces, double skin facades)

- Consideration of user-behaviour (window-ventilation, attendance, internal loads …)



Space heating energy for varying indoor air temperature in a Passive house

- Worst/best case scenarios regarding climate

Effects of the EPBD on the Design Process of Buildings

- Energy demand for heating and cooling will be relevant already in architectural competitions.

- As the first sketch of the architect fixes about 40 % of the energy demand of the building, integrated design approaches (architect, civil engineer, mechanical engineer...) will become relevant

- Building codes and subsidy schemes will use the EPBD certificates.

- Detailed questions to the building still need dynamic building simulation.

Further upcoming EU-regulations

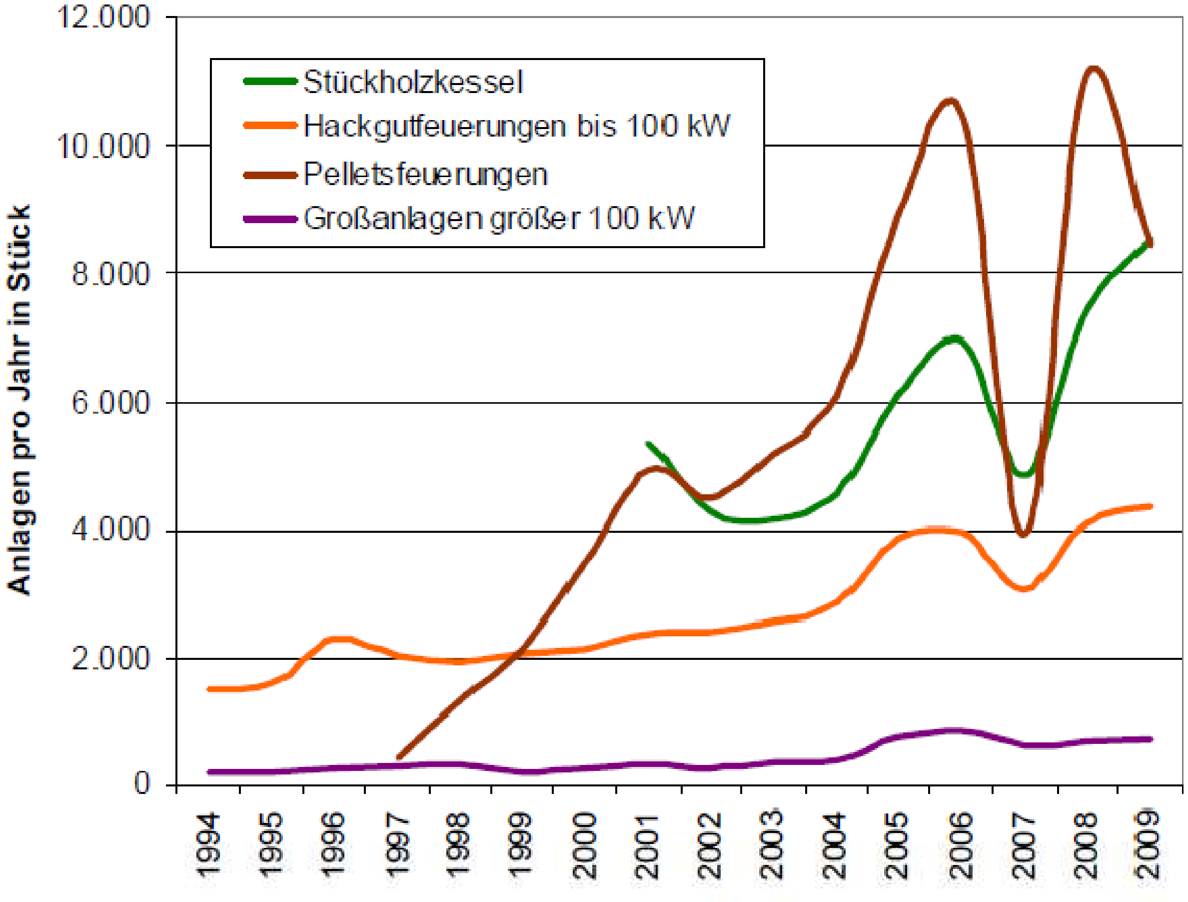
- **Draft Standardization Mandate to CEN, "Development of horizontal standardized methods for the assessment of the integrated environmental performance of buildings" (into force presumably 12/2007)**

- **Directive on energy end-use efficiency and energy services (into force presumably 6/2006).**
  (1 % increase of end-use energy efficiency per year)

- **Thematic strategy for urban environment (sustainable building) (KOM(2004)60, 11.02.2004**

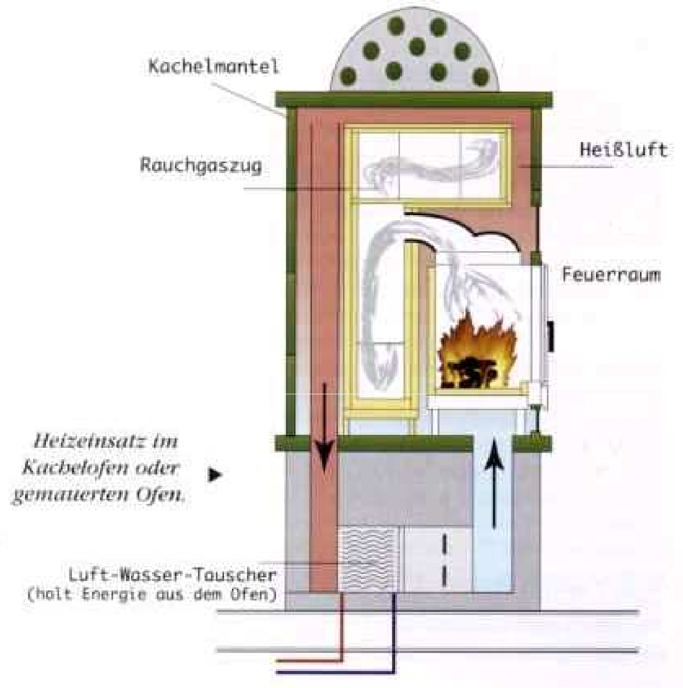
Biomass

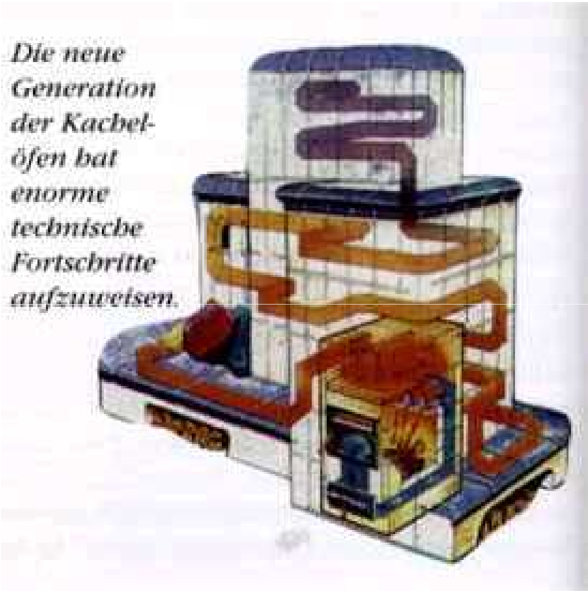
Yearly increase of biomass heating systems in Austria



Innovative Energietechnologien in Österreich, Marktentwicklung 2009, BMVIT

„Kachelofen“





- Positioning that several rooms can be heated, with water HX inside a coupling to a water heating system can be done
- Efficiency about 60-70 %
- High startup emissions (cold burning chamber)

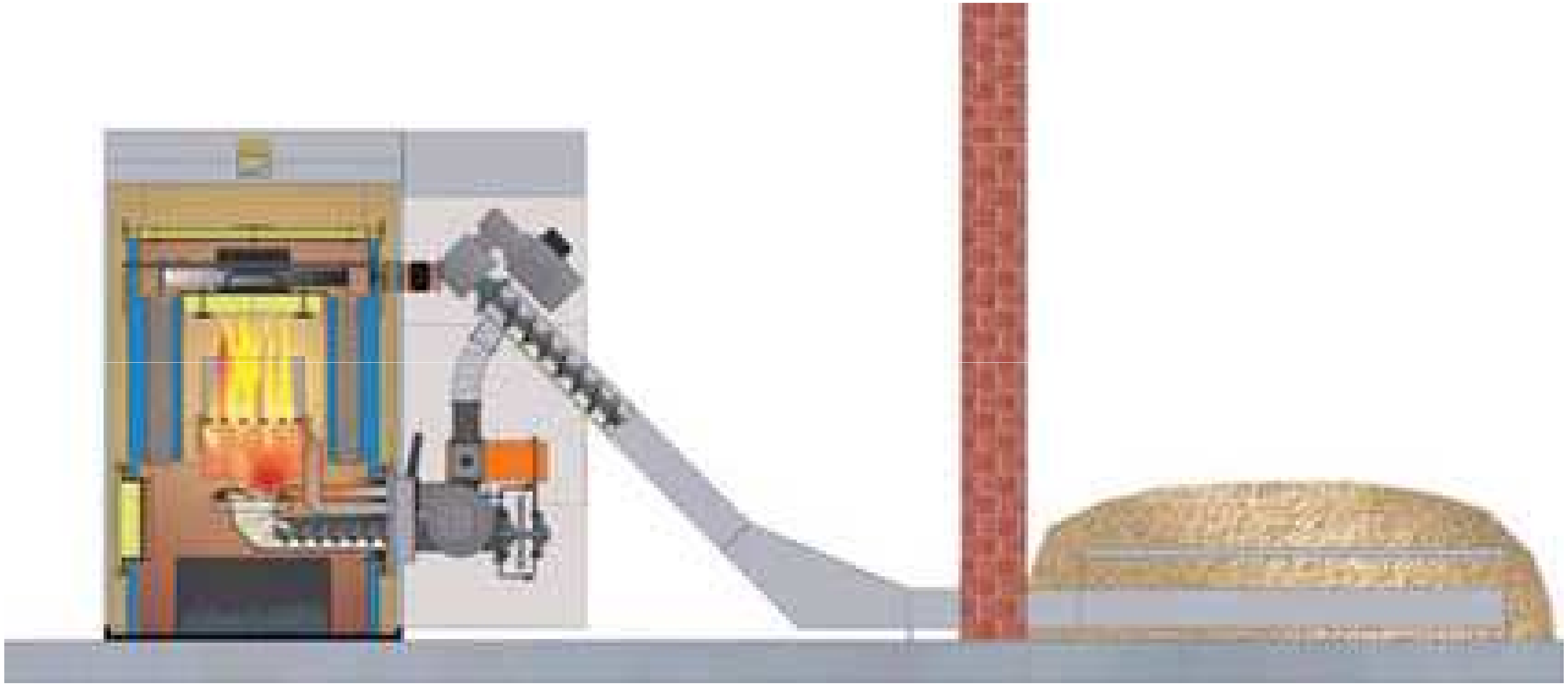
"Kaminofen"

- Positioning that several rooms can be heated, with water HX inside a coupling to a water heating system can be done
- Efficiency about 60-70 %
- High startup emissions (cold burning chamber)

Log wood burner with downward flame

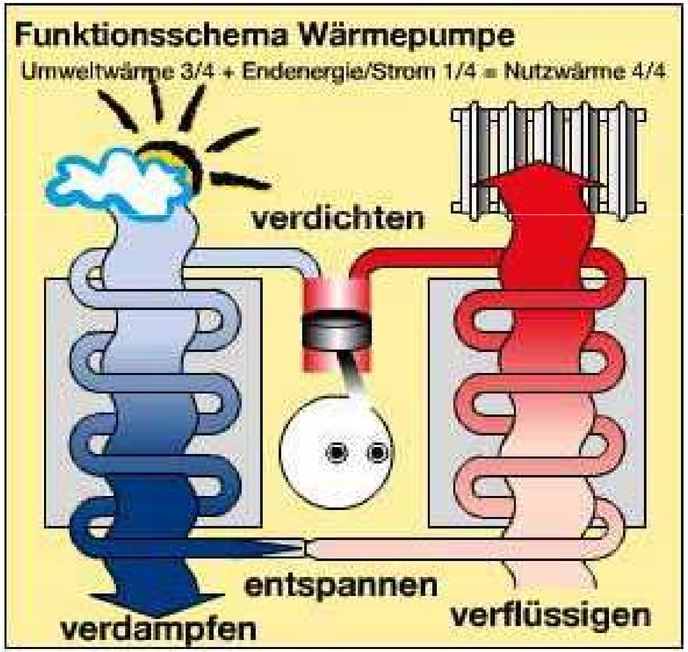
- Logs and ash is transported autmomatically downwards
- Logs are dries before burned
- Burning chamber is NOT cooled

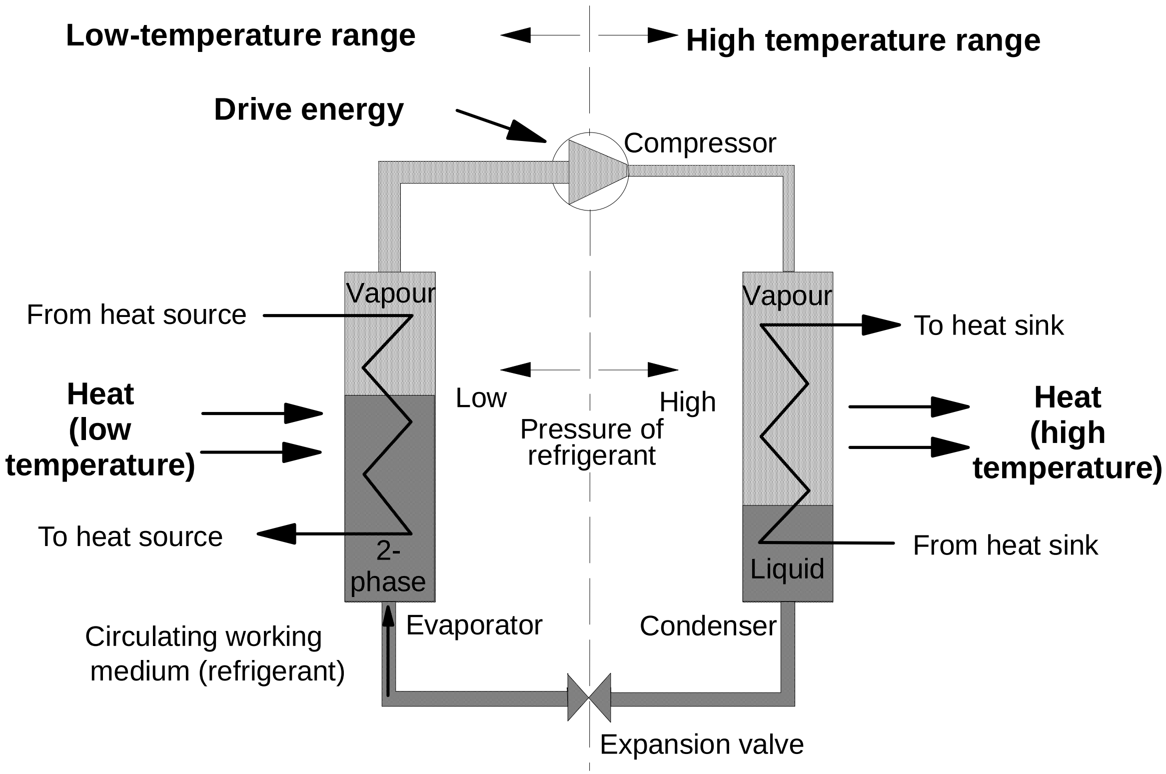
Automatic wood chips/pellets burner



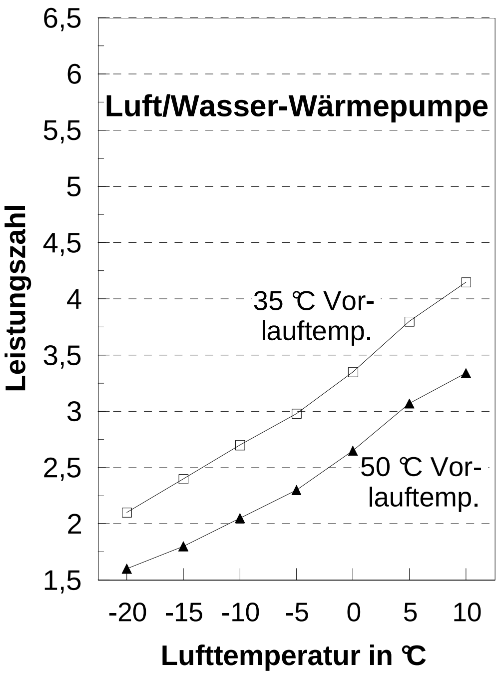
- Similar maintenance a soil or gas burners
- Similar emissions as oil burner
- Slightly higher investment than oil burner
- Biomass store has to be reached yb the blowing tube of the truck

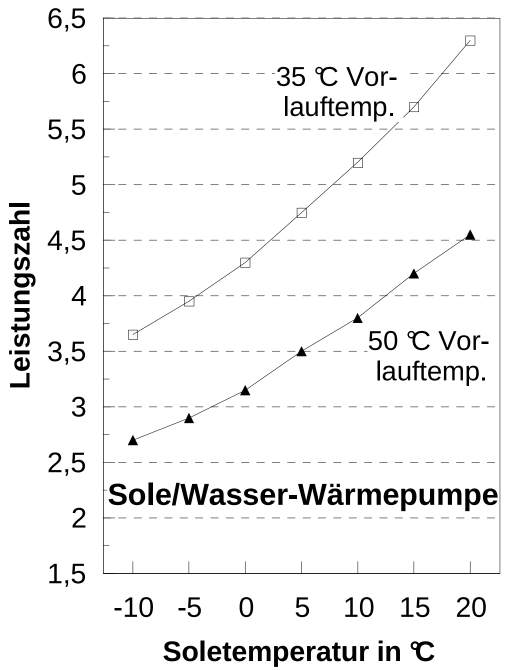
Heat pumps

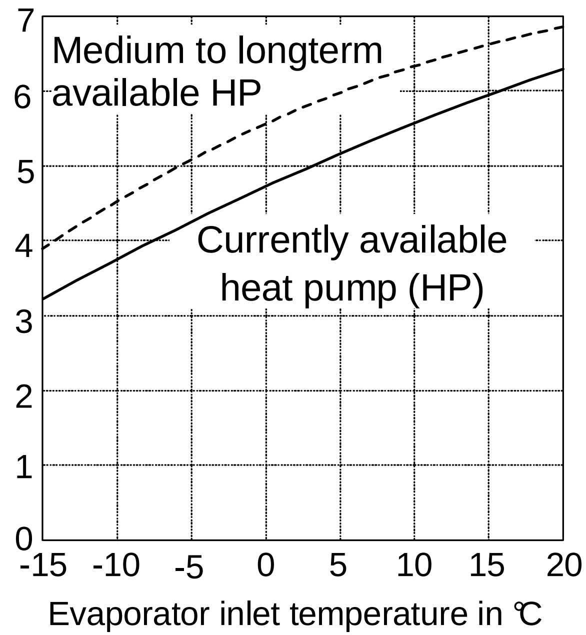

Funktionsschema Wärmepumpe
Umweltwärme 3/4 + Endenergie/Strom 1/4 = Nutzwärme 4/4
verdichten
entspannen
verdampfen
verflüssigen

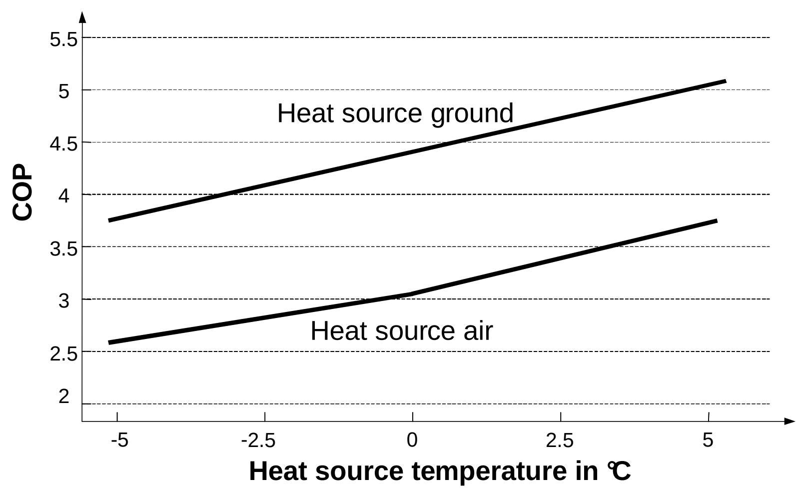

Low-temperature range
High temperature range
Drive energy
Compressor
From heat source
Vapour
Vapour
To heat sink
Heat
(low
temperature)
Low
High
Pressure of
refrigerant
Heat
(high
temperature)
To heat source
2-
phase
Liquid
From heat sink
Evaporator
Condenser
Circulating working
medium (refrigerant)
Expansion valve

Heat pump COP and boundary conditions



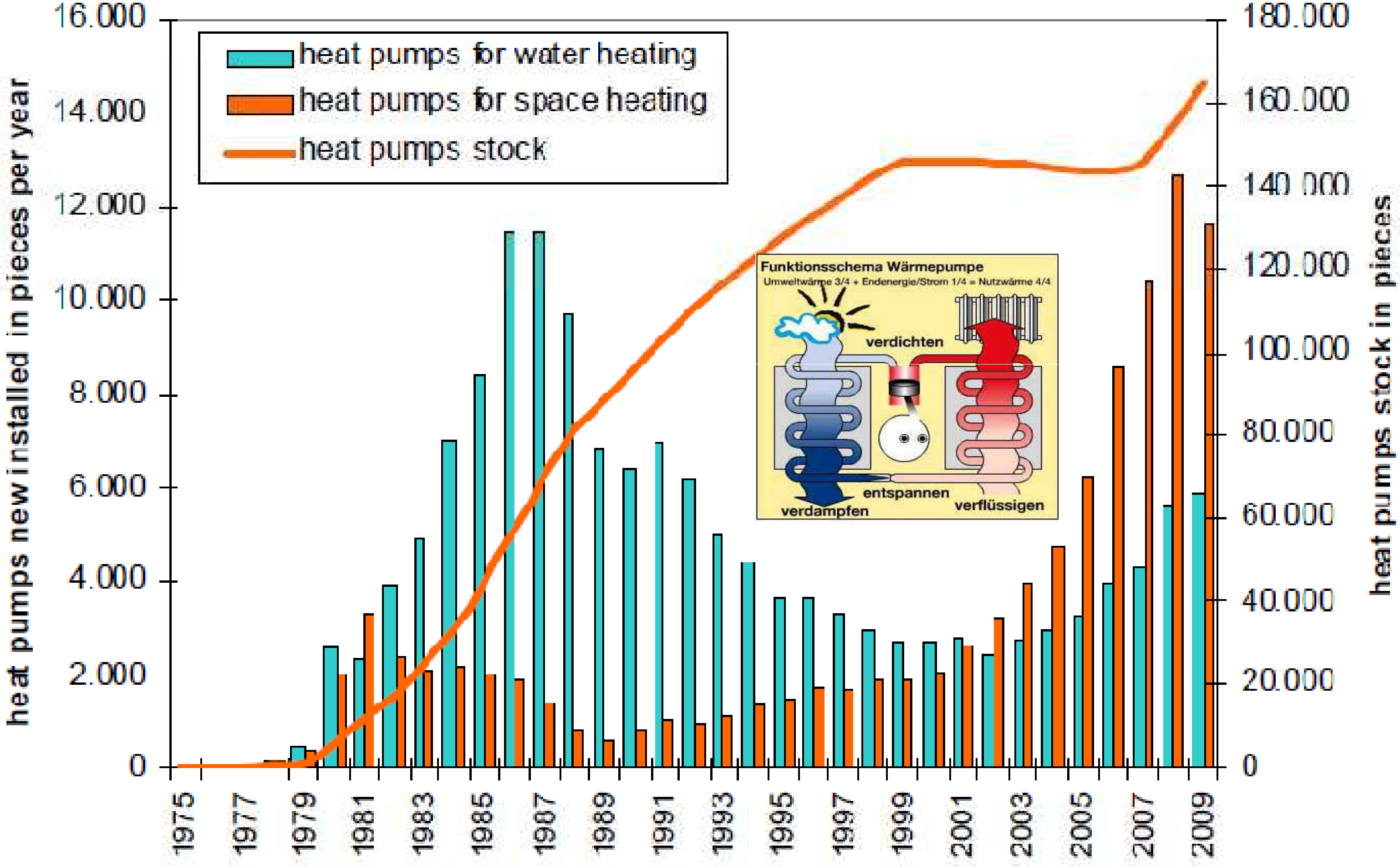






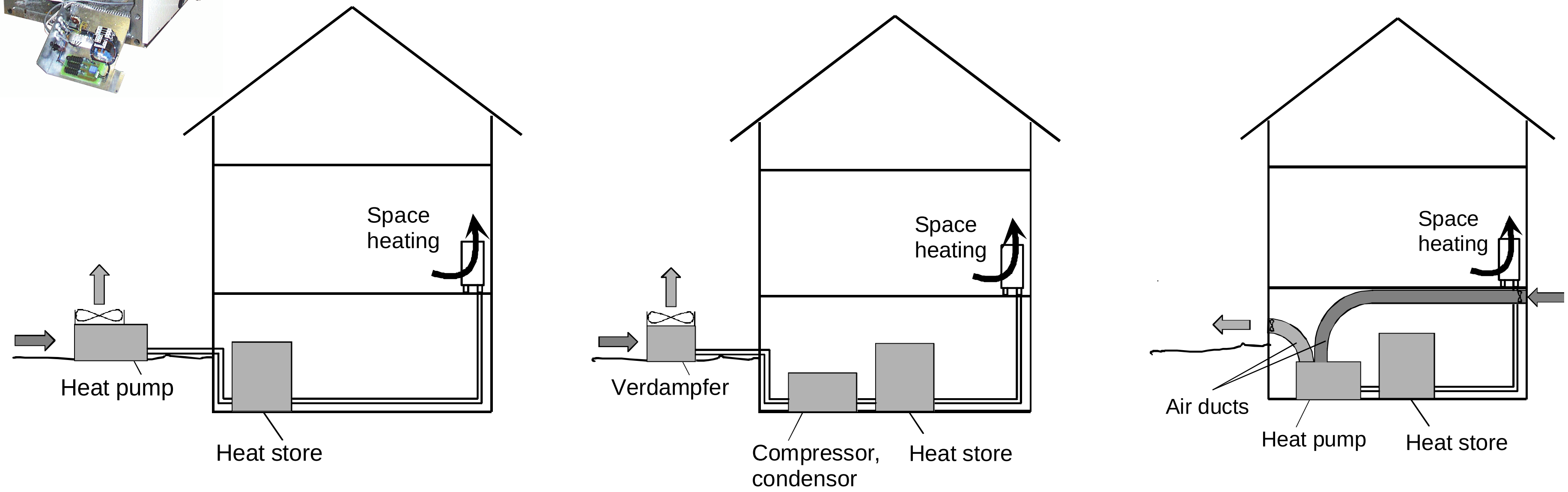
Quelle: Kaltschmitt, Streicher, Wiese, 2006

Development of the Austrian heat pump market



Innovative Energietechnologien in Österreich, Marktentwicklung 2009, BMVIT

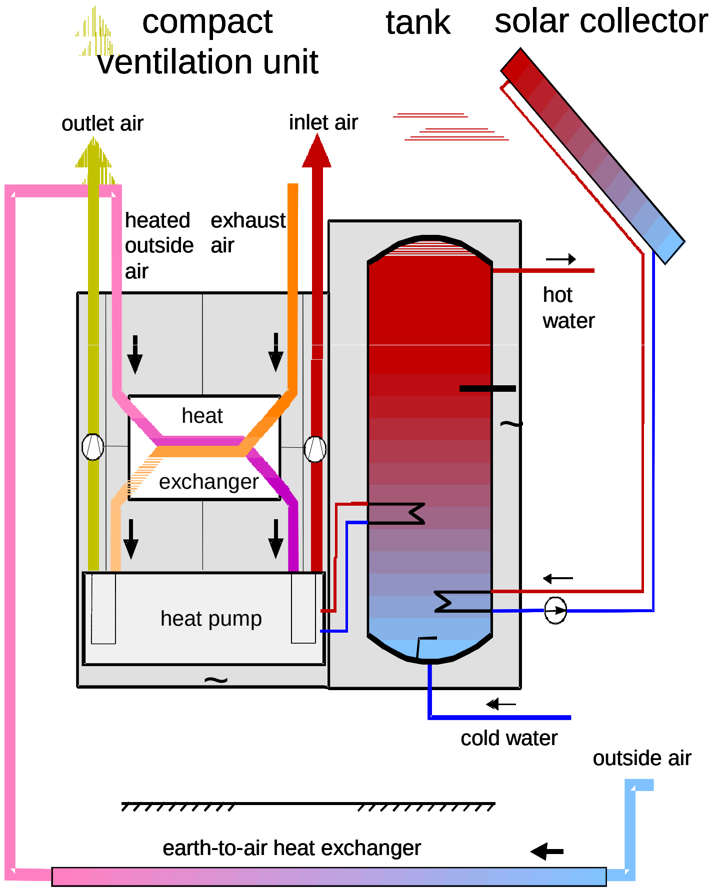
Ambient air as heat source



Quelle: Kaltschmitt, Streicher, Wiese, 2006

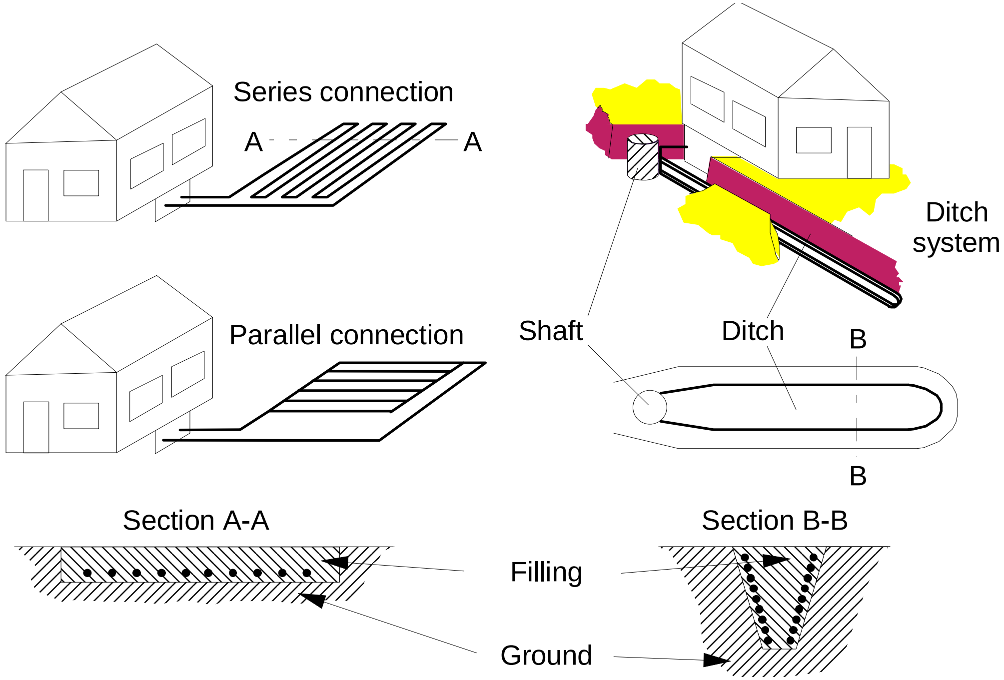
Compact heating and domestic hot water unit

- air-to-air heat recovery
- exhaust air heat pump
- storage
- solar collector
- earth-to-air heat exchanger



Source: Fraunhofer-Institut für Solare Energiesysteme ISE, 2000

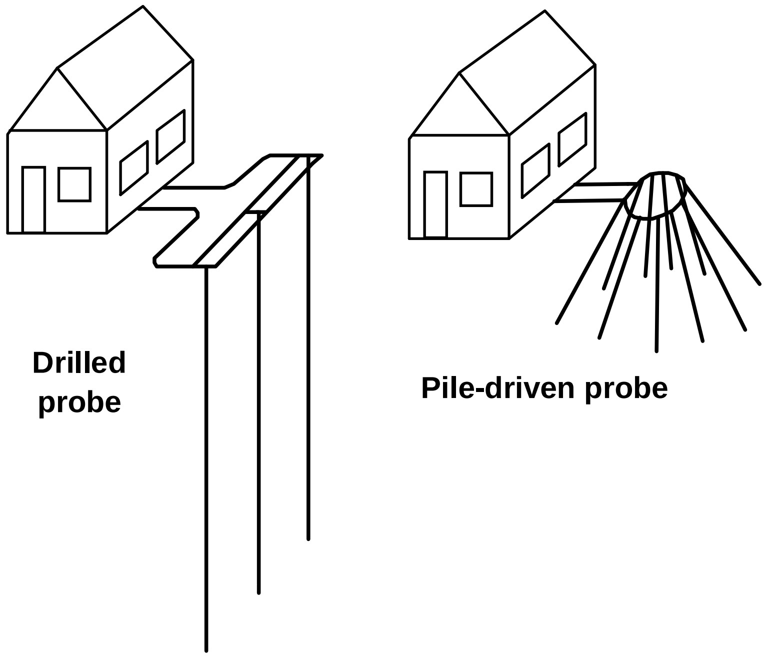
Ground as heat source

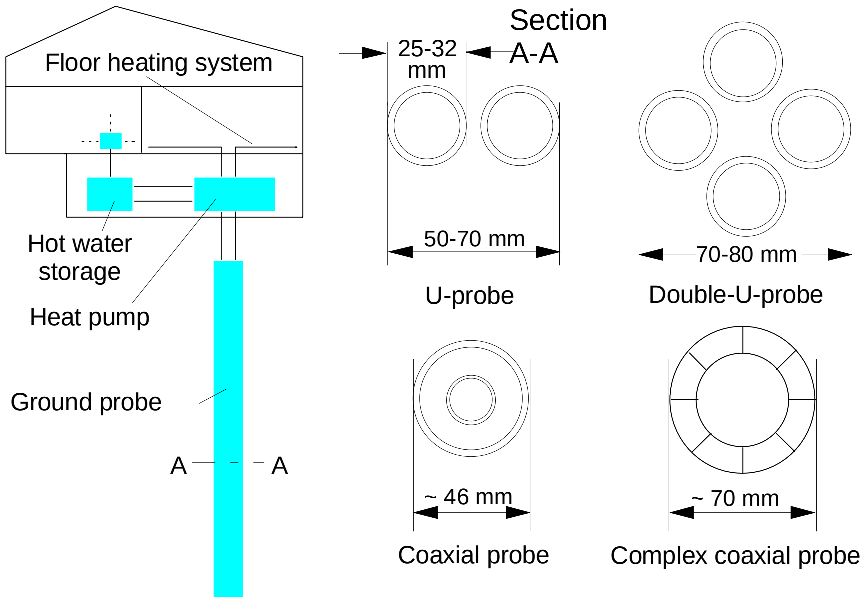


Type of soil	Withdrawn heat capacity
Dry, sandy soil	10 – 15 W/m^2
Humid, sandy soil	15 – 20 W/m^2
Dry loamy soil	20 – 25 W/m^2
Humid loamy soil	25 – 30 W/m^2
Water saturated sand/gravel	30 – 40 W/m^2

Quelle: Kaltschmitt, Streicher, Wiese, 2006, VDI 4640

Ground as heat source





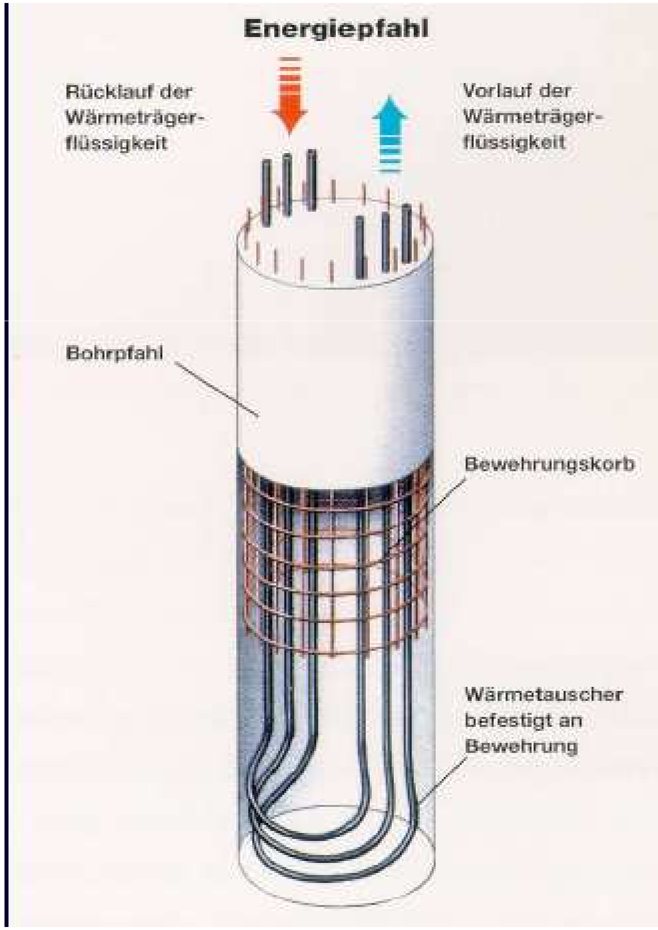
Quelle: Kaltschmitt, Streicher, Wiese, 2006

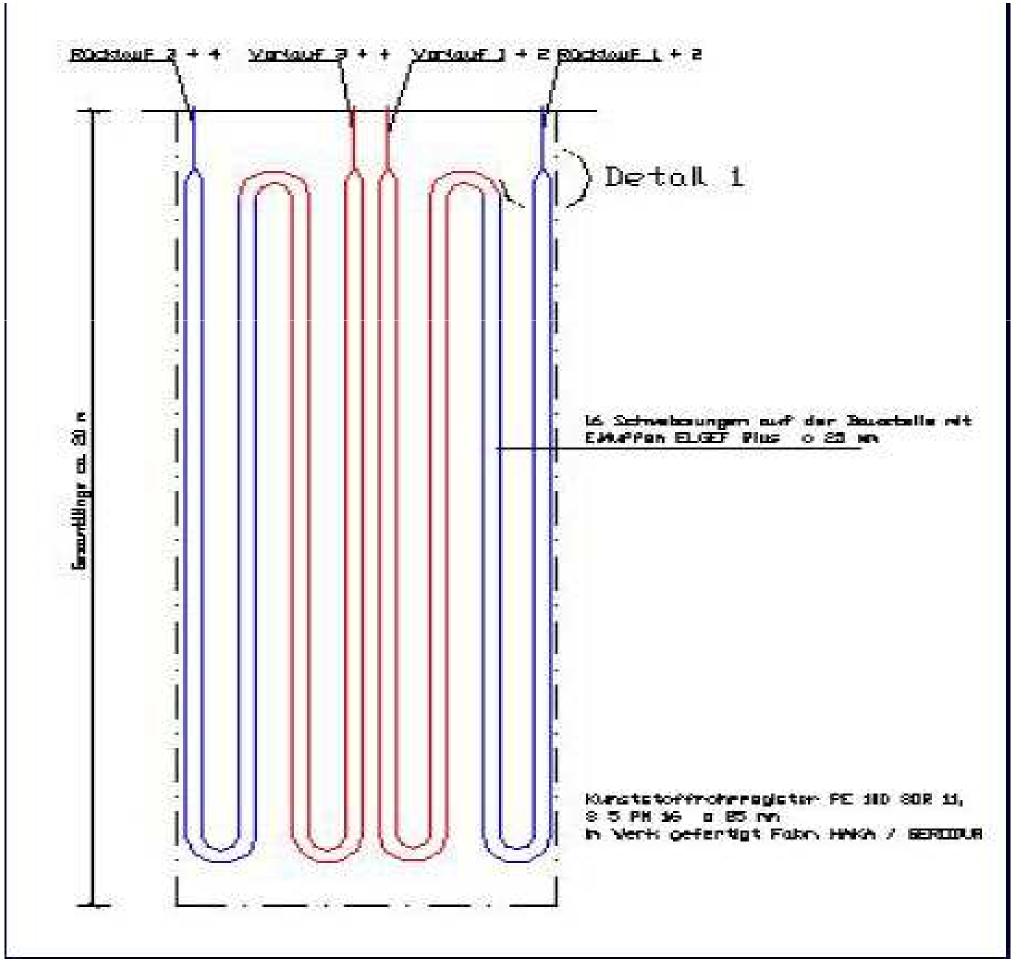
	1 800 h/a	2 400 h/a
General guidelines		
Bad subsoil (dry lose rocks)	25 W/m	20 W/m
Solid rock subsoil, water-saturated lose rock	60 W/m	50 W/m
Solid rock with high heat conductivity	84 W/m	70 W/m
Individual soils		
Gravel, sand, dry	< 25 W/m	< 20 W/m
Gravel, sand, carrying water	65 – 80 W/m	55 – 65 W/m
Gravel, sand, strong groundwater flow, for small systems.	80 – 100 W/m	80 – 100 W/m
Clay, loam, moist	35 – 50 W/m	30 – 40 W/m
Limestone (solid)	55 – 70 W/m	45 – 60 W/m
Sandstone	65 – 80 W/m	55 – 65 W/m
Acidic magmatites (e. g. granite)	65 – 85 W/m	55 – 70 W/m
Alkaline magmatites (e. g. basalt)	40 – 65 W/m	35 – 55 W/m
Gneiss	70 – 85 W/m	60 – 70 W/m

The requirement for using the table: only heat withdrawal (heating incl. hot water) takes place; length of the individual ground probes between 40 and 100 m; smallest space between two ground probes would be a minimum of 5 m for ground probe lengths of 40 to 50 m or at least 6 m for ground probes with lengths of over 50 to 100 m. Suitable ground probes are double-U probes with an individual tube diameter of 25 or 32 mm or coaxial probes with at least a diameter of 60 mm. The values given above can fluctuate considerably, depending on rock formations such as crevasses, foliation and weathering.

Quelle: Kaltschmitt, Streicher, Wiese, 2006, VDI 4640

Energy poles

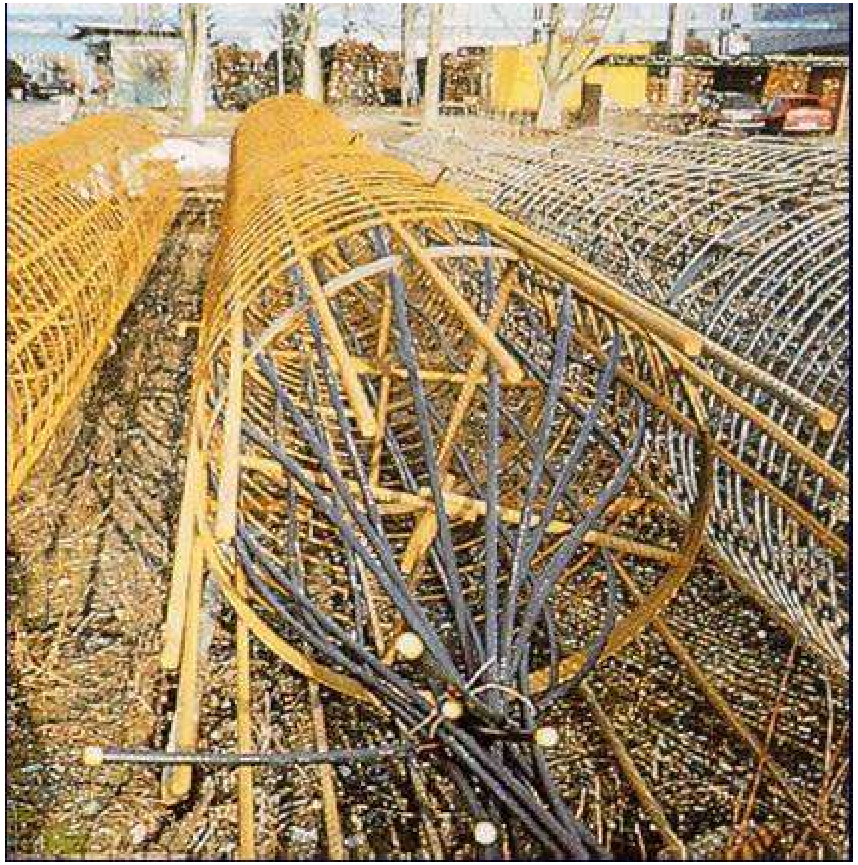




Quelle: Sauerwein, Bilfinger Berger,

Energy poles

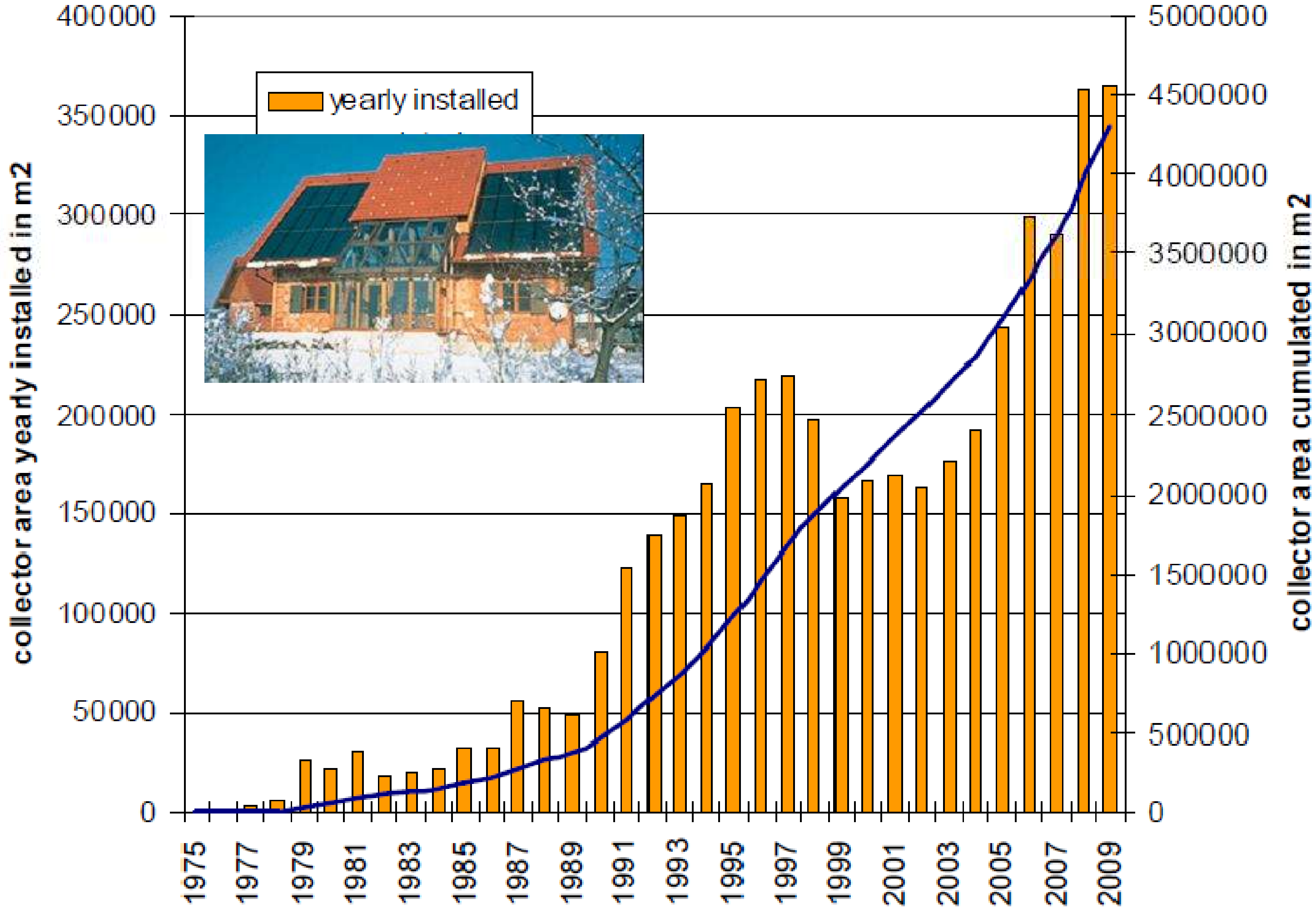
Vorgefertigter Bewehrungskorb



Verteilerstation Energiepfähle

Solar Thermal Systems

Austrian market development of solar thermal systems



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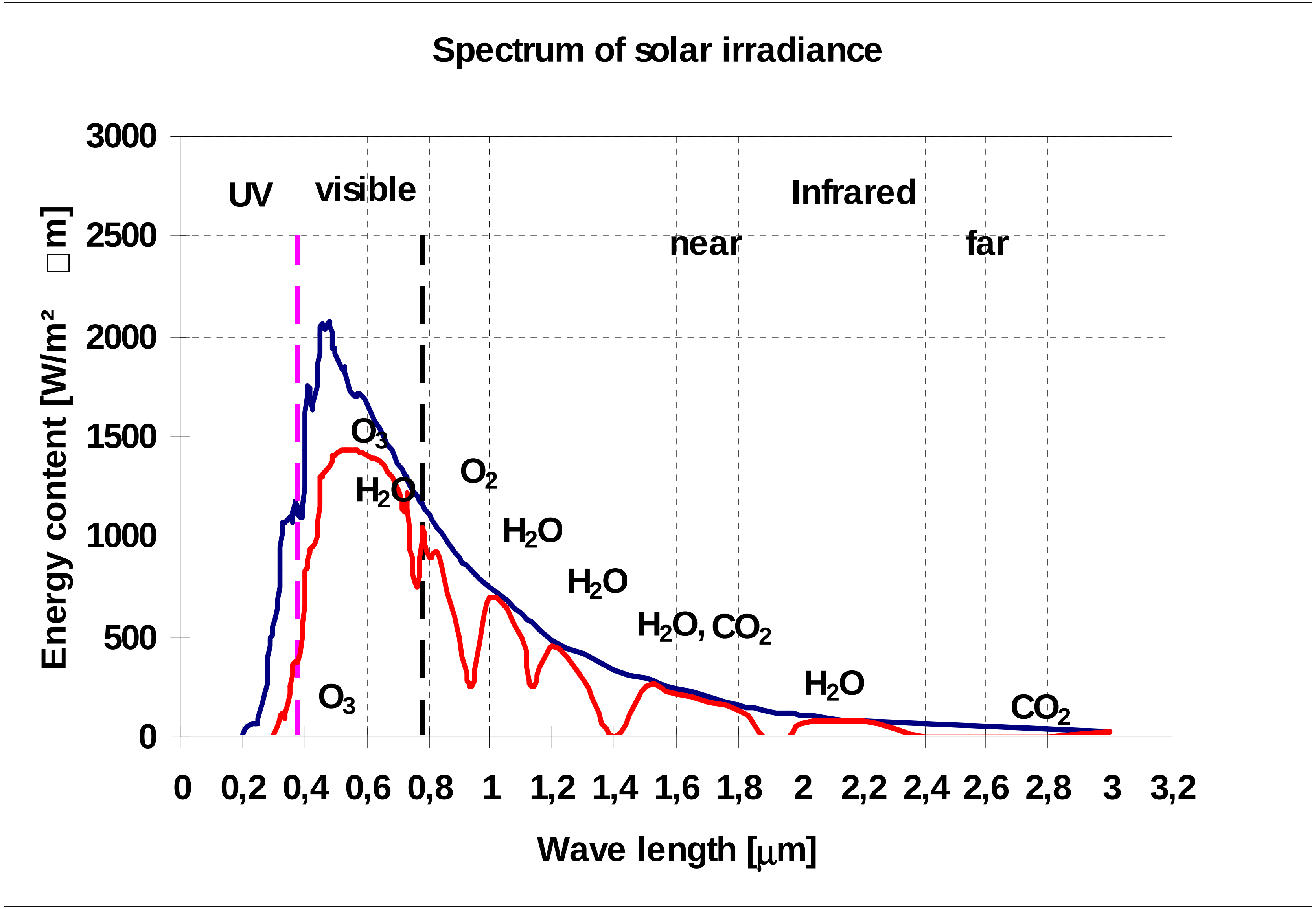
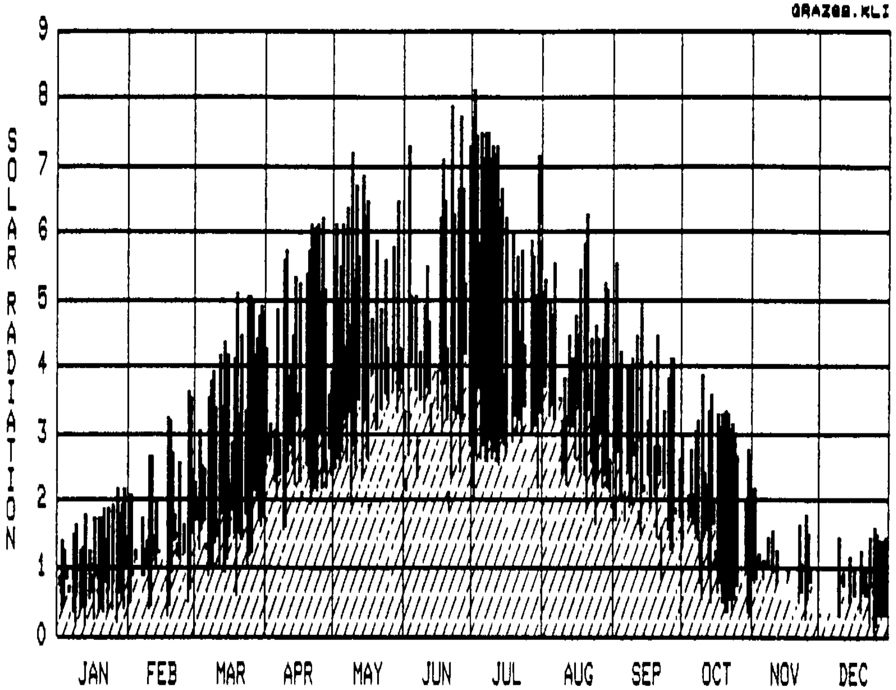
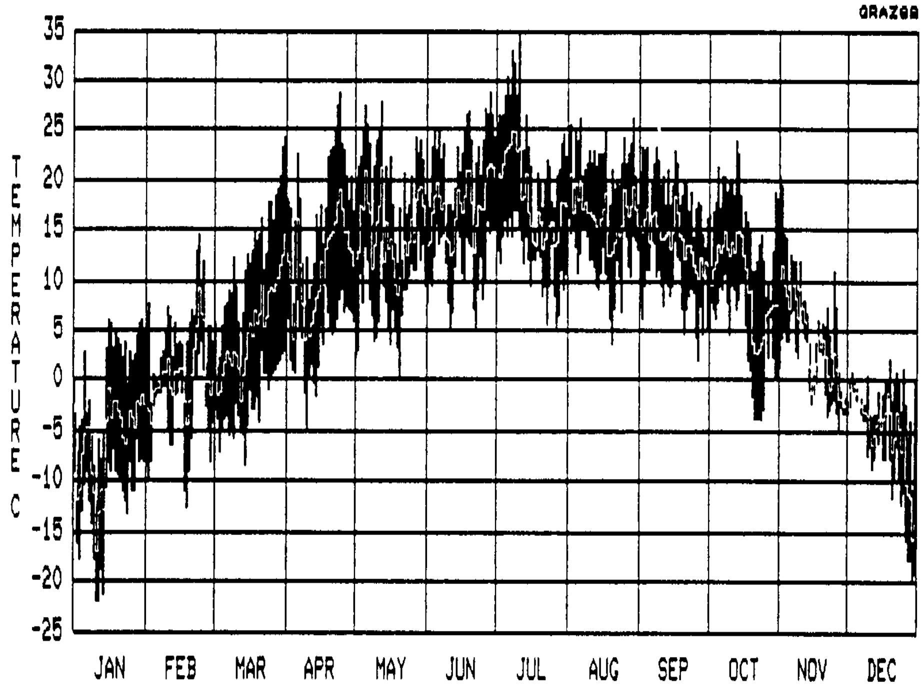
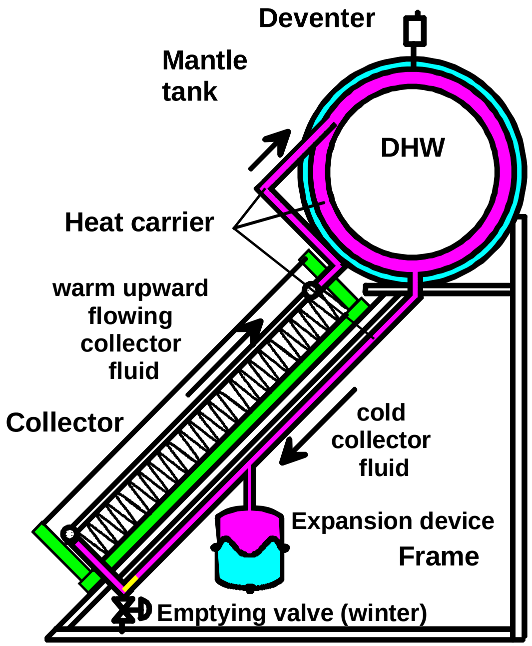

Spectrum of solar irradiance
Energy content [W/m² µm]
Wave length [µm]
3000
2500
2000
1500
1000
500
0
0
0,2
0,4
0,6
0,8
1
1,2
1,4
1,6
1,8
2
2,2
2,4
2,6
2,8
3
3,2
UV
visible
Infrared
near
far
O3
H2O
O2
H2O
H2O
H2O, CO2
H2O
CO2
O3

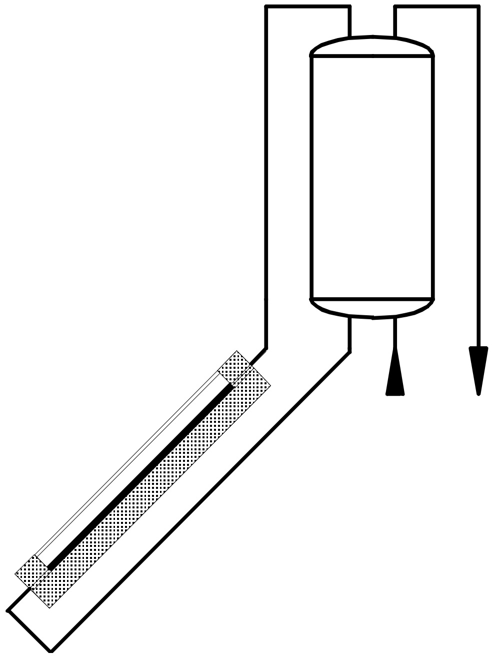
Daily global irradiation
(on a horizontal surface)
and hourly ambient temperature of Graz climate





Principle of Solar Thermal Energy Use Natural Circulation Systems



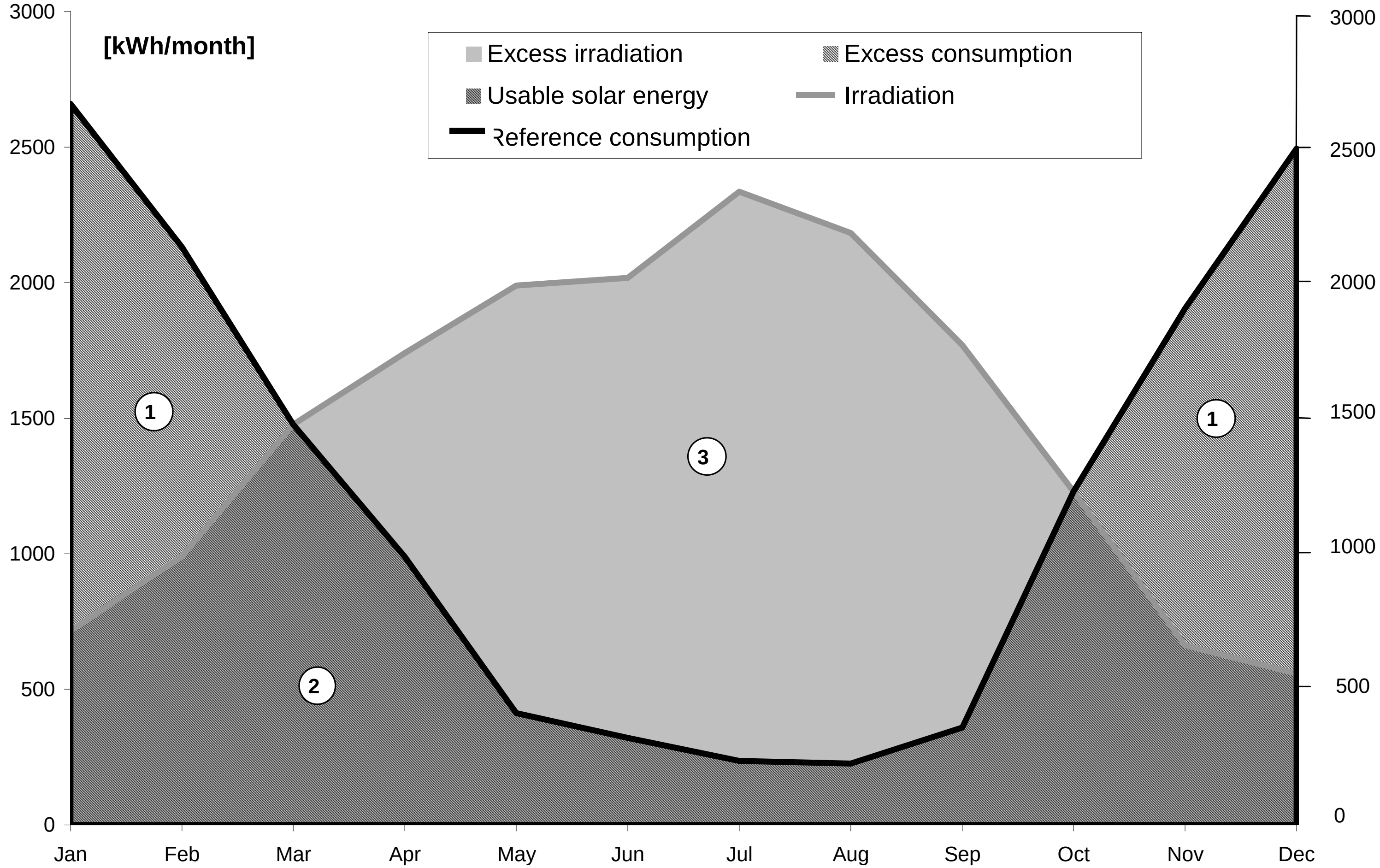


Where to use solar thermal

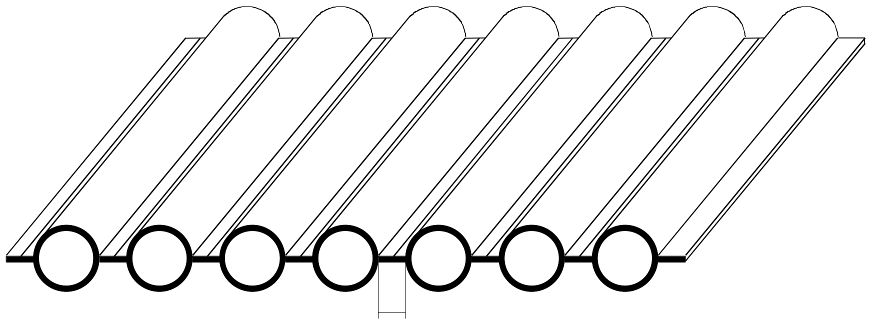
- Domestic hot water (DHW)
- Space heating + DHW
- District heating networks
- Swimming pools
- Cooling
- Process Heat
- Electricity production

Solar Combisystems

Solar Combisystems,space heating demand



Solar heated swimming pools

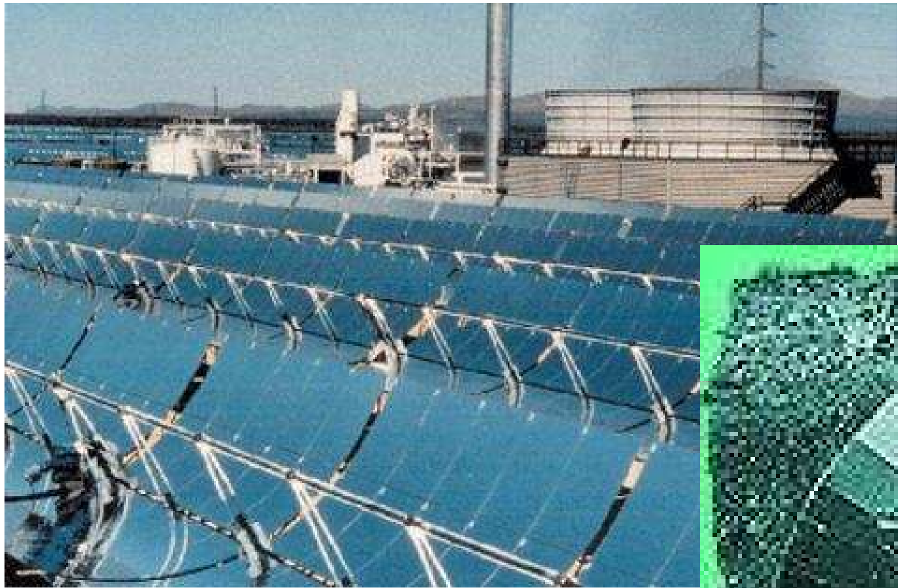


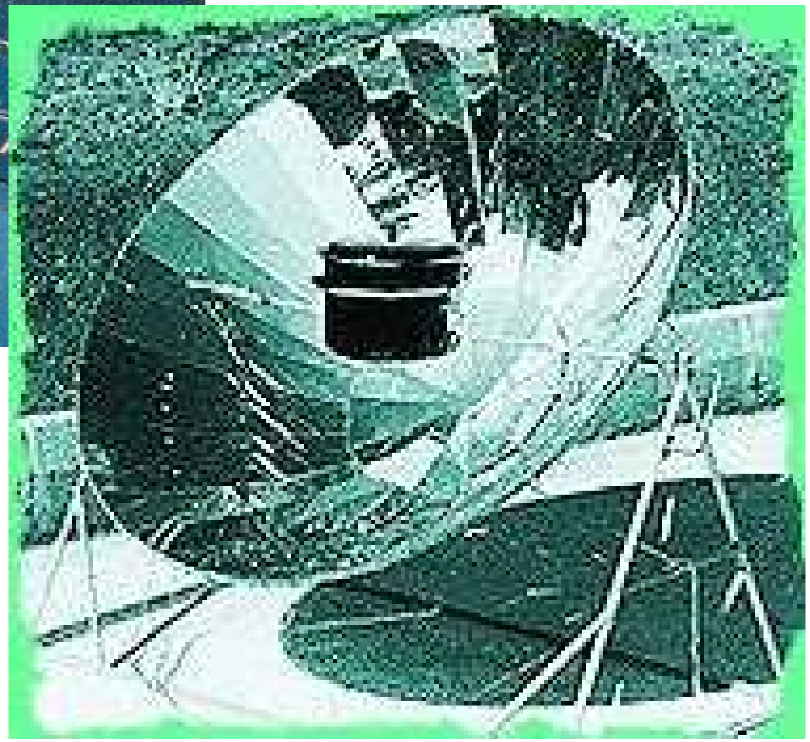
Solar assisted cooling

Deccicant system

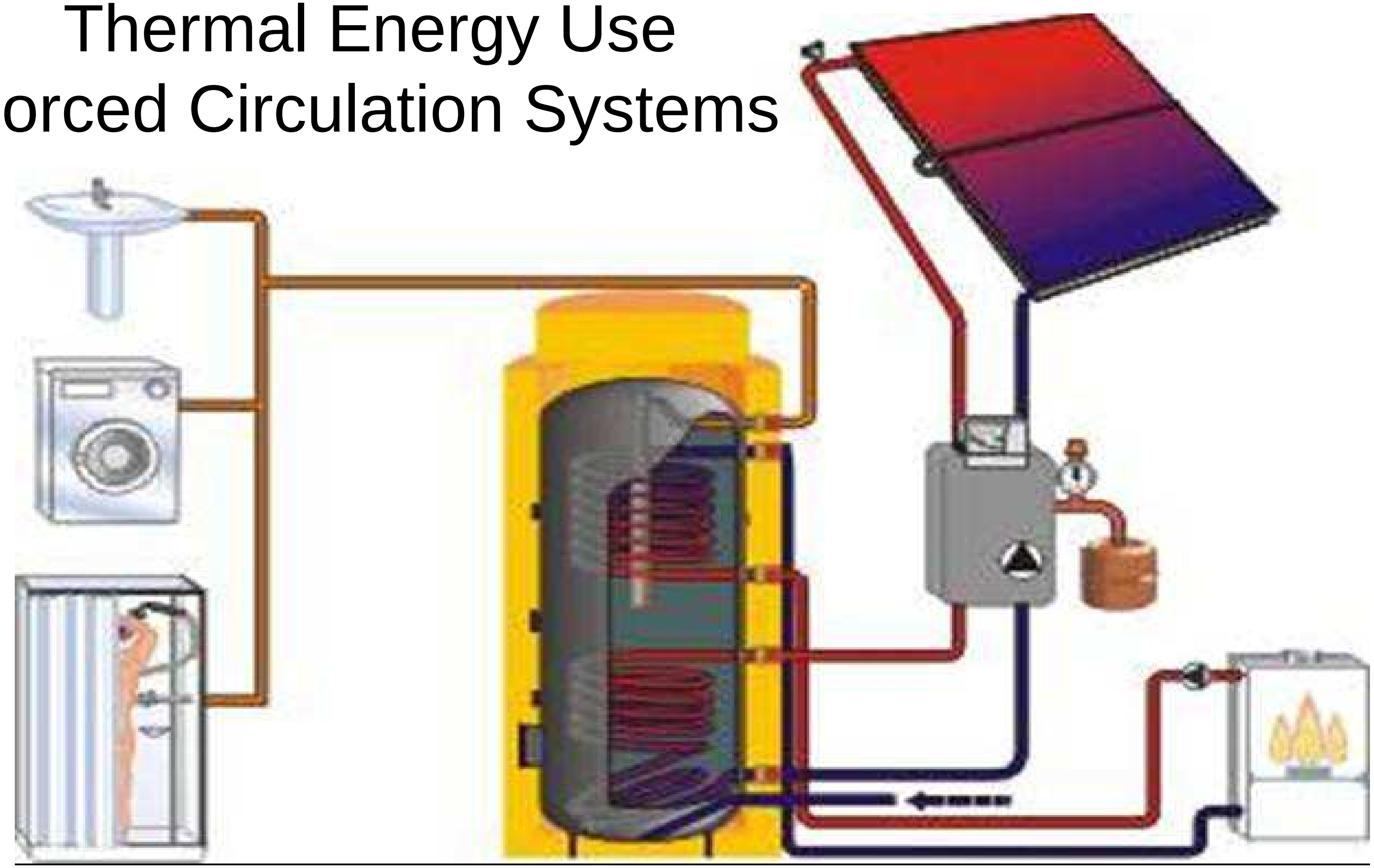
Ab/Adsorption system

Process heat

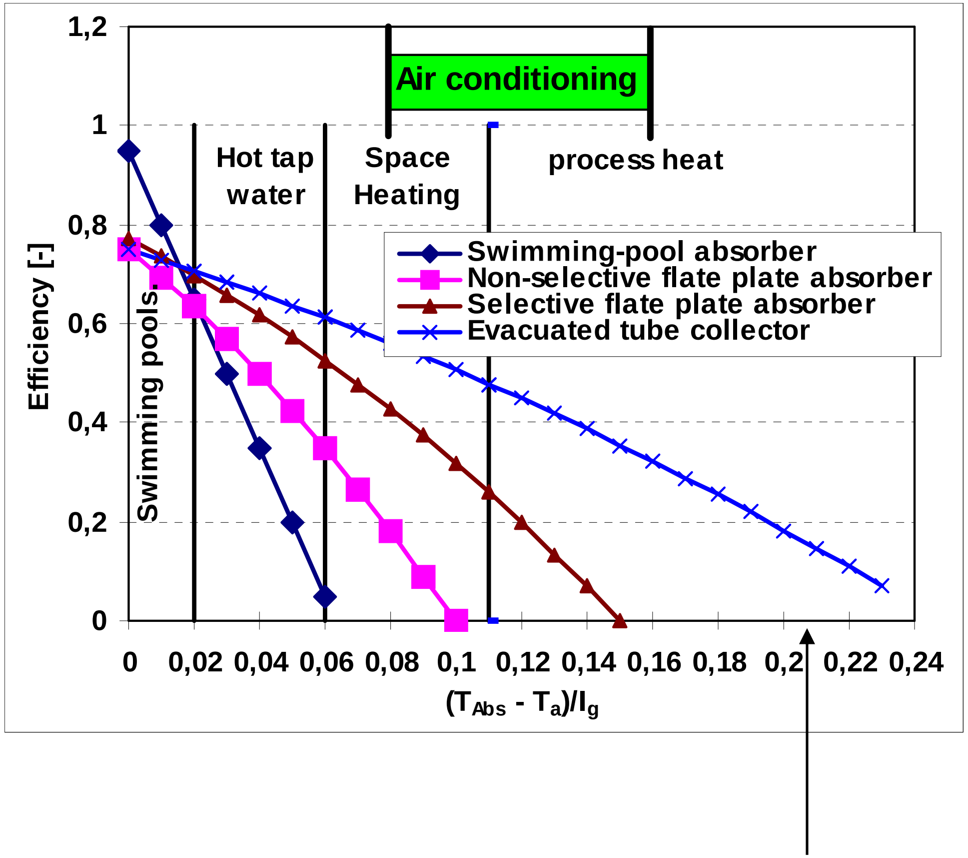


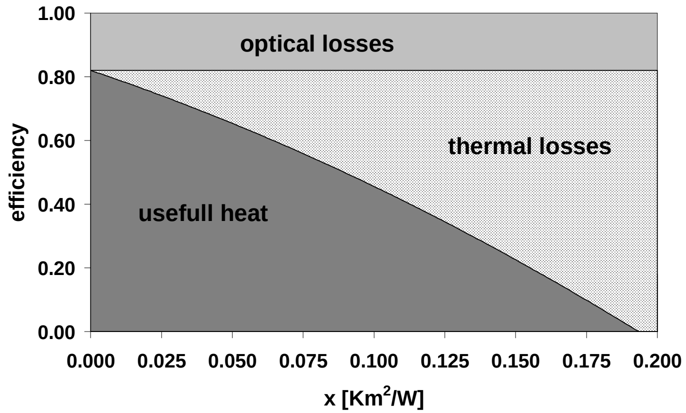


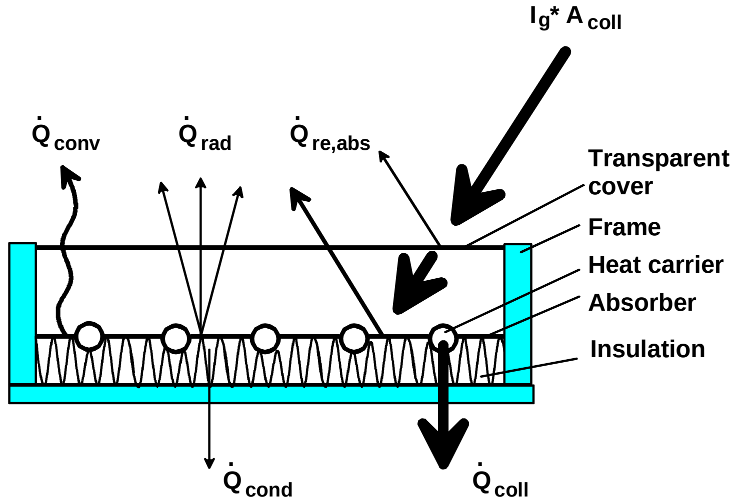
Principle of Solar Thermal Energy Use Forced Circulation Systems



Collector characteristics

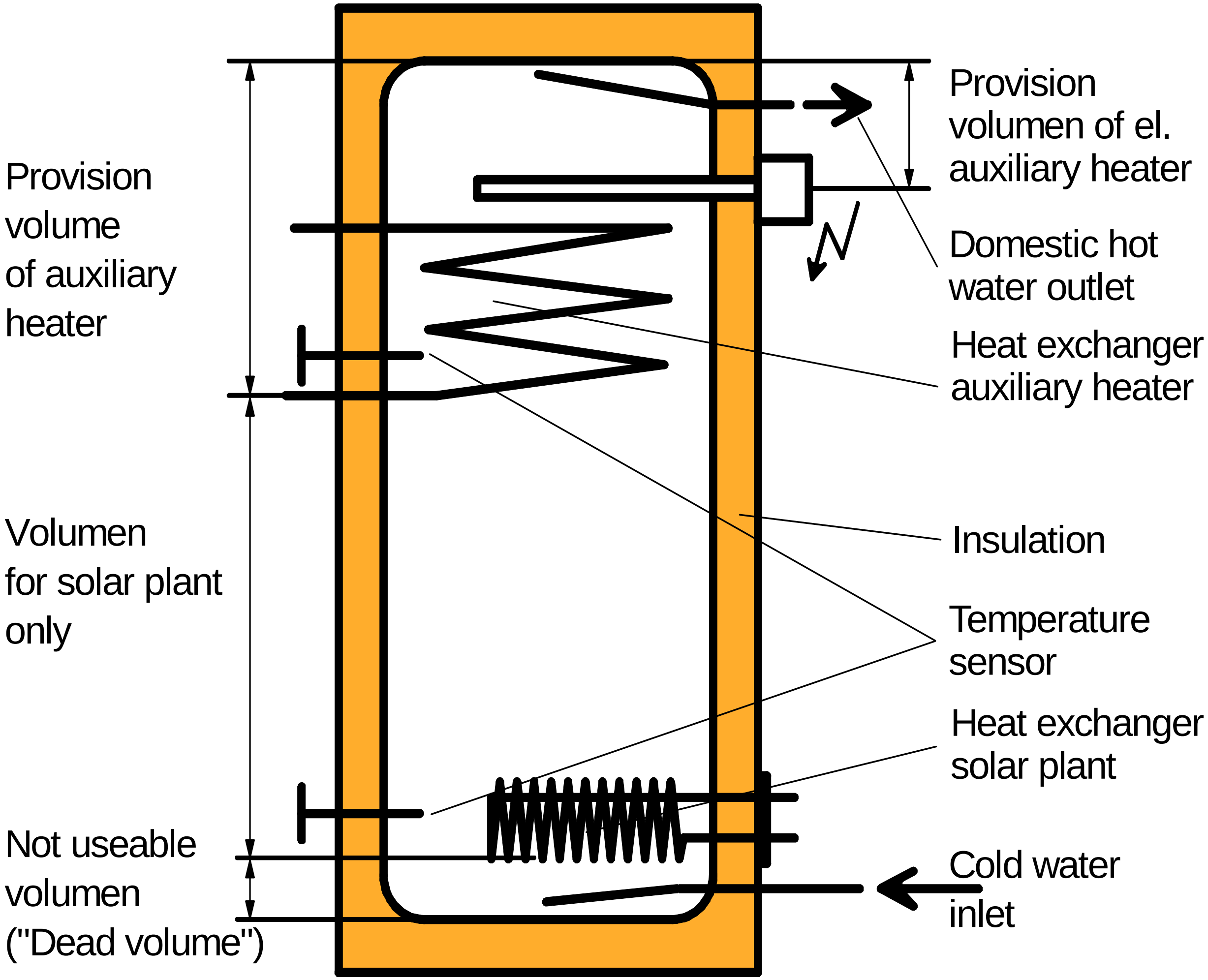




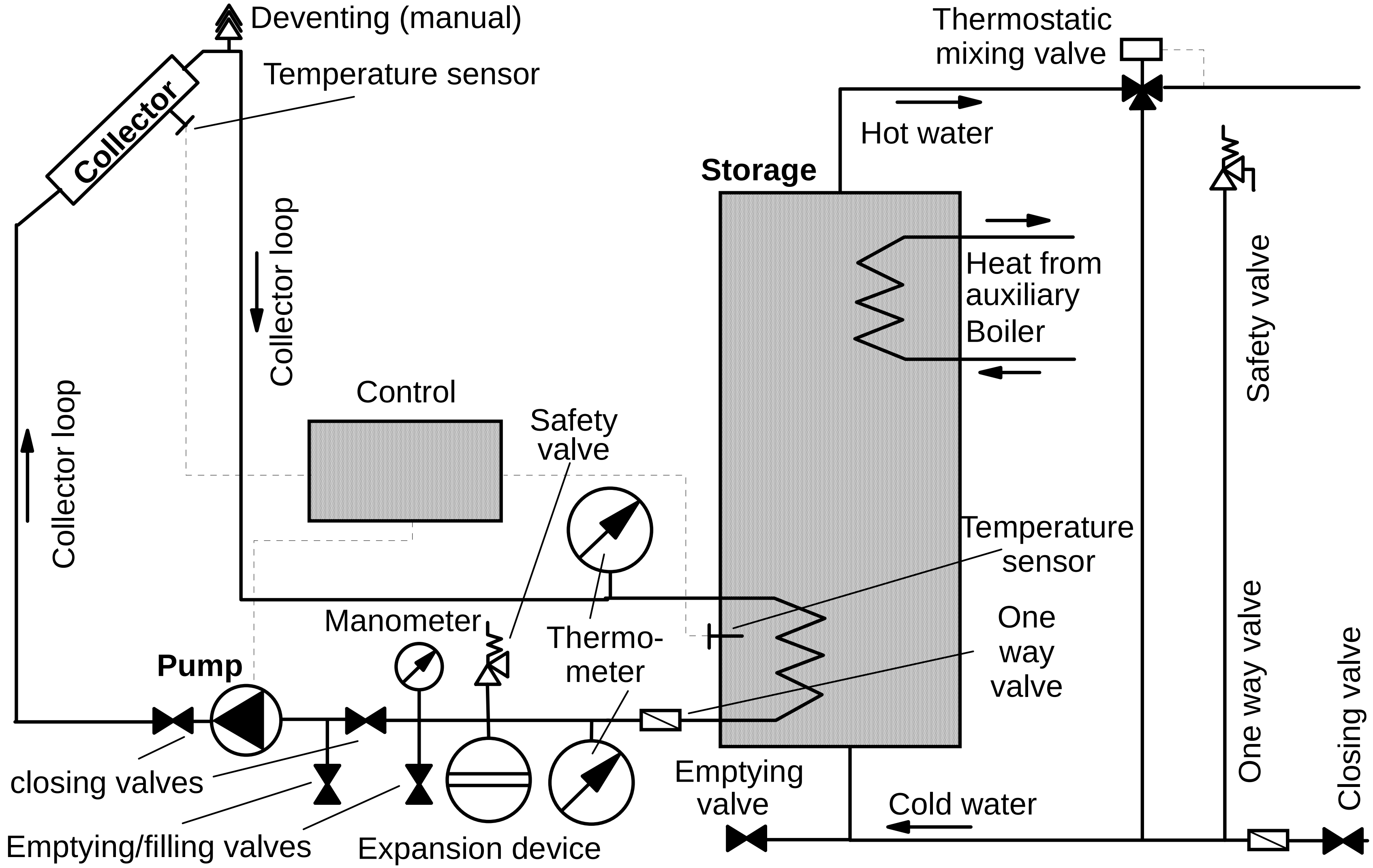


Note : Maximum collector standstill temperature at 1000 W/m^2 irradiance and 30 ℃ ambient temperature: Tabs = (0,14*1000)+30 = 170 ℃

Solar Domestic Hot Water Stores

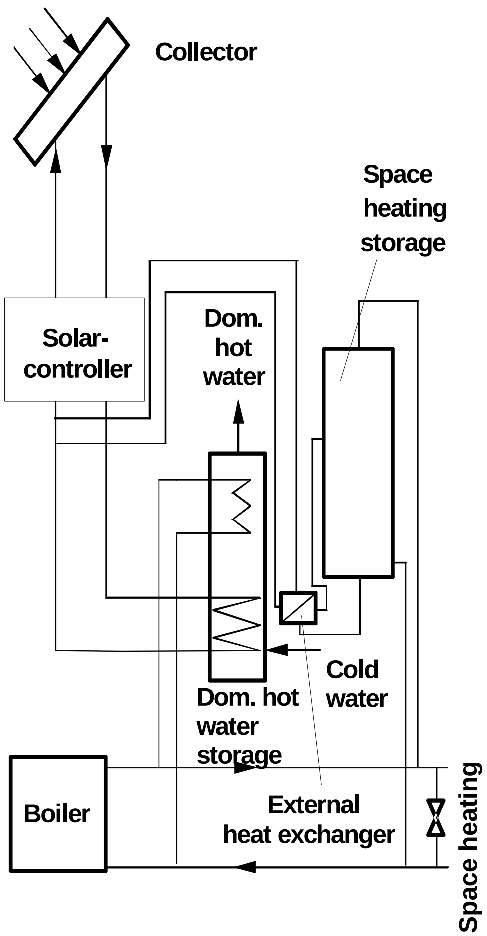


Domestic hot water forced hydraulics

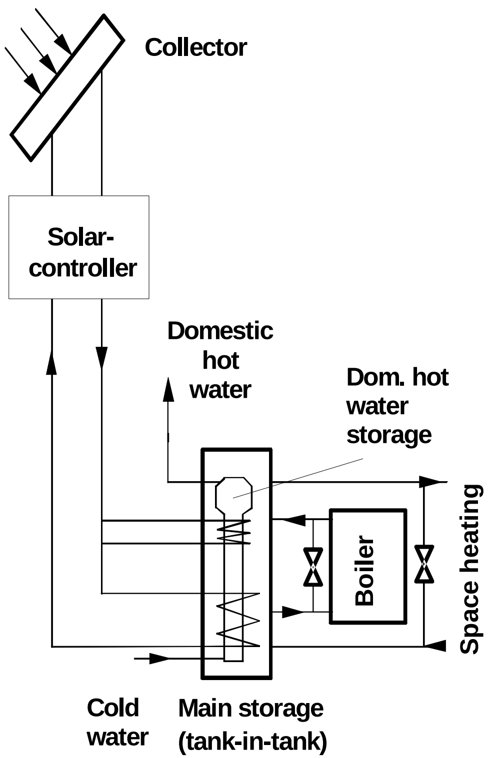


Solar combisystem schemes

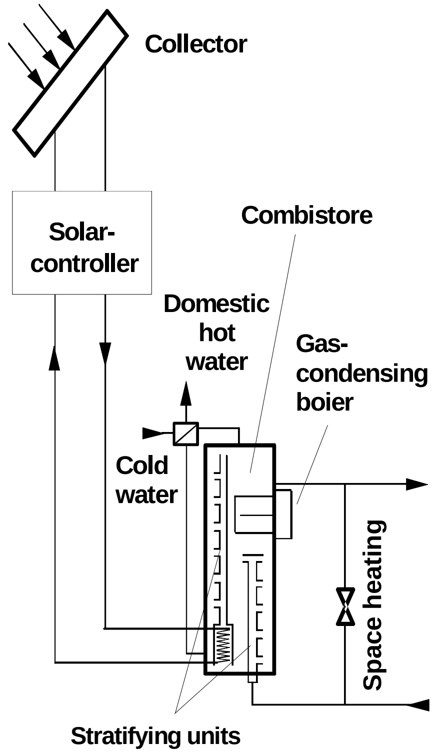
Two stores with oil or gas-fired boiler



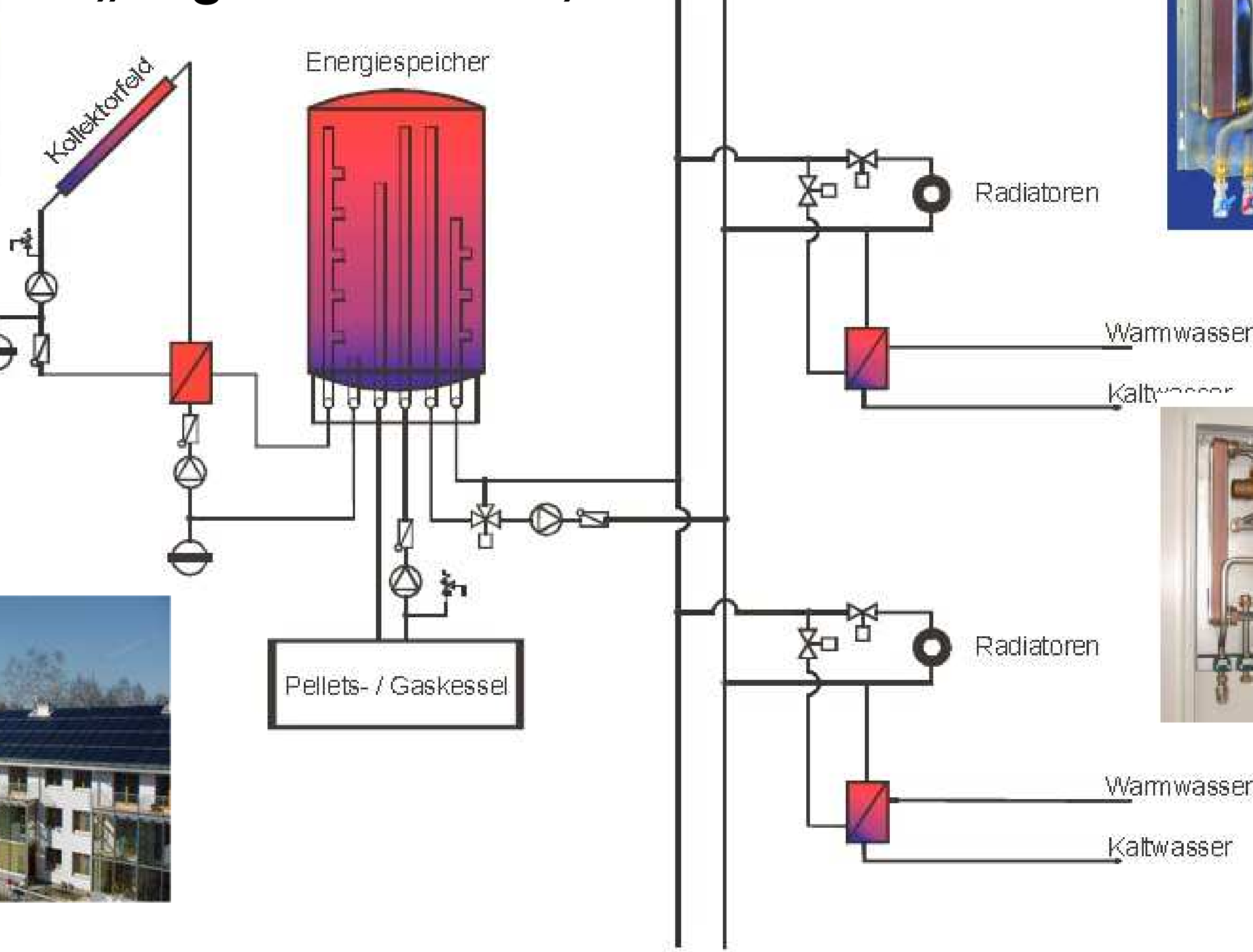
Tank in tank storage with solid fuel boiler



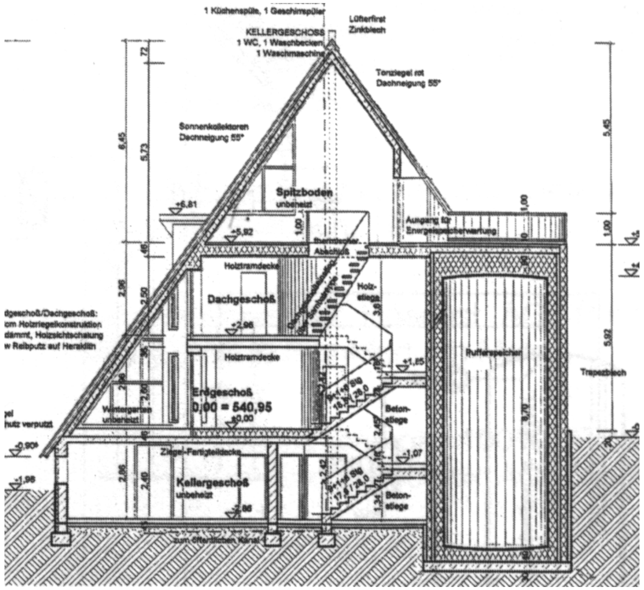
Single storage with inegrated gas-condensing boiler

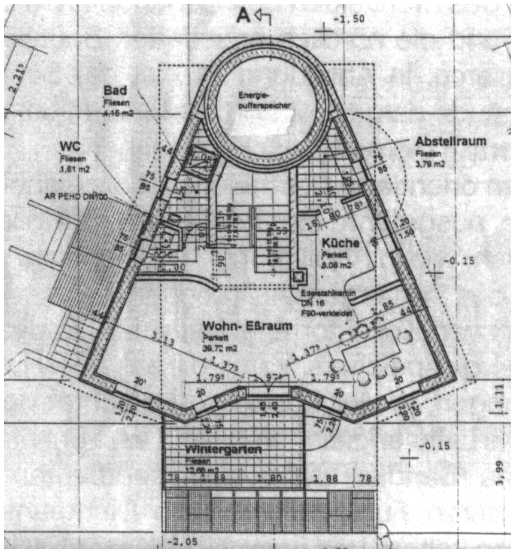


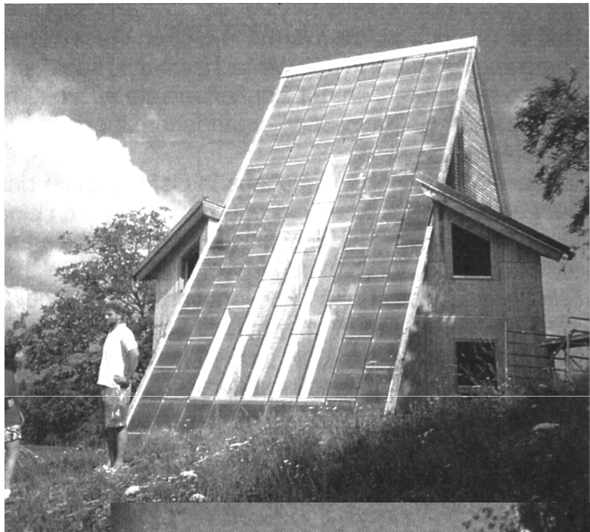
Systems for Multi Family House „Legionella free“, ÖNORM B 5019

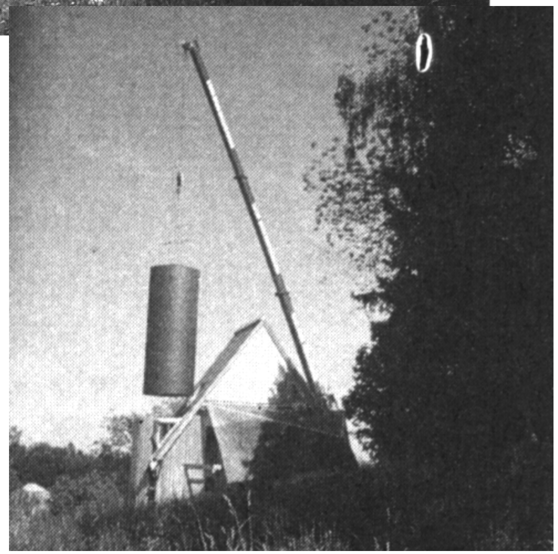


Example of purely solar heated house

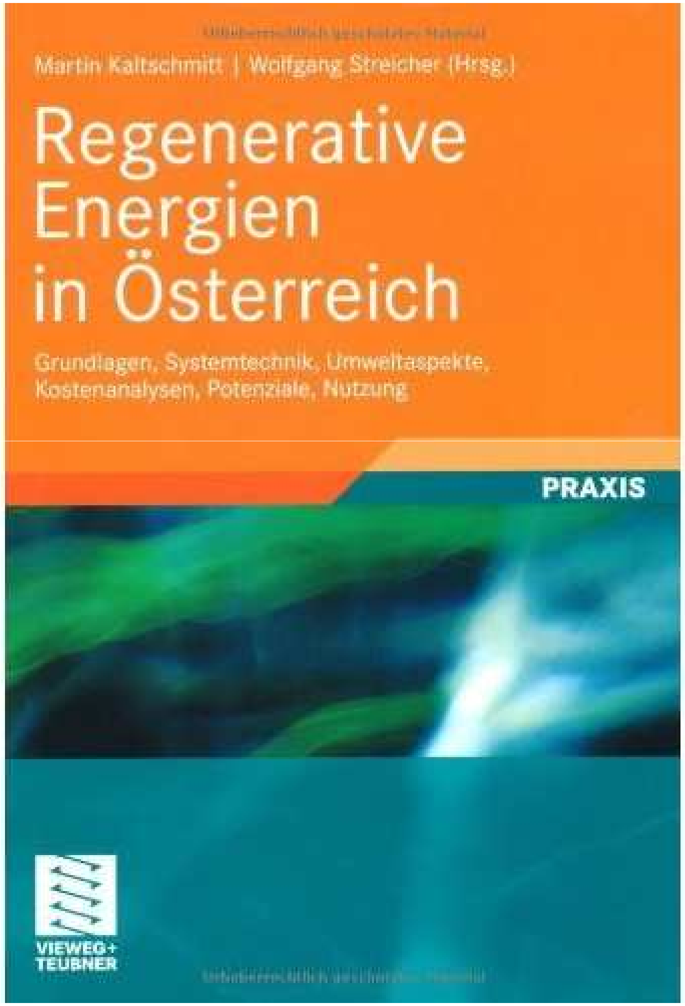








Renewable Energy in Austria – Perspektives and Potentials –

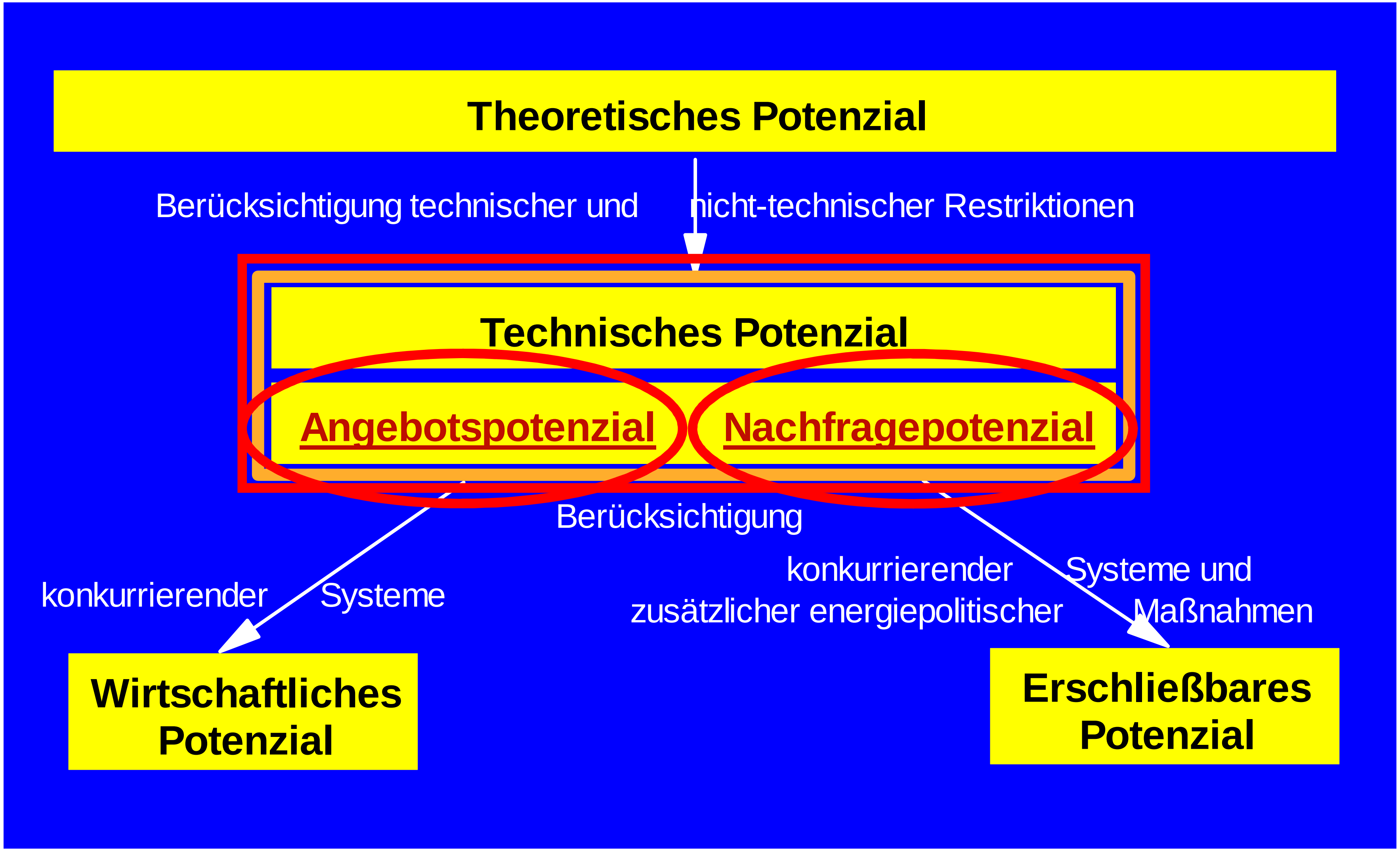


Martin Kaltschmitt, Wolfgang Streicher

Studie im Auftrag des Verbandes der Elektrizitätswerke Österreichs

Verlag Vieweg&Teubner

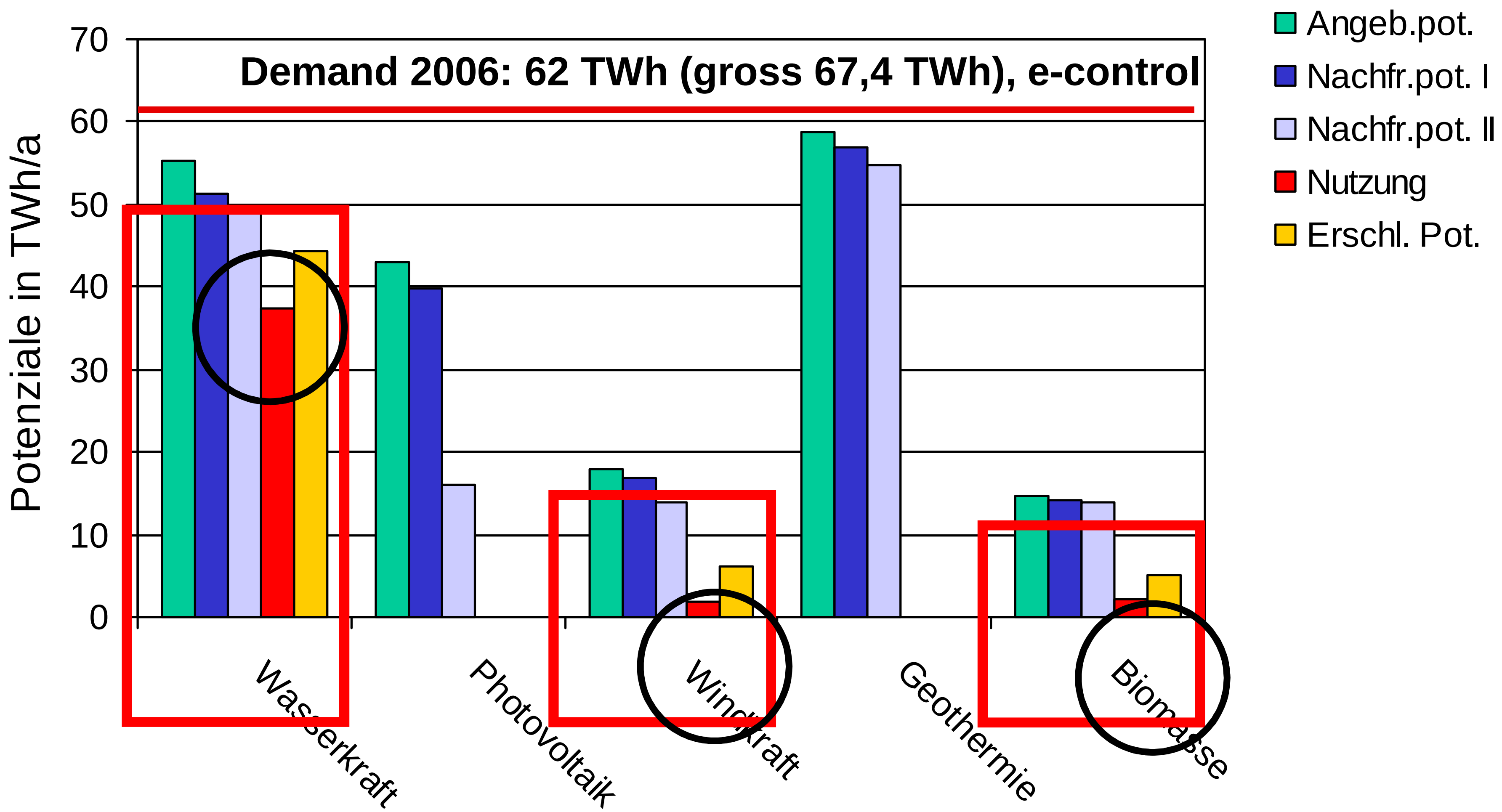
Potenzialbegriffe



Institut für Wärmetechnik

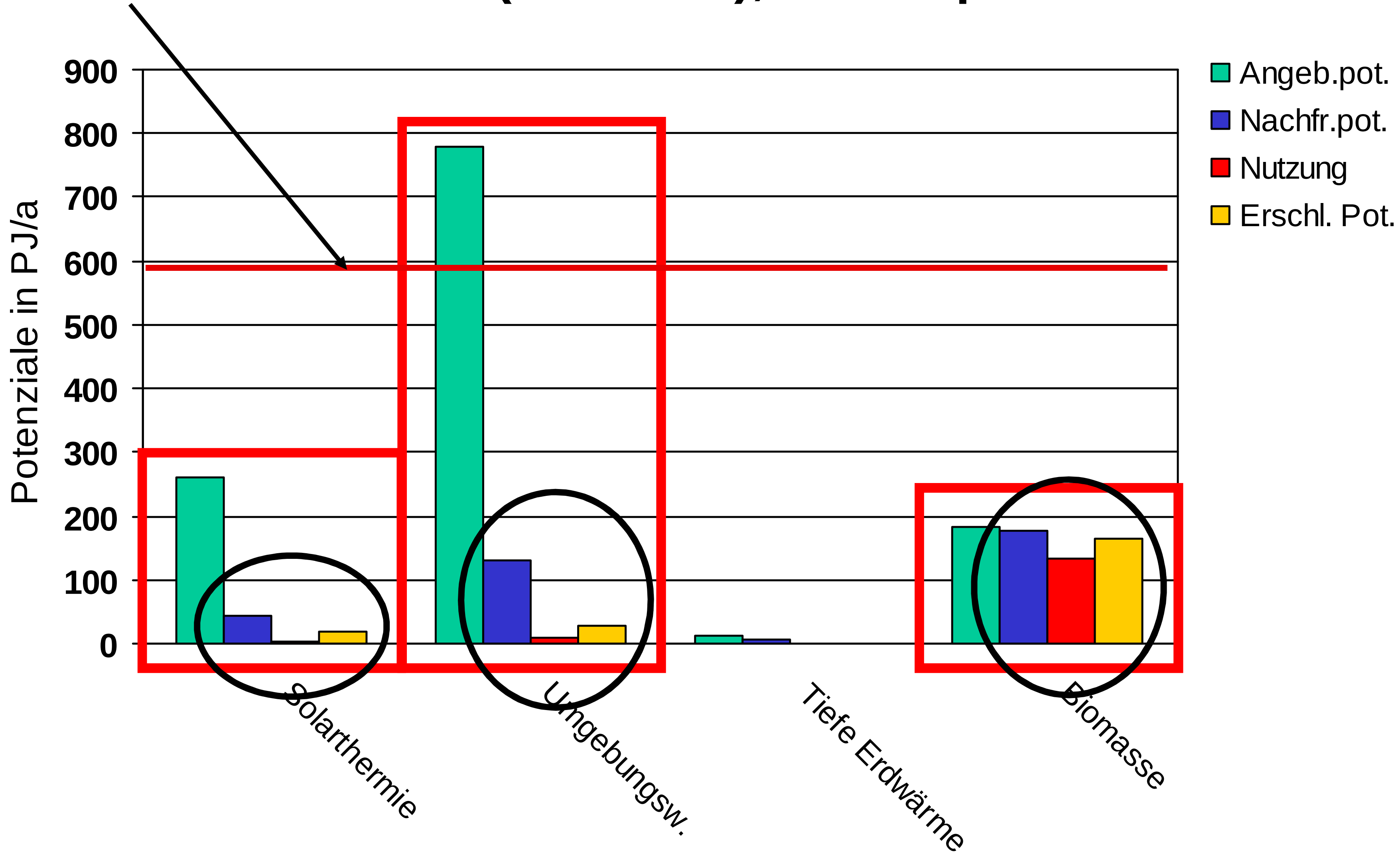
TU Graz

Electrical Energy – Medium term potentials in Austria

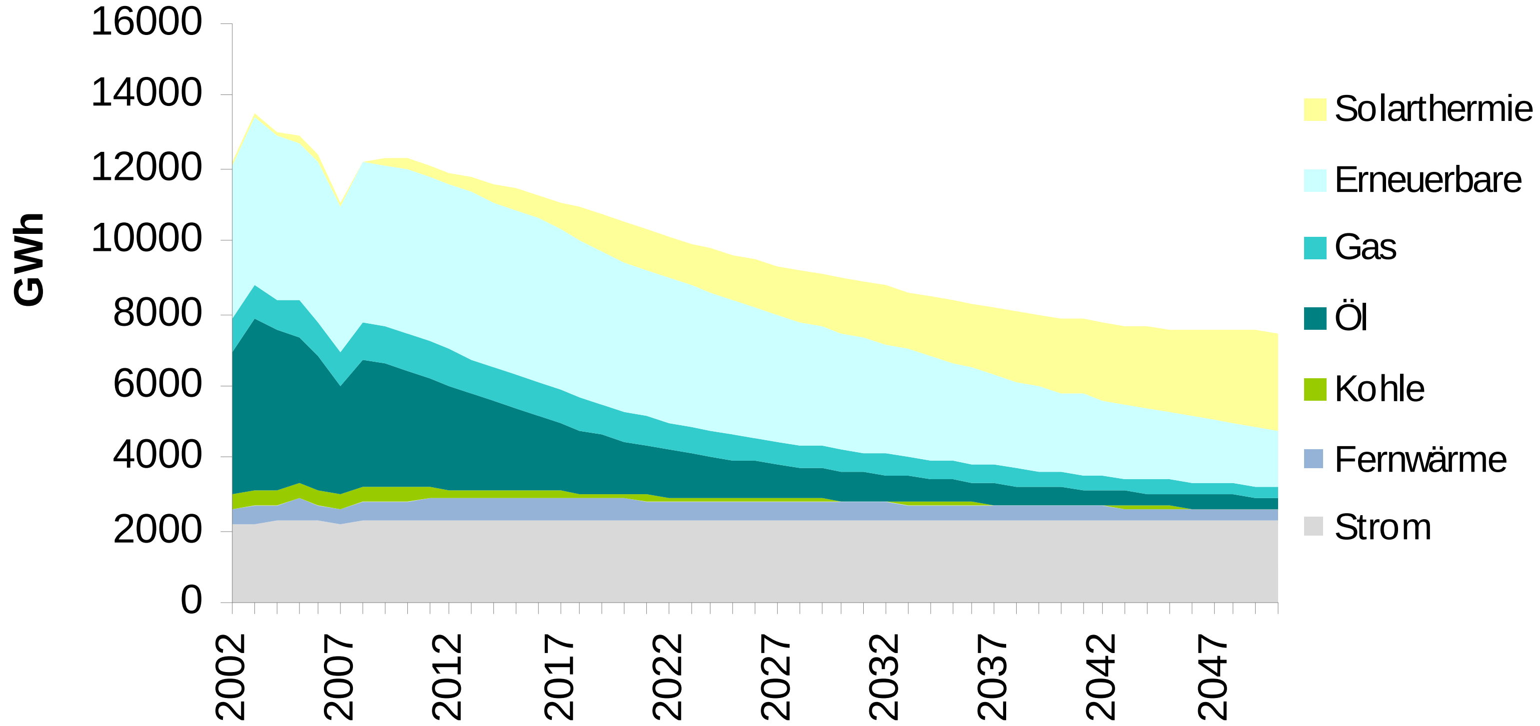


Thermal Energy – Medium term potentials in Austria

Demand 2006: 592 PJ (DHW+SH), 251 PJ process heat

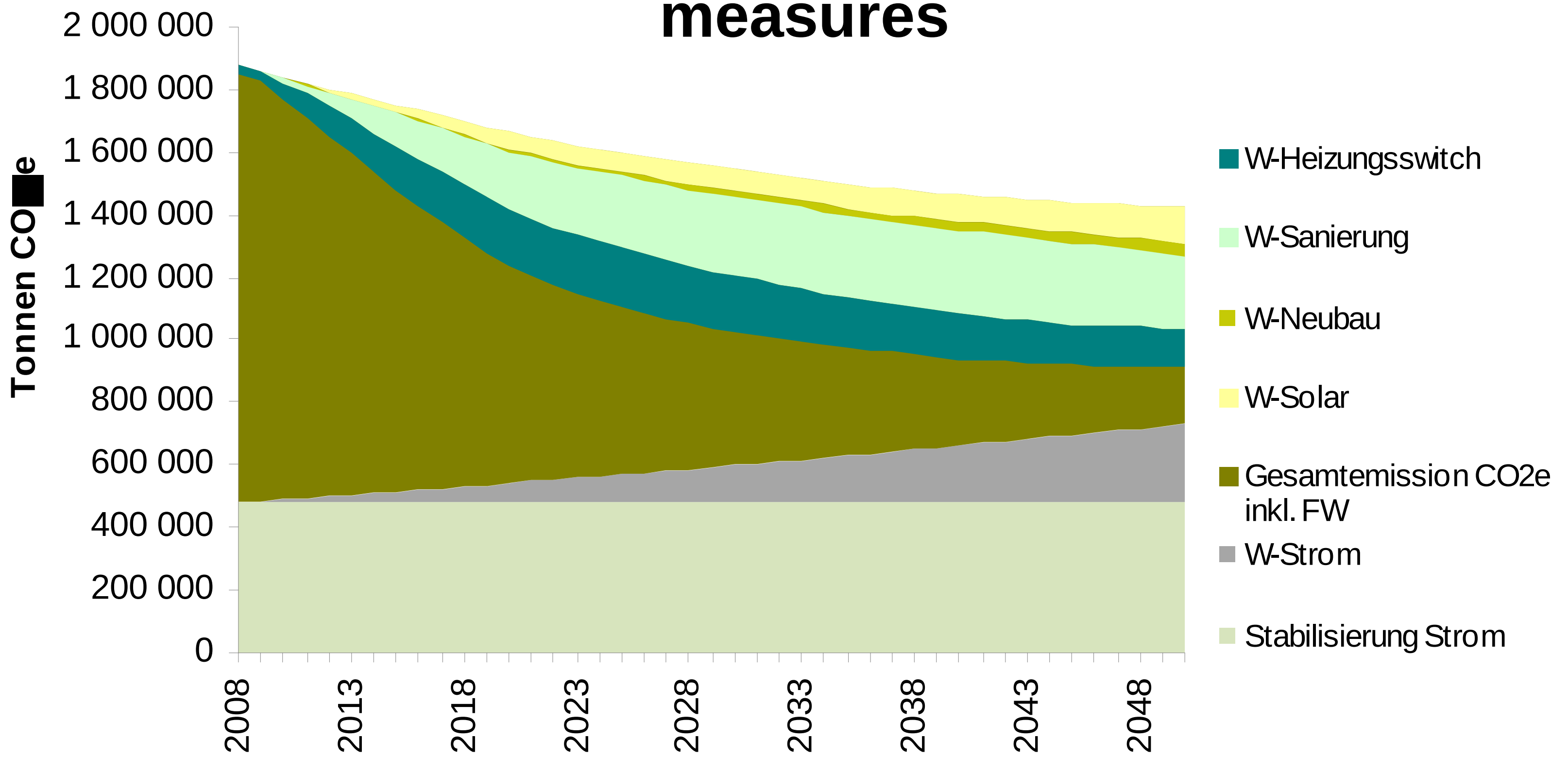


Trendscenario of on Austrian province for various



- Renovation rate to todays standard, in the firt years 4 % renovation rate , then reduced
- New builidngs: no new CO2 Emissionen
- 4 – 1 % switch of heating fuel to renewables, district heat and gas, increase of efficiency

Trendscenario of on Austrian province for various measures



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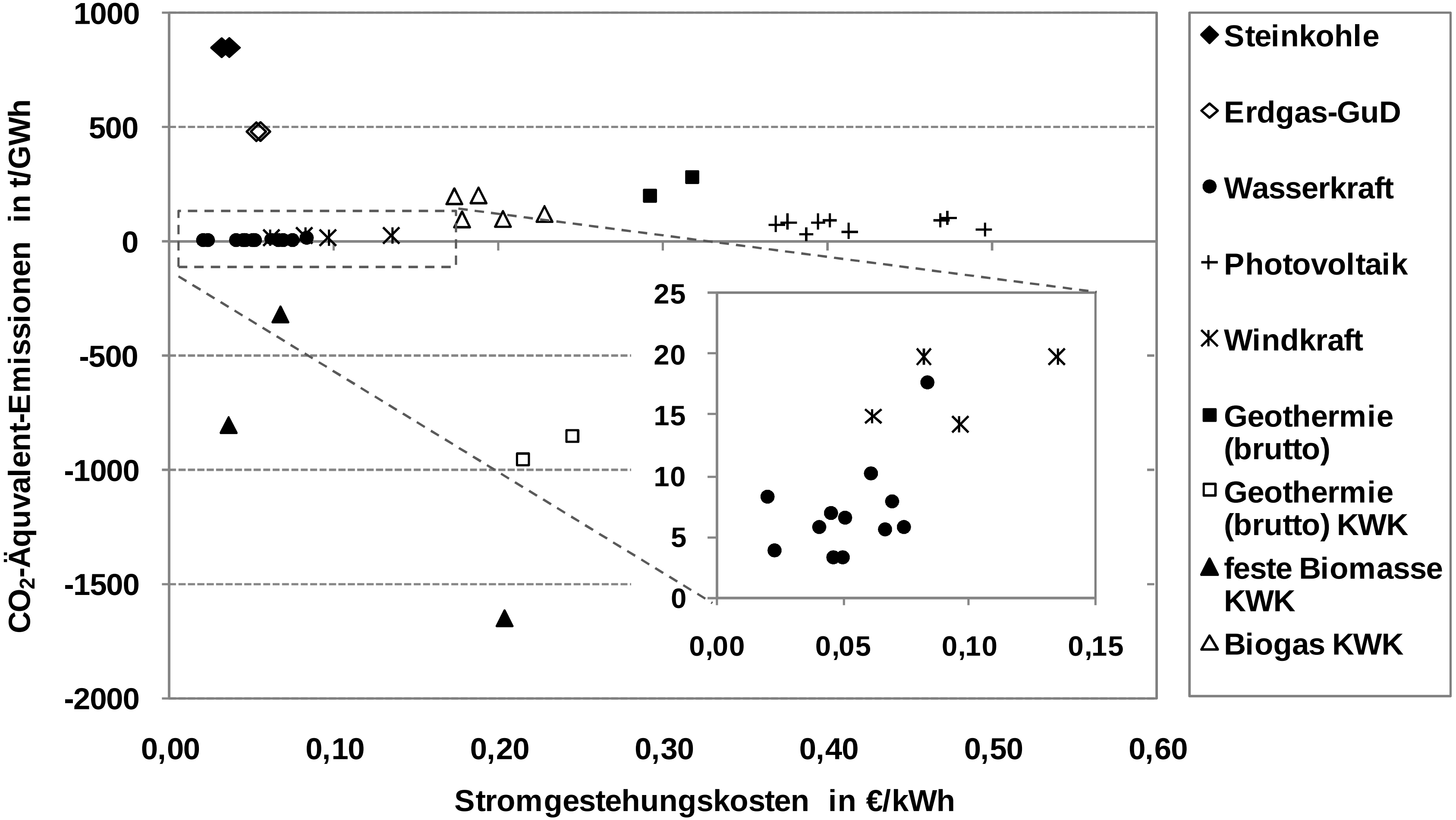
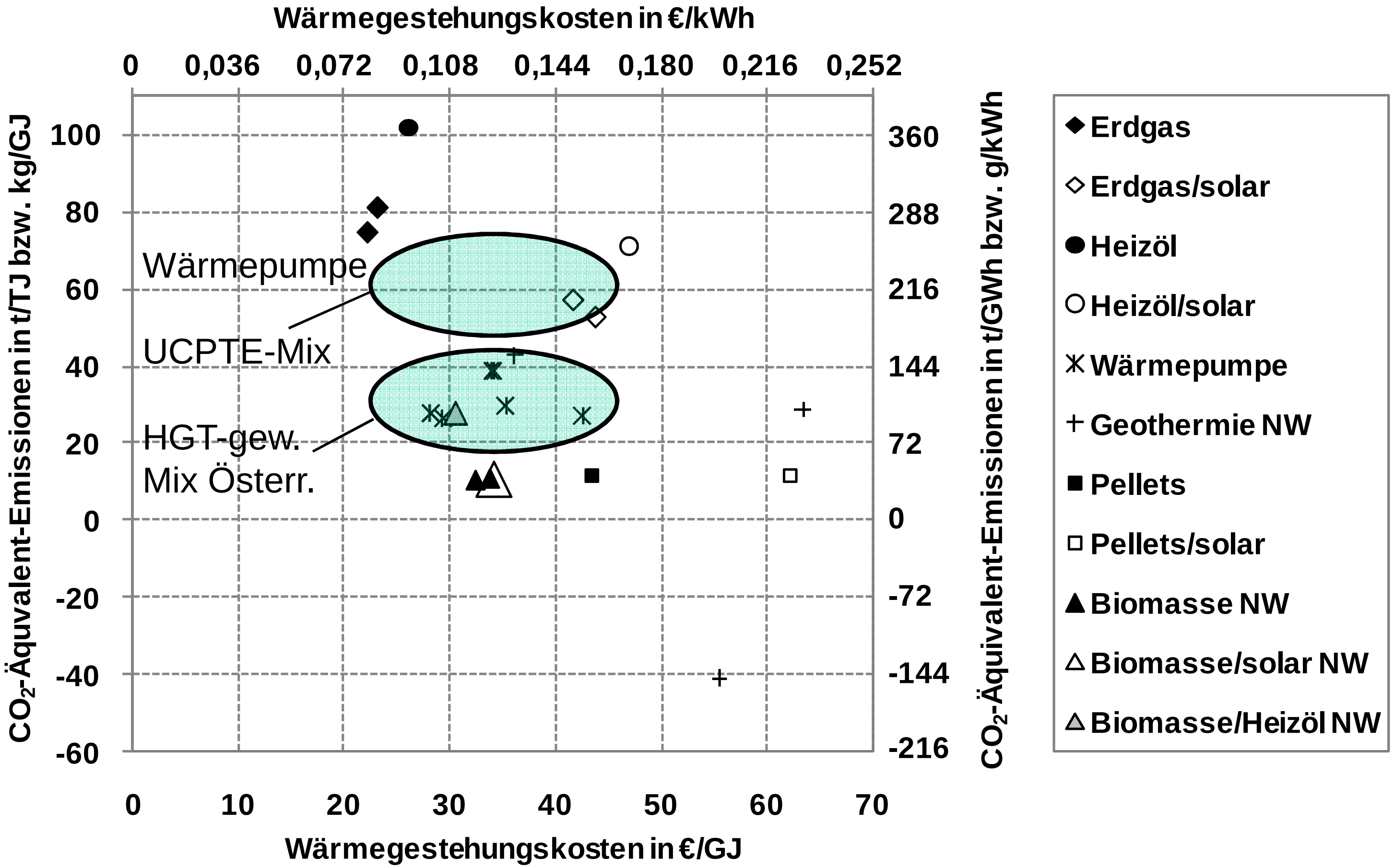
Electricity

specific CO2-equivalent-emissions – electricity generation costs



Heat generation

specific CO2-equivalent-emissions – heat generation costs
Example of EFH-1 with 8 KW heating load



Biofuels

specific CO2-equivalent-emissions – fuel generation costs