Arbeitsbereich
Energieeffizientes Bauen

universität innsbruck

# Low Energy Buildings and Renewable Energy Use

# Czech-Austrian Winter/Summer School

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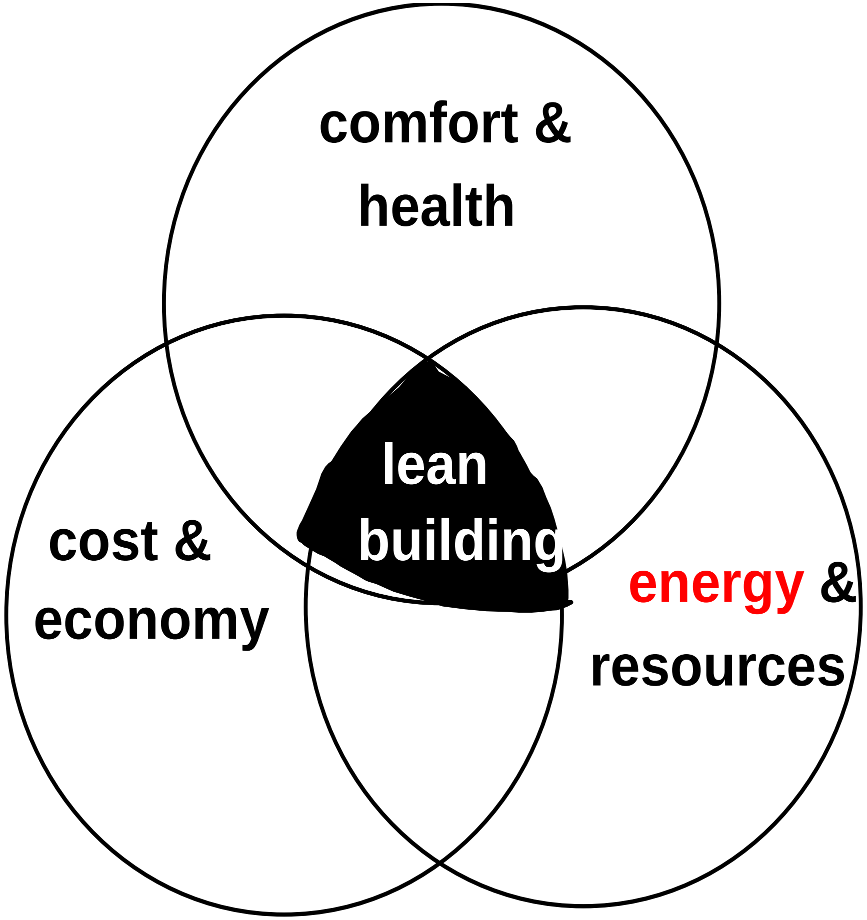
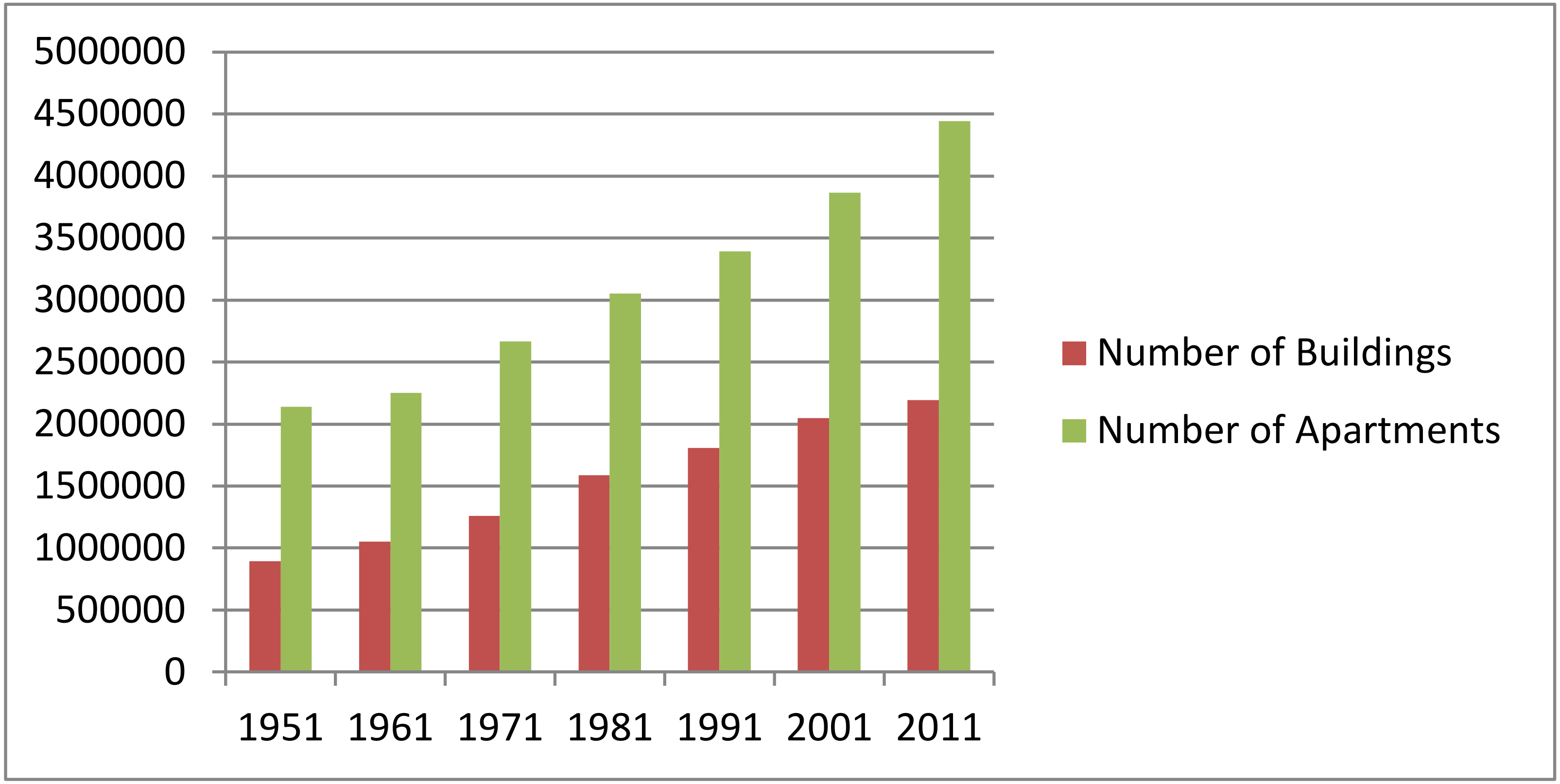
**Whole life optimised building**

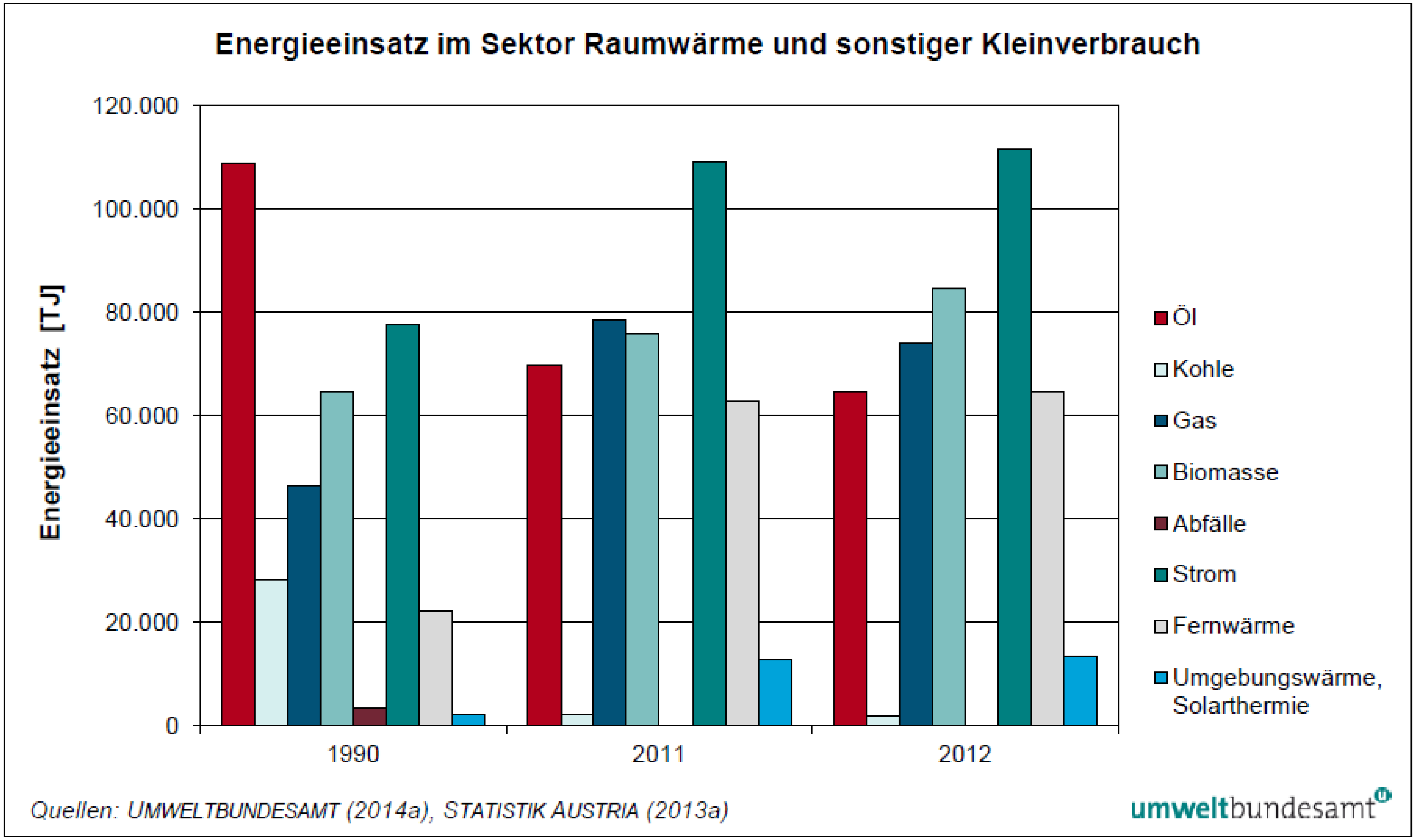
=>



# Numer of Buildings and Appartments in Austria

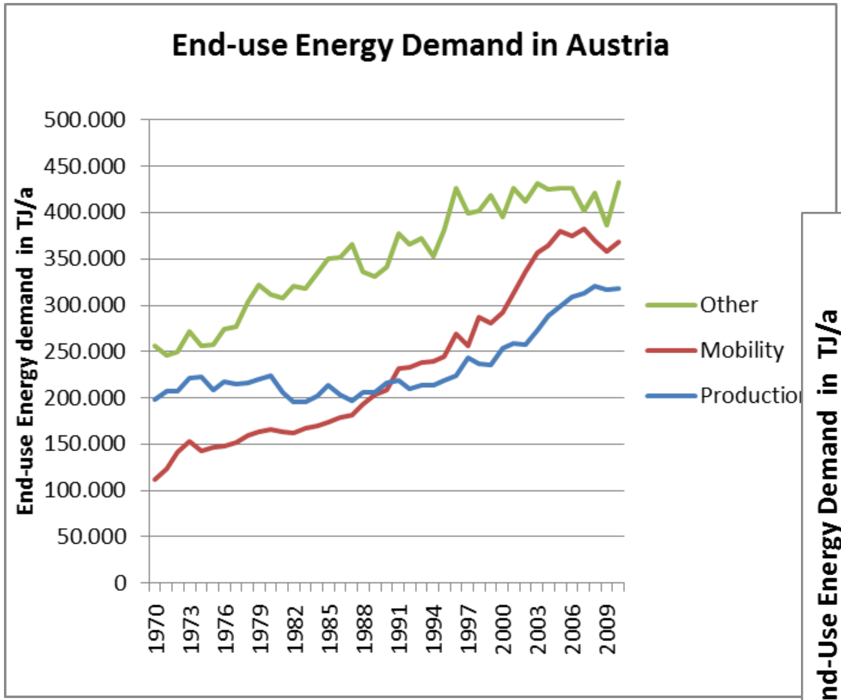


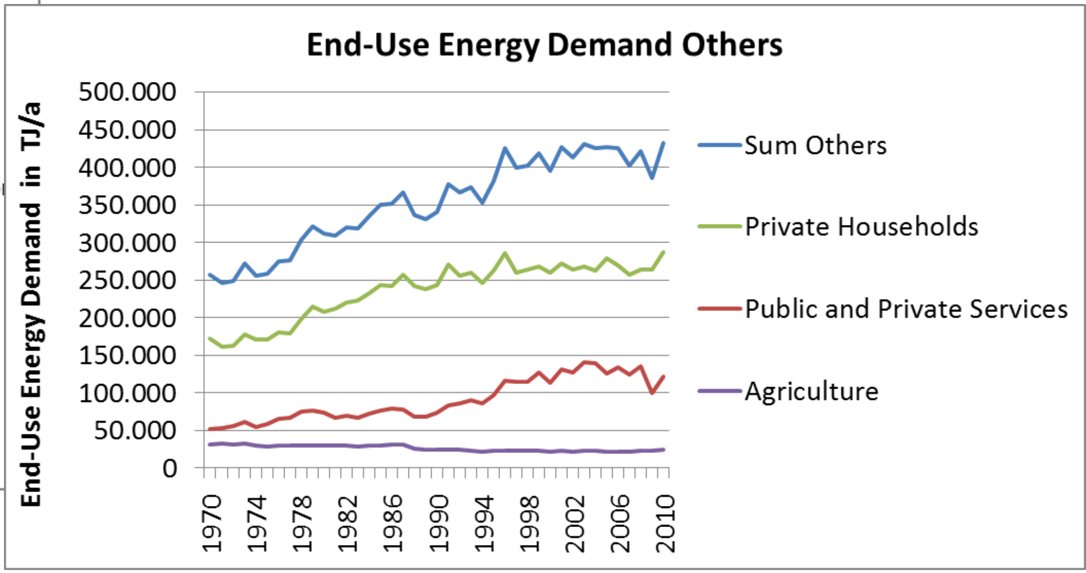
# Energy carriers in Austrian households




Quelle: Statistik Austria, (2013)

# Energy use energy demand (EE) of the sector „others“ and out of this households (Haushalte)

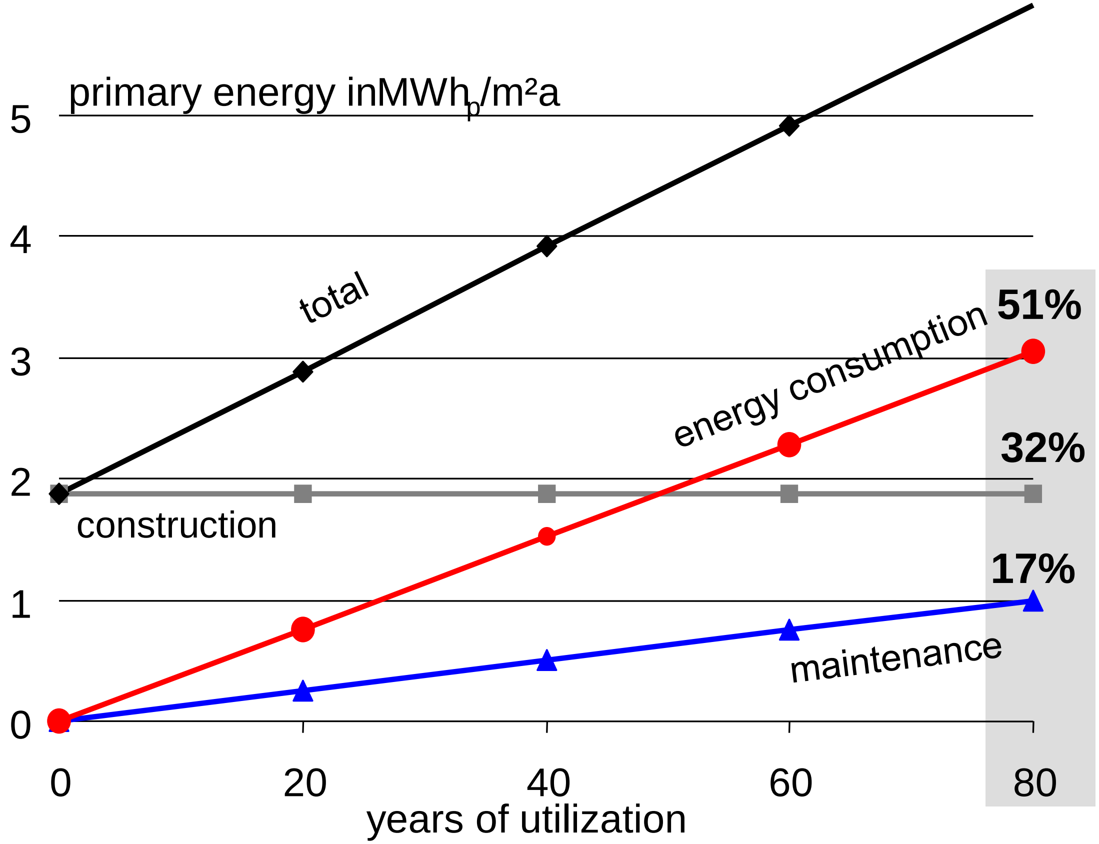



Source : Statistik Austria, superwebquest 2012

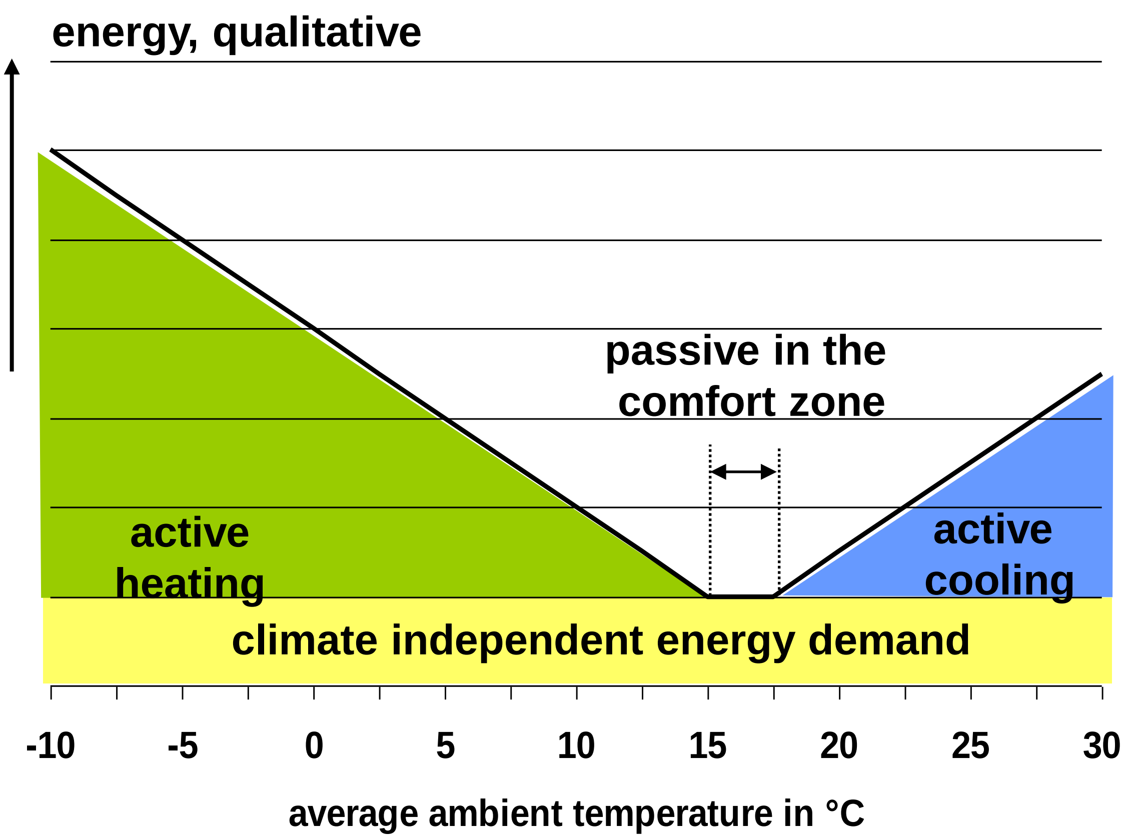
# Life Cycle Energy

**embodied energy 1,9 MWh/m²**



# Current Buildings

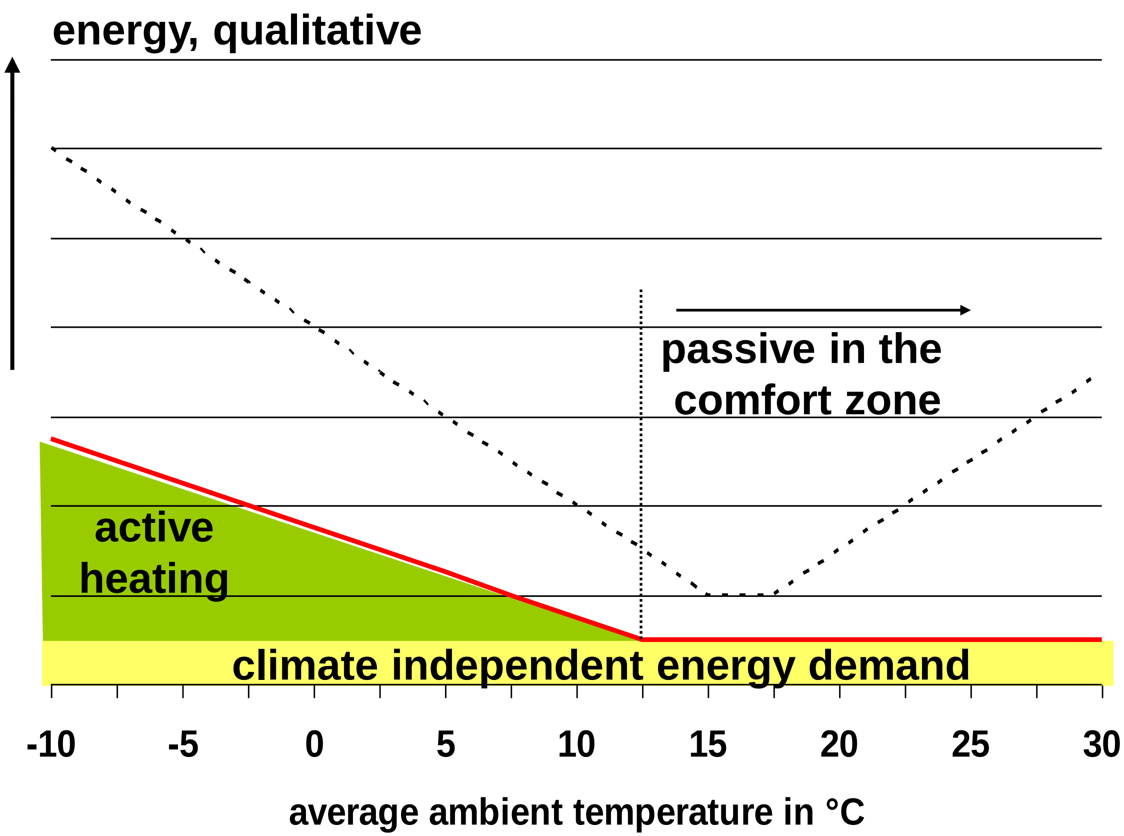
Energy for:
•heating
•cooling
•ventilation
•lighting
•utilization




Example: Mid European climate

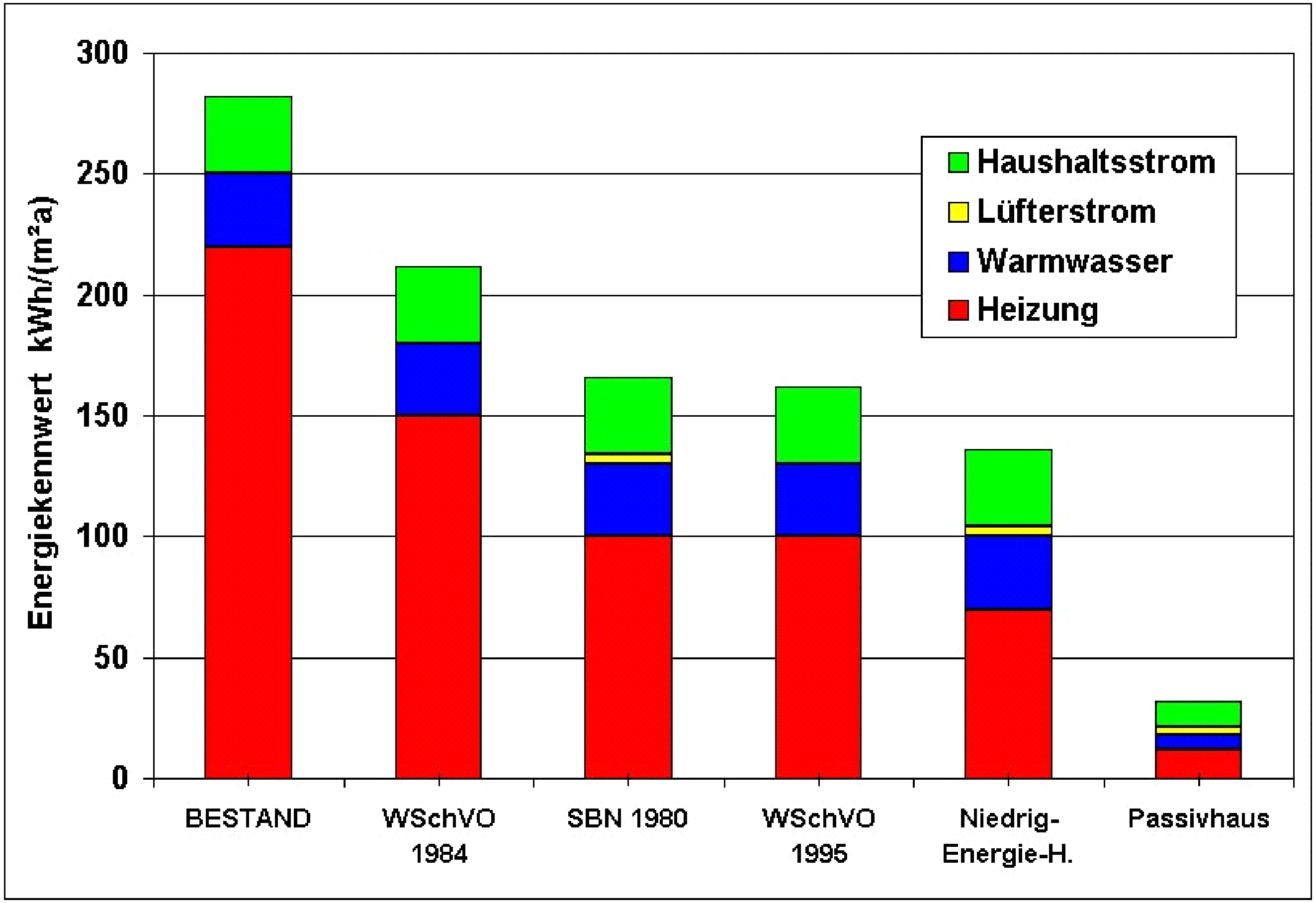
# Lean Buildings

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

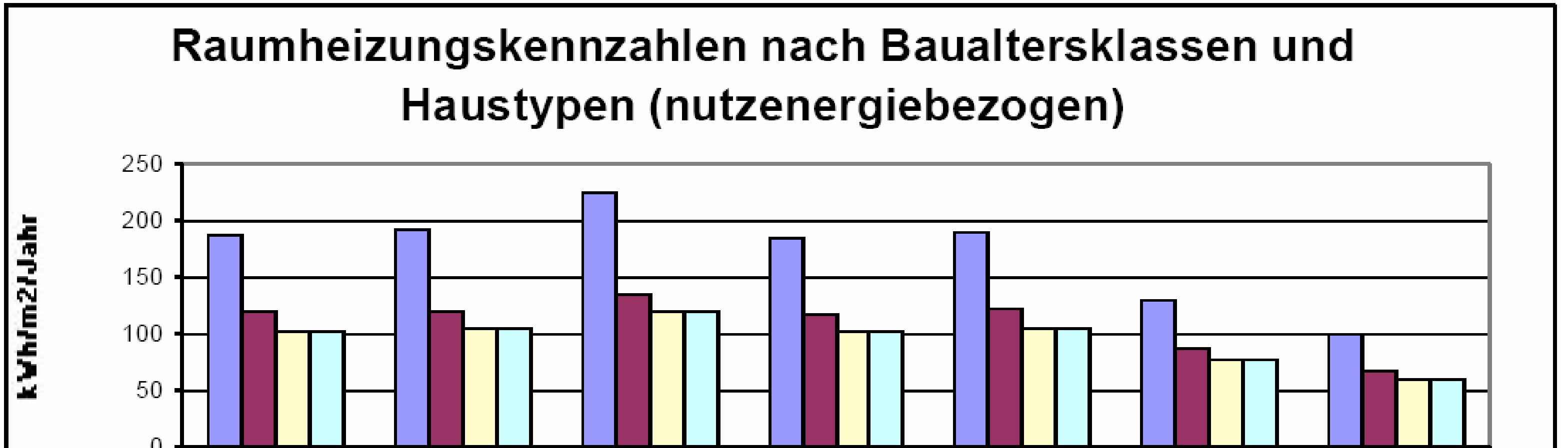



Example: Mid European climate

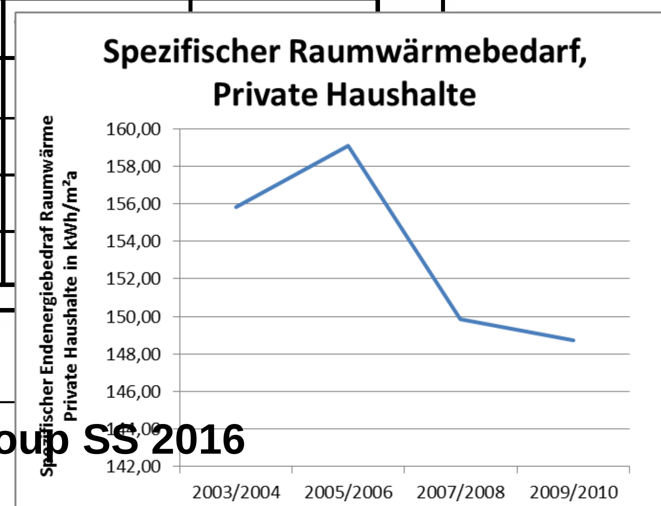
# Energy demand of buildings



# 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



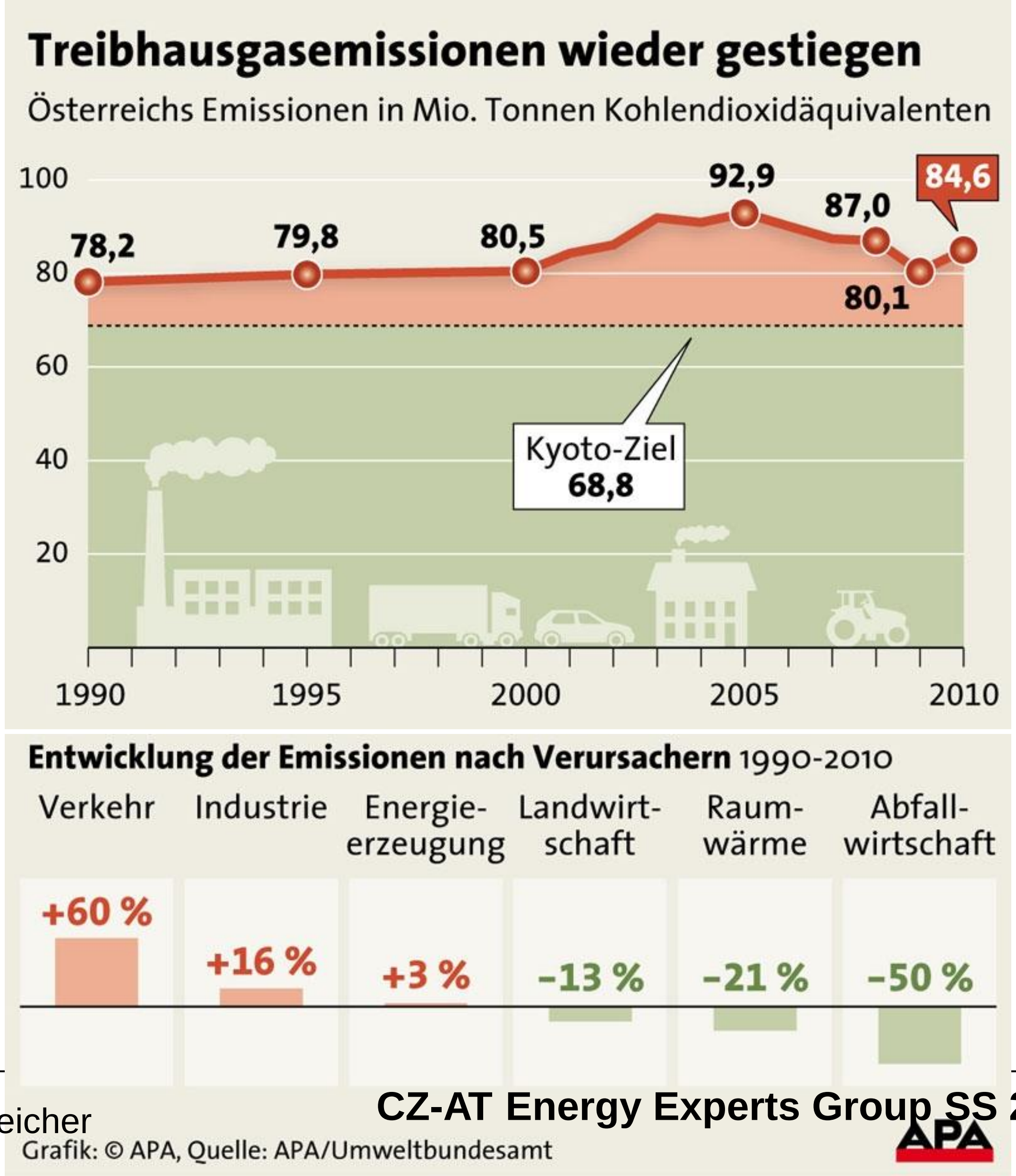

| | vor 1919 | 1919 - 1945 | 1945 - 1960 | 1961 - 1970 | 1971 - 1980 |
|---|---|---|---|---|---|
| EFH | 188 | 193 | 226 | 186 | 191 |
| MFH-K | 121 | 121 | 136 | 118 | 122 |
| MFH-G | 103 | 106 | 120 | 103 | 104 |
| NWG | 103 | 106 | 120 | 103 | 104 |



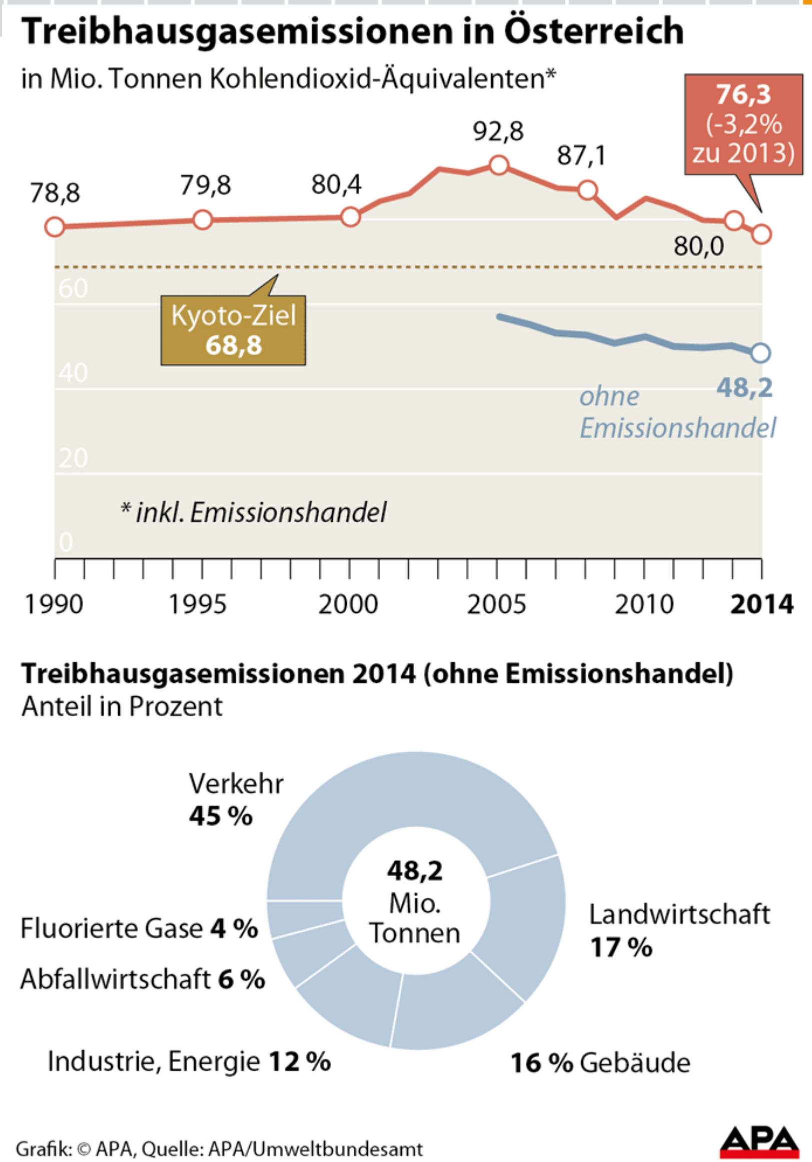

Quelle: Jungmeier, et al. (1996)

# Heating values and specific CO2-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 |

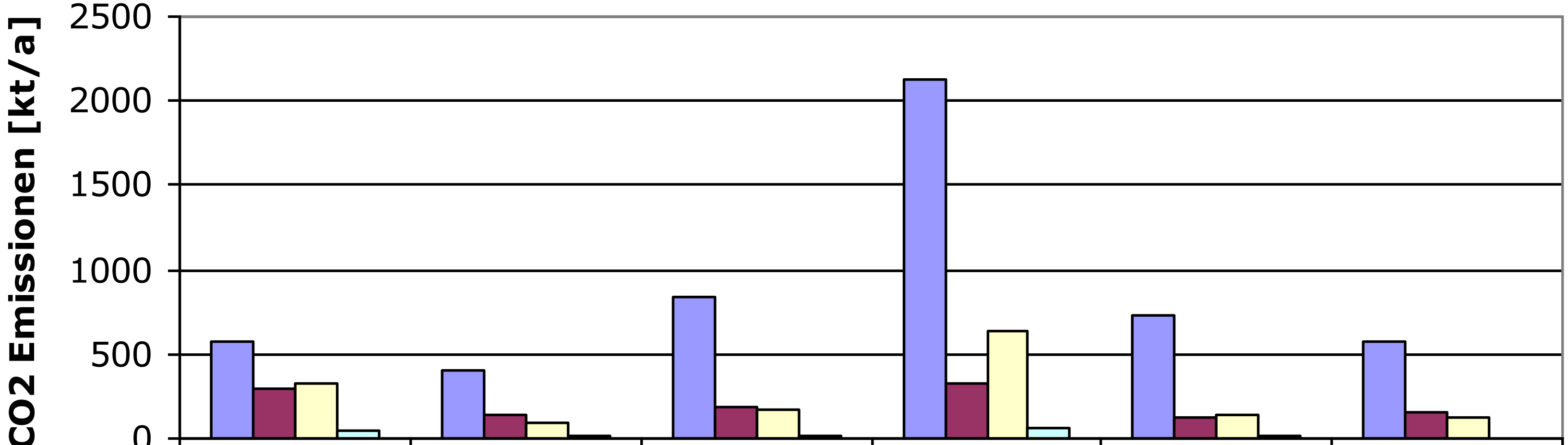

Treibhausgasemissionen wieder gestiegen
Österreichs Emissionen in Mio. Tonnen Kohlendioxidäquivalenten
100
80
60
40
20
78,2
79,8
80,5
92,9
87,0
84,6
80,1
Kyoto-Ziel
68,8
1990
1995
2000
2005
2010
Entwicklung der Emissionen nach Verursachern 1990-2010
Verkehr
Industrie
Energie-erzeugung
Landwirt-schaft
Raum-wärme
Abfall-wirtschaft
+60 %
+16 %
+3 %
-13 %
-21 %
-50 %
Grafik: © APA, Quelle: APA/Umweltbundesamt
APA

# Austrian greenhouse gas emissions




Quelle: APA/UBA, 2016

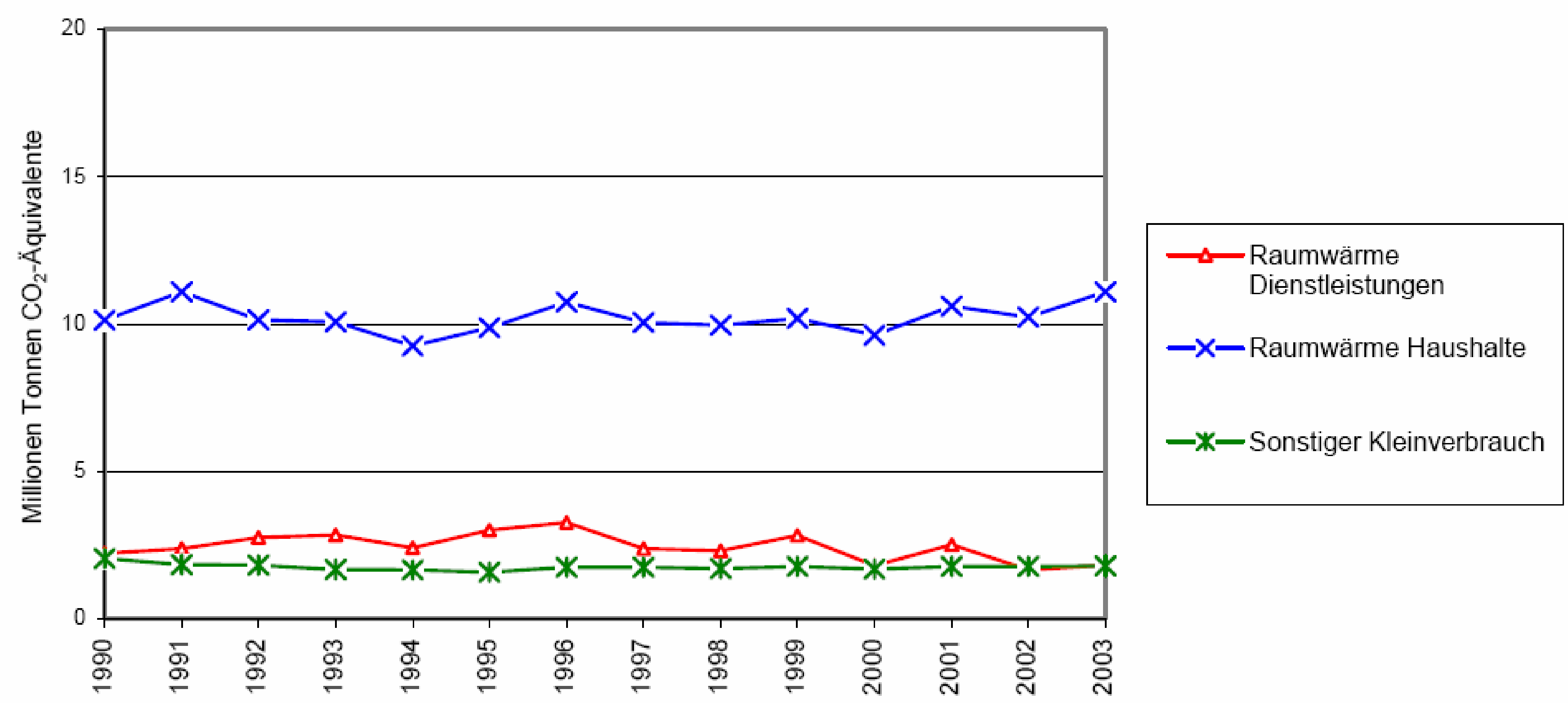
# CO2-emissions from space heating of appartements in Austria




| | 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 |

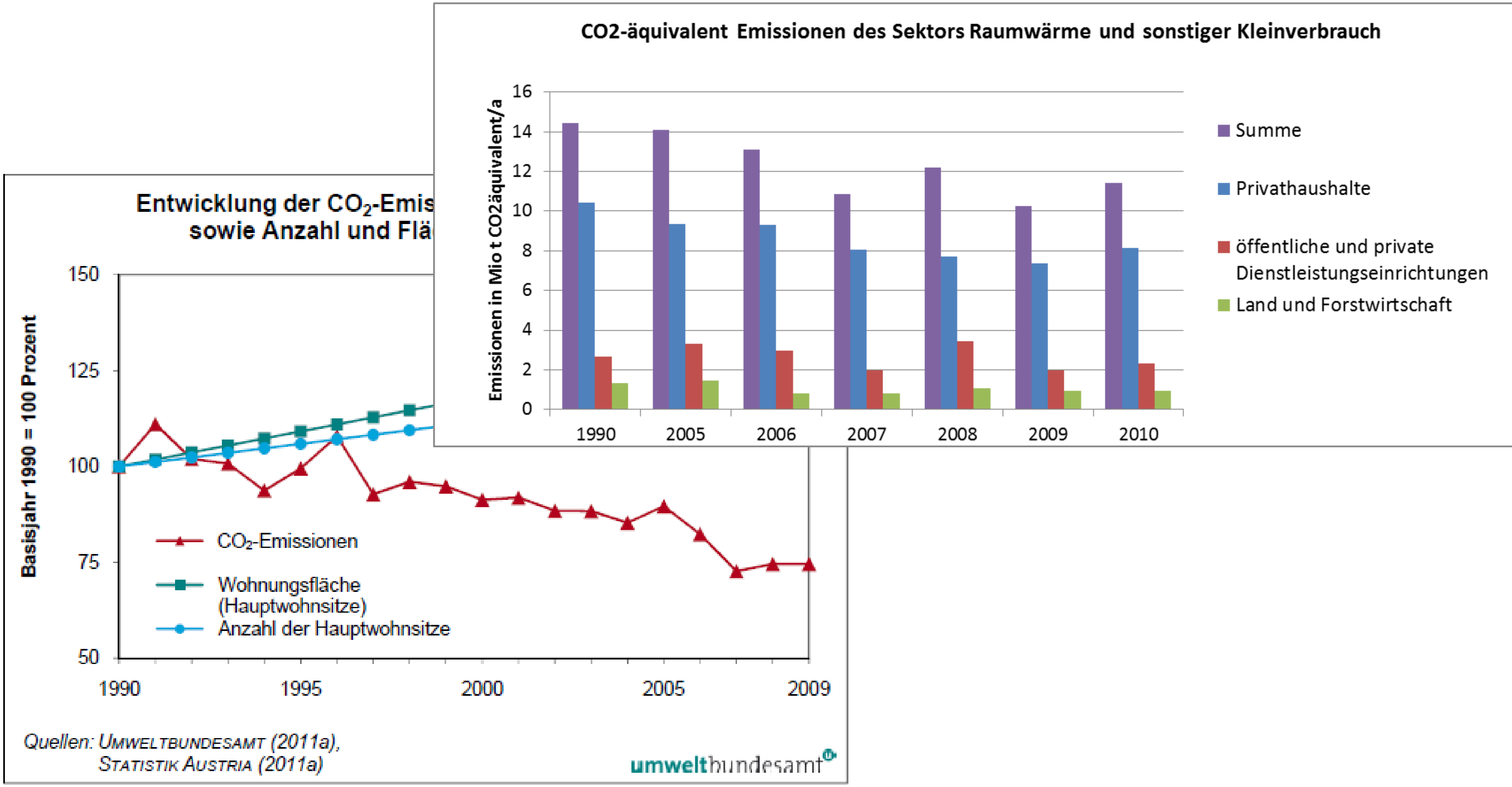
Quelle: eigene Berechnung

# CO2-equivalent emissions from the residential sector (Raumwärme Haushalte) and other small use in Austria

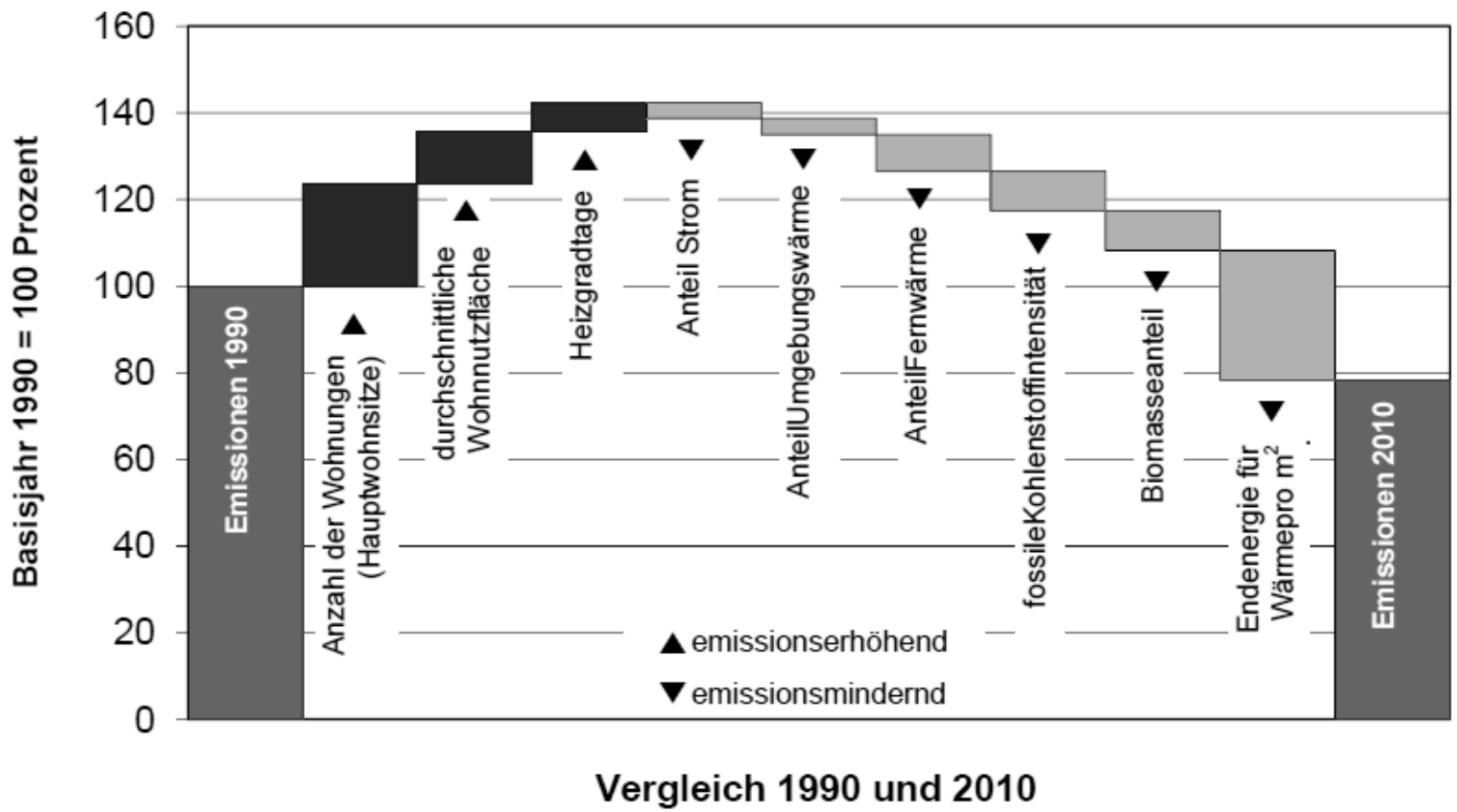



Quelle: BMLFUW (2005)

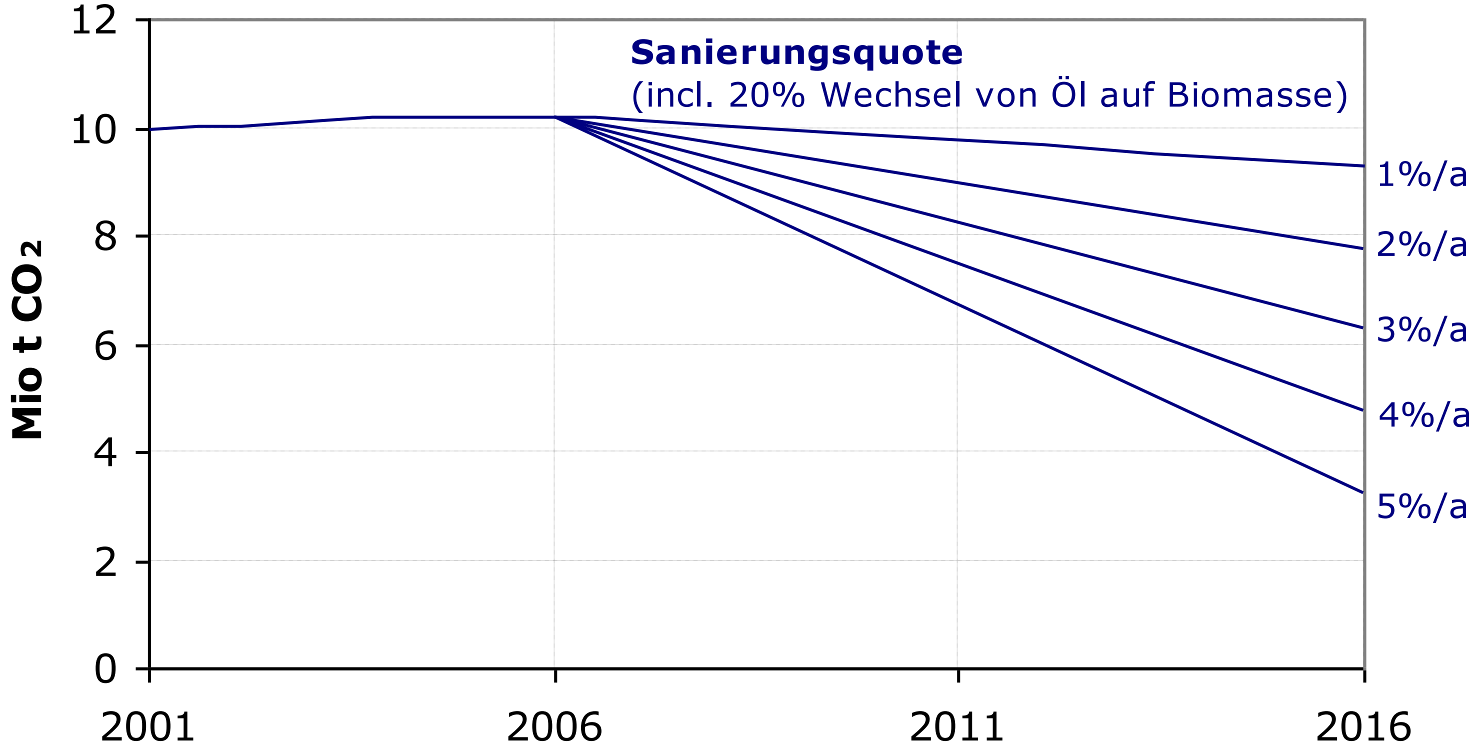
# CO2-emissions from the residential sector (Raumwärme Haushalte) in Austria



# CO2-emissions from the residential sector (Raumwärme Haushalte) in Austria



# 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)

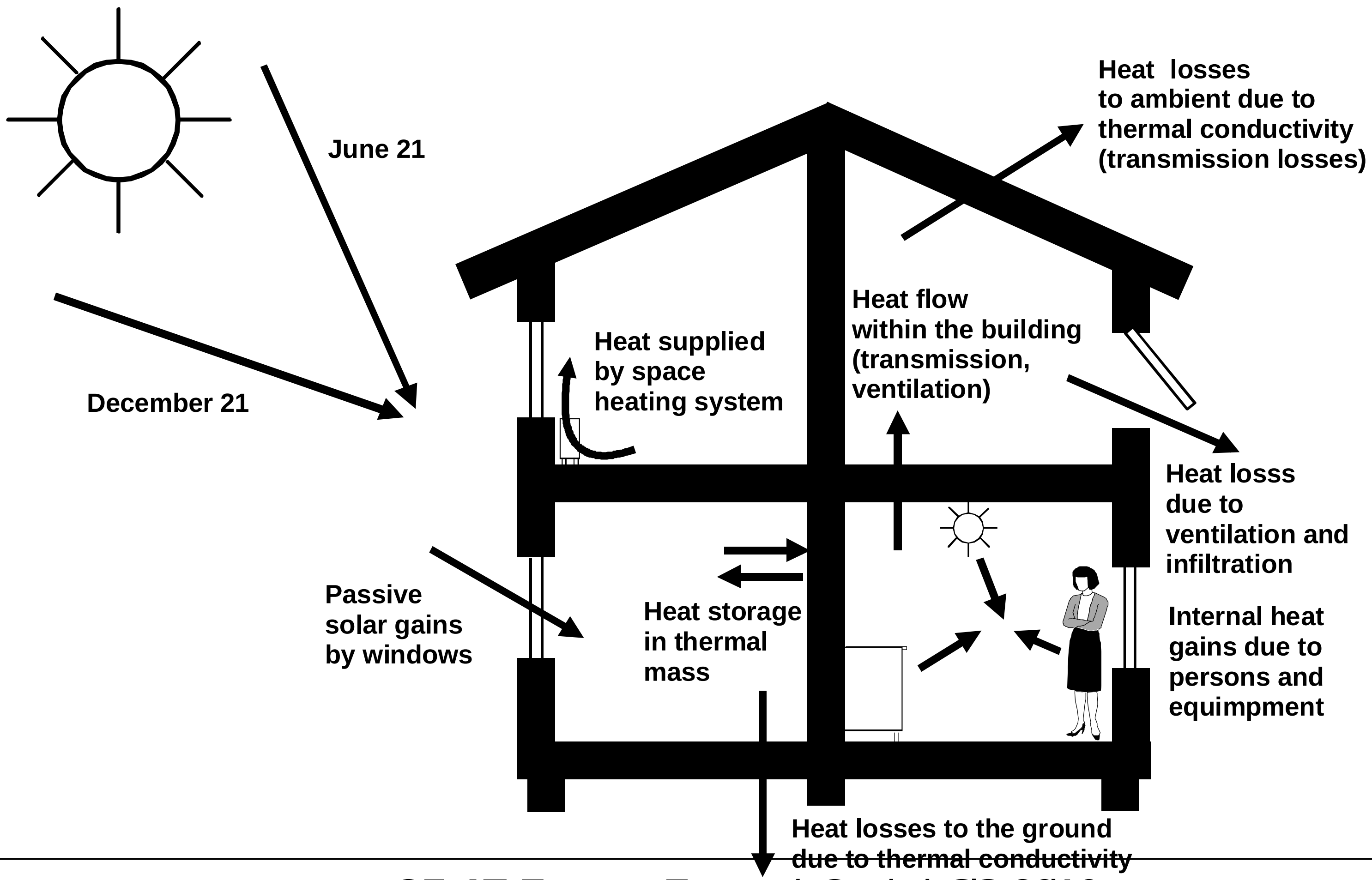
# Energetical System Building

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



# Heat transfer coefficient for transmission heat losses

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

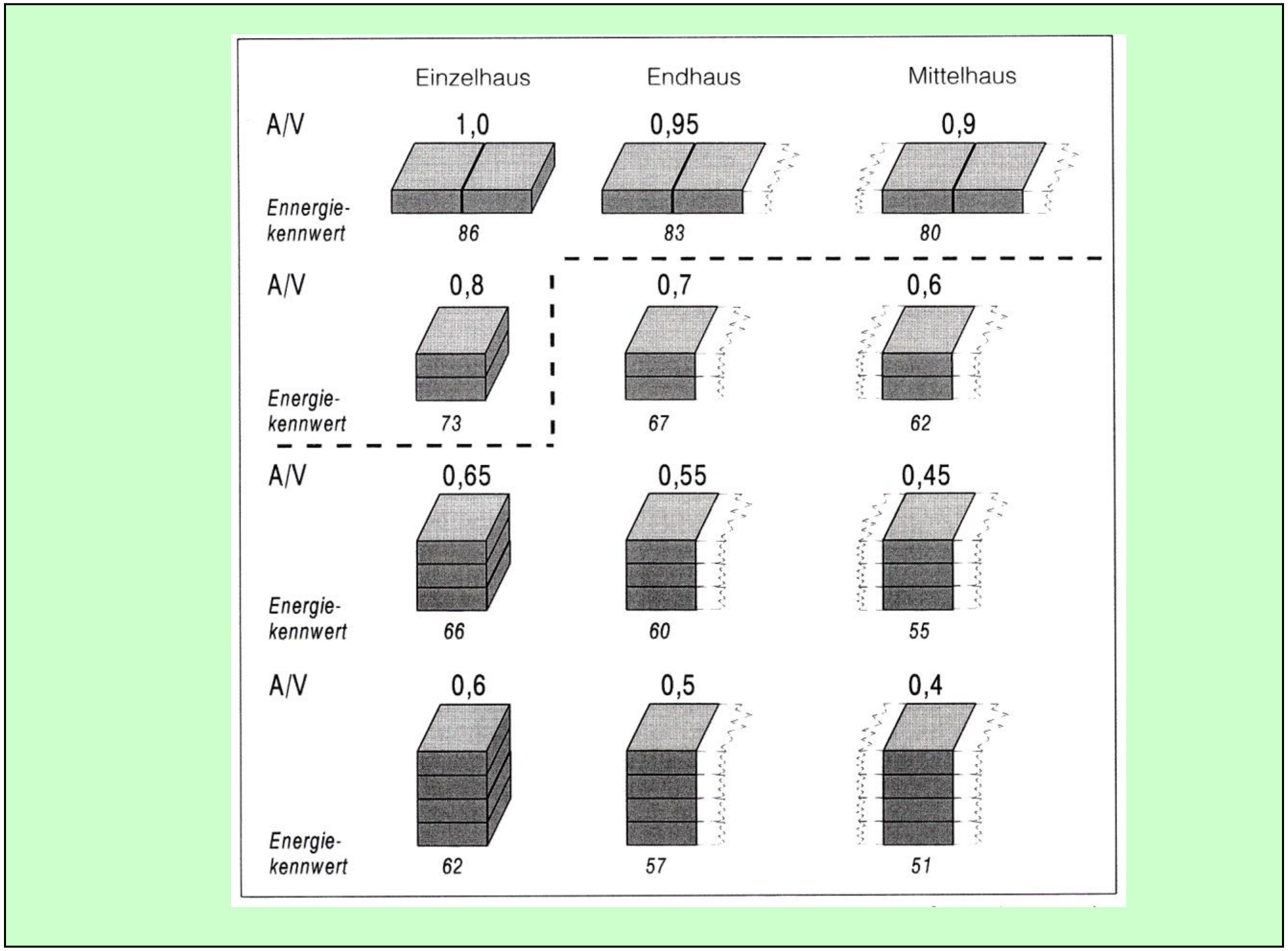
mit $A$... Heat transfer surface $[m^2]$

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

$\Delta T$... Forcing temperature difference $[K]$

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

# Building Shape: Ratio of A/V for different shapes




Quelle: Feist, W., 1998, Das Niedrigenergiehaus

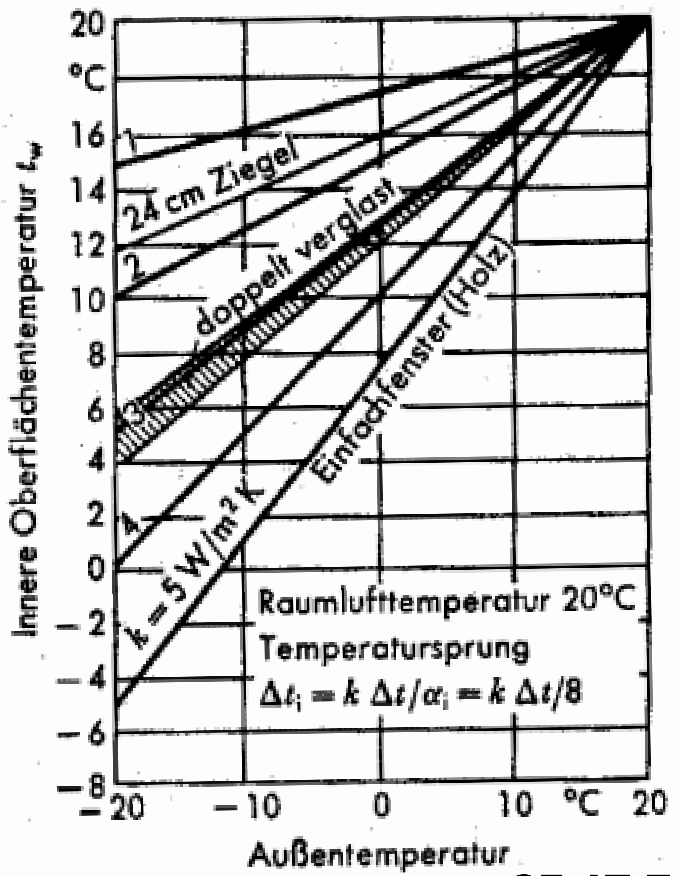
# Maximum U-values (W/m²K) OIB Richtlinie 6 Austria (2011)

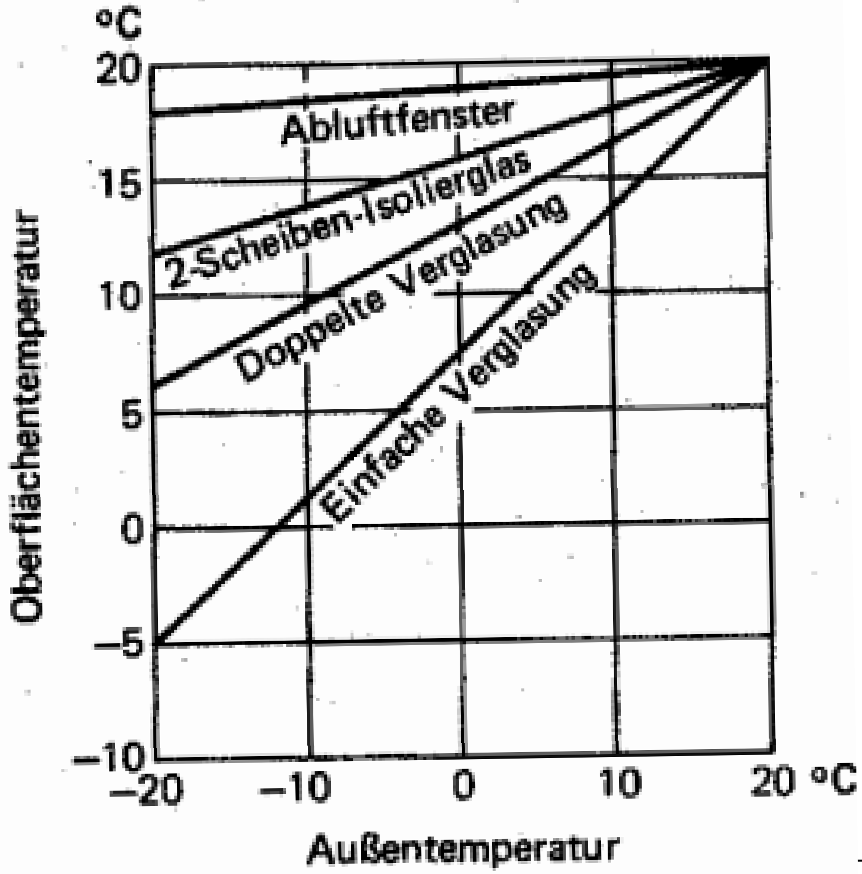
| | Bauteil | | U-Wert [W/m²K] |
|---|---|---|---|
| 1 | WÄNDE | gegen Außenluft | 0,35 |
| 2 | WÄNDE | gegen unbeheizte oder nicht ausgebaute Dachräume | 0,35 |
| 3 | WÄNDE | gegen unbeheizte, frostfrei zu haltende Gebäudeteile (ausgenommen Dachräume) sowie gegen Garagen | 0,60 |
| 4 | WÄNDE | erdberührt | 0,40 |
| 5 | WÄNDE | (Trennwände) zwischen Wohn- oder Betriebseinheiten | 0,90 |
| 6 | WÄNDE | gegen andere Bauwerke an Grundstücks- bzw. Bauplatzgrenzen | 0,50 |
| 7 | WÄNDE | kleinflächig 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 |
| 8 | WÄNDE | (Zwischenwände) innerhalb von Wohn- und Betriebseinheiten | - |
| 9 | FENSTER, FENSTERTÜREN, VERGLASTE TÜREN jeweils in Wohngebäuden | (WG) gegen Außenluft[2] | 1,40 |
| 10 | FENSTER, FENSTERTÜREN, VERGLASTE TÜREN jeweils in Nicht- | Wohngebäuden (NWG) gegen Außenluft[2] | 1,70 |
| 11 | sonstige | TRANSPARENTE BAUTEILE vertikal gegen Außenluft[1] | 1,70 |
| 12 | sonstige | TRANSPARENTE BAUTEILE horizontal oder in Schrägen gegen Außenluft[2] | 2,00 |
| 13 | sonstige | TRANSPARENTE BAUTEILE vertikal gegen unbeheizte Gebäudeteile[1] | 2,50 |
| 14 | DACHFLÄCHENFENSTER gegen Außenluft[2] | | 1,70 |
| 15 | TÜREN | unverglast, gegen Außenluft[2] | 1,70 |
| 16 | TÜREN | unverglast, gegen unbeheizte Gebäudeteile[2] | 2,50 |
| 17 | TORE | Rolltore, Sektionaltore u.dgl. gegen Außenluft | 2,50 |
| 18 | INNENTÜREN | | - |
| 19 | DECKEN | und DACHSCHRÄGEN jeweils gegen Außenluft und gegen Dachräume (durchlüftet oder ungedämmt) | 0,20 |
| 20 | DECKEN | gegen unbeheizte Gebäudeteile | 0,40 |
| 21 | DECKEN | gegen getrennte Wohn- und Betriebseinheiten | 0,90 |
| 22 | DECKEN | innerhalb von Wohn- und Betriebseinheiten | - |
| 23 | DECKEN | über Außenluft (z.B. über Durchfahrten, Parkdecks) | 0,20 |
| 24 | DECKEN | gegen Garagen | 0,30 |
| 25 | BÖDEN | erdberührt | 0,40 |

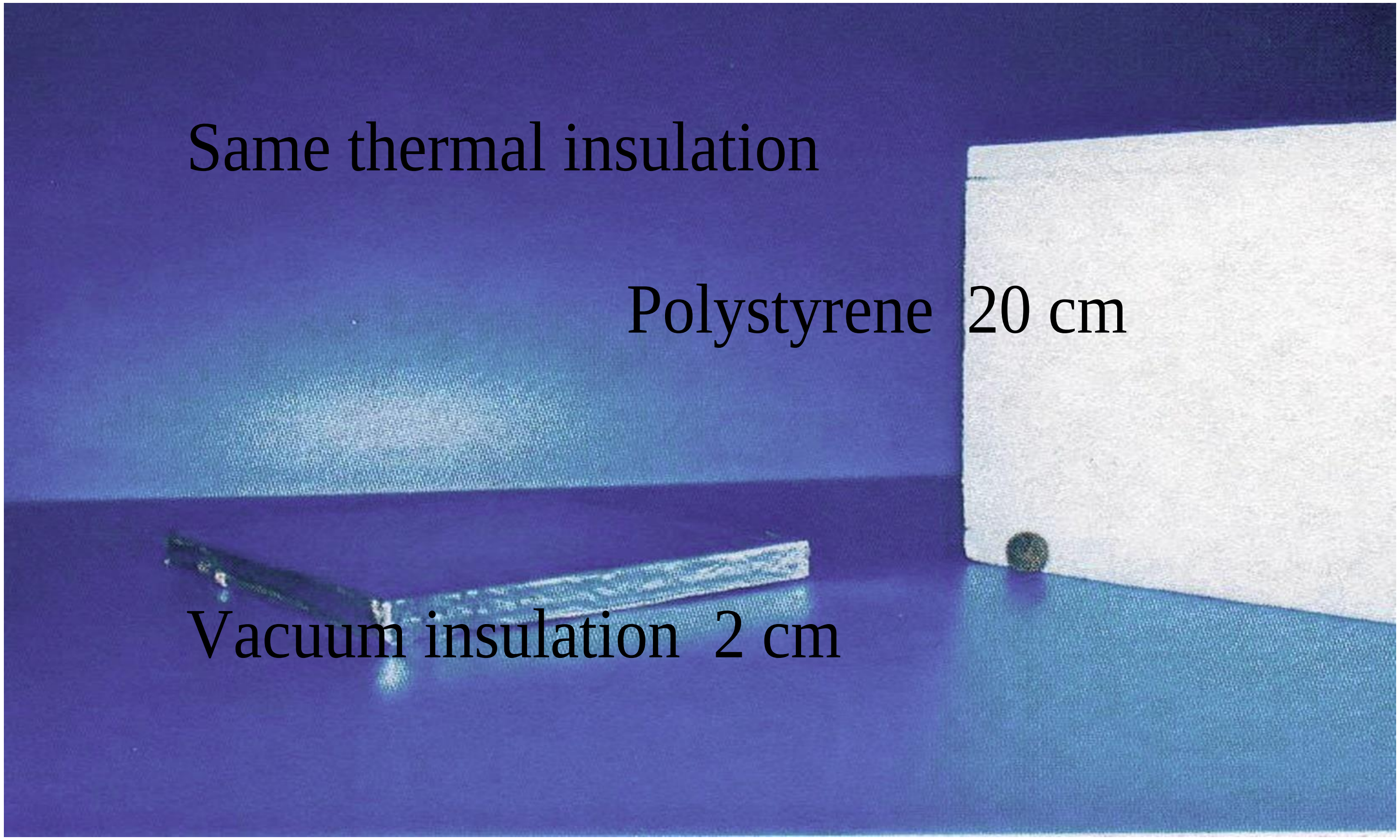
[1] Die Konstruktion ist auf ein Prüfnormmaß von 1,23 m x 1,48 m zu beziehen, wobei die Symmetrieebenen an den Rand des Prüfnormmaßes zu legen sind

[2] Bezogen auf ein Prüfnormmaß von 1,23 m x 1,48 m

# Room air temperature – temperature of surrounding surfaces ⇔ thermal comfort



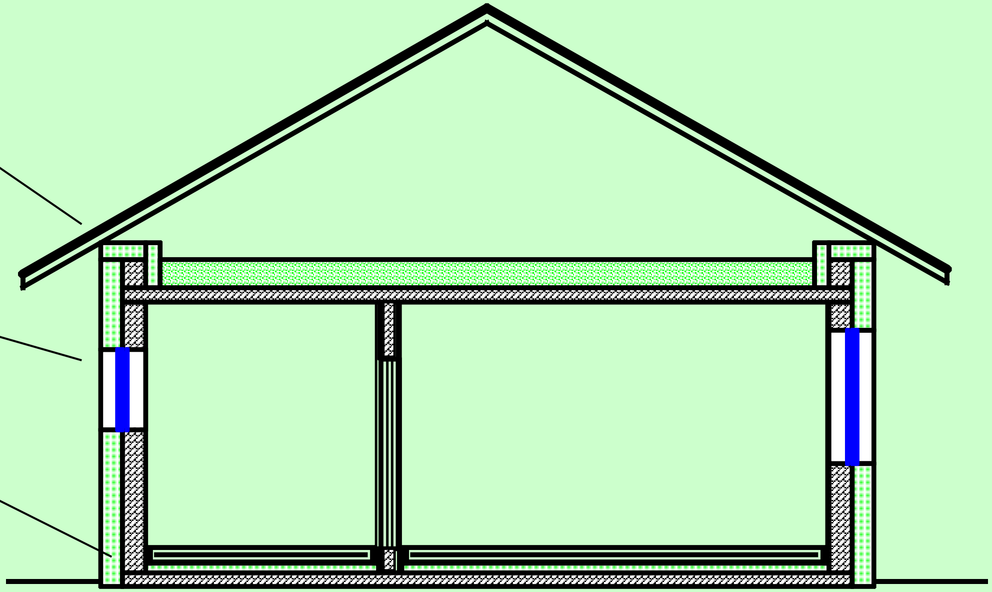




Same thermal insulation
Polystyrene 20 cm
Vacuum insulation 2 cm

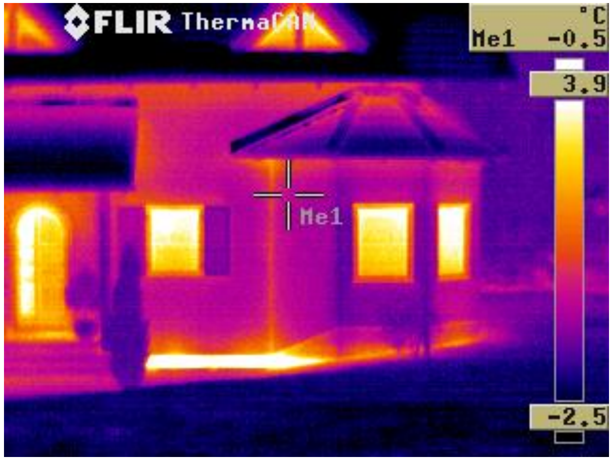
# Avoiding thermal bridges

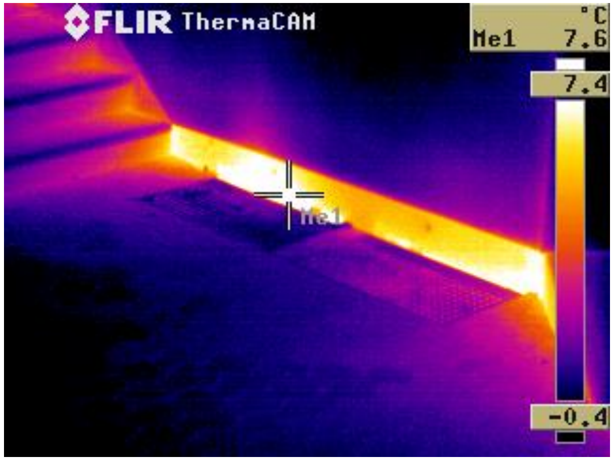
## Problematic zones:

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

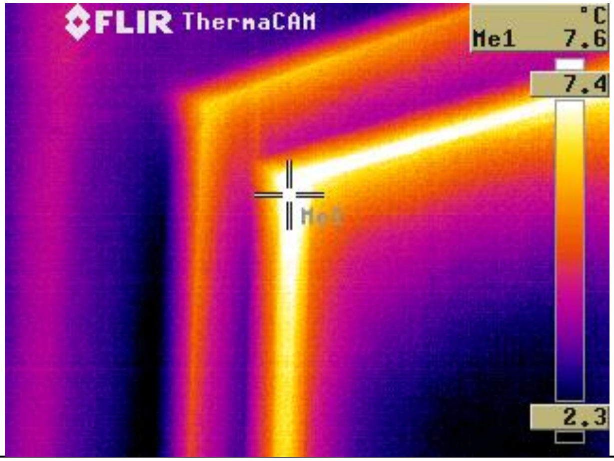


# Thermal bridges, Thermographie



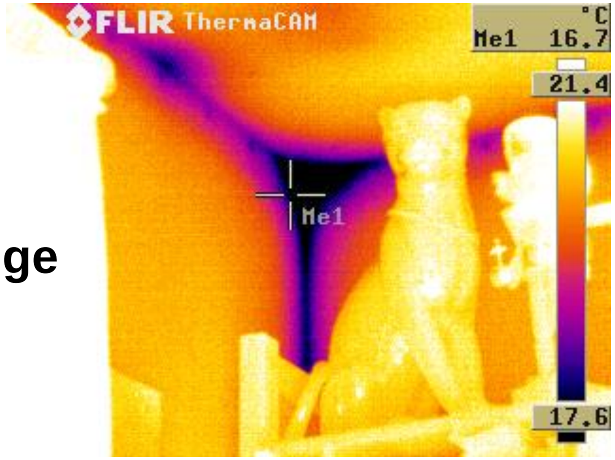




Ground floor to cellar,



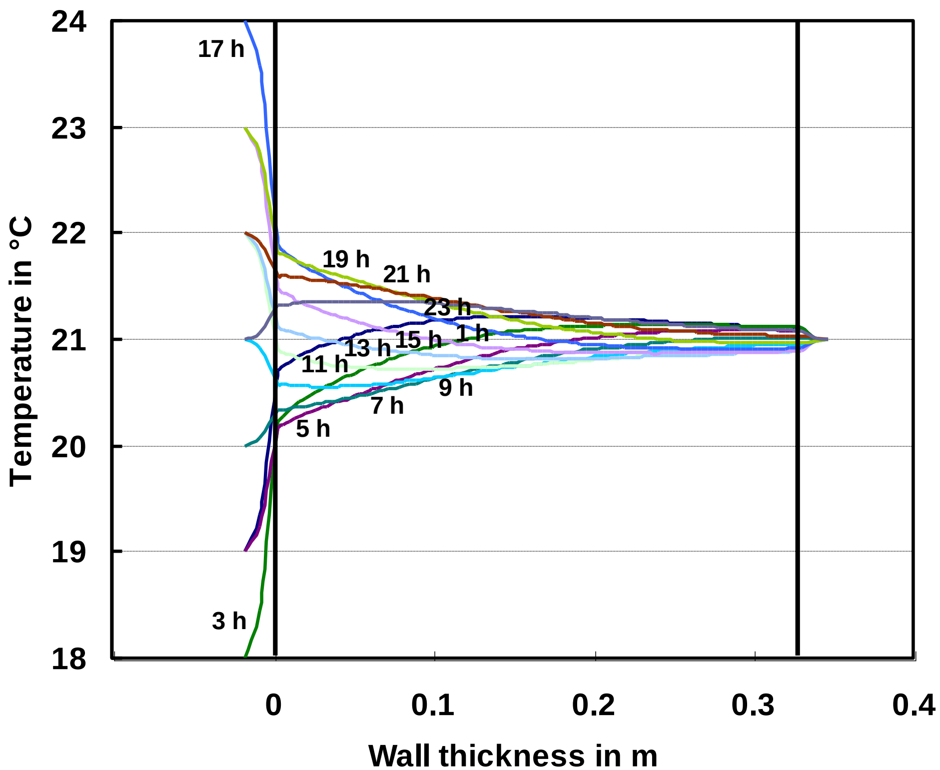

Window

interior edge



# Principle 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**

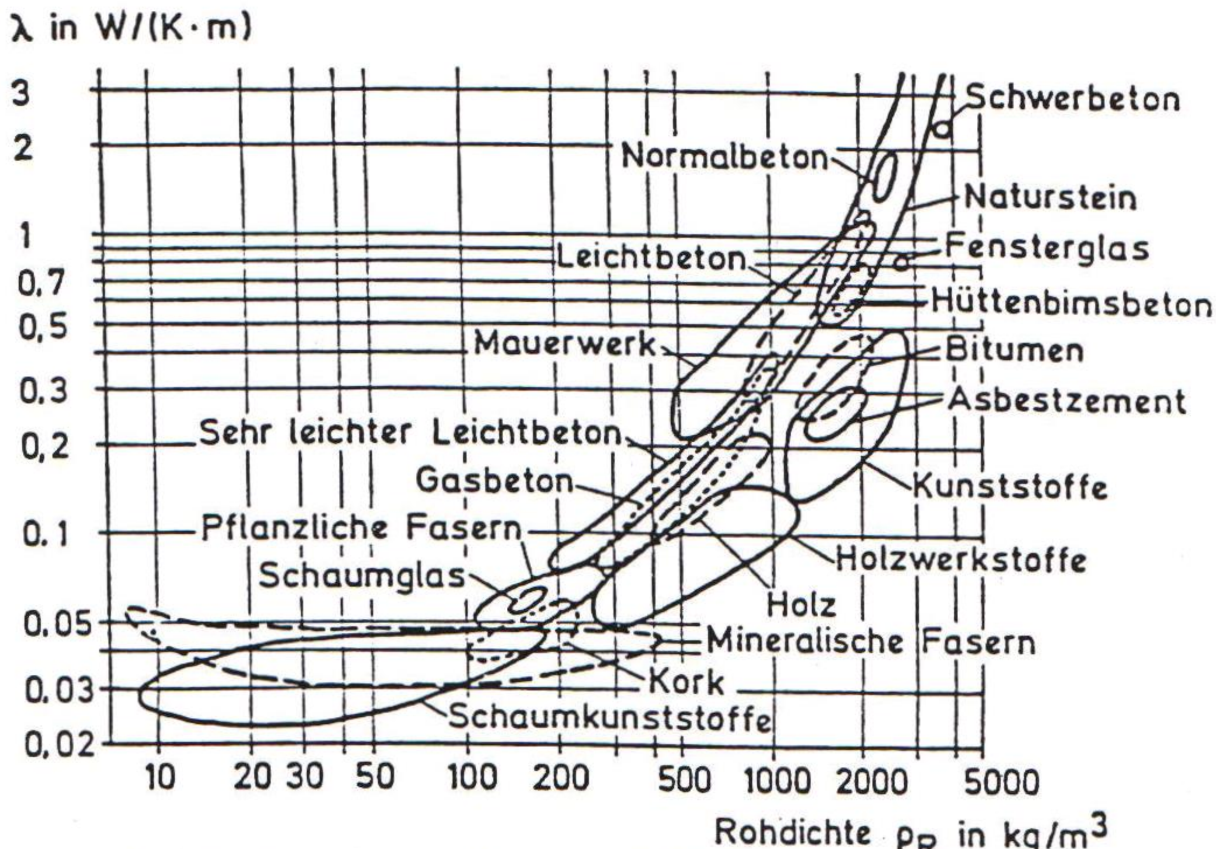
**Stored and released heat : 0.076 kWh/(m² d).**

**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**

# Material: Thermal conductivity λ and density ρ

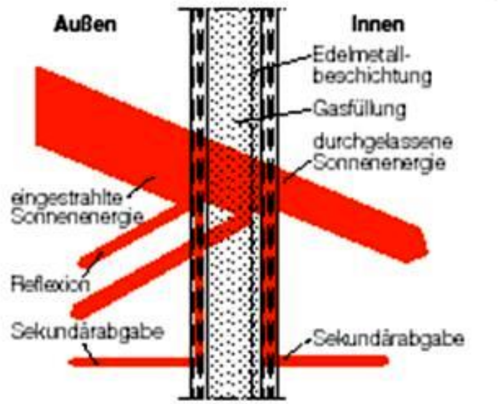


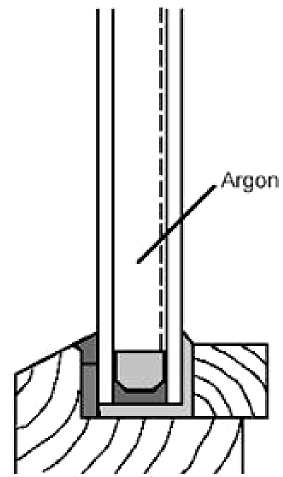

Beziehung zwischen Wärmeleitfähigkeit λ und Rohdichte $\varrho_R$

# Energy transmitttance through windows

**Solar Energy input by radiation convection and conduction**

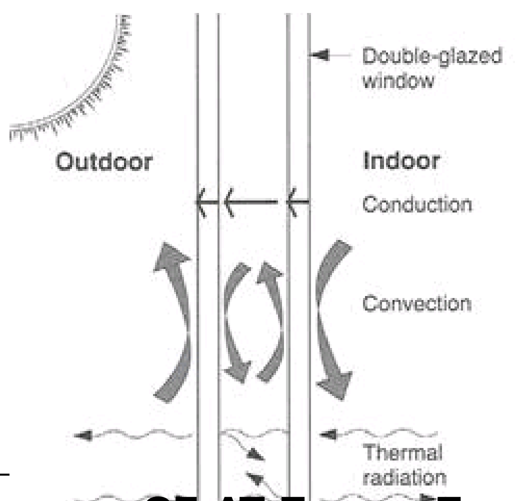
Bild 3.7: Wärmedurchgang durch ein Fenster mit Wärmeschutzglas (schematische Darstellung)

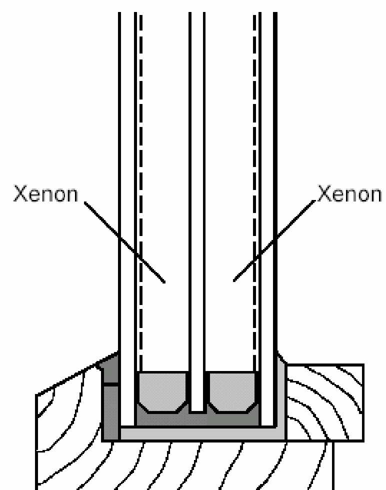



$k_V$ = 1,3 W/(m² K)
$k_F$ = 1,4 W/(m² K)
$g_F$ = 0,62
$k_{eq,F,Nord}$ = 0,81 W/(m² K)
$k_{eq,F,Ost/West}$ = 0,38 W/(m² K)
$k_{eq,F,Süd}$ = -0,09 W/(m² K)

**Heat losses by conection, radiation and conduction**




$k_V$ = 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)

# 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.

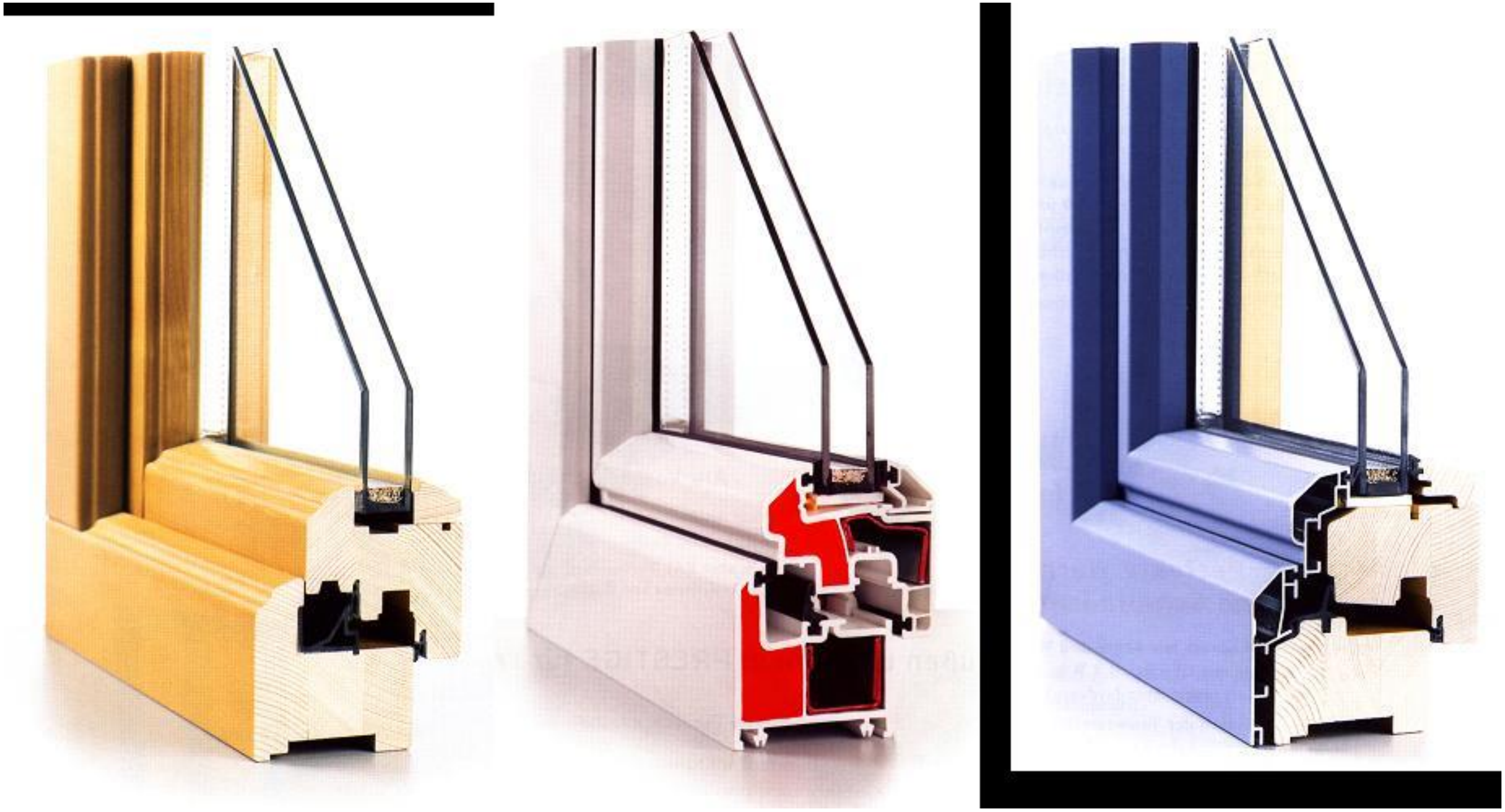
$$U_{eq} = U_W - S_F\, g$$

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

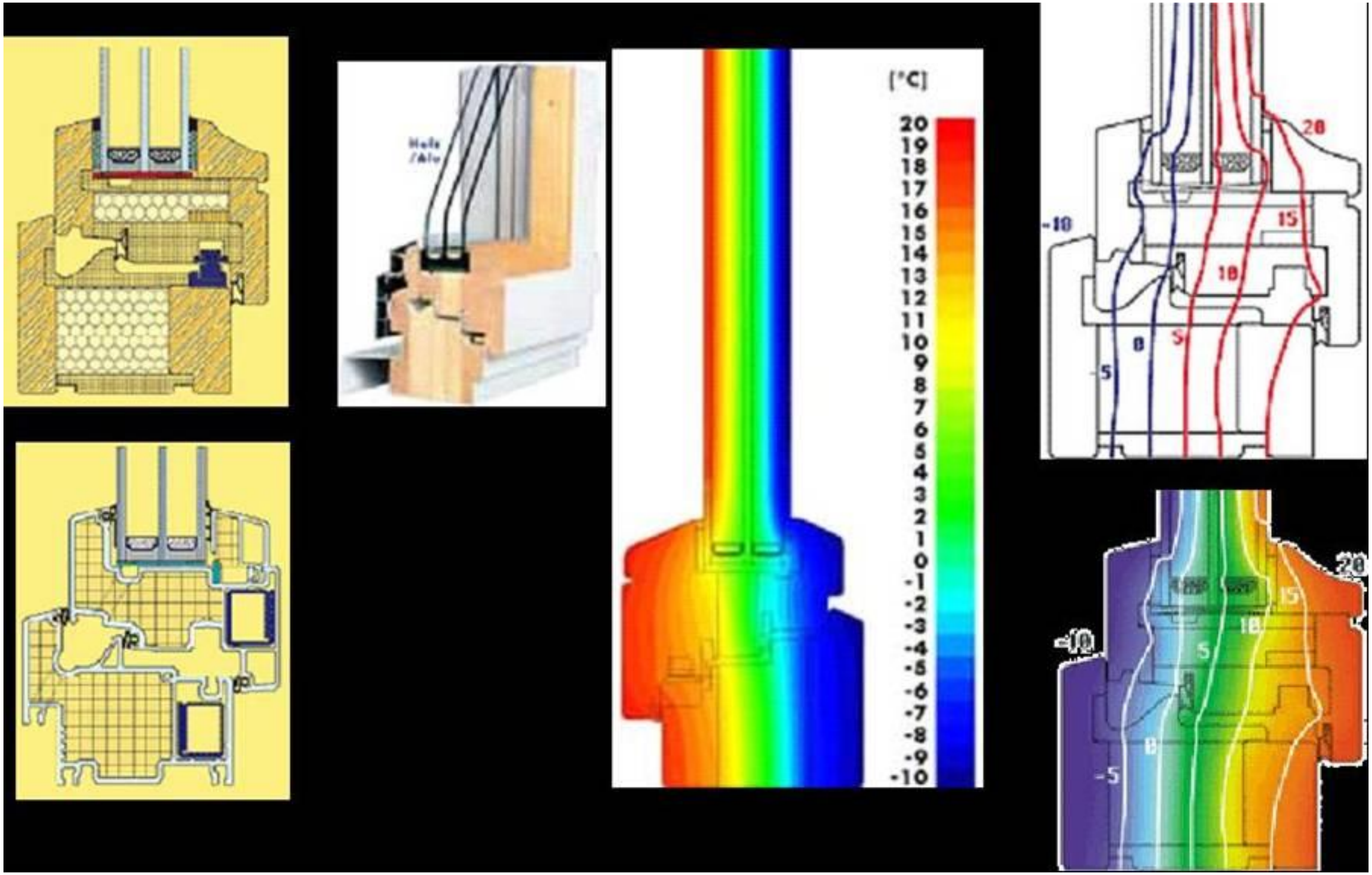
Diffuse g-value ($g_{diffuse}$), $U$-value of the window ($U_w$) and equivalent $U$-values ($U_{eq}$) corresponding to different glazing types (see /3-5/)

| | $g_{diffuse}$ | $U_w$ | $U_{eq}$ (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

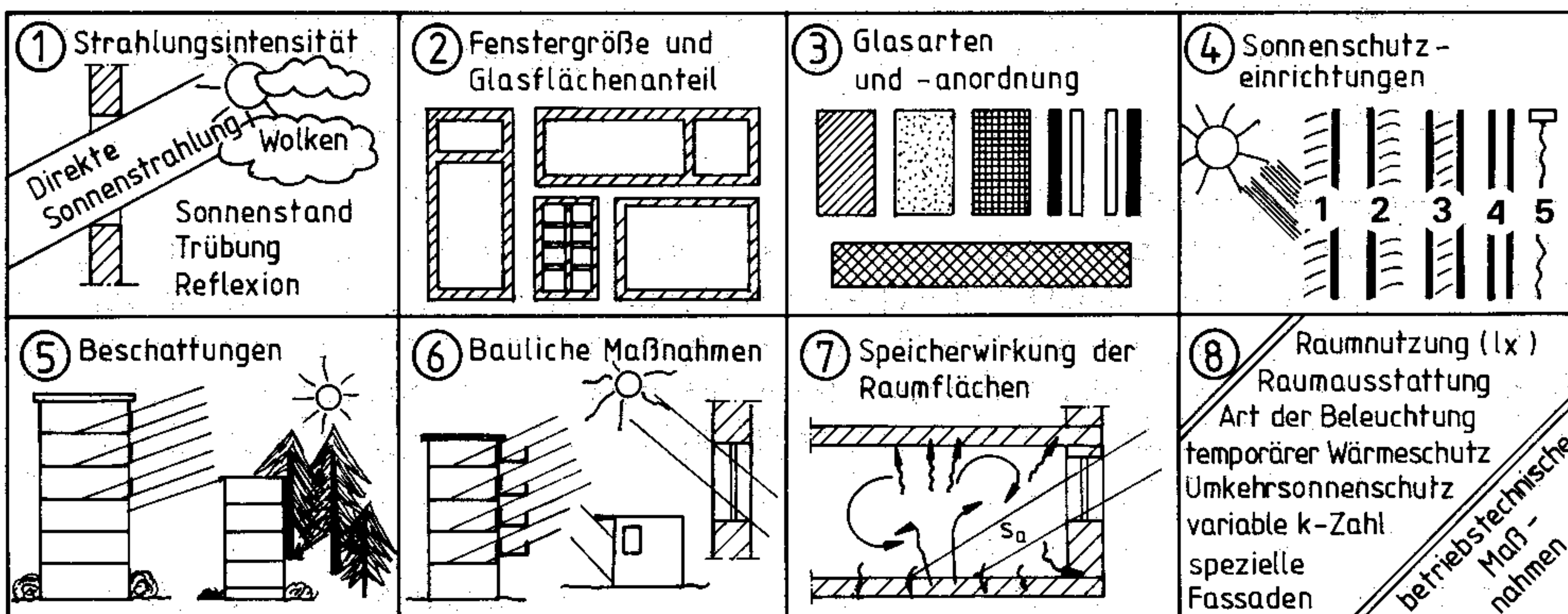
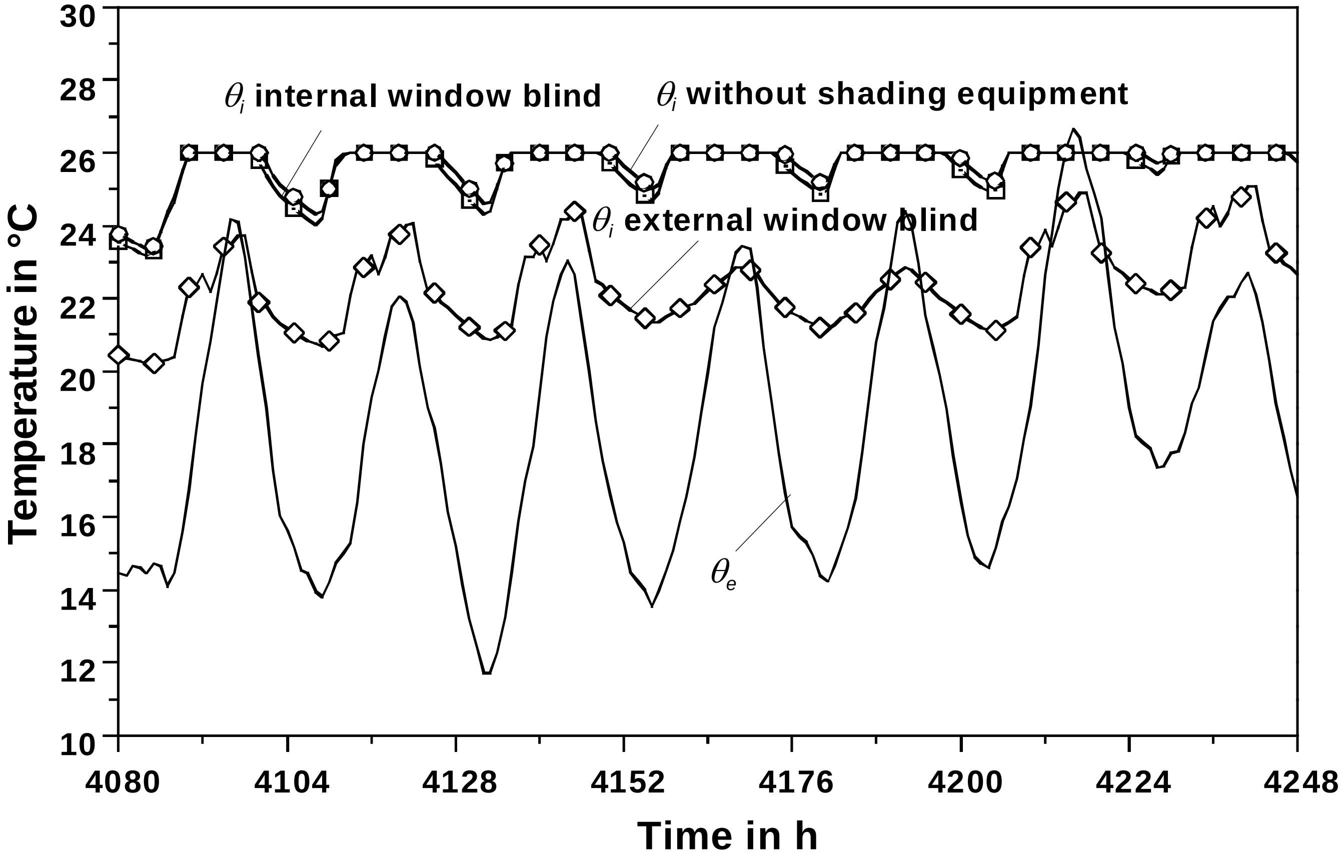
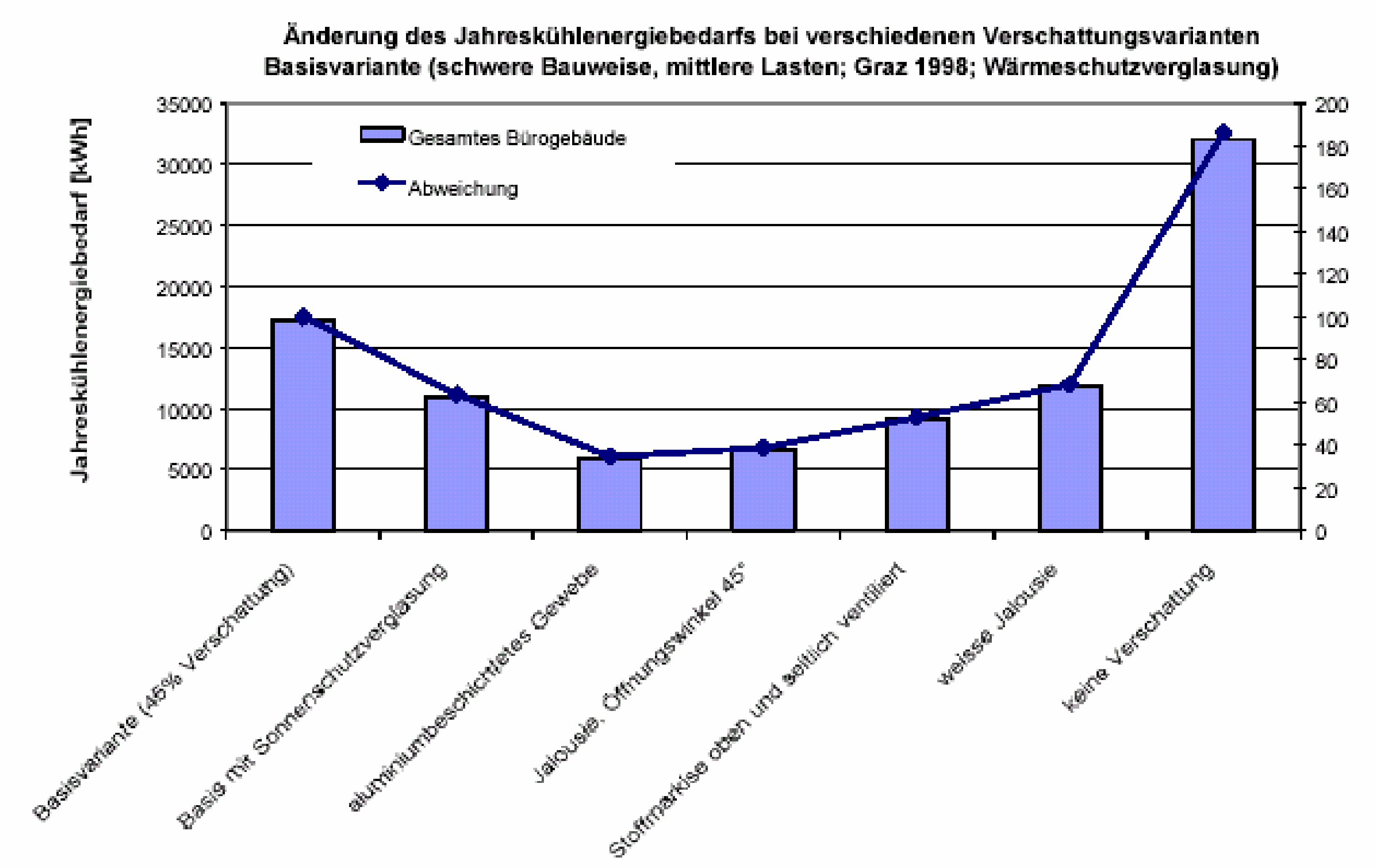



Abb. 7.24 Einflußgrößen auf Sonnenwärme durch Fenster

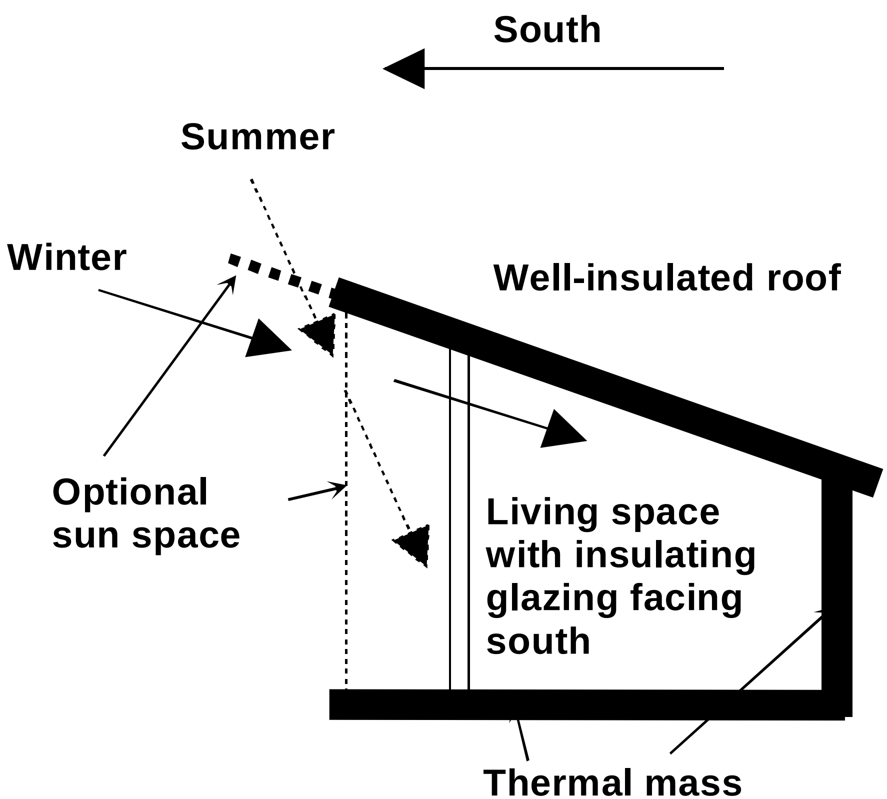
# Shading by internal and external window blinds ($\theta_e$ ambient temperature, $\theta_i$ room temperature)

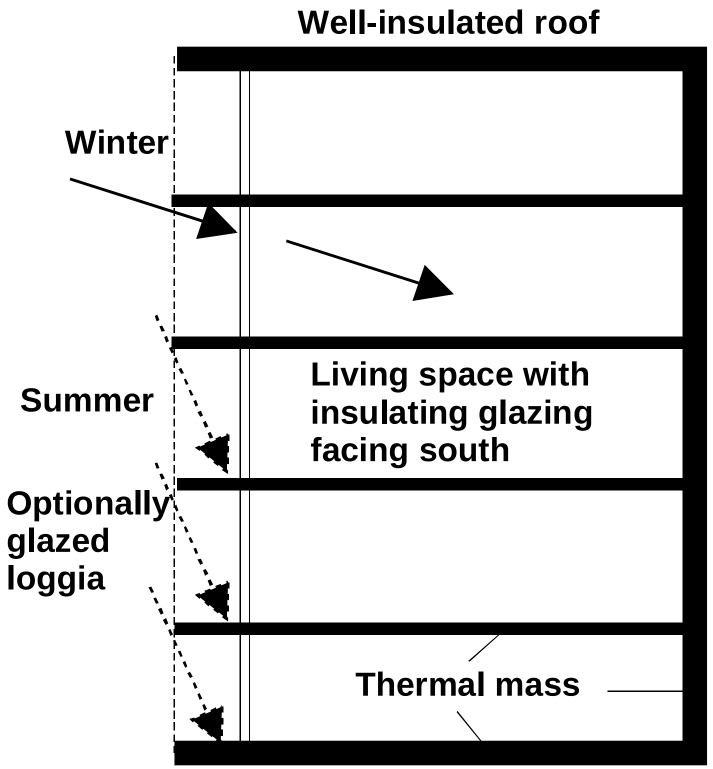


# Cooling energy demand for different shading strategies in an office building

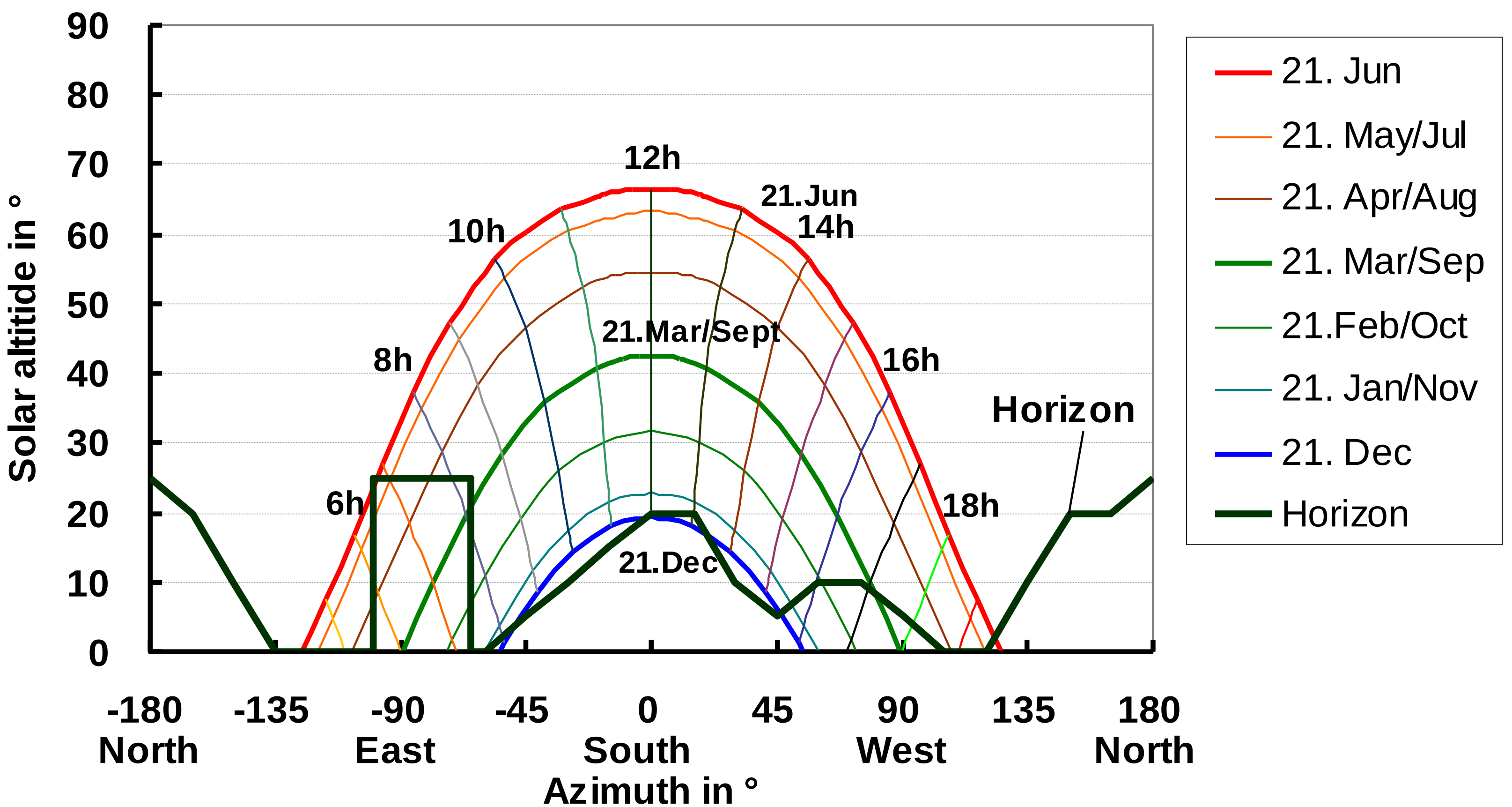


# Shading of transparent building surfaces by roof overhangs (left: one family home, right: multiple families home)

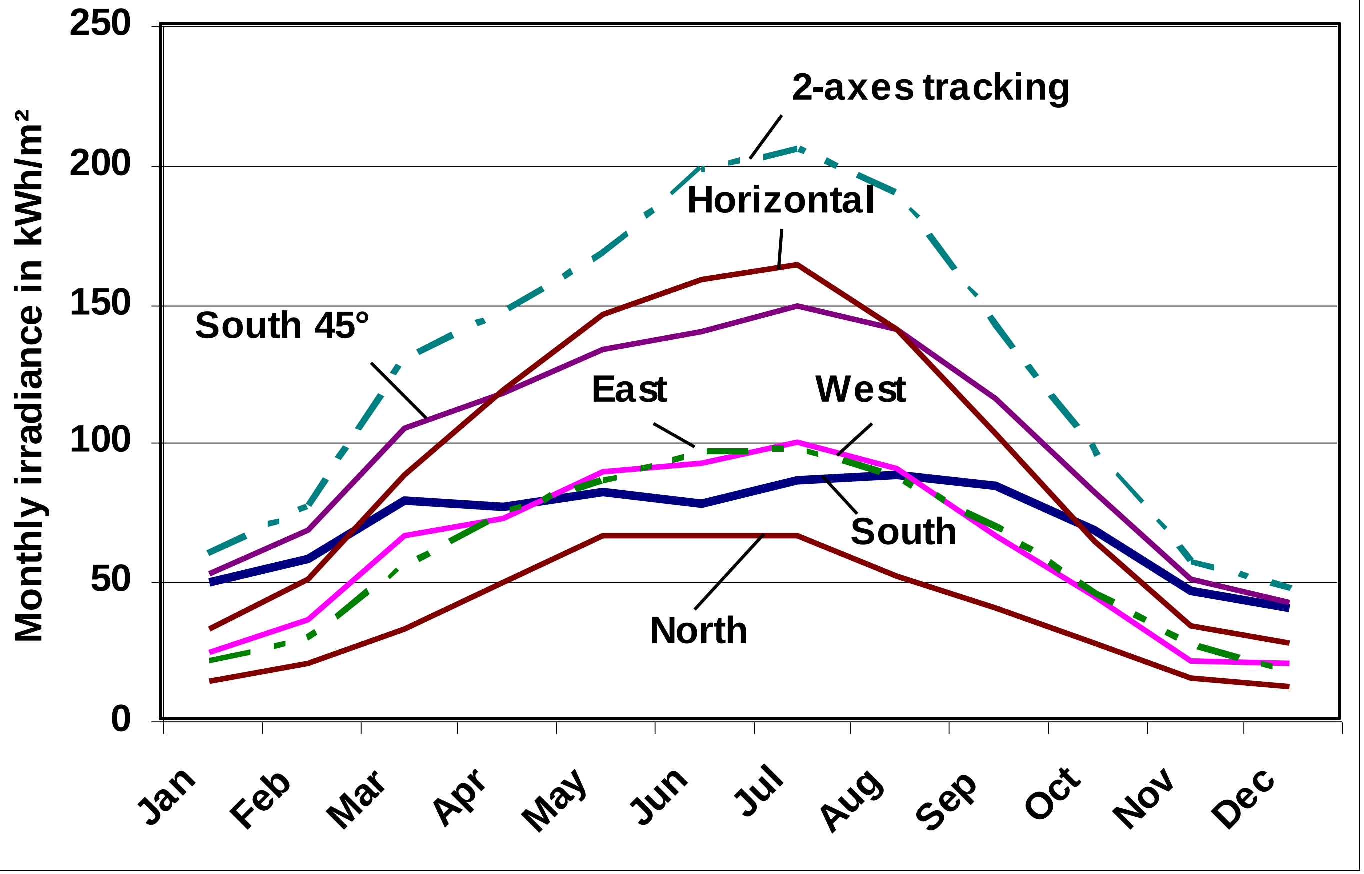


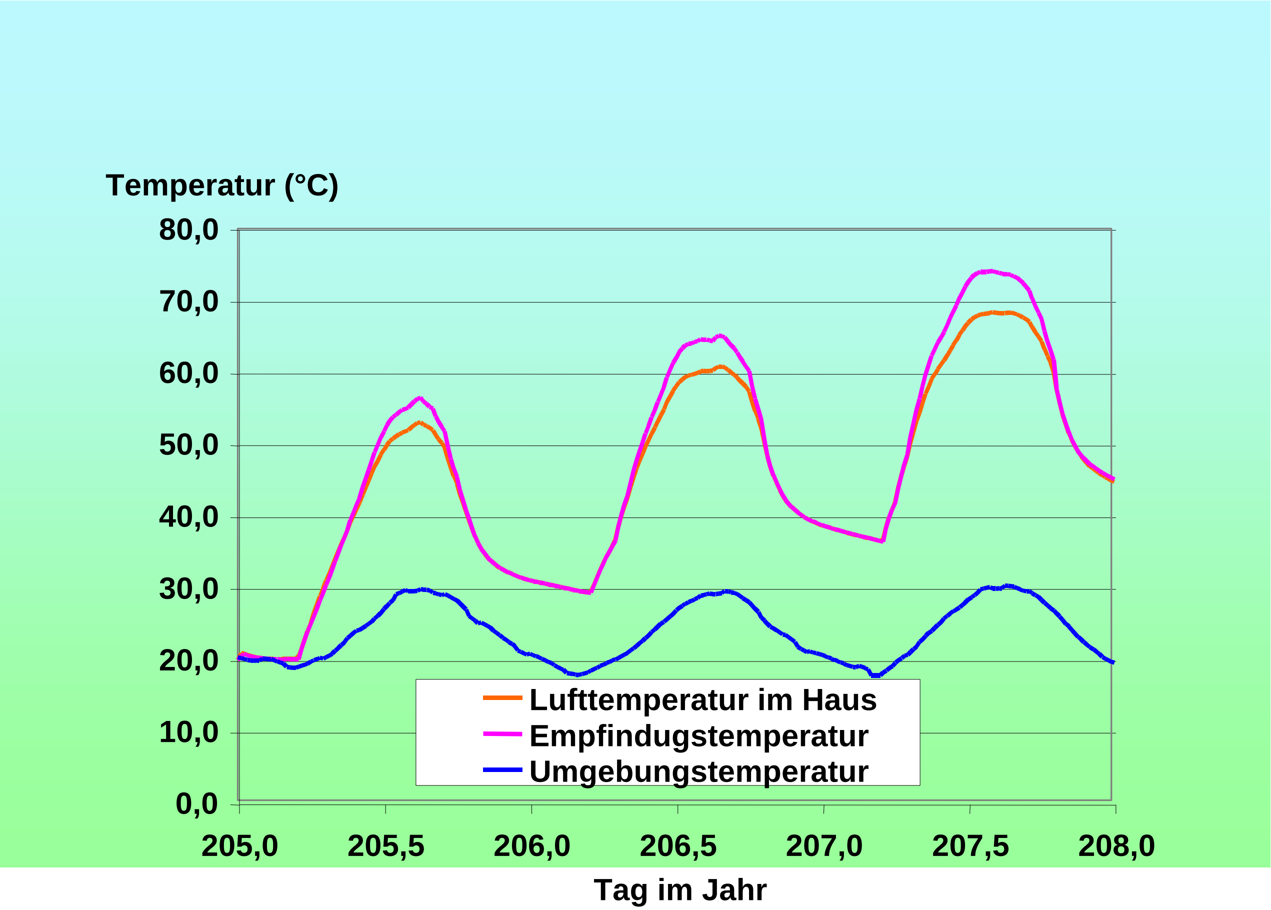
# Solar position plot



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

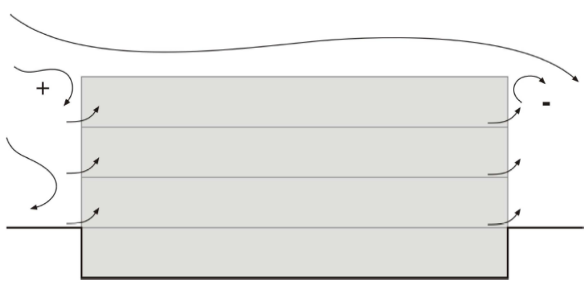


# Summer Overheating in an office building (simulated)

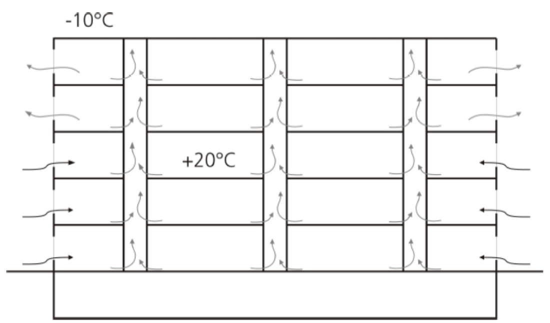


# Natural ventilation

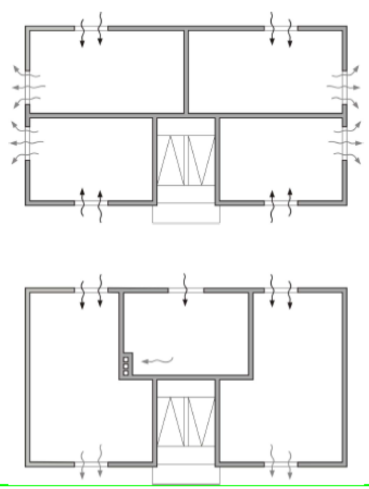
Natürliche Luftströmung durch Gebäude



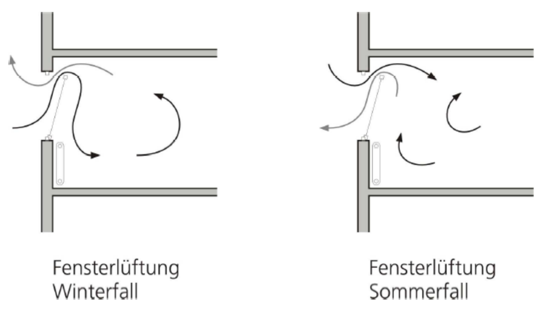

Schachtwirkung durch thermischen Auftrieb




Querlüftung bei natürlicher Lüftung



Natürliche Lüftung Sommer/Winter




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

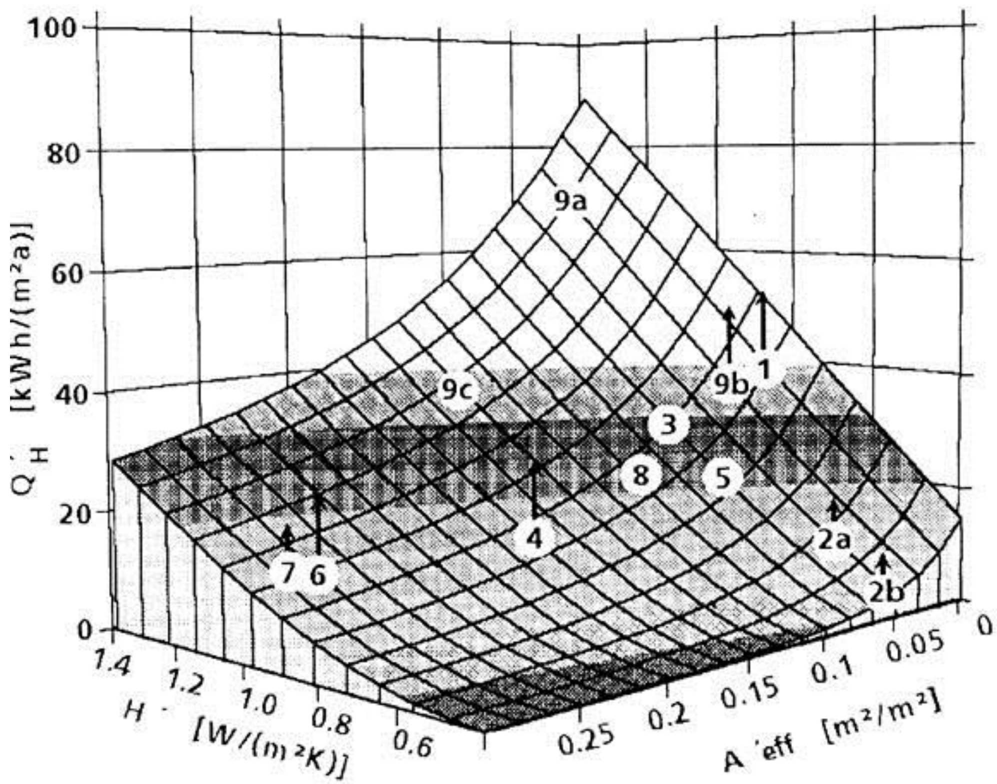
# Low-energy lean multi family building

# 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)



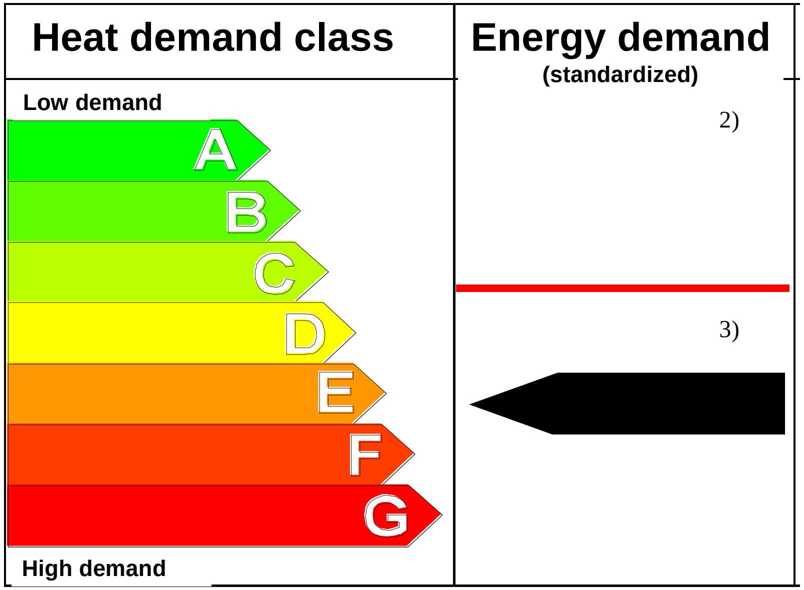
# EU Directive on the overall energy performance of buildings (EPBD) and its effect on the planning of buildings
# Directive 2002/91/EG of the European Parliament and the Commission

# Motivation for Directive (16.12.2002)

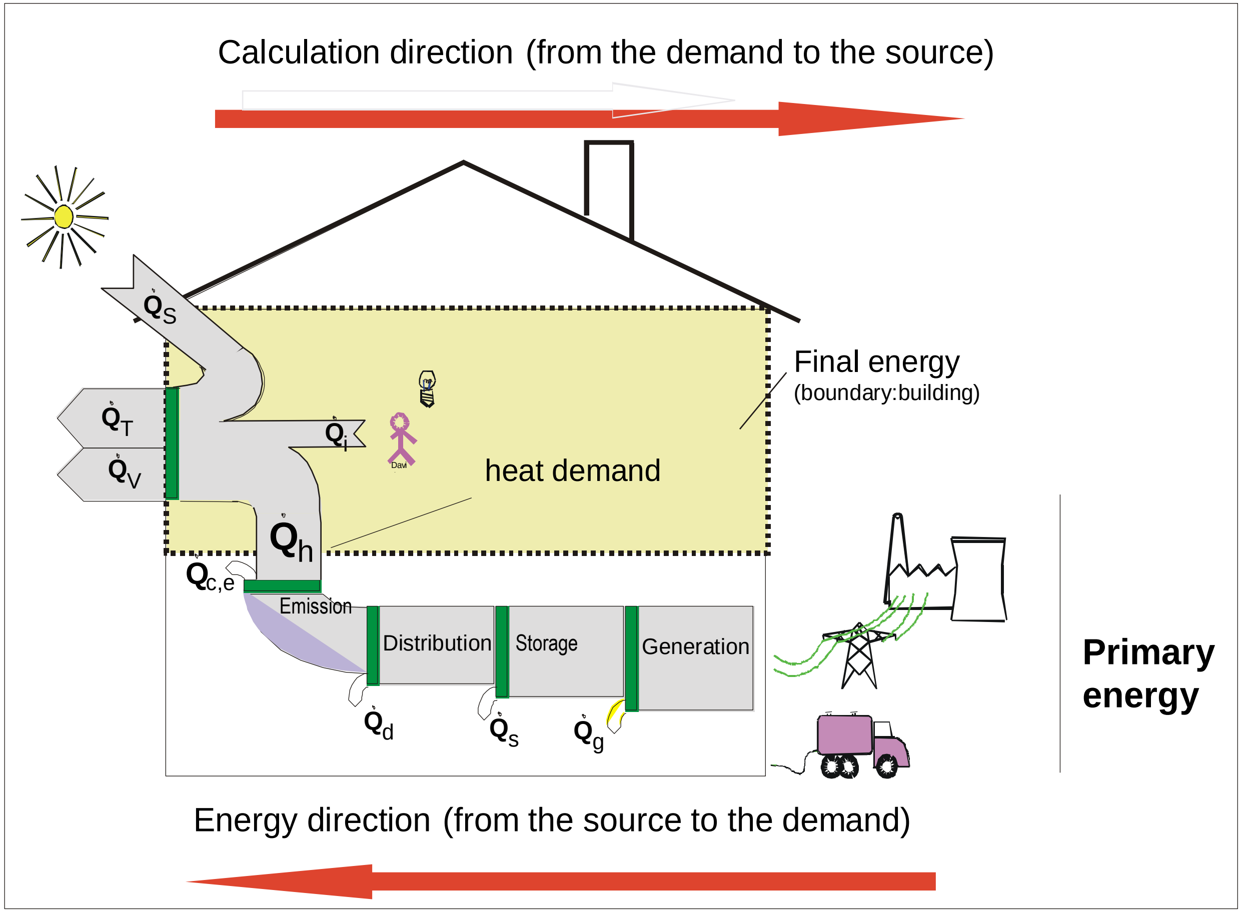
- Reduction of the energy demand and the CO2 emission of buildings (space heating and hot tap water amounts to 40% of the total end-use energy demand in Europe)
- Value of buildings not (only) because of the location but also because of the energy demand and the operating costs
- European harmonization 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

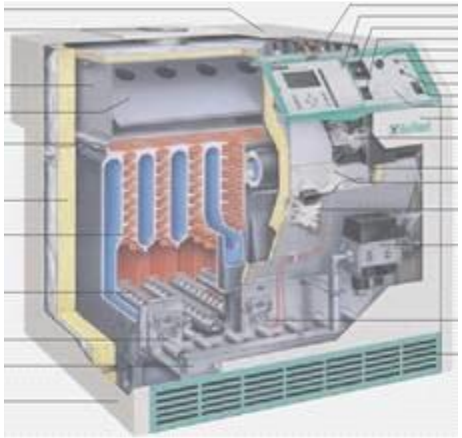
- $CO_2$ – key figure $kgCO_2/m^2.a$

# 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 in Austria since
  !!! 2009 !!!

# 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

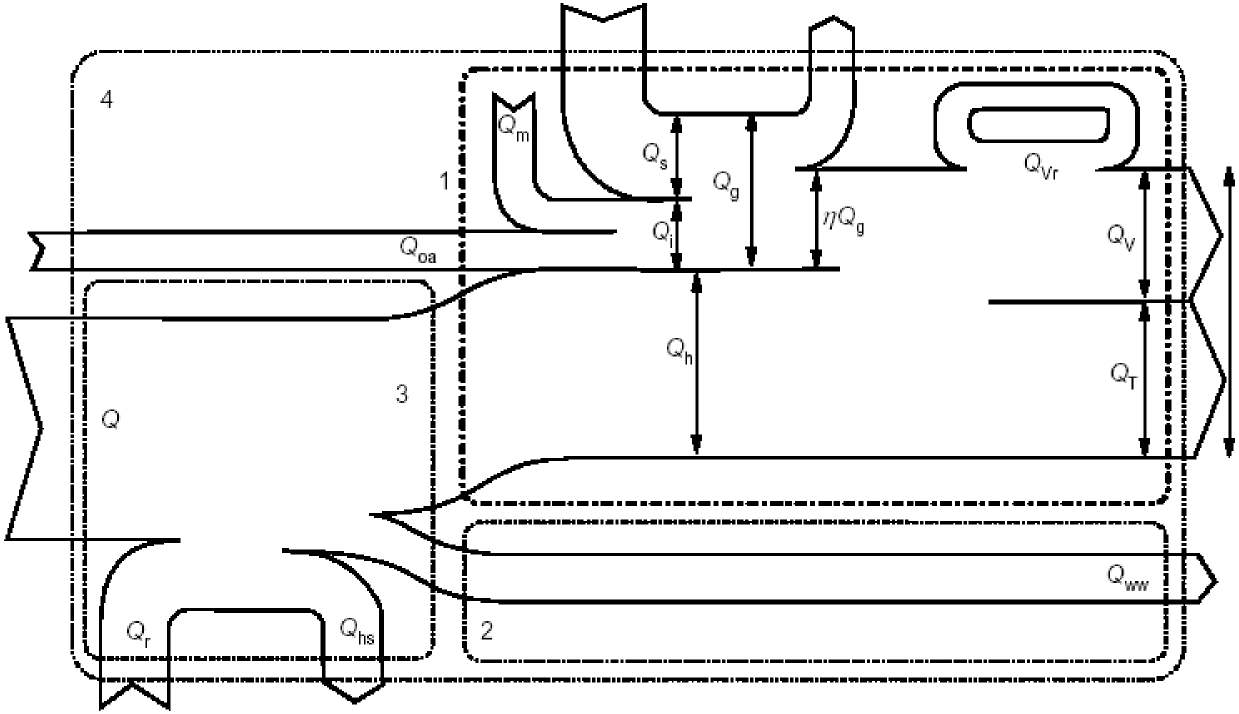
# New Directive on the Energy Performance of Buildings 2010/31/EU

- For all new buildings the possible use of renewable energies has to be evaluated

- All new buildings have to be build as nearly zero energy buildings by 2020 (public authorities starting with 2018)

- ‘nearly zero-energy building’ means a building that has a very high energy performance. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby;

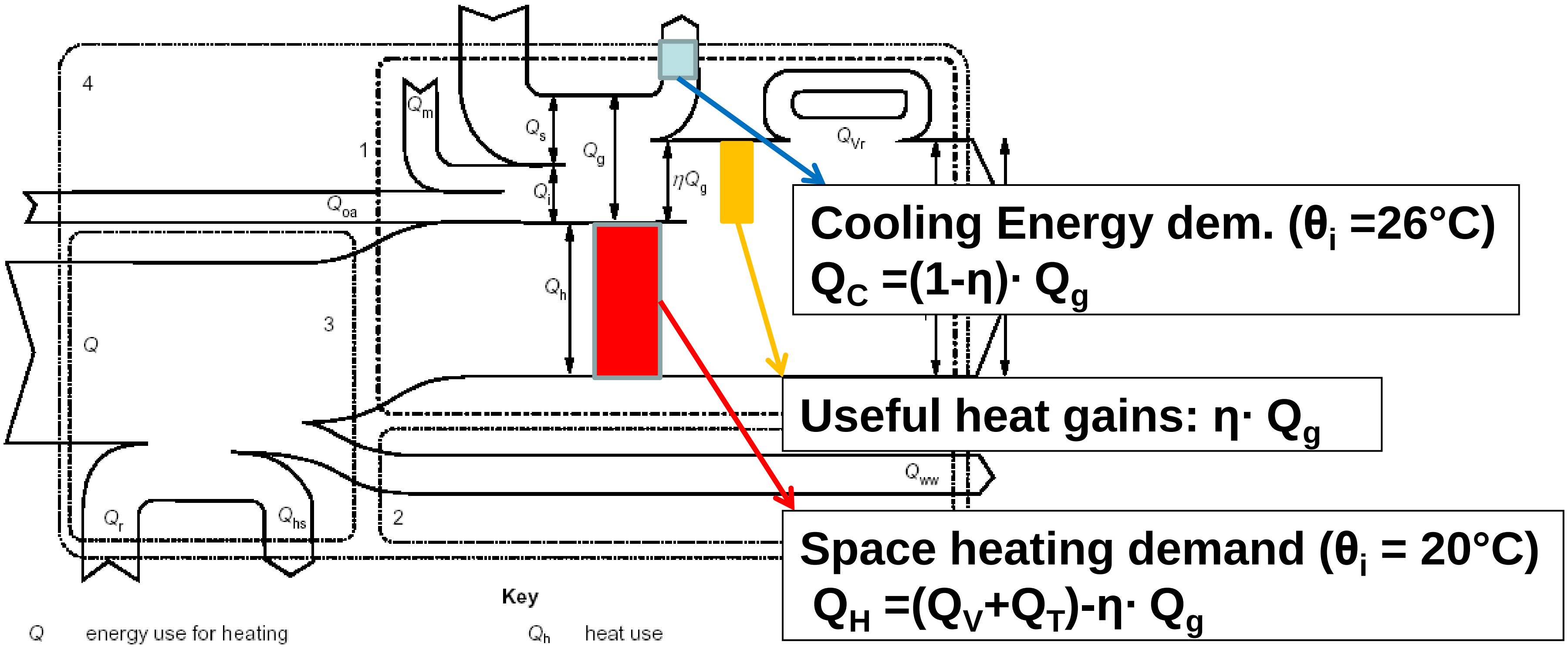
# Energy Flow in Buildings by EN ISO 13790




**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 Flow in Buildings by EN ISO 13790

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# Energy Certificate Berlaymont Gebäude

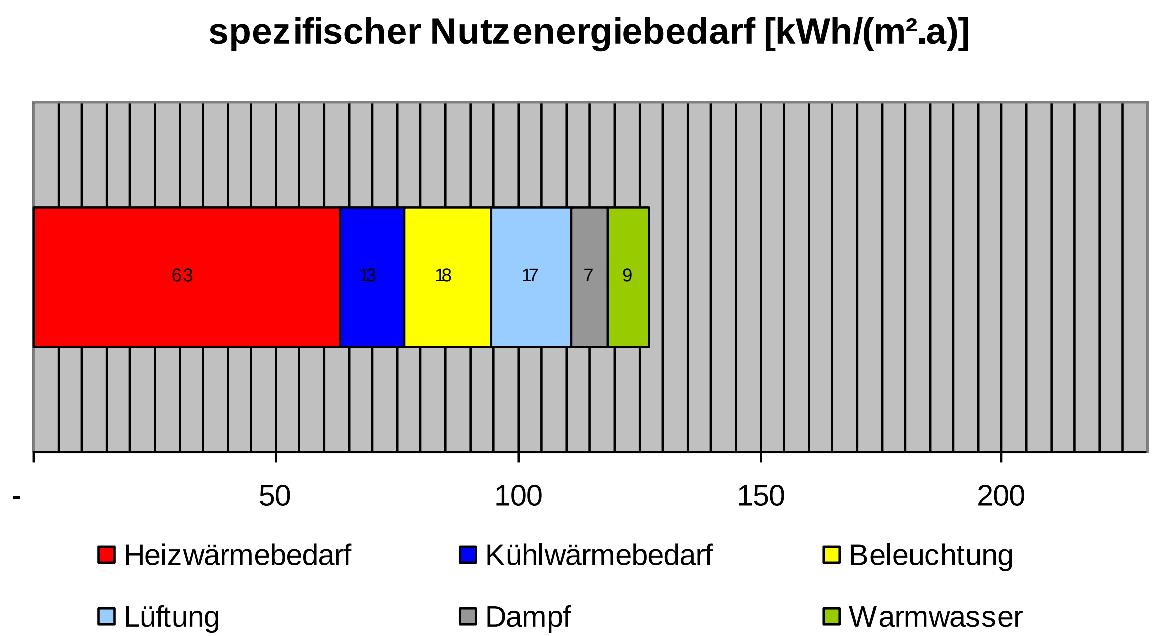
| | |
|---|---|
| Year of errection: | 1967 (renovated from 1995 to 2004) |
| Useful area: | 241.515 m² |
| Persons: | over 3000 Persons per day |
| Heating: | 3 Gas burners with a total capacity of 7.800 [kW] |
| Cooling: | 4 Compression cooling machines with a total cooling capacity of 8.900 [kW] |

# 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)] |



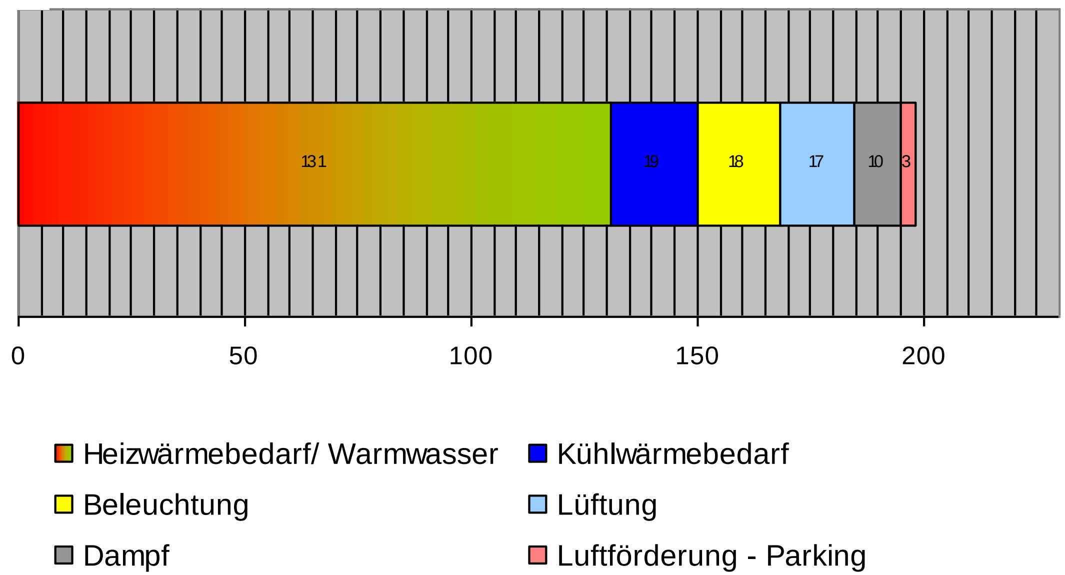
## Endenergie:

| | | |
|---|---|---|
| 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)] |

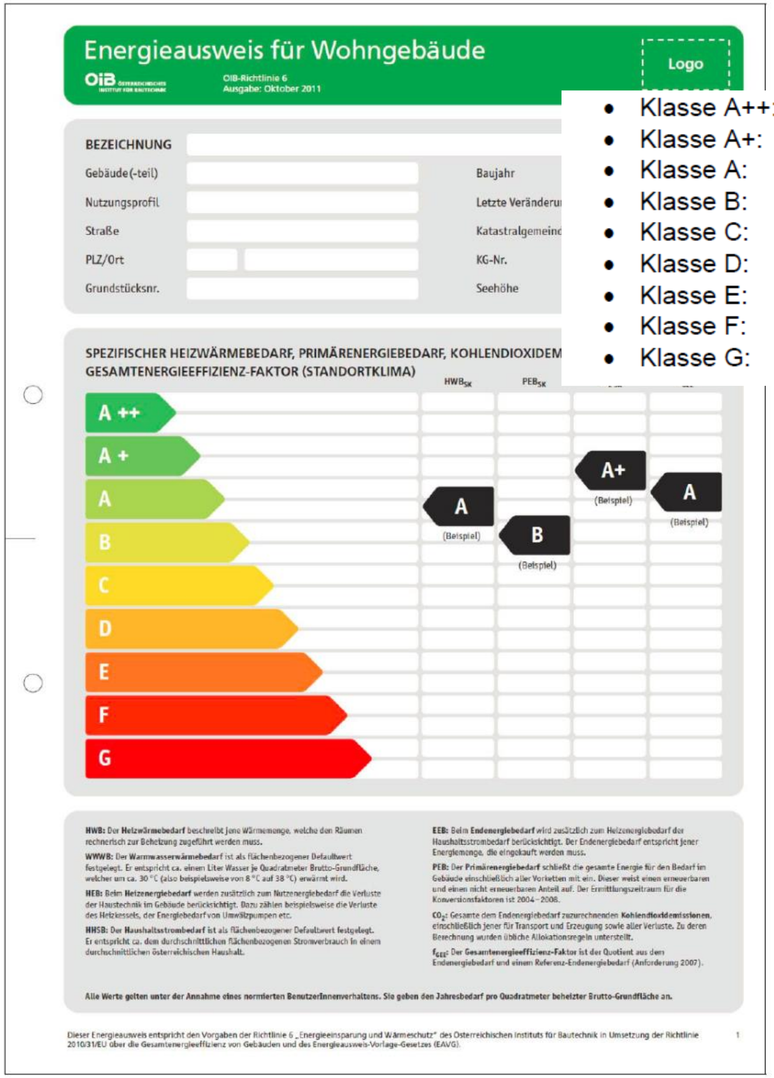
| | |
|---|---|
| Summe | 198[kWh/(m².a)] |

# Results end use energy, example Berlaymont, Brüssel

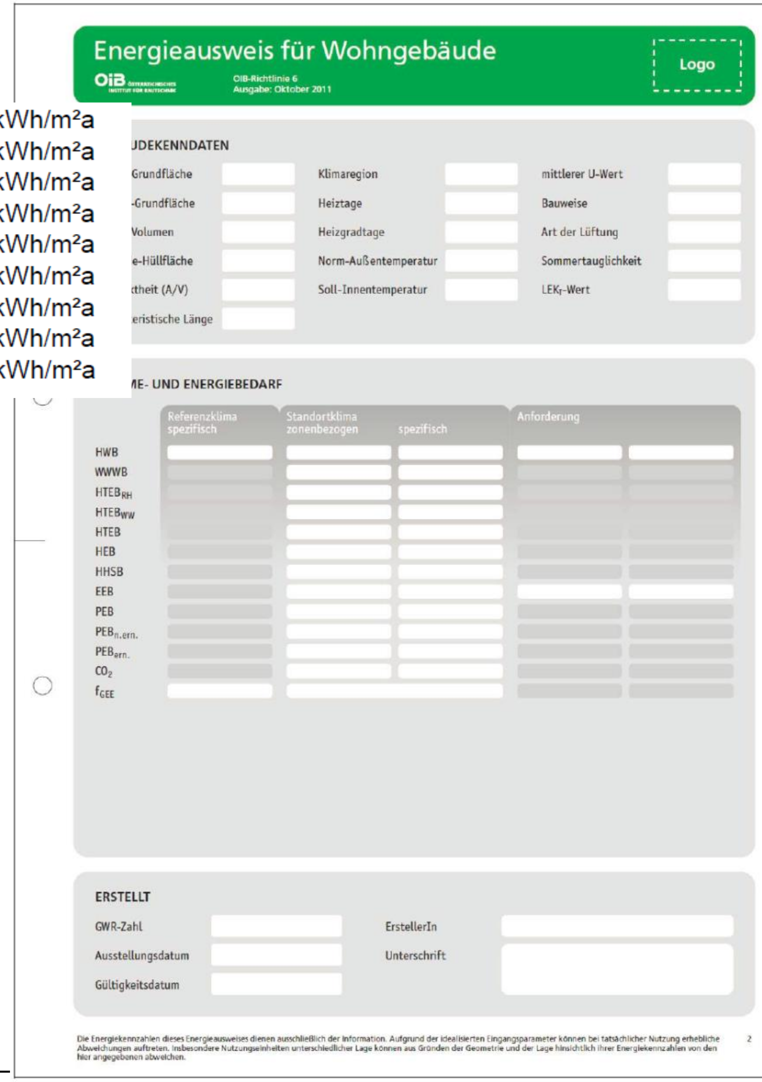
spezifischer Endenergiebedarf [kWh/(m².a)]



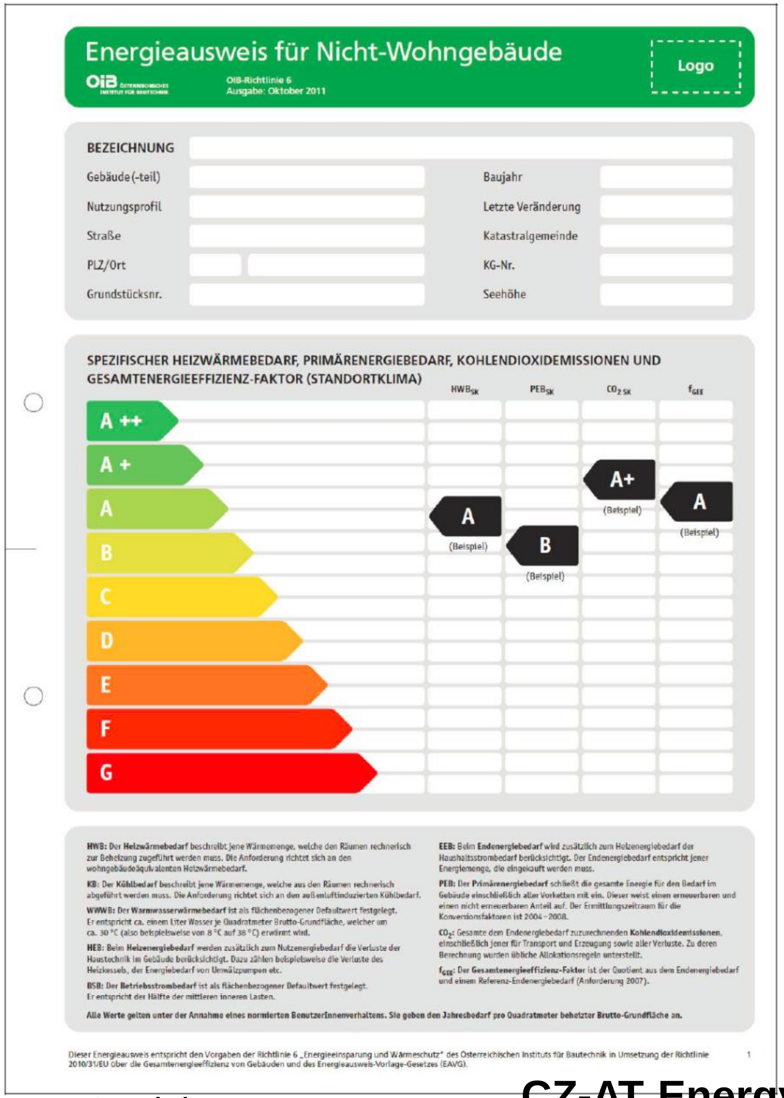
# Energy Certificate Residential Buildings, Austria 2012




- Klasse A++: $HWB_{BGF,SK} \leq$ 10 kWh/m²a
- Klasse A+: $HWB_{BGF,SK} \leq$ 15 kWh/m²a
- Klasse A: $HWB_{BGF,SK} \leq$ 25 kWh/m²a
- Klasse B: $HWB_{BGF,SK} \leq$ 50 kWh/m²a
- Klasse C: $HWB_{BGF,SK} \leq$ 100 kWh/m²a
- Klasse D: $HWB_{BGF,SK} \leq$ 150 kWh/m²a
- Klasse E: $HWB_{BGF,SK} \leq$ 200 kWh/m²a
- Klasse F: $HWB_{BGF,SK} \leq$ 250 kWh/m²a
- Klasse G: $HWB_{BGF,SK} >$ 250 kWh/m²a



# Energy Certificate Non-Residential Buildings, Austria 2012



## Energieausweis für Nicht-Wohngebäude

OIB ÖSTERREICHISCHES INSTITUT FÜR BAUTECHNIK — OIB-Richtlinie 6, Ausgabe: Oktober 2011 — Logo

**BEZEICHNUNG**

| | | | |
|---|---|---|---|
| Gebäude(-teil) | | Baujahr | |
| Nutzungsprofil | | Letzte Veränderung | |
| Straße | | Katastralgemeinde | |
| PLZ/Ort | | KG-Nr. | |
| Grundstücksnr. | | Seehöhe | |

**SPEZIFISCHER HEIZWÄRMEBEDARF, PRIMÄRENERGIEBEDARF, KOHLENDIOXIDEMISSIONEN UND GESAMTENERGIEEFFIZIENZ-FAKTOR (STANDORTKLIMA)**

| | $HWB_{SK}$ | $PEB_{SK}$ | $CO_{2\,SK}$ | $f_{GEE}$ |
|---|---|---|---|---|
| A ++ | | | | |
| A + | | | A+ (Beispiel) | |
| A | A (Beispiel) | | | A (Beispiel) |
| B | | B (Beispiel) | | |
| C | | | | |
| D | | | | |
| E | | | | |
| F | | | | |
| G | | | | |

**HWB:** Der **Heizwärmebedarf** beschreibt jene Wärmemenge, welche den Räumen rechnerisch zur Beheizung zugeführt werden muss. Die Anforderung richtet sich an den wohngebäudeäquivalenten Heizwärmebedarf.

**KB:** Der **Kühlbedarf** beschreibt jene Wärmemenge, welche aus den Räumen rechnerisch abgeführt werden muss. Die Anforderung richtet sich an den außenluftinduzierten Kühlbedarf.

**WWWB:** Der **Warmwasserwärmebedarf** ist als flächenbezogener Defaultwert festgelegt. Er entspricht ca. einem Liter Wasser je Quadratmeter Brutto-Grundfläche, welcher um ca. 30 °C (also beispielsweise von 8 °C auf 38 °C) erwärmt wird.

**HEB:** Beim **Heizenergiebedarf** werden zusätzlich zum Nutzenergiebedarf die Verluste der Haustechnik im Gebäude berücksichtigt. Dazu zählen beispielsweise die Verluste des Heizkessels, der Energiebedarf von Umwälzpumpen etc.

**BSB:** Der **Betriebsstrombedarf** ist als flächenbezogener Defaultwert festgelegt. Er entspricht der Hälfte der mittleren inneren Lasten.

**EEB:** Beim **Endenergiebedarf** wird zusätzlich zum Heizenergiebedarf der Haushaltsstrombedarf berücksichtigt. Der Endenergiebedarf entspricht jener Energiemenge, die eingekauft werden muss.

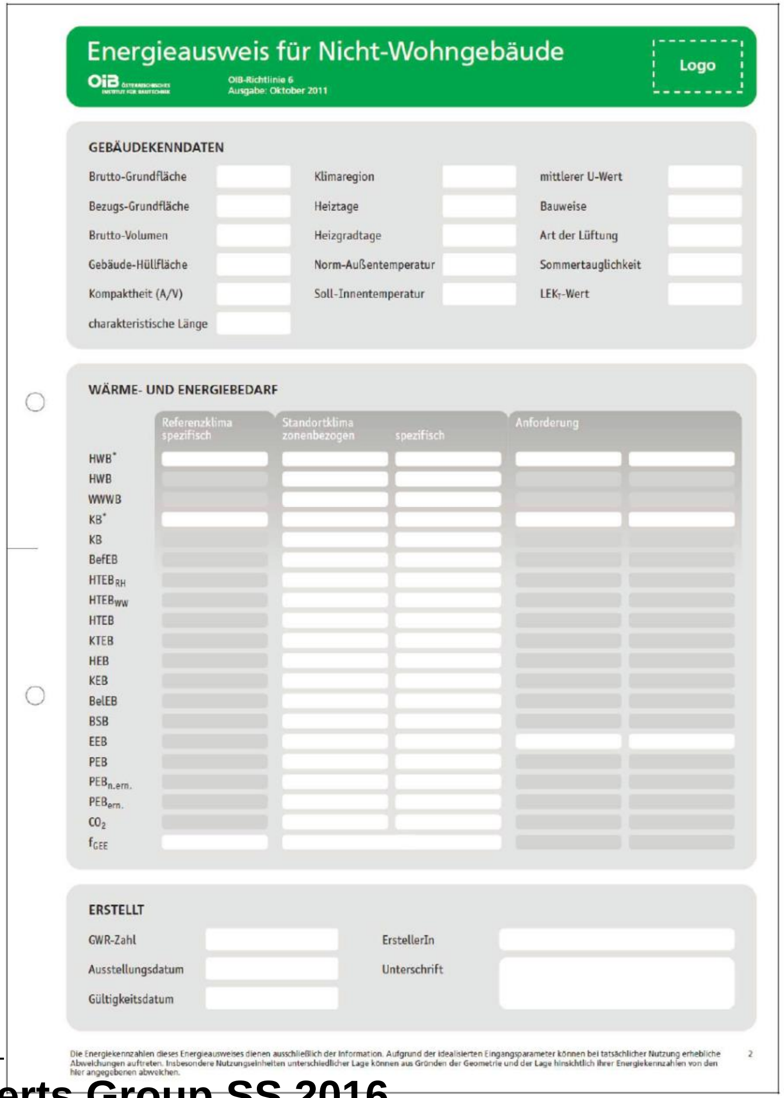
**PEB:** Der **Primärenergiebedarf** schließt die gesamte Energie für den Bedarf im Gebäude einschließlich aller Vorketten mit ein. Dieser weist einen erneuerbaren und einen nicht erneuerbaren Anteil auf. Der Ermittlungszeitraum für die Konversionsfaktoren ist 2004 – 2008.

**$CO_2$:** Gesamte dem Endenergiebedarf zuzurechnenden **Kohlendioxidemissionen**, einschließlich jener für Transport und Erzeugung sowie aller Verluste. Zu deren Berechnung wurden übliche Allokationsregeln unterstellt.

**$f_{GEE}$:** Der **Gesamtenergieeffizienz-Faktor** ist der Quotient aus dem Endenergiebedarf und einem Referenz-Endenergiebedarf (Anforderung 2007).

**Alle Werte gelten unter der Annahme eines normierten BenutzerInnenverhaltens. Sie geben den Jahresbedarf pro Quadratmeter beheizter Brutto-Grundfläche an.**

Dieser Energieausweis entspricht den Vorgaben der Richtlinie 6 „Energieeinsparung und Wärmeschutz" des Österreichischen Instituts für Bautechnik in Umsetzung der Richtlinie 2010/31/EU über die Gesamtenergieeffizienz von Gebäuden und des Energieausweis-Vorlage-Gesetzes (EAVG). 1



## Energieausweis für Nicht-Wohngebäude

OIB ÖSTERREICHISCHES INSTITUT FÜR BAUTECHNIK — OIB-Richtlinie 6, Ausgabe: Oktober 2011 — Logo

**GEBÄUDEKENNDATEN**

| | | | | | |
|---|---|---|---|---|---|
| Brutto-Grundfläche | | Klimaregion | | mittlerer U-Wert | |
| Bezugs-Grundfläche | | Heiztage | | Bauweise | |
| Brutto-Volumen | | Heizgradtage | | Art der Lüftung | |
| Gebäude-Hüllfläche | | Norm-Außentemperatur | | Sommertauglichkeit | |
| Kompaktheit (A/V) | | Soll-Innentemperatur | | $LEK_T$-Wert | |
| charakteristische Länge | | | | | |

**WÄRME- UND ENERGIEBEDARF**

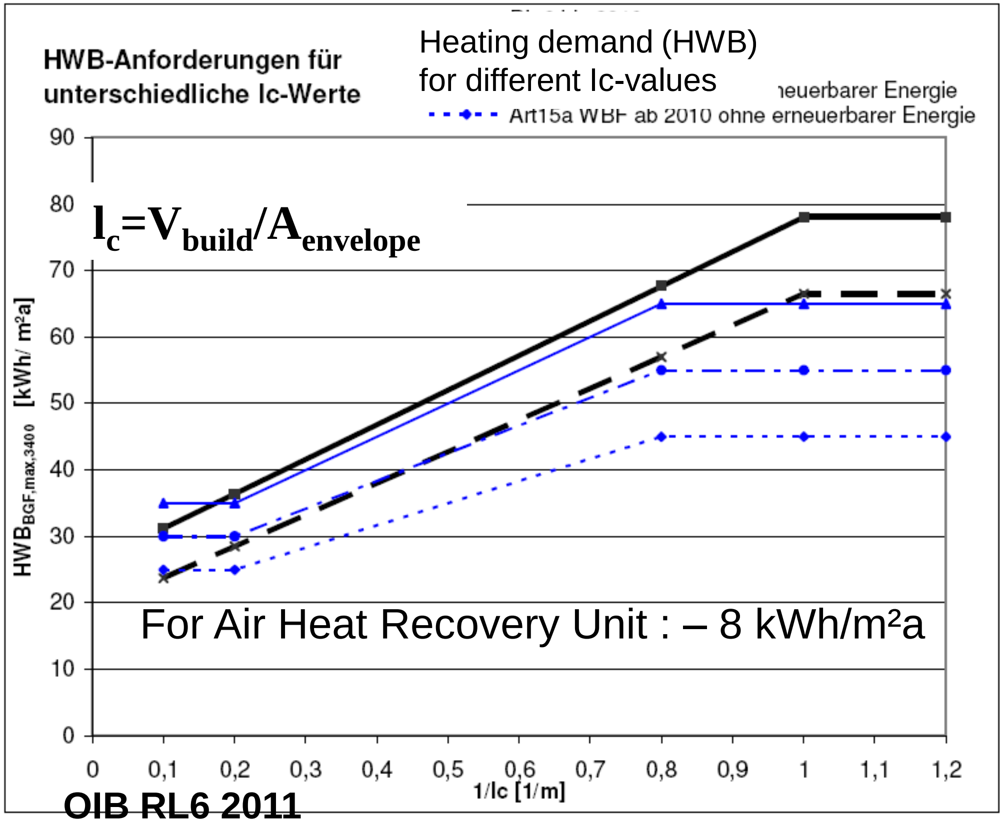
| | Referenzklima spezifisch | Standortklima zonenbezogen | spezifisch | Anforderung | |
|---|---|---|---|---|---|
| HWB* | | | | | |
| HWB | | | | | |
| WWWB | | | | | |
| KB* | | | | | |
| KB | | | | | |
| BefEB | | | | | |
| $HTEB_{RH}$ | | | | | |
| $HTEB_{WW}$ | | | | | |
| HTEB | | | | | |
| KTEB | | | | | |
| HEB | | | | | |
| KEB | | | | | |
| BelEB | | | | | |
| BSB | | | | | |
| EEB | | | | | |
| PEB | | | | | |
| $PEB_{n.ern.}$ | | | | | |
| $PEB_{ern.}$ | | | | | |
| $CO_2$ | | | | | |
| $f_{GEE}$ | | | | | |

**ERSTELLT**

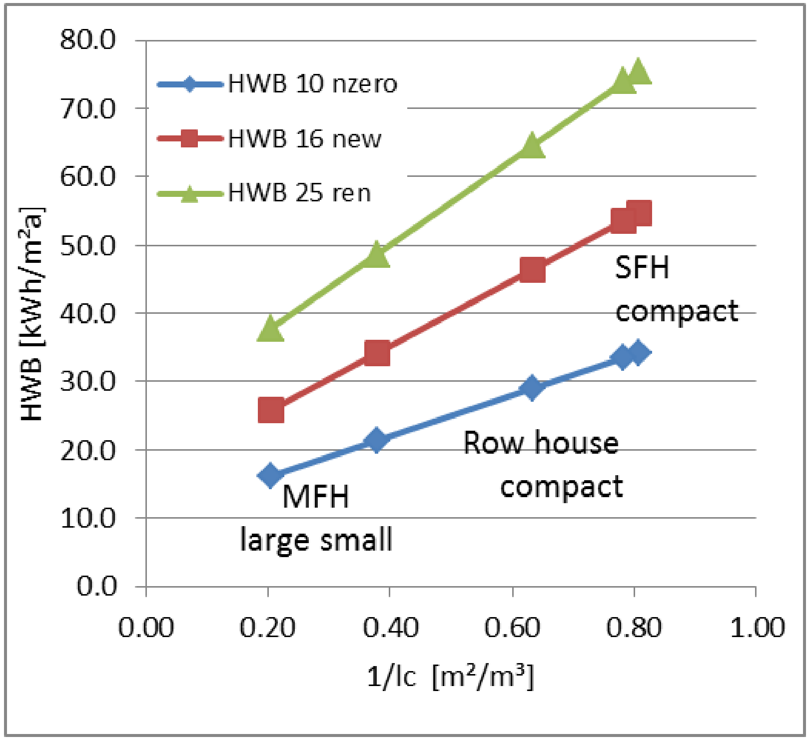
| | | | |
|---|---|---|---|
| GWR-Zahl | | ErstellerIn | |
| Ausstellungsdatum | | Unterschrift | |
| Gültigkeitsdatum | | | |

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. 2

# Example Austria: Limits: Useful Energy Demand Heating New residential Buildings (OIB - Richtlinie 6 (2011))




OIB RL6 2011




| | | | |
|---|---|---|---|
| Coming into effect | $HWB_{BGF,WG,max,RK} = 16 \times (1+3{,}0/l_c)$ [kWh/m²a] | Maximum | 54,4 [kWh/m²a][1)] |

1) For buildings with a conditioned brutto area of max. 100 m² the max. value of 54,4 kWh/m²a is invalid.

# Situation Austria, proposed limits

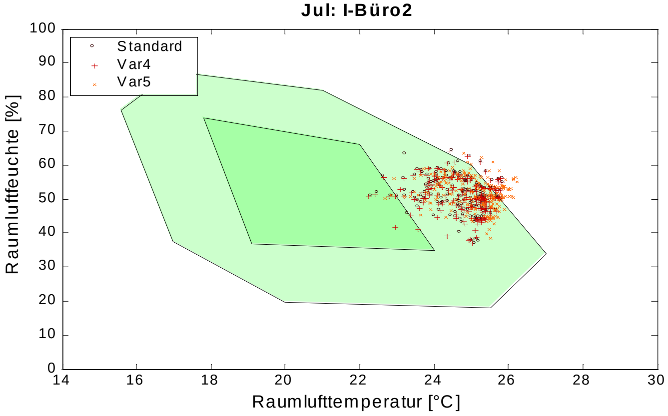
- **For residential buildings cooling demand is NOT allowed** (building must be build in a way that NO summer cooling load occurs, ÖNORM B 8110 Part 3)

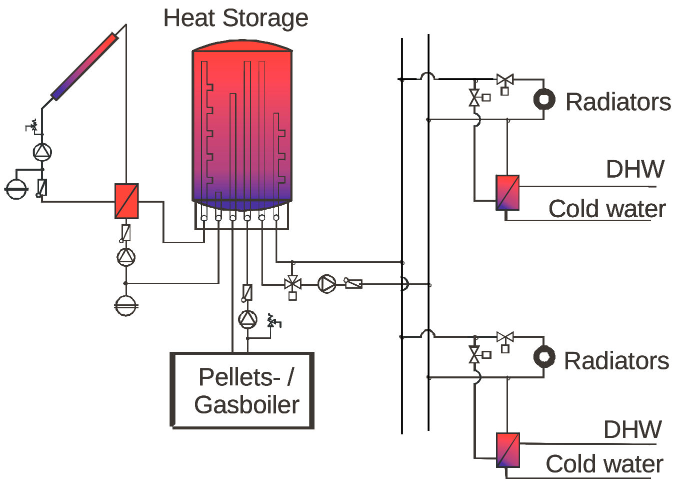
- Also for **non-residential buildings cooling demand is not allowed** when the internal gains and the ventilation are taken into account as for residential buildings (glass-palaces are not allowed with this in the future).

- No maximum allowed values for the end-use of non-residential buildings are given (lack of experience)

# What can‘t be done with the calculation via EPBD

- Heating / cooling load
- Statistic about over-temperature
- Detailed effects of complex hydraulics and controls

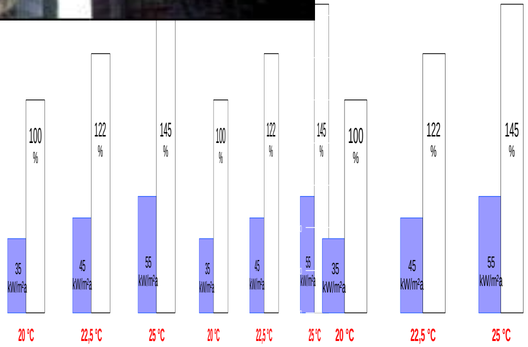


# What can't be done with the calculation via EPBD

- 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.

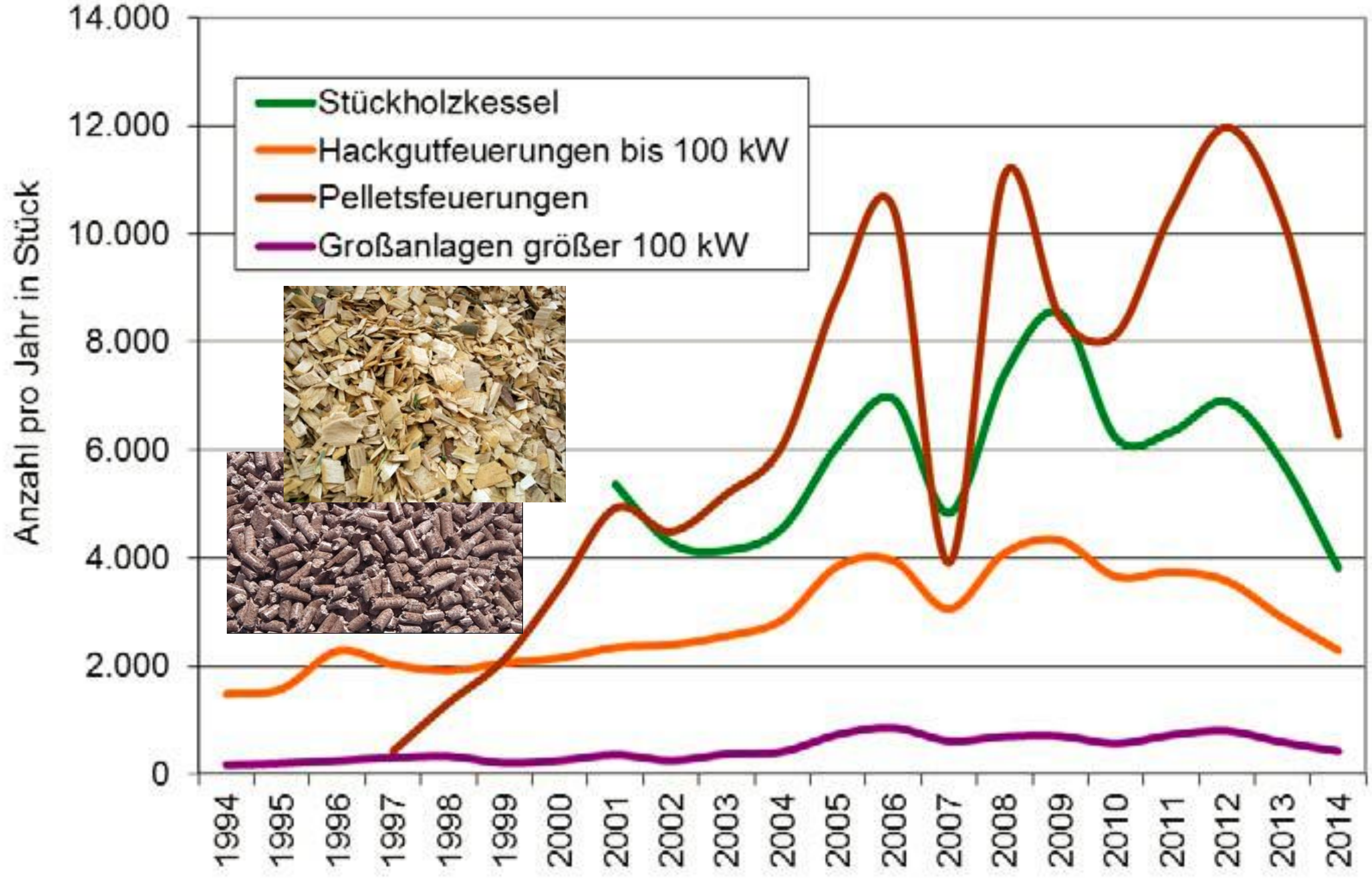
# Further EU-regulations

- **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)**

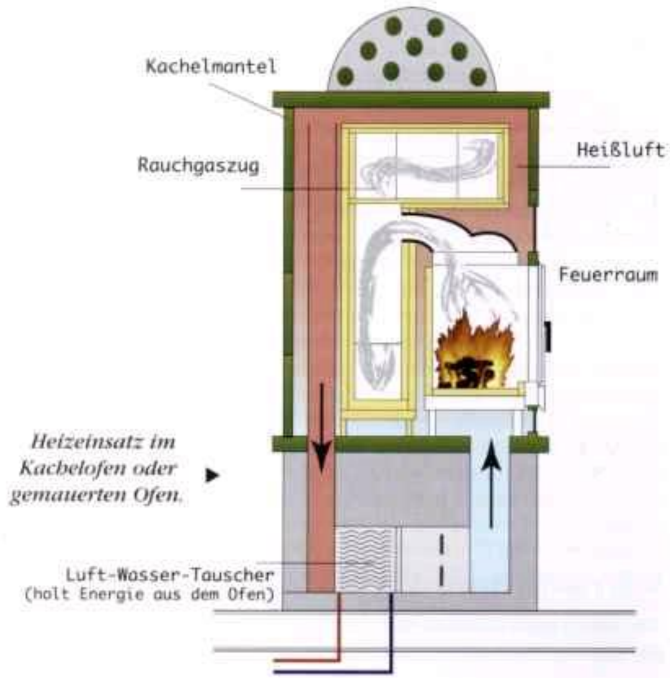
# Biomass

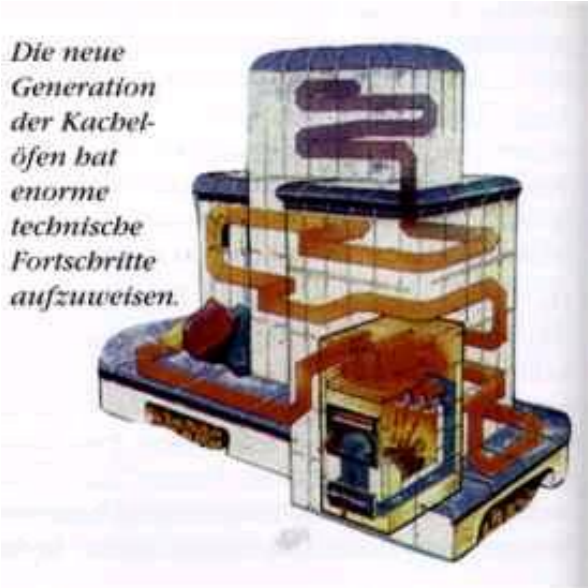
# Yearly increase of biomass heating systems in Austria




Innovative Energietechnologien in Österreich, Marktentwicklung 2015, 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)

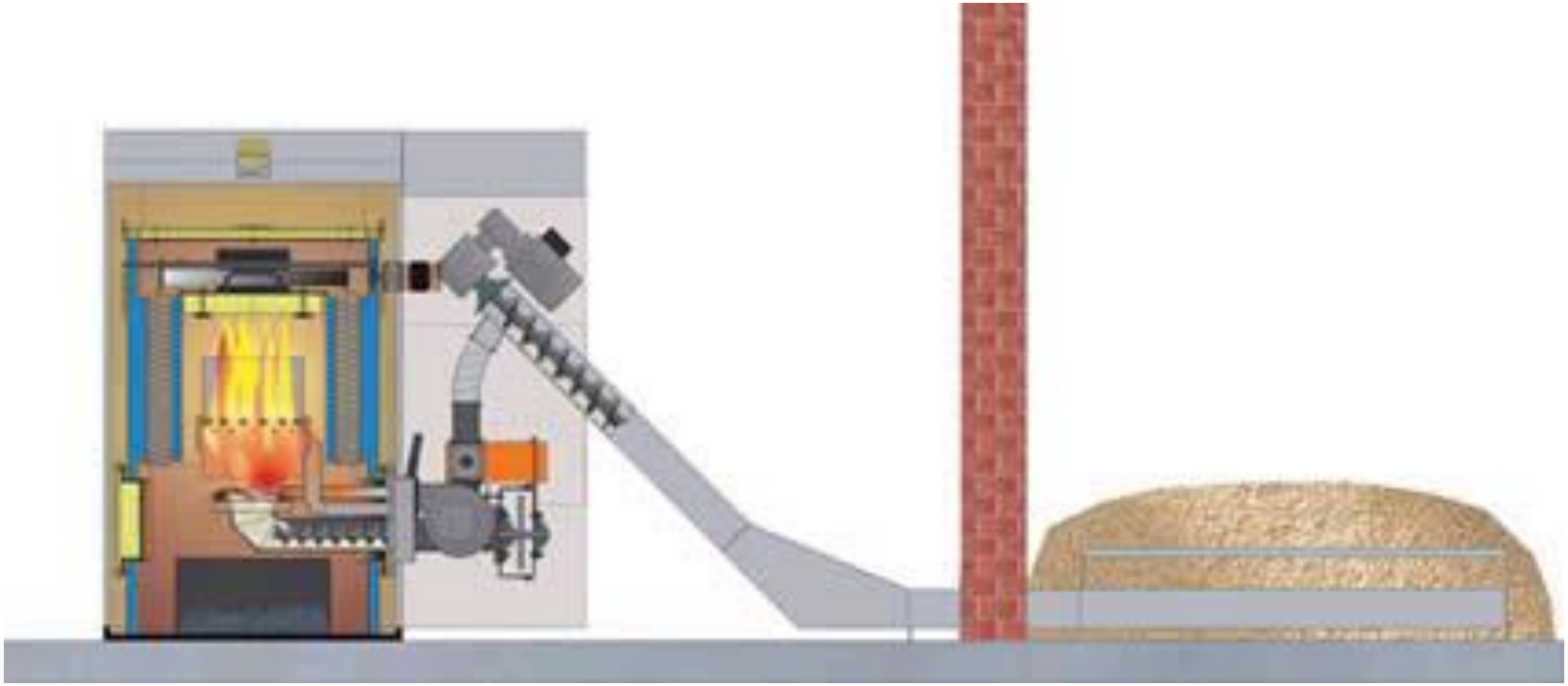
# "Kaminofen"

- 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

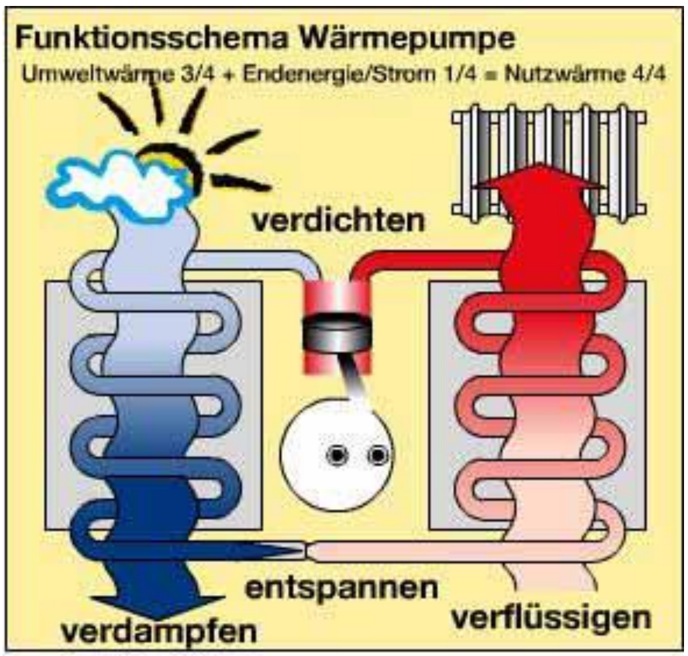

- Logs and ash is transported autmomatically downwards
- Logs are dries before burned
- Burning chamber is NOT cooled

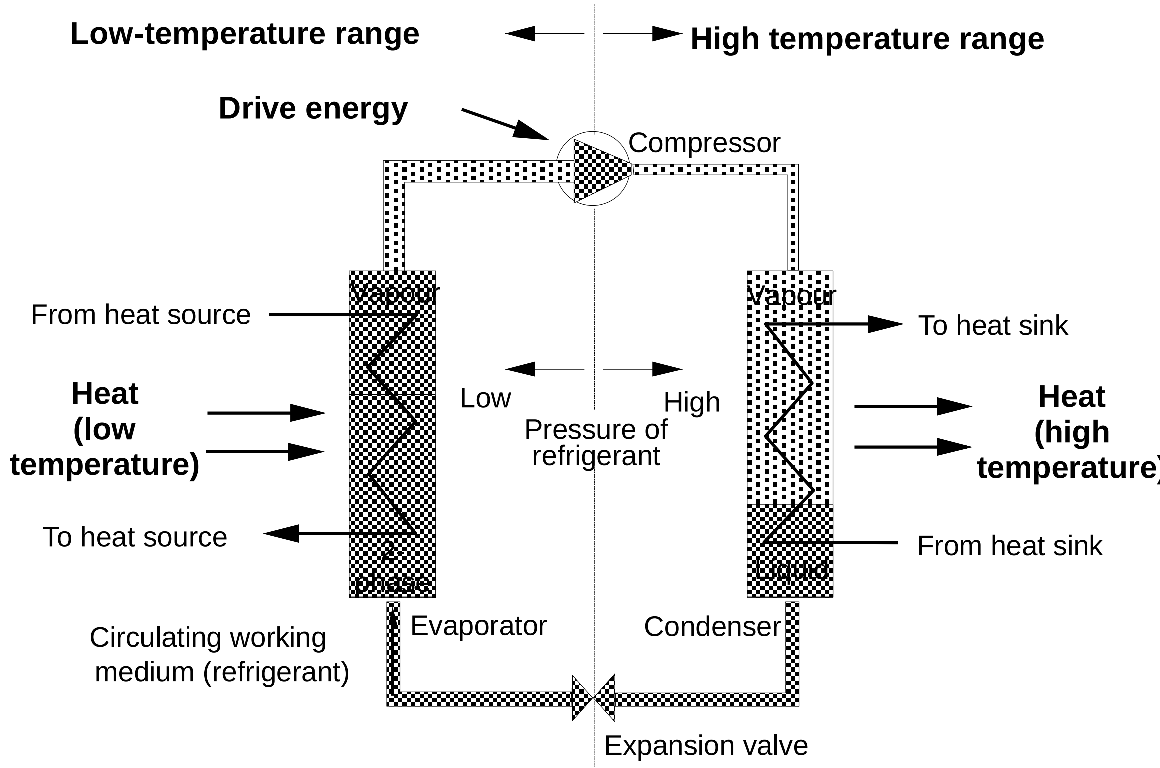
# Automatic wood chips/pellets burner



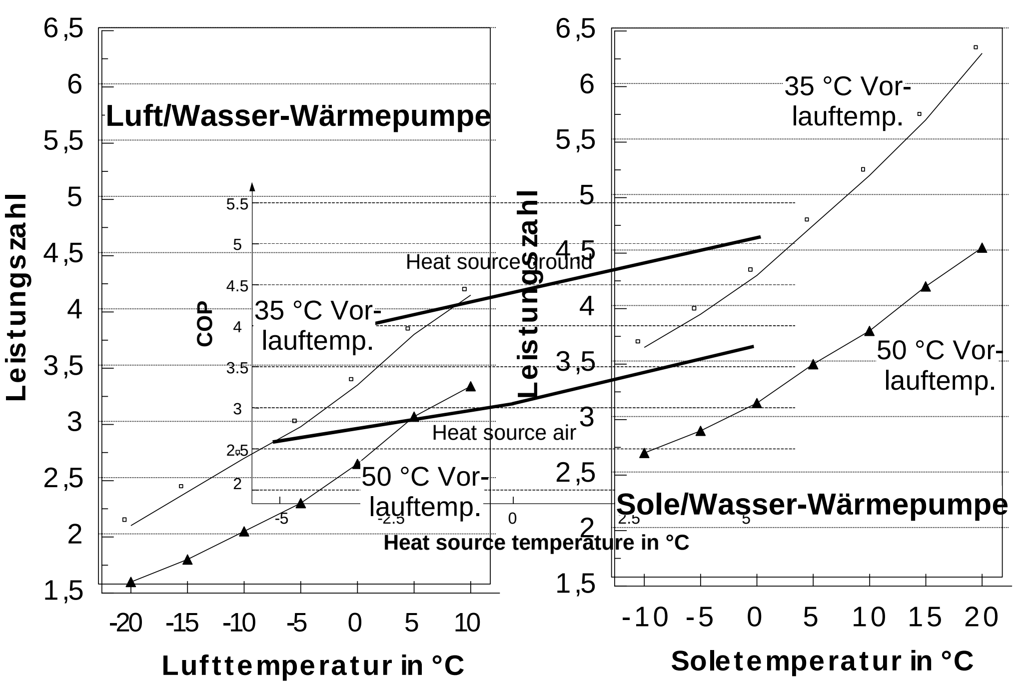
- Similar maintenance a soil or gas burners
- Similar emissions as oil burner
- Slightly higher investment than oil burner
- Biomass store has to be reached yb the blowing tube of the truck

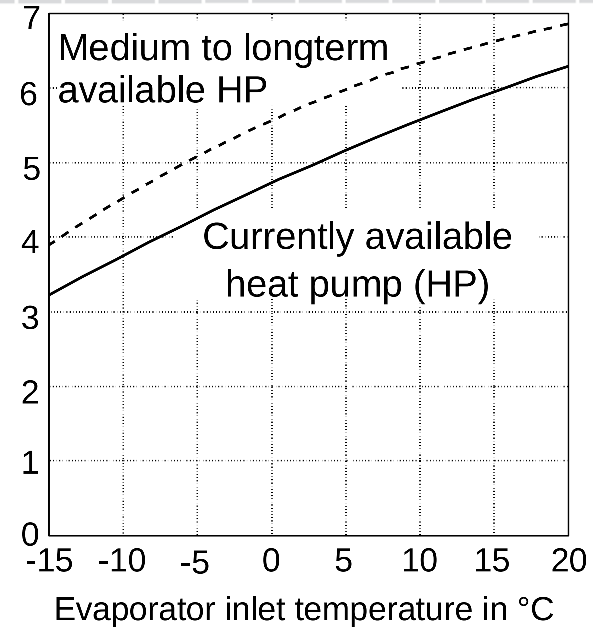
# Heat pumps


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
From heat sink
Liquid
2
phase
Circulating working
medium (refrigerant)
Evaporator
Condenser
Expansion valve

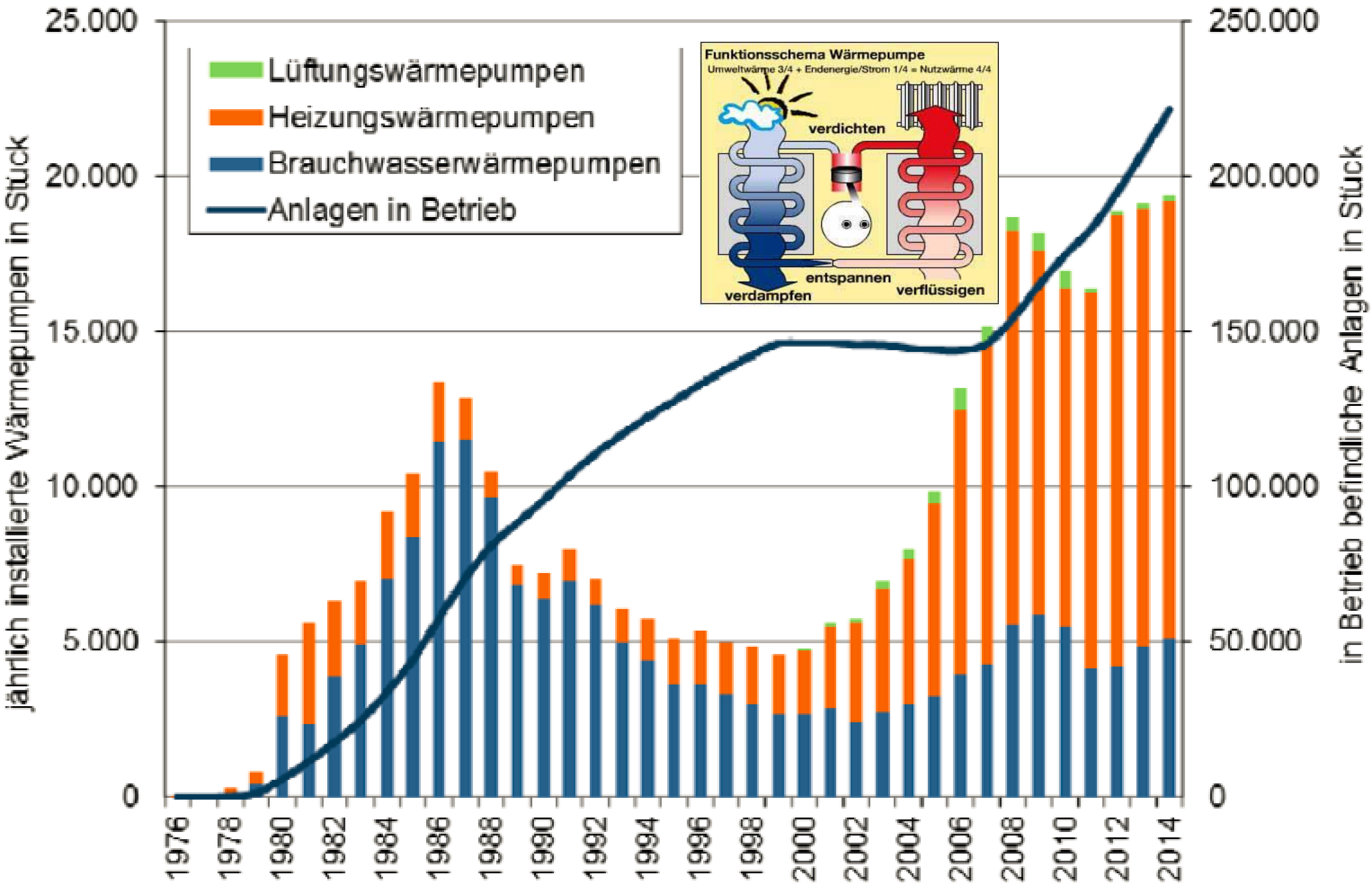
# Heat pump COP and boundary conditions



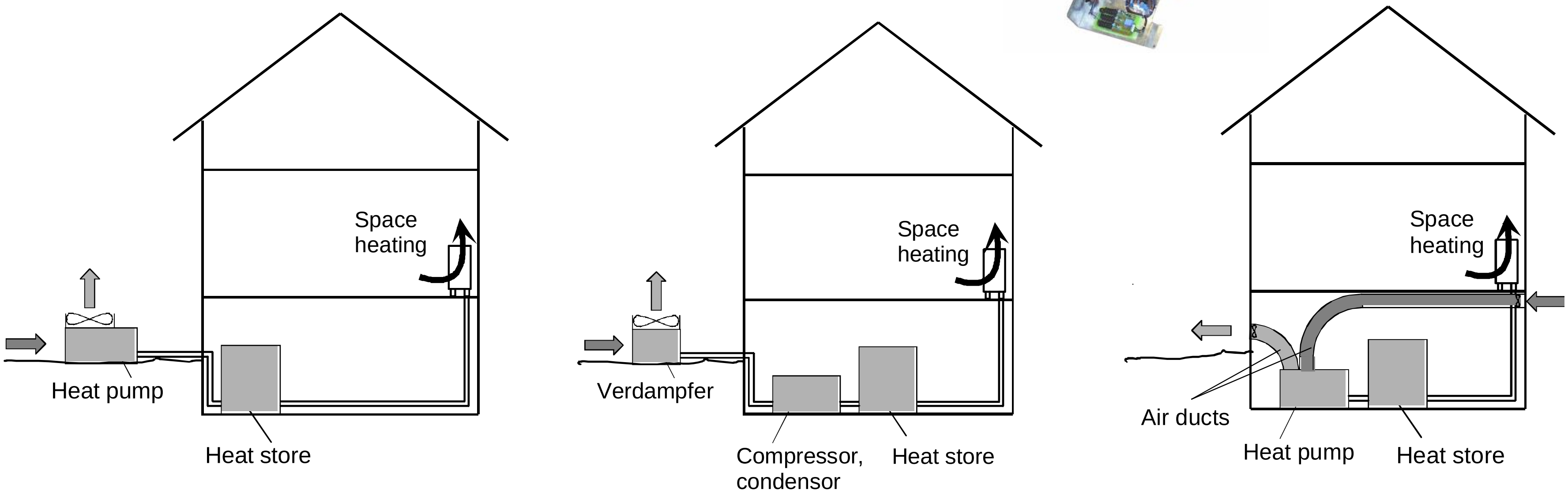

Quelle: Kaltschmitt, Streicher, Wiese, 2006

# Development of the Austrian heat pump market




Innovative Energietechnologien in Österreich, Marktentwicklung 2015, BMVIT

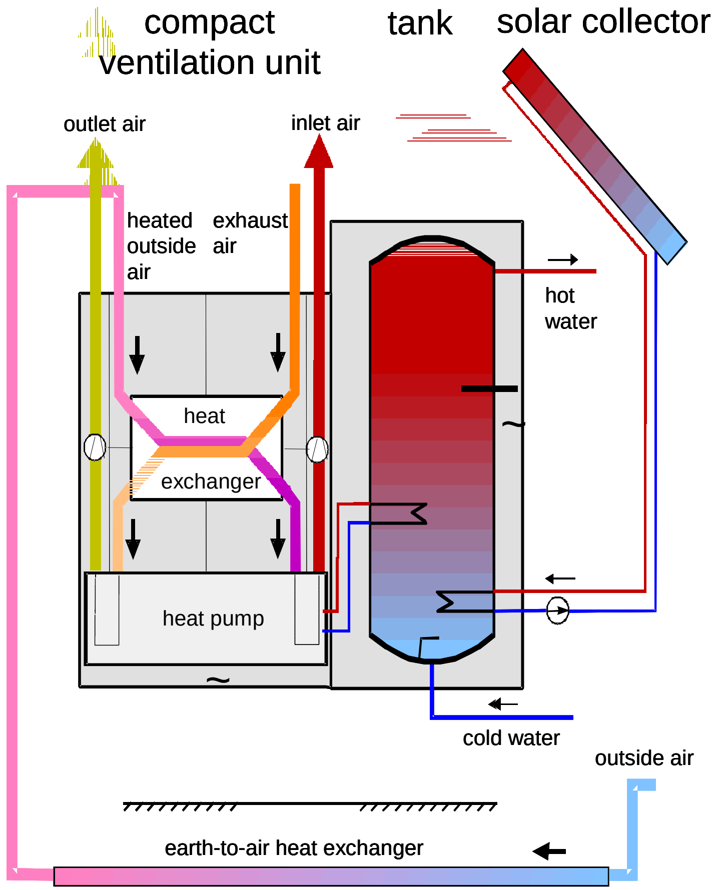
# Ambient air as heat source



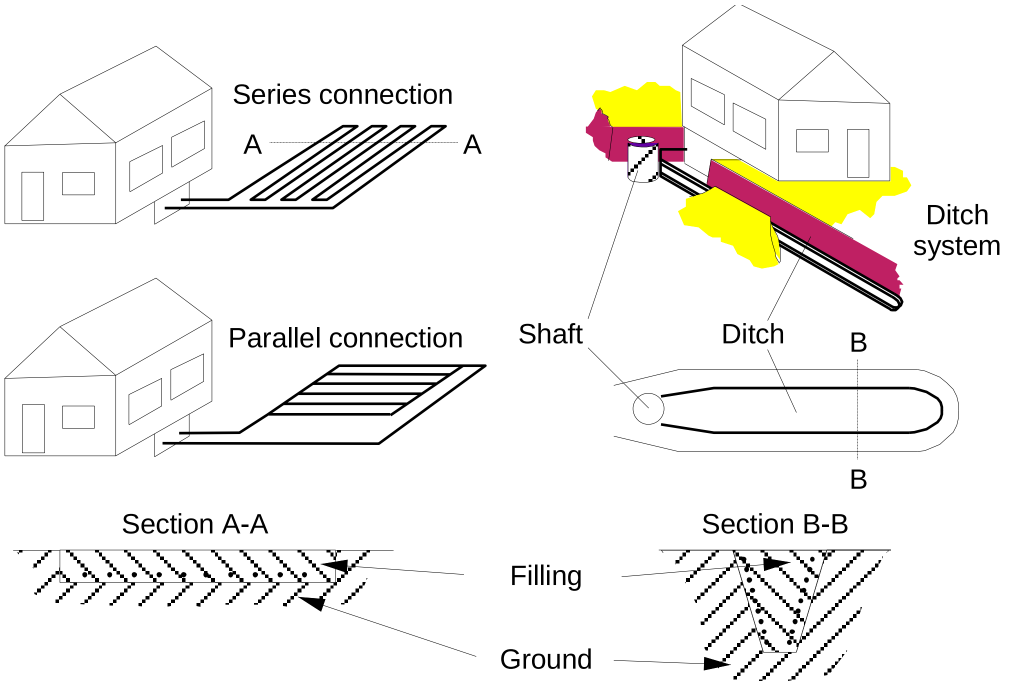

Quelle: Kaltschmitt, Streicher, Wiese, 2006

# 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

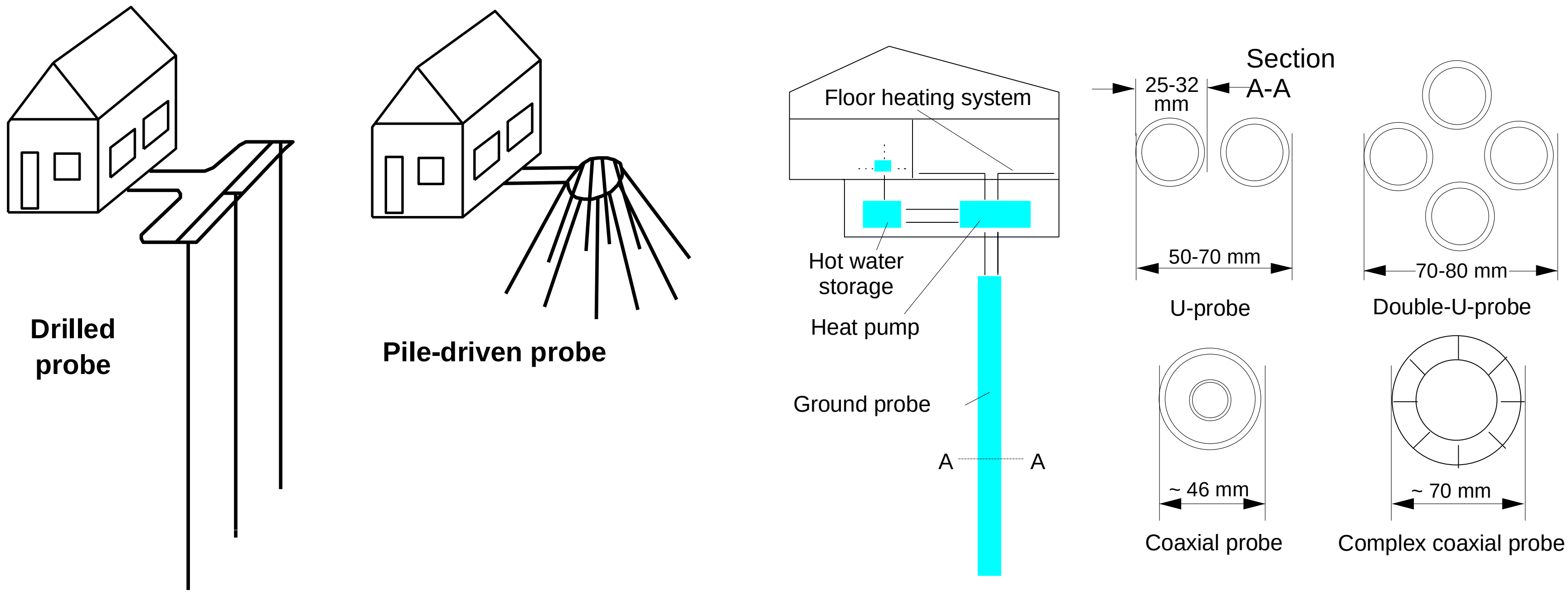



# Ground as heat source

| 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



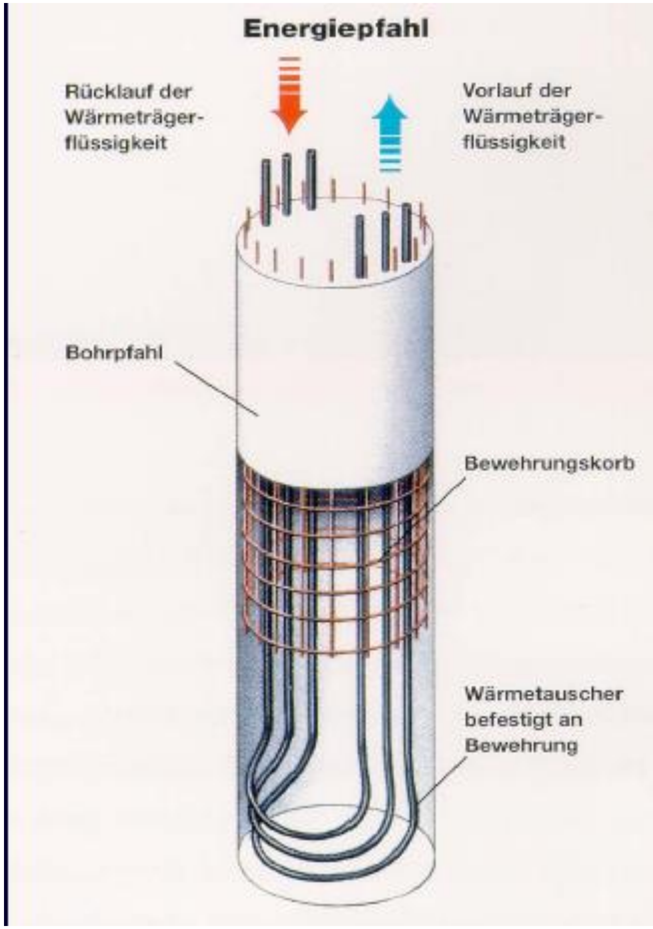

Quelle: Kaltschmitt, Streicher, Wiese, 2006

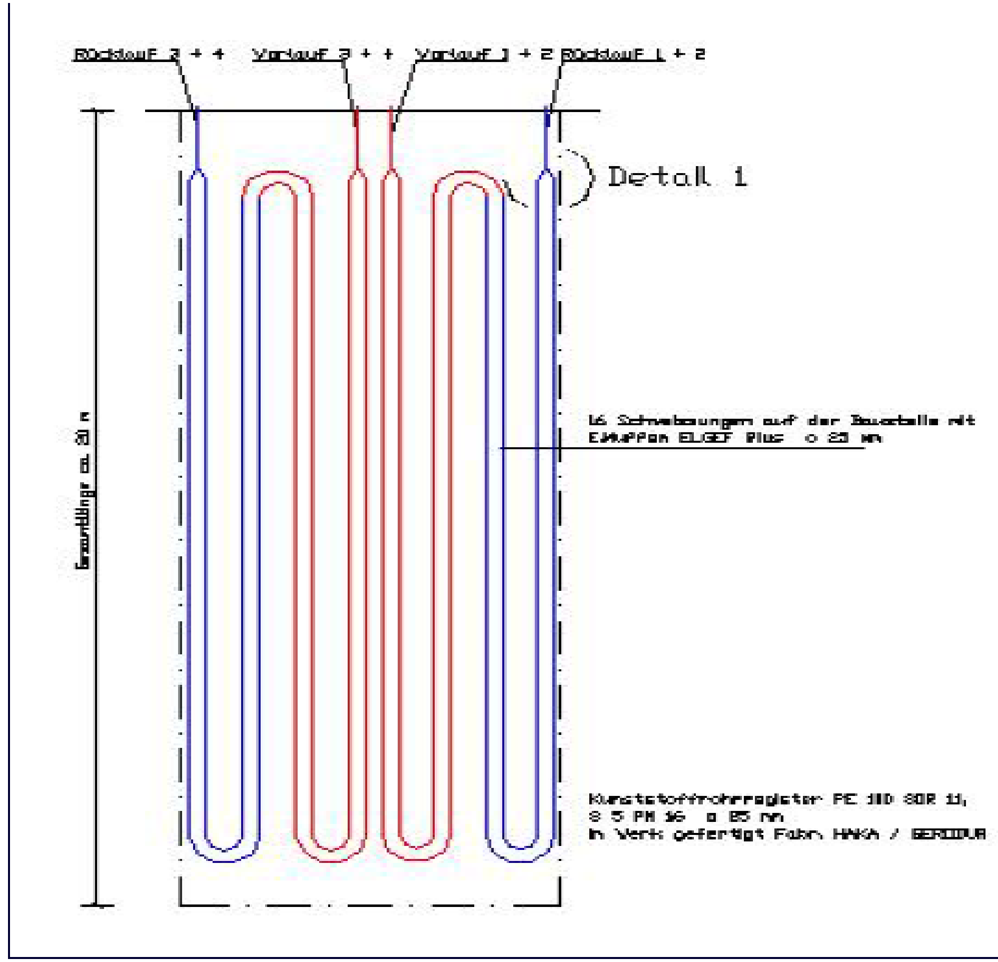
| | 1 800 h/a | 2 400 h/a |
|---|---|---|
| General guidelines | | |
| Bad subsoil (dry lose rocks) | 25 W/m | 20 W/m |
| Solid rock subsoil, water-saturated lose rock | 60 W/m | 50 W/m |
| Solid rock with high heat conductivity | 84 W/m | 70 W/m |
| Individual soils | | |
| Gravel, sand, dry | < 25 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

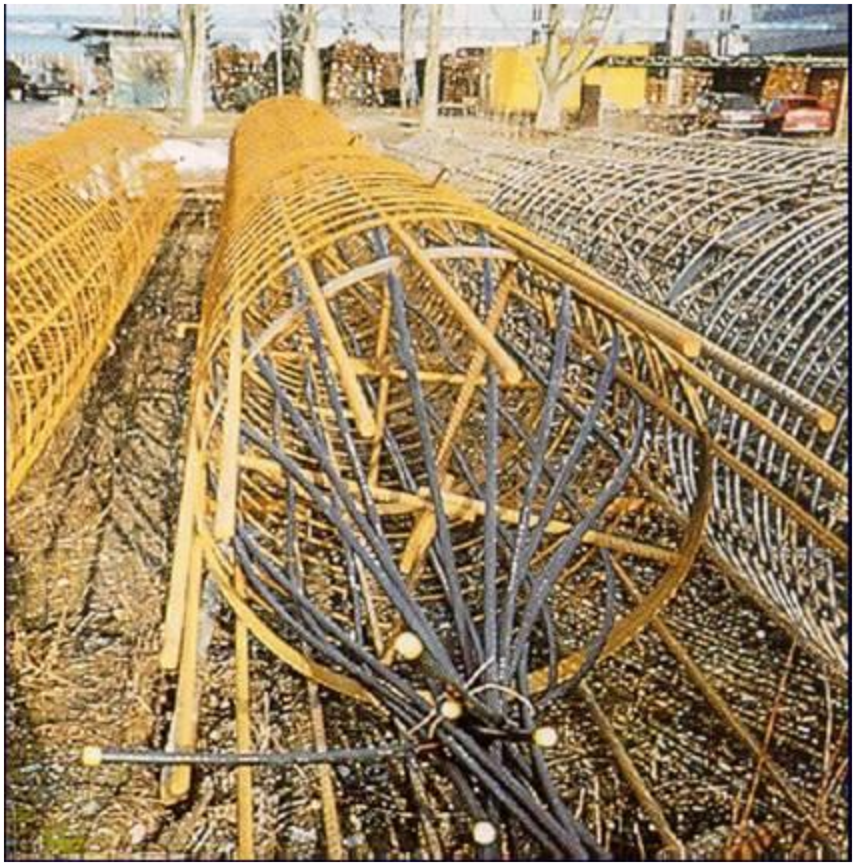



Quelle: Sauerwein, Bilfinger Berger,

# Vorgefertigter Bewehrungskorb

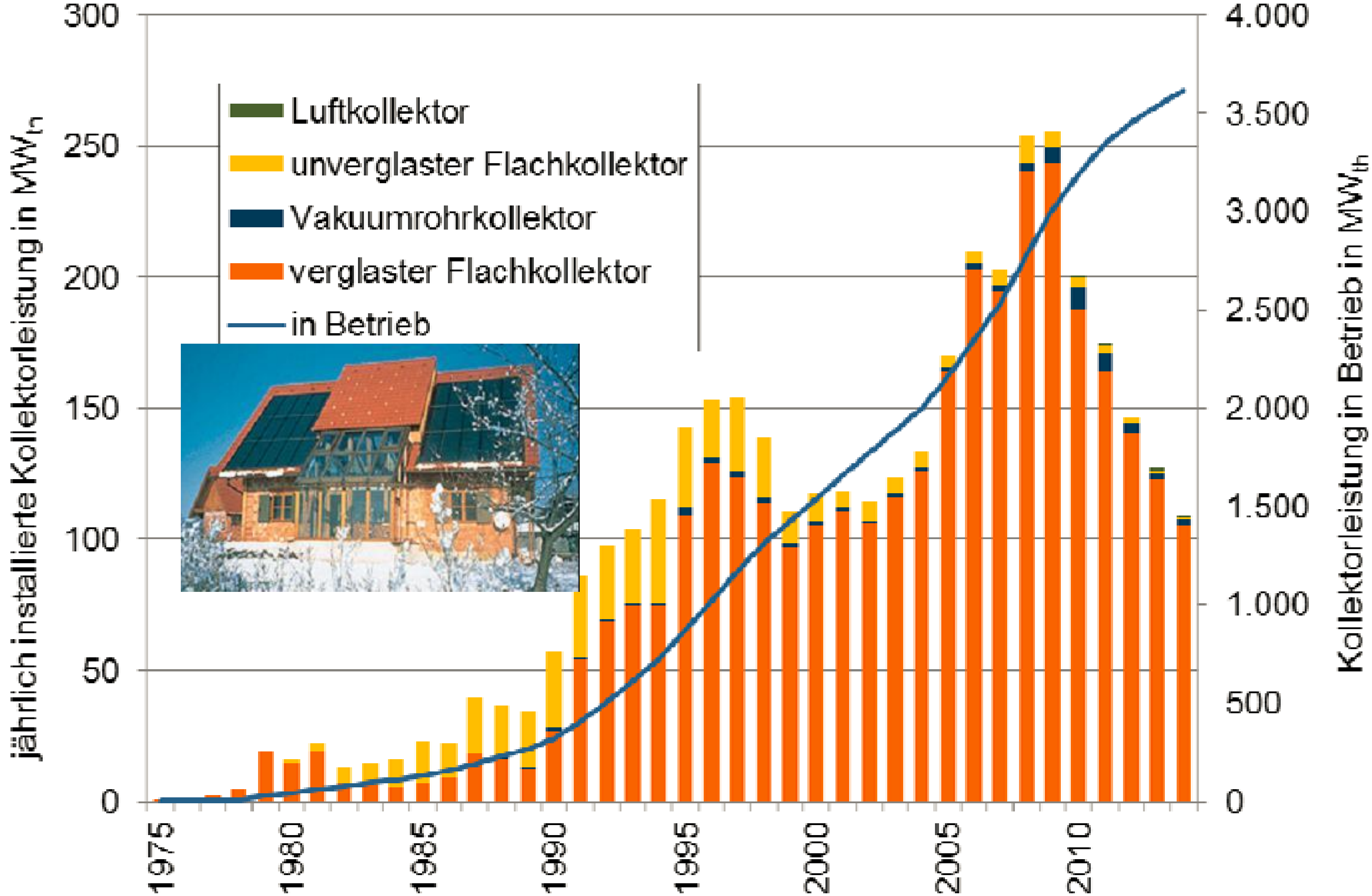
## Energy poles



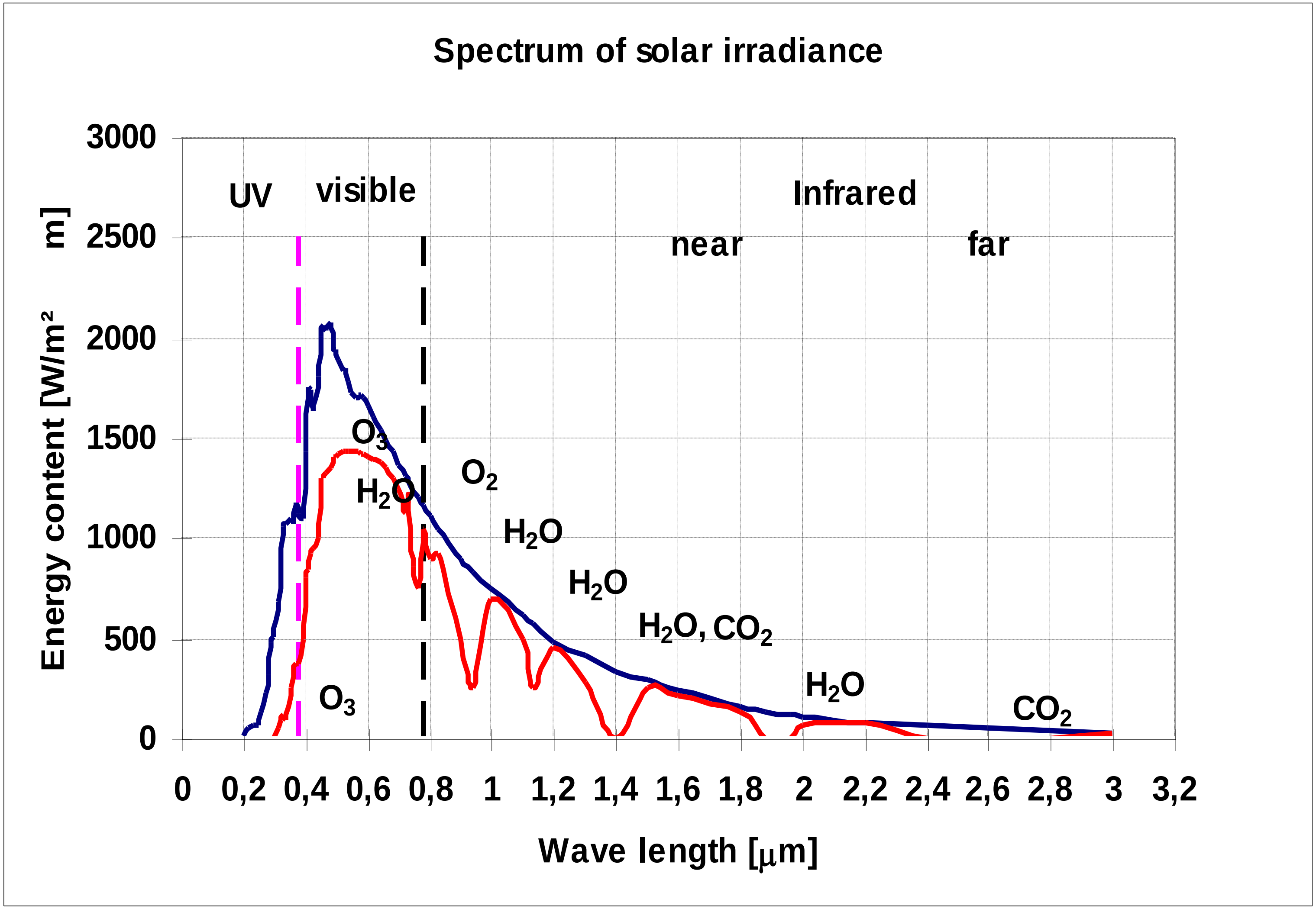
## Verteilerstation Energiepfähle

# Solar Thermal Systems

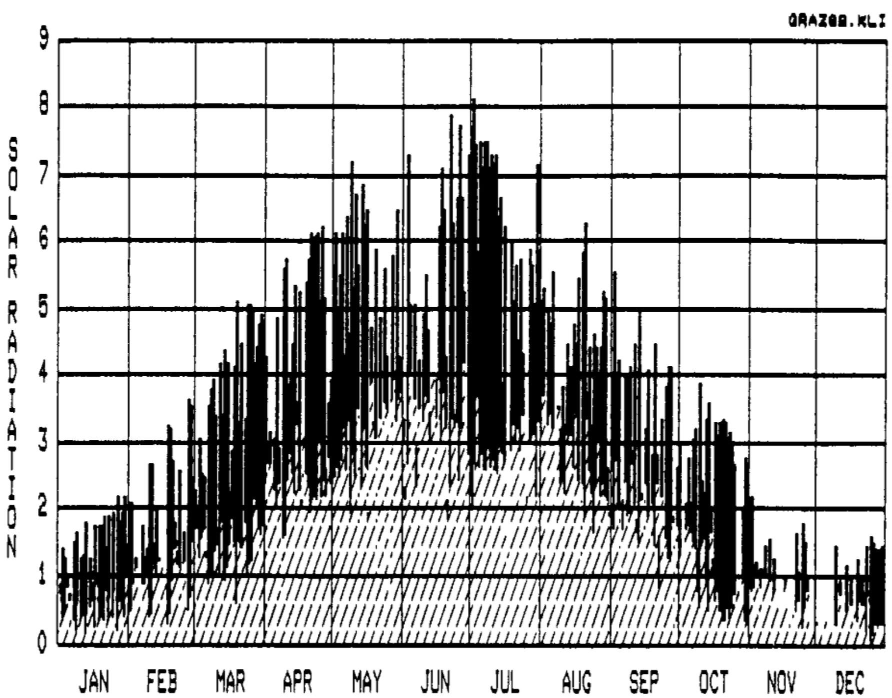
# Austrian market development of solar thermal systems

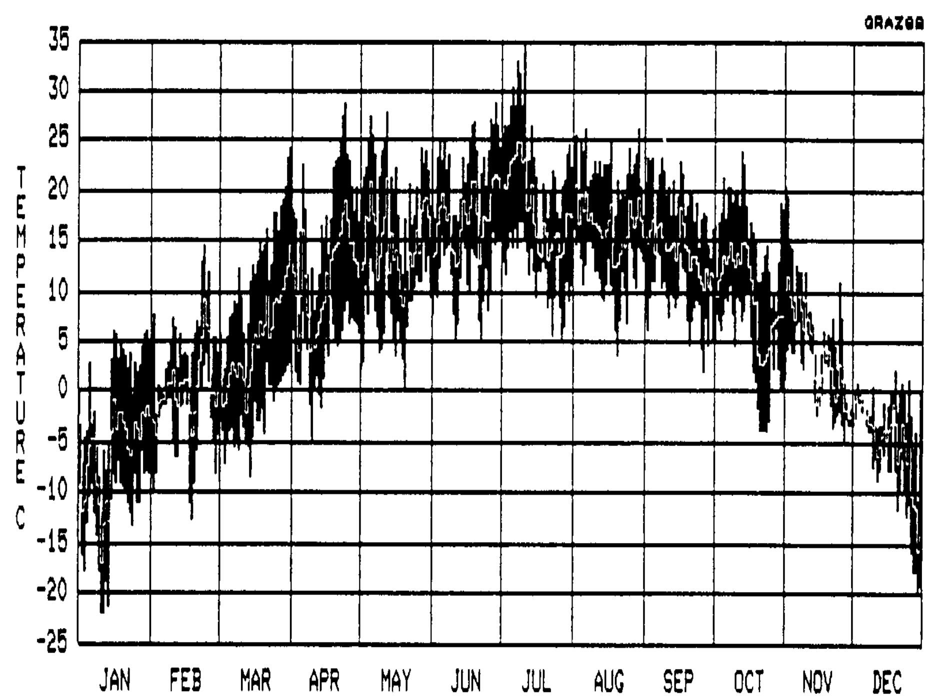



Innovative Energietechnologien in Österreich, Marktentwicklung 2011, BMVIT


Spectrum of solar irradiance
Energy content [W/m² m]
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

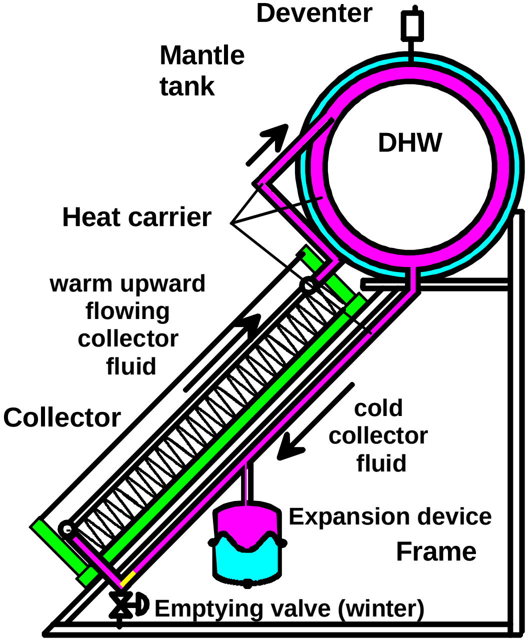


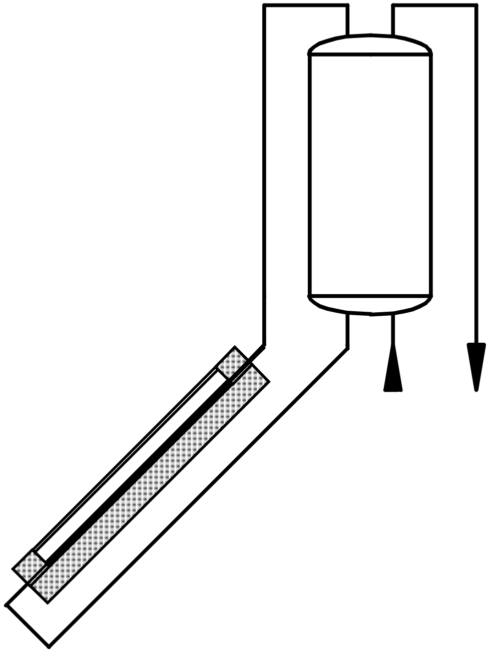



# Where to use solar thermal

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

# Principle of Solar Thermal Energy Use Natural Circulation Systems

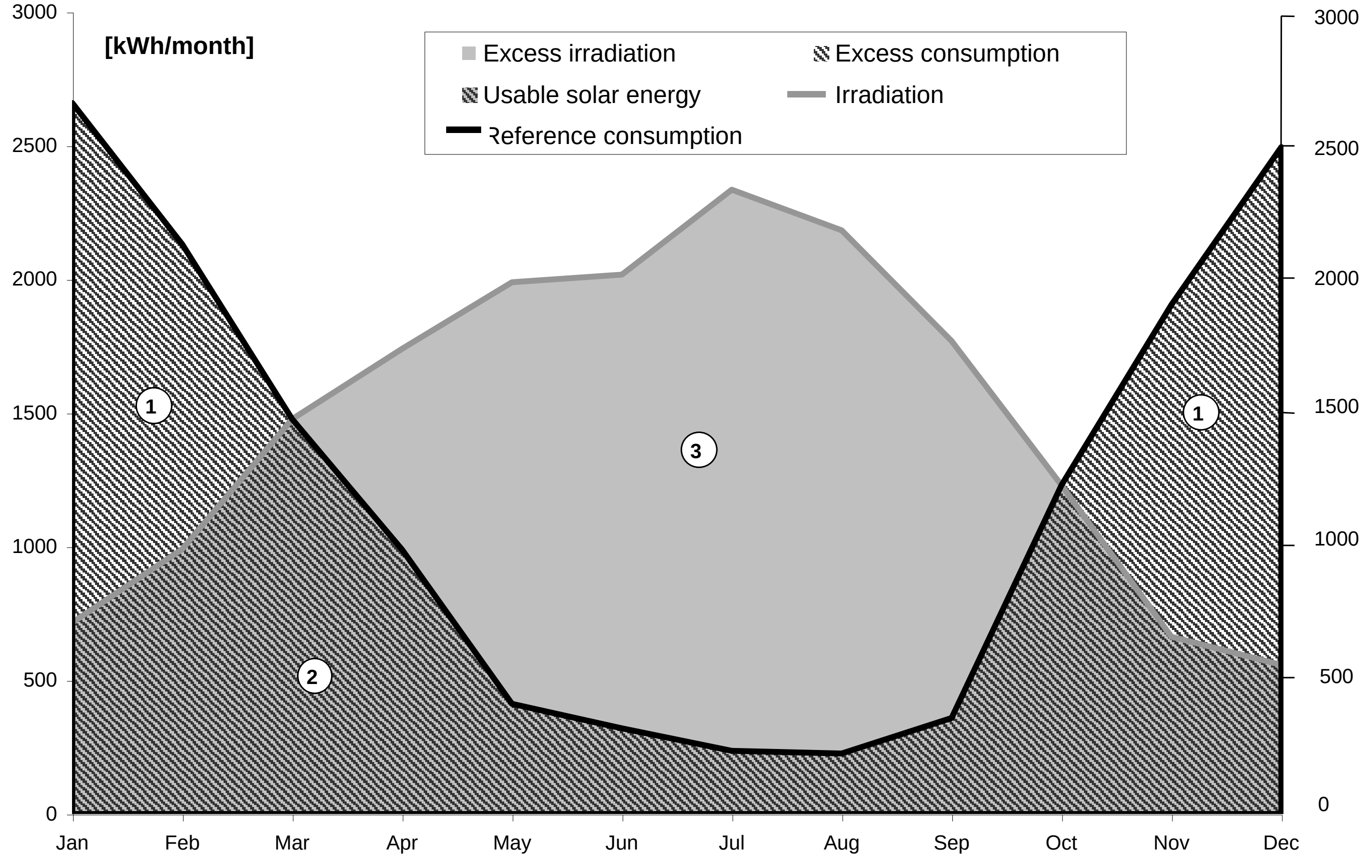


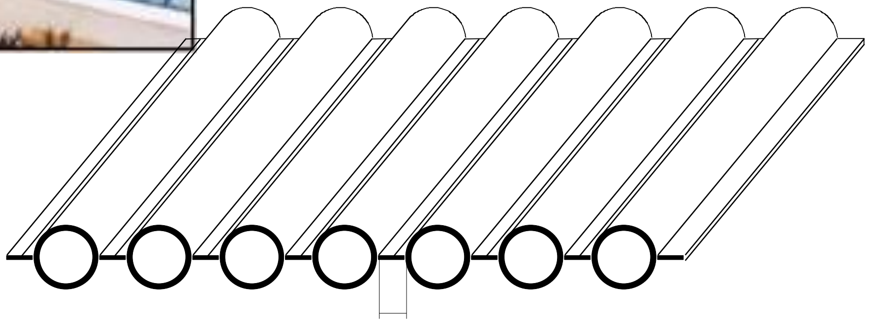
# Solar Combisystems



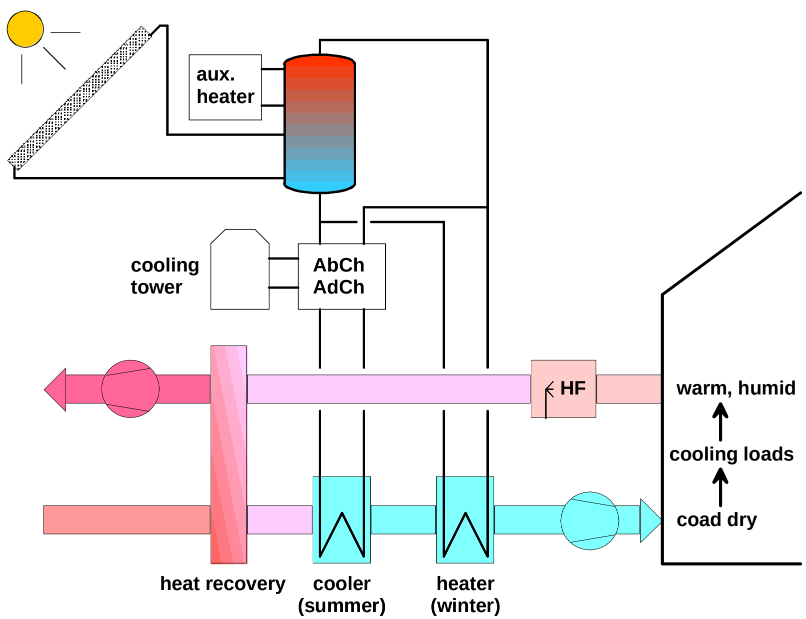
# Solar Combisystems,space heating demand



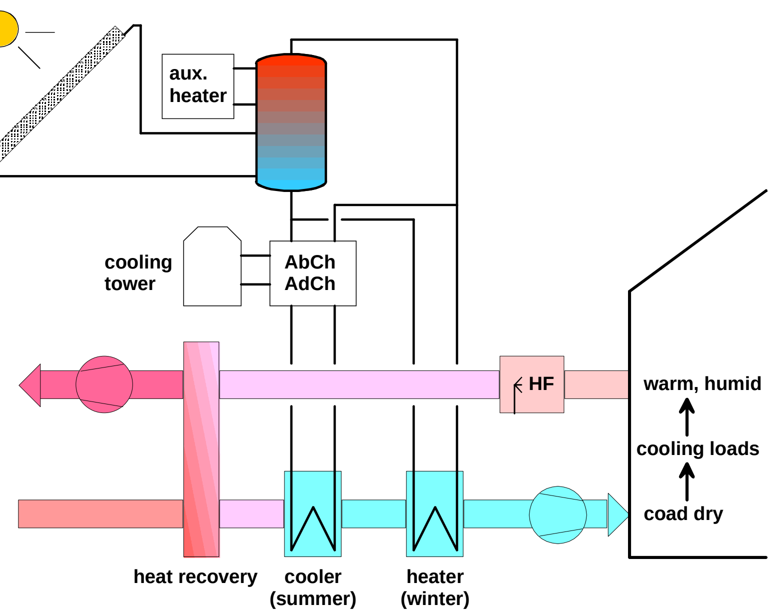
# Solar heated swimming pools



# Solar assisted cooling

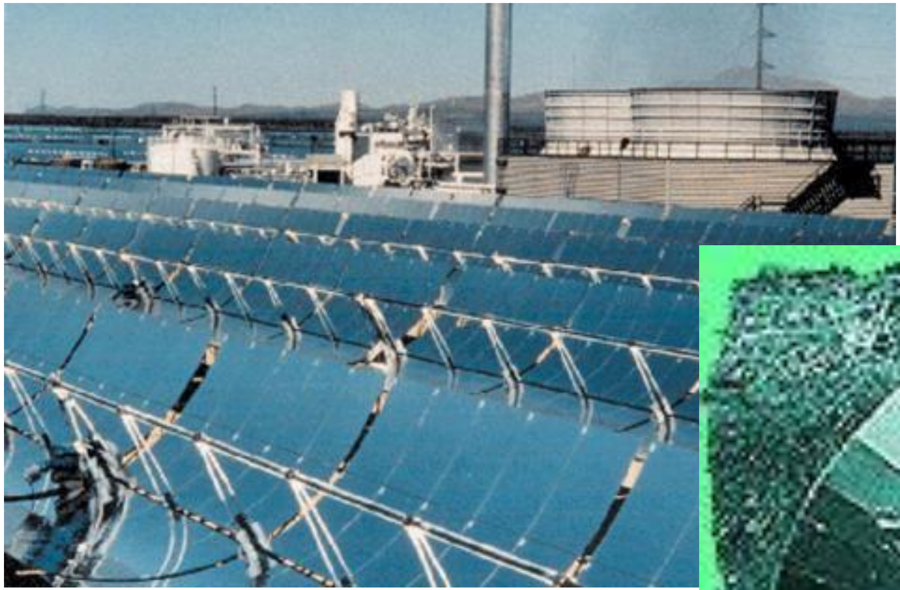


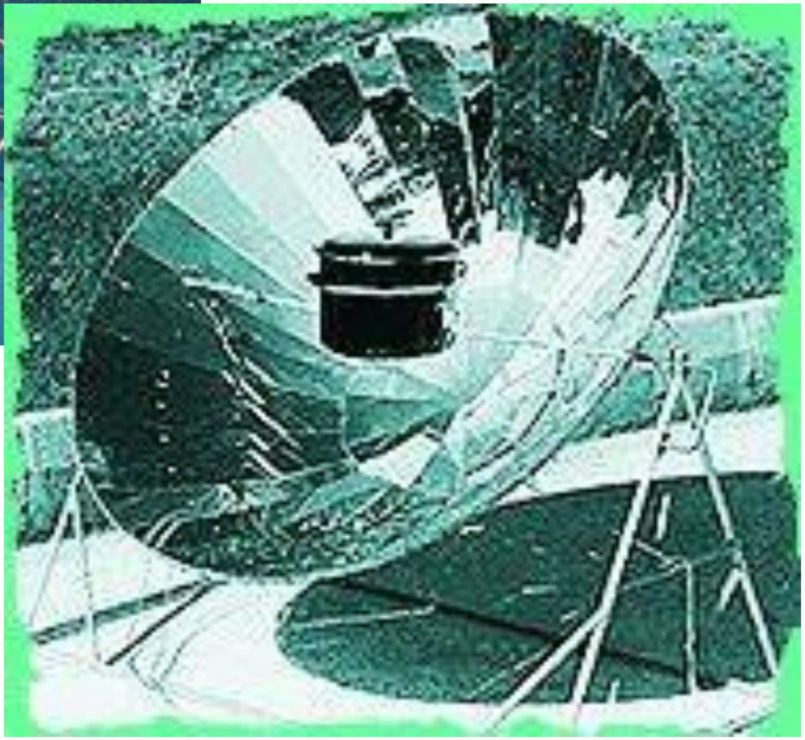

Deccicant system



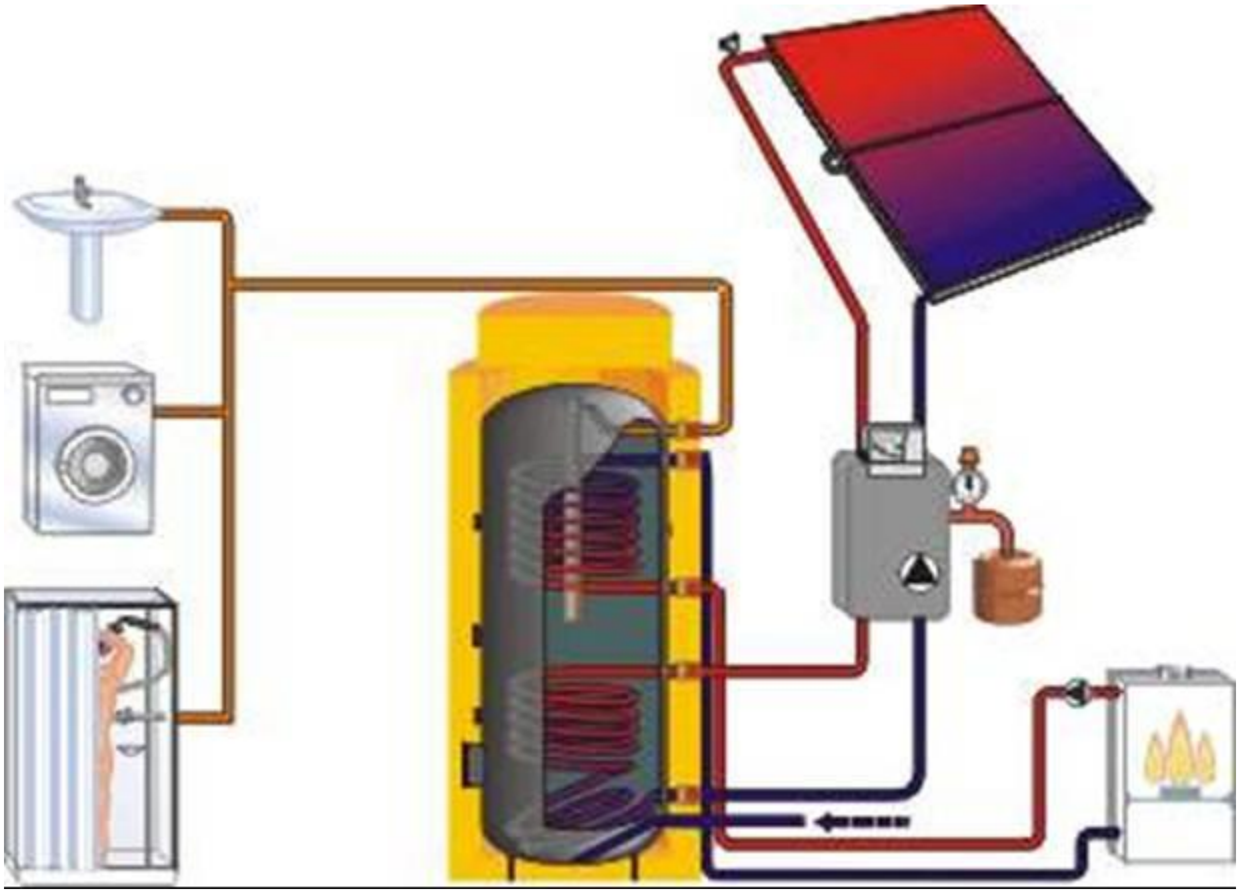

Ab/Adsorption system

# Process heat

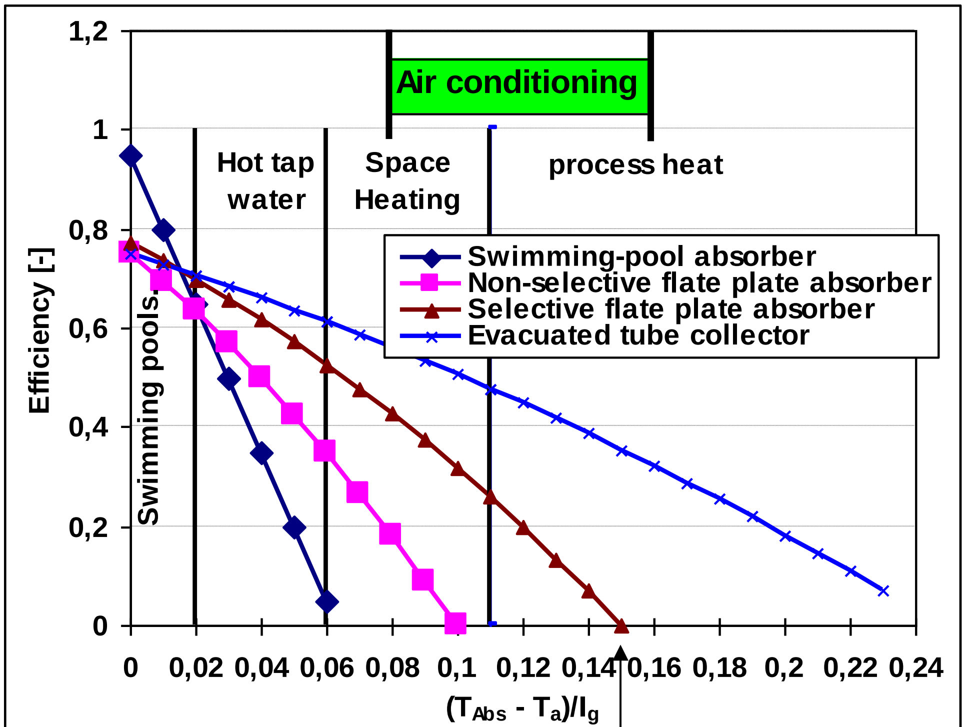


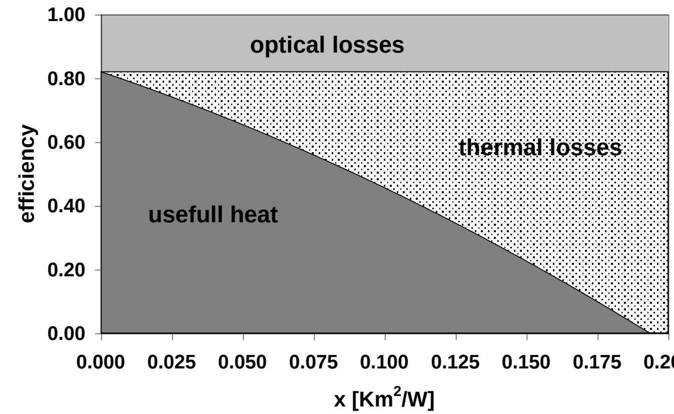


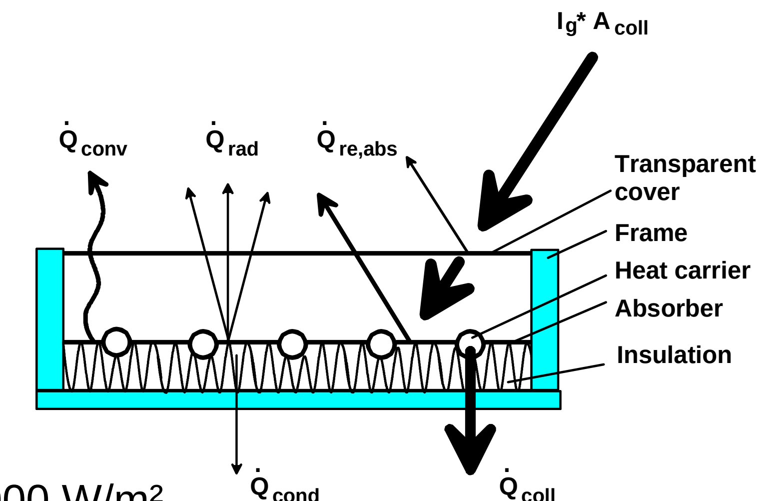
# Principle of Solar Thermal Energy Use
# Forced Circulation Systems



# Collector characteristics

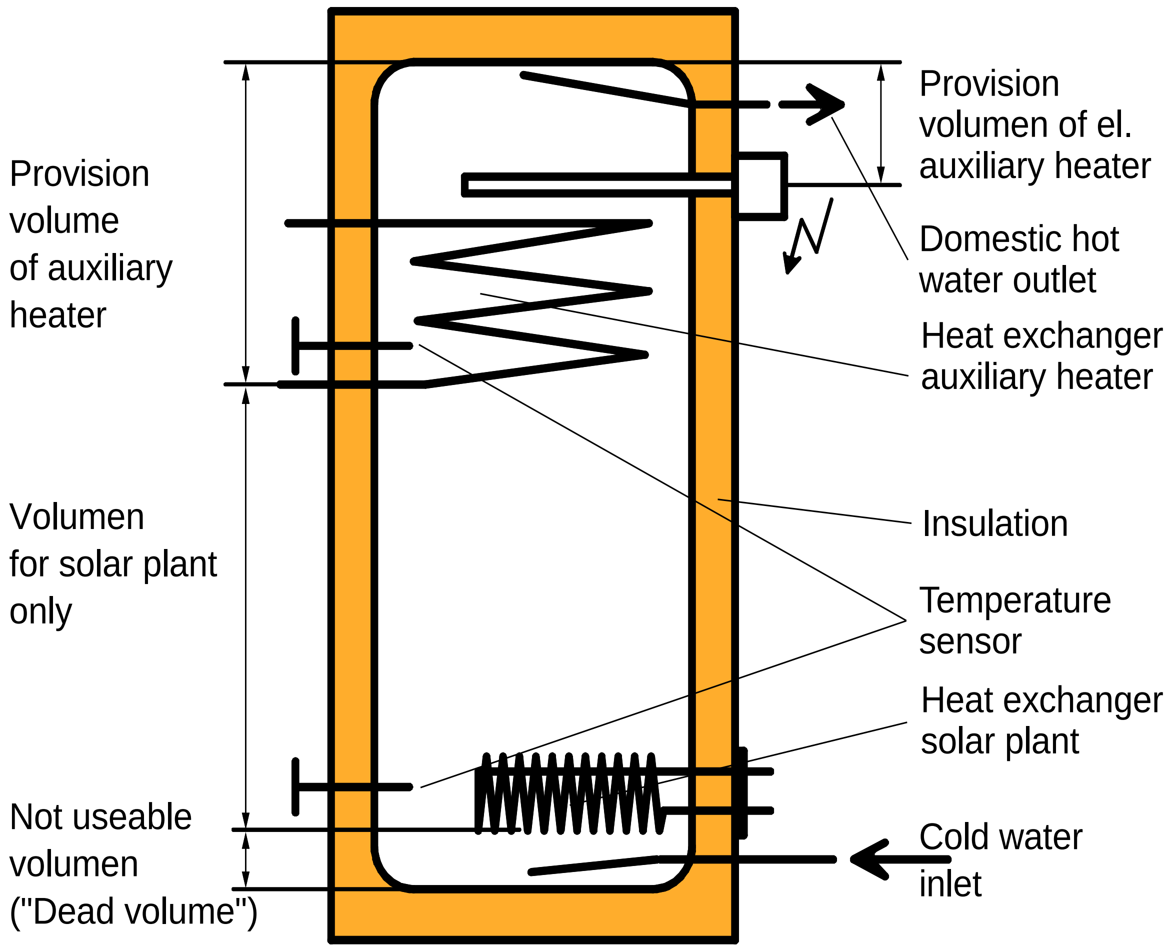


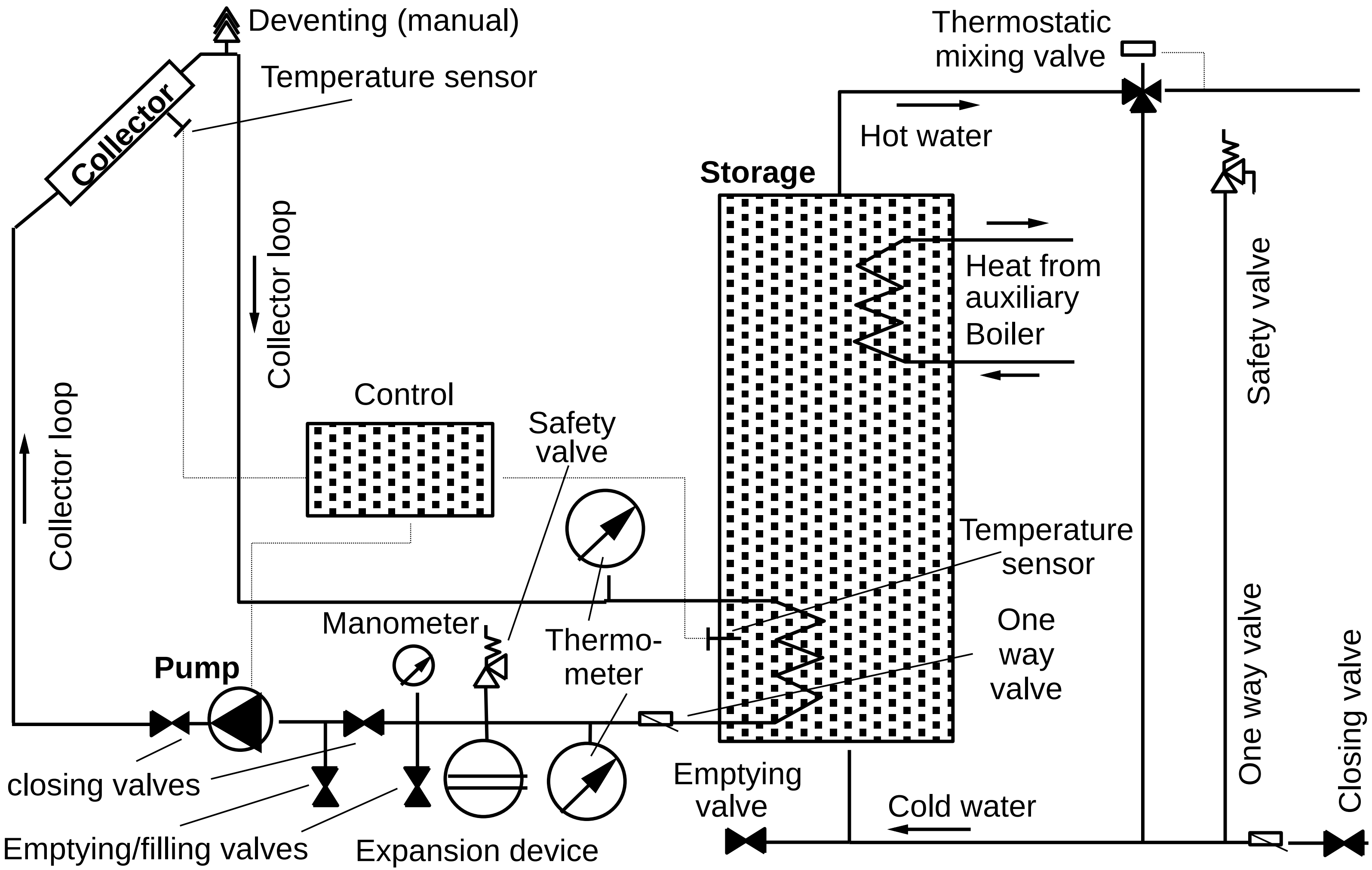




Note : Maximum collector standstill temperature at 1000 W/m² irradiance and 30 °C ambient temperature: Tabs = (0,15*1000)+30 = 180 °C

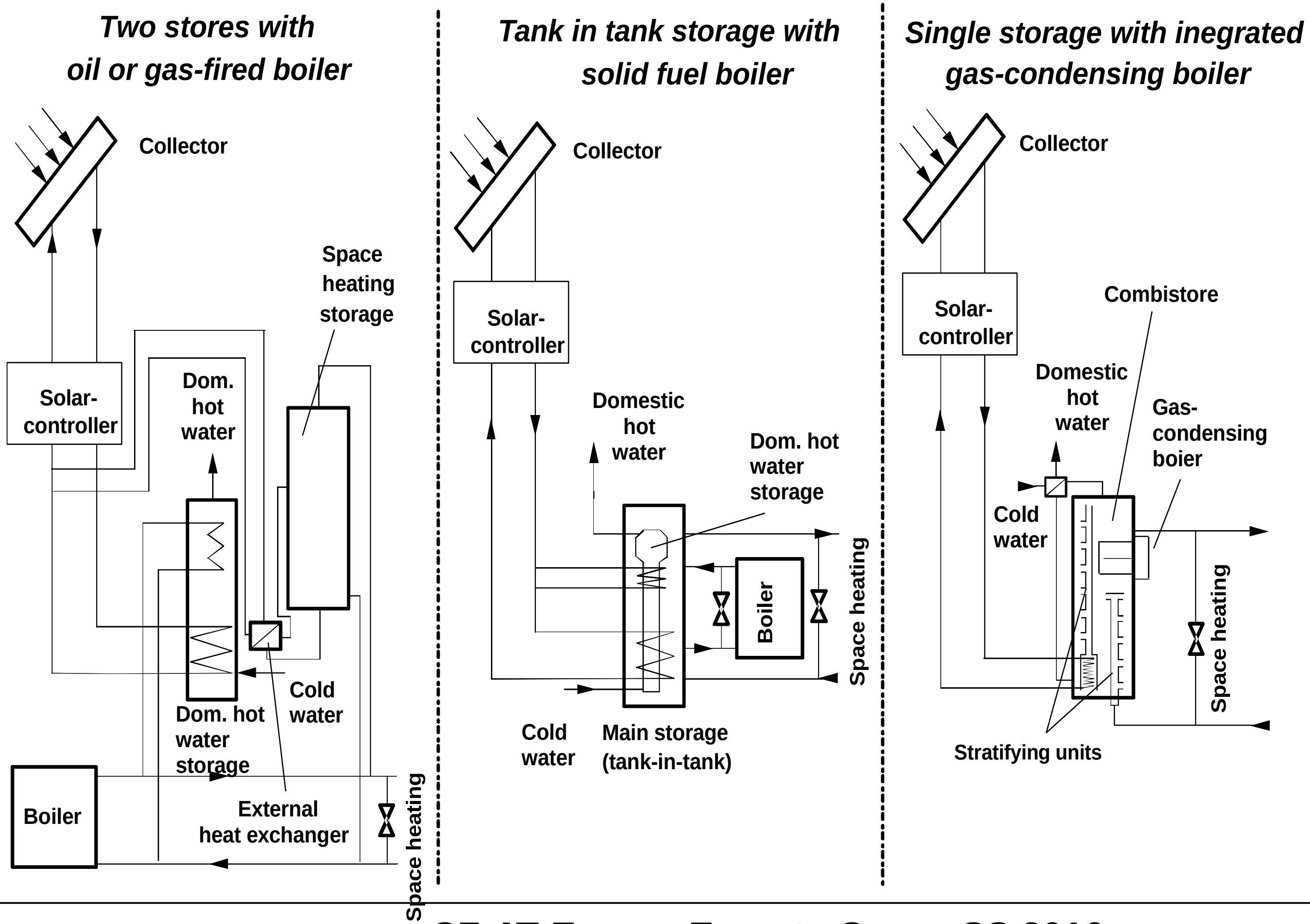
# Solar Domestic Hot Water Stores



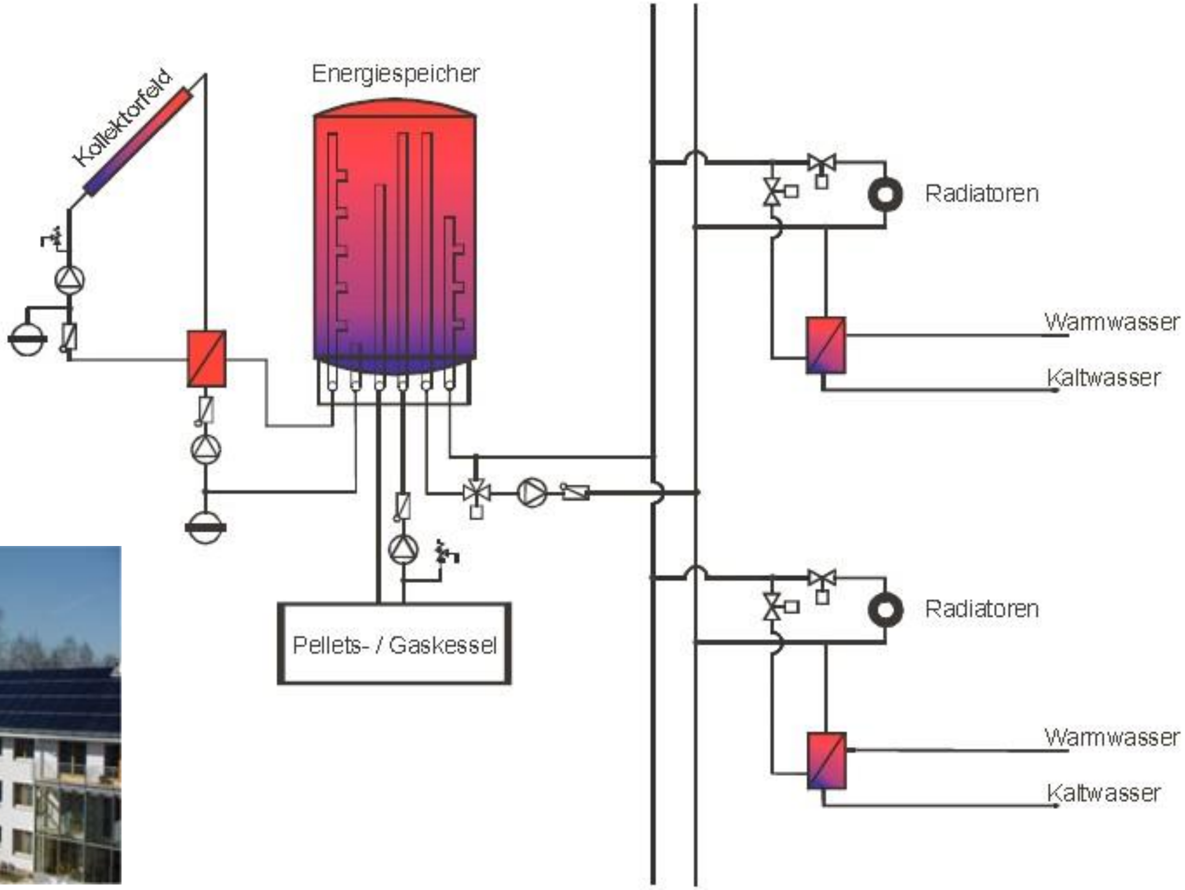
# Domestic hot water forced hydraulics



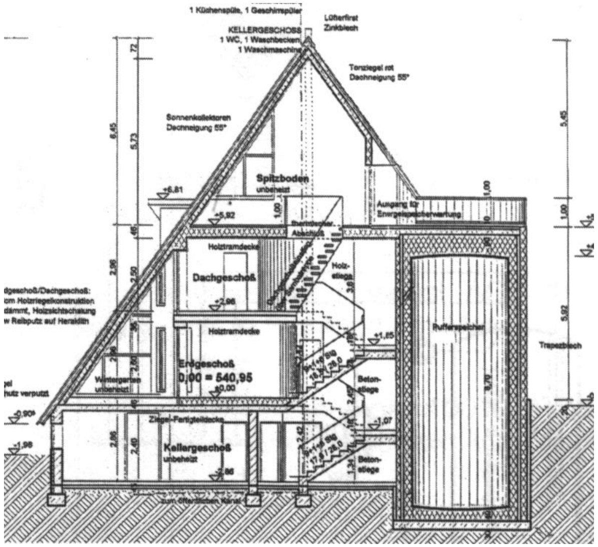
# Solar combisystem schemes

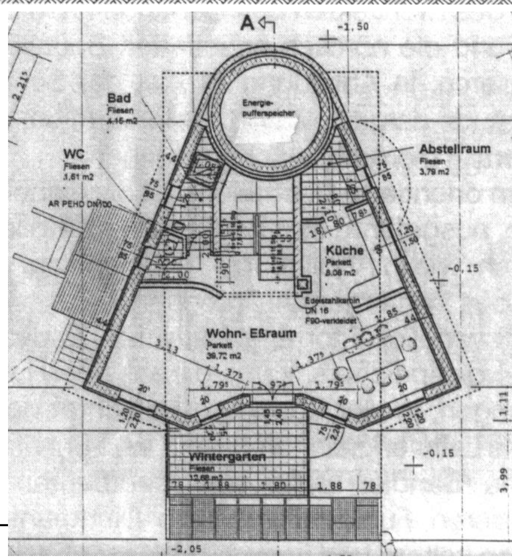


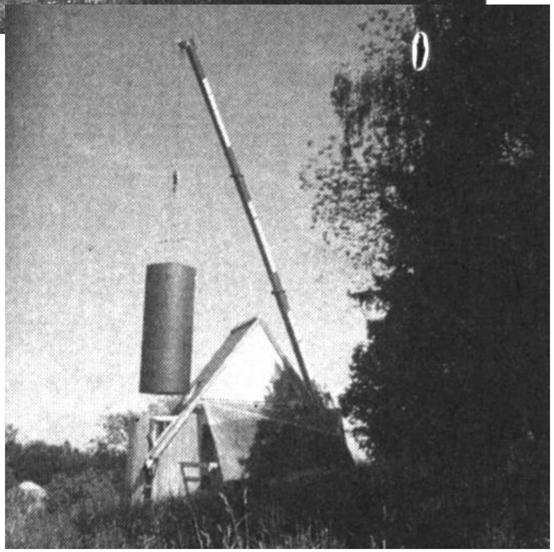
# Systems for Multi Family House „Legionella free“, ÖNORM B 5019




# Example of purely solar heated house



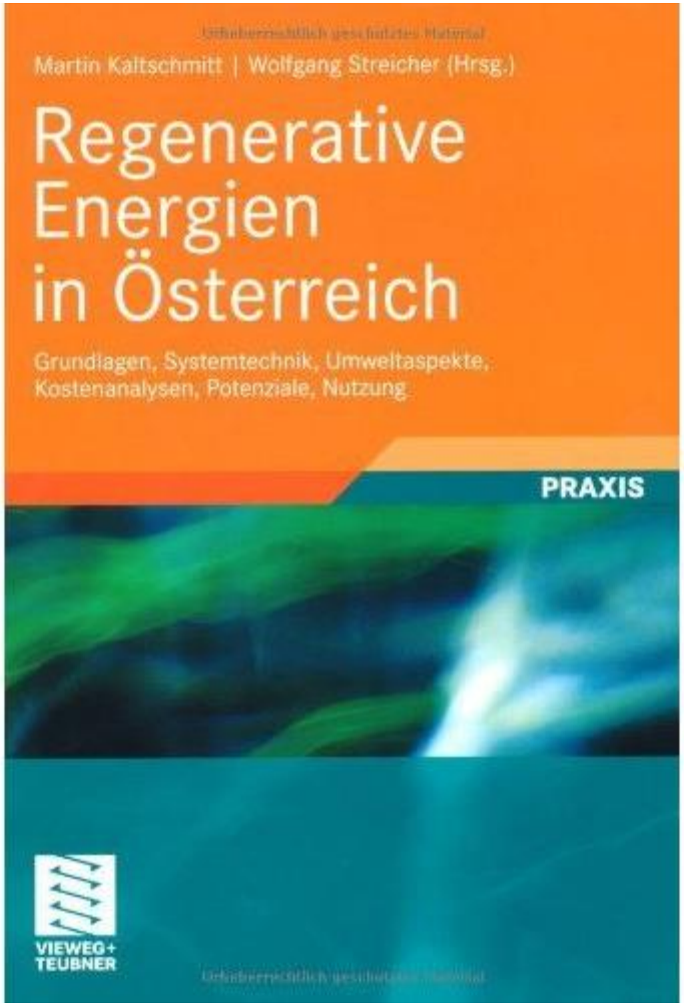



# Renewable Energy in Austria – Perspektives and Potentials –

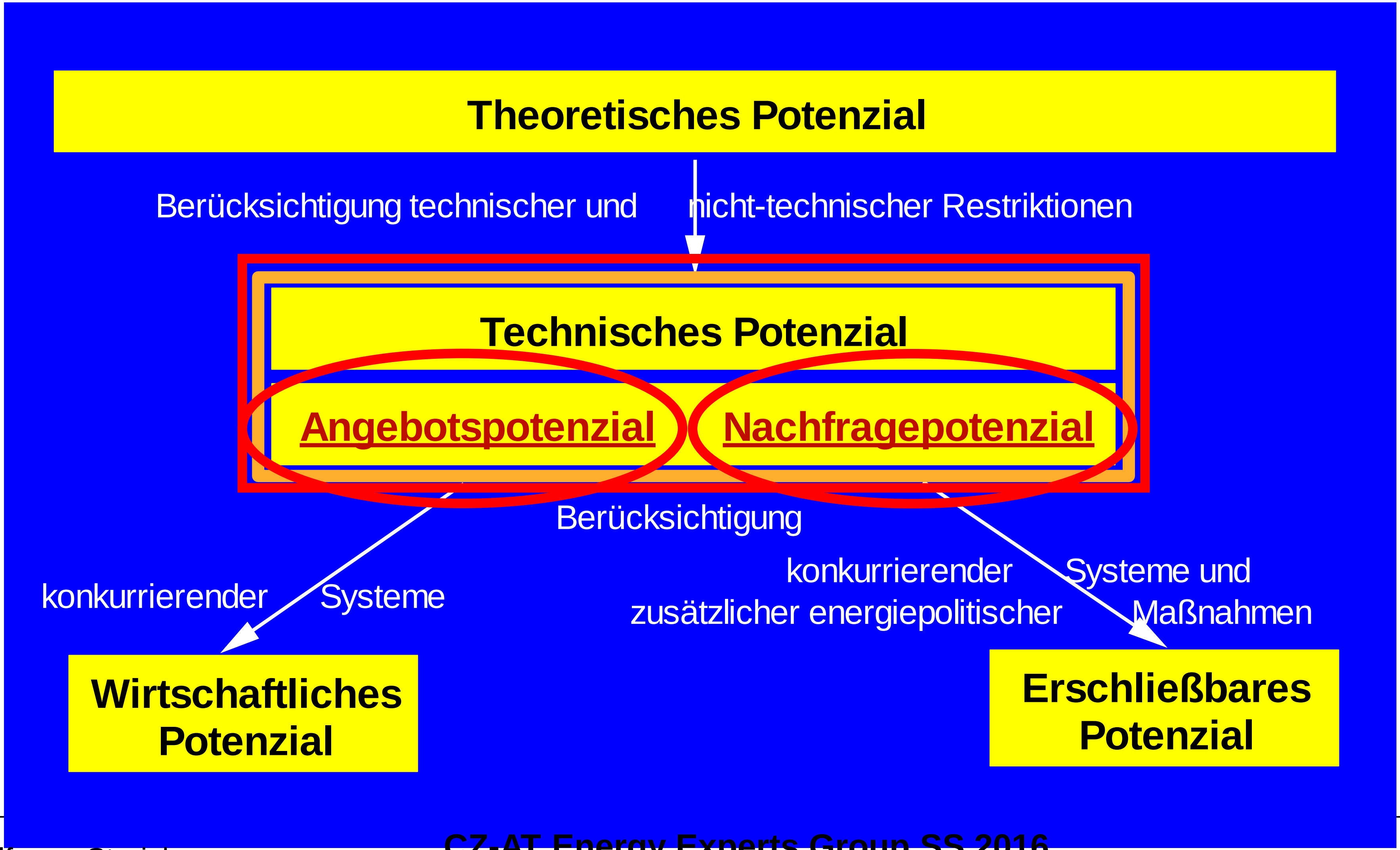
Martin Kaltschmitt, Wolfgang Streicher

Studie im Auftrag des Verbandes der Elektrizitätswerke Österreichs

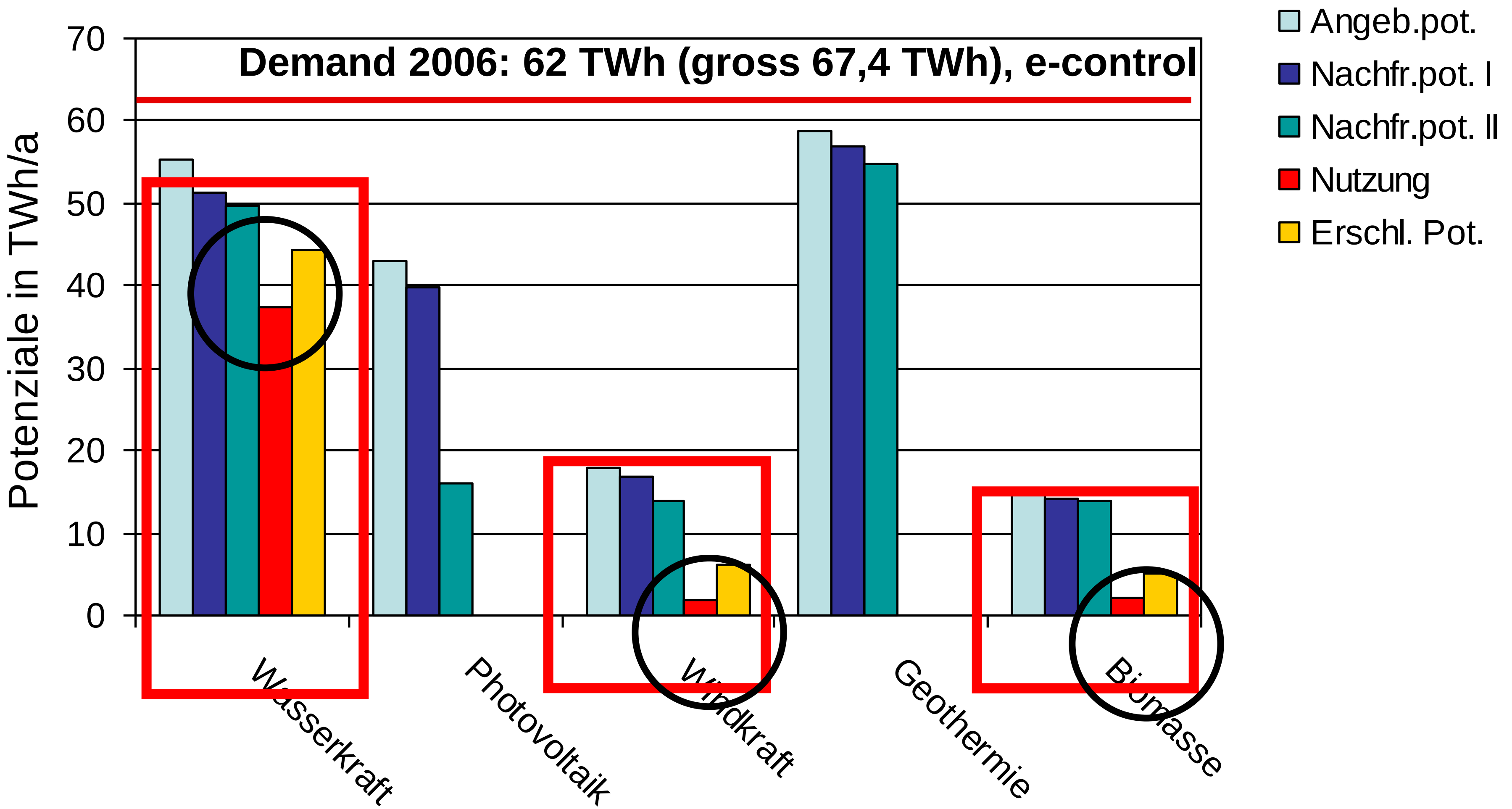
Verlag Vieweg&Teubner



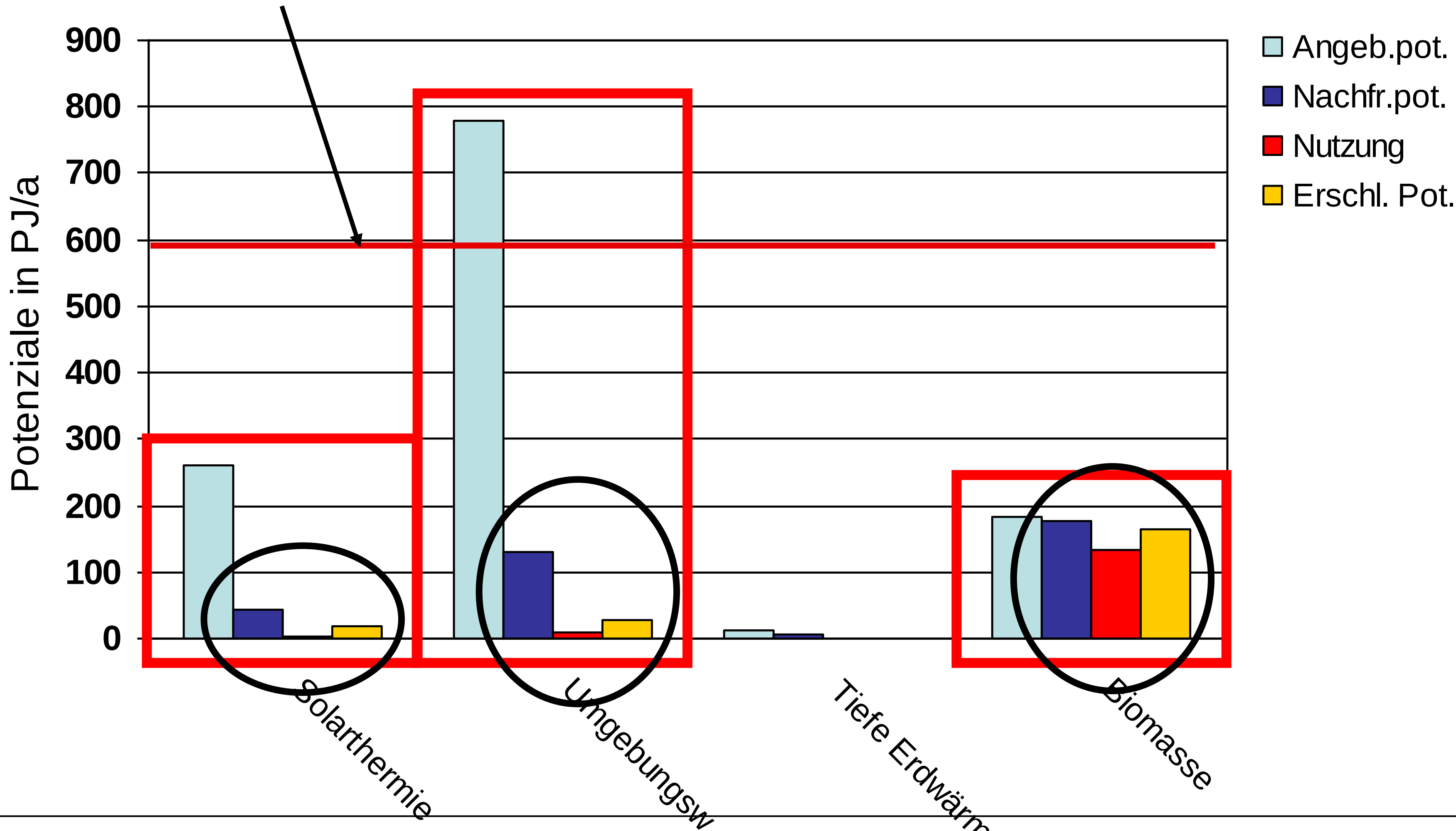
# Definition of Potentials



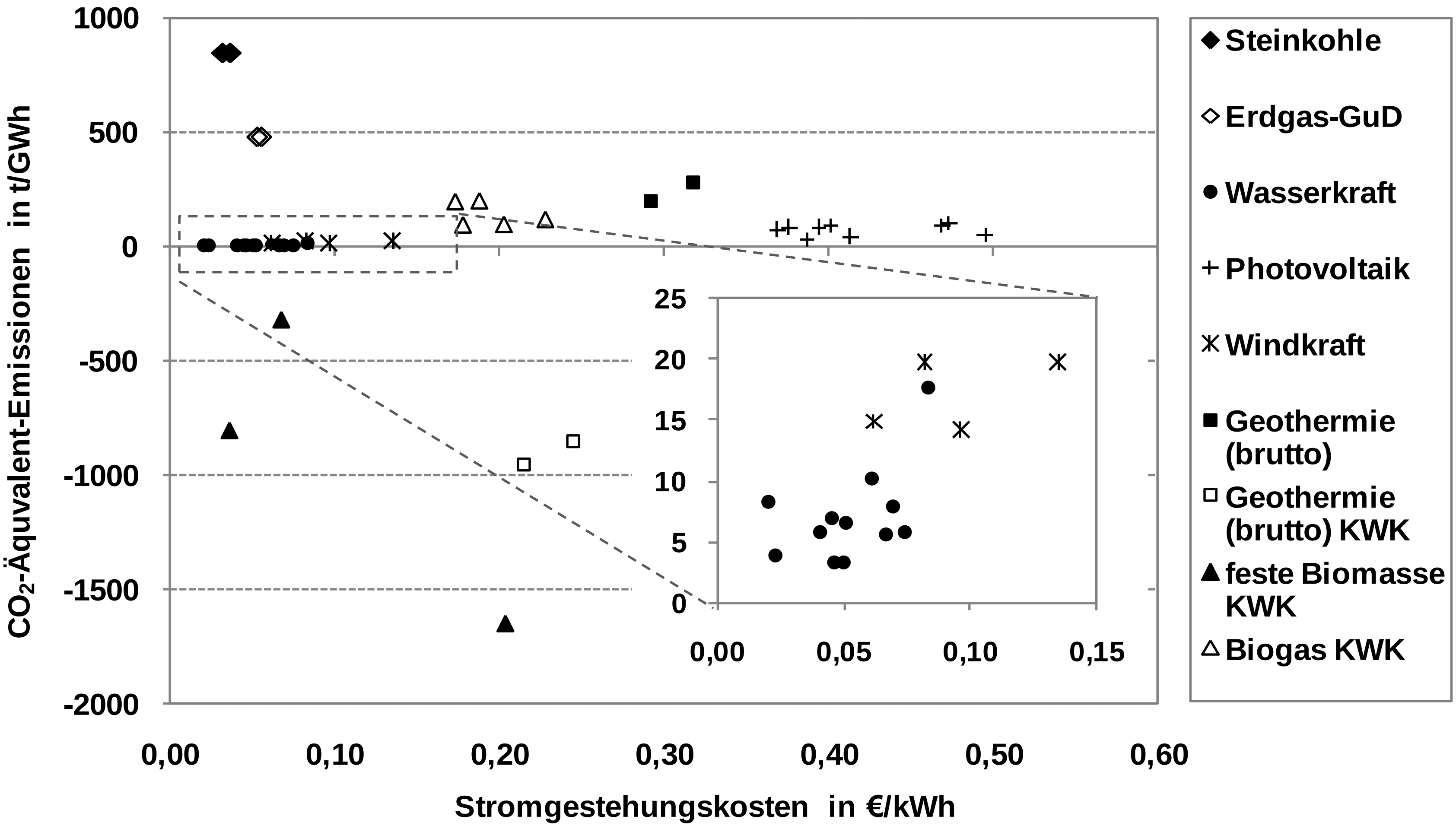
# Electrical Energy – Medium term potentials in Austria



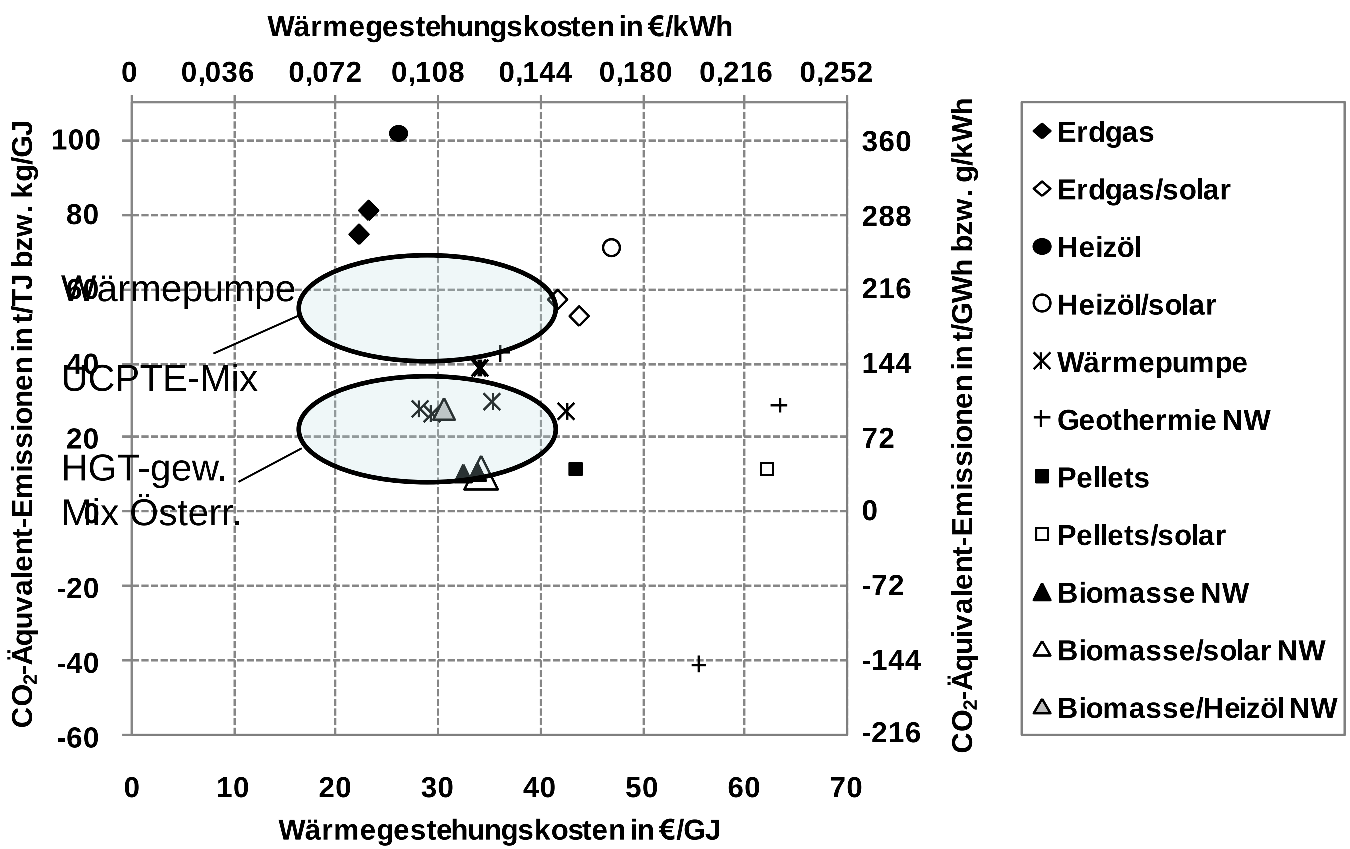
# Thermal Energy – Medium term potentials in Austria Demand 2006: 592 PJ (DHW+SH), 251 PJ process heat



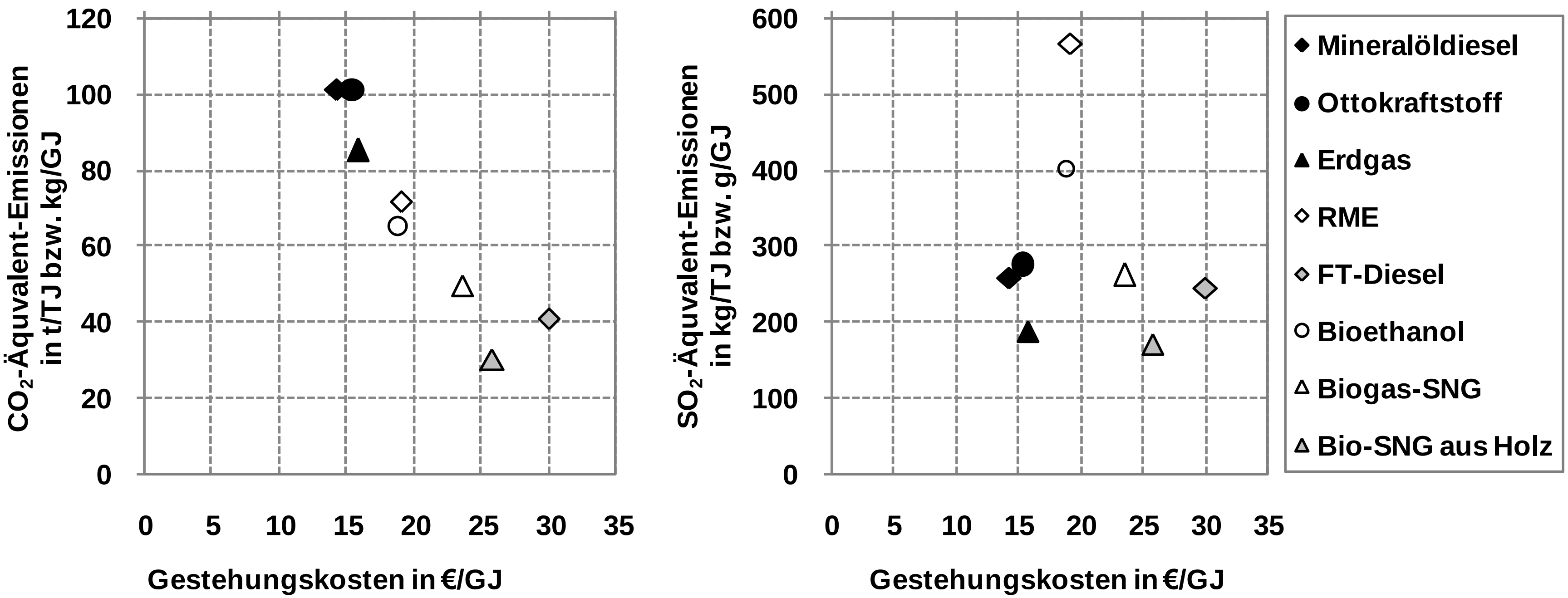
# Electricity specific CO2-equivalent-emissions – electricity generation costs



# 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



# Energyautarky Austria 2050
# Feasibility Study

lebensministerium.at

## Lead, Overall Modell

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### Sector Industry/Production

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### Sector Buildings

Florian Tatzber, Richard Heimrath, Ina Wetz, TU Graz, Institut für Wärmetechnik

### Sector Transportation

Stefan Hausberger, TU Graz, Institut für Verbrennungskraftmaschinen und Thermodynamik
Andrea Damm, Karl Steininger, Universität Graz - Wegener Center for Climate and Global Change

### Sector Energy Economy

Reinhard Haas, Gerald Kalt, TU Wien, Institut für Elektrische Anlagen und Energiewirtschaft, Energy Economics Group
Stephan Oblasser, Landesenergiebeauftragter Tirol

### Review

Michael Cerveny, Andreas Veigl, ÖGUT, Wien

### Consulting

Martin Kaltschmitt, Universität Hamburg-Harburg

# Boundary Conditions

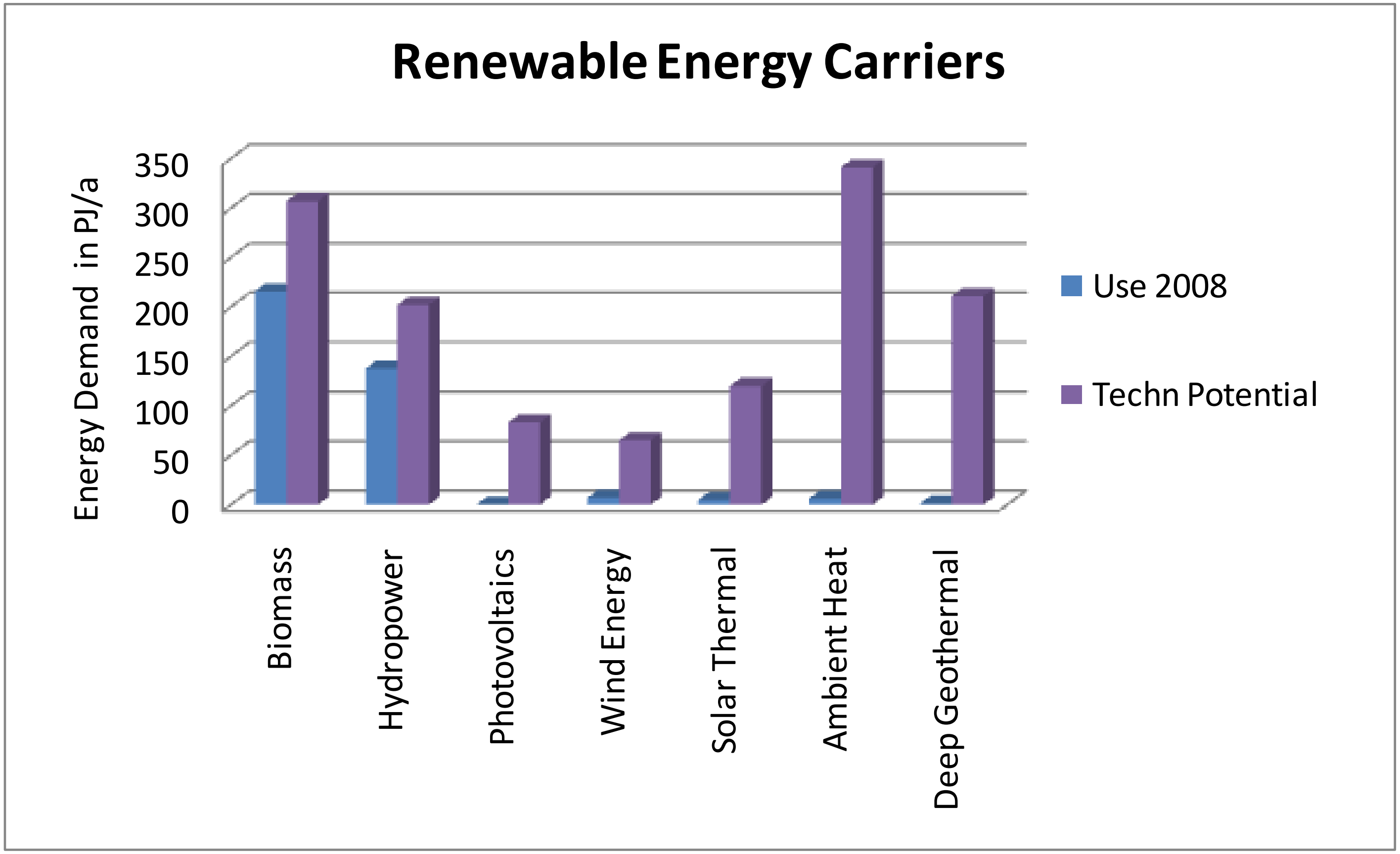
- Only Potentials of Renewable Energy Carriers from Austria (biomass, water, wind, sun, ambient heat, deep geothermal heat)
- Daily and weekly electricity exchange with neighbouring countries (European Context)
- Seasonal storage of electricity and Bio fuels in Austria
- Constant agricultural area for food and animal feed
- No fossil energy carriers, no nuclear energy
- „Backpack“ from imported food and goods is NOT taken into account (about 44 % of today fossil energy needs).
- Included sectors: Buildings, Mobility and Production (Industry)
- NO economic analysis

## 2 Scenarios

- *Constant-Scenario*: Constant Energy service until 2050 (conditioned m² building floor area, Pkm, tkm, constant gross value added of the industry)
- *Growth-Scenario*: Increase of the energy services by 0,8 %/a (ca. 40 % total growth from 2008 to 2050)

=> No reduction of population needs

# Current Use and Technical Potential of Renewable Energies in Austria

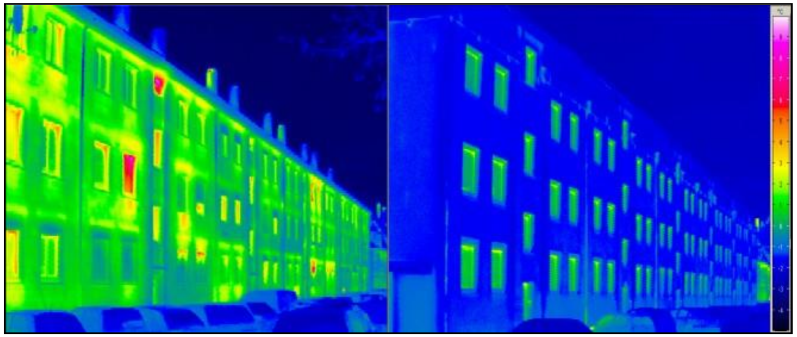


# Solutions:

Reduction of Energy Demand Buildings

- High Level Thermal Renovation of Old Buildings
- Building Codes, Spatial Planning

  MFH rather than SFH



# Solutions:

Reduction of Energy Demand in Mobility

- Spatial planning (Mixed Land Use)
- Modal Split (Switch to Public Transportation and Non Motorized Traffic)
  (= Infrastructure)
- Low Fleet Fuel Demand, E-Mobility
- Interregional/International transport 100 % on rail

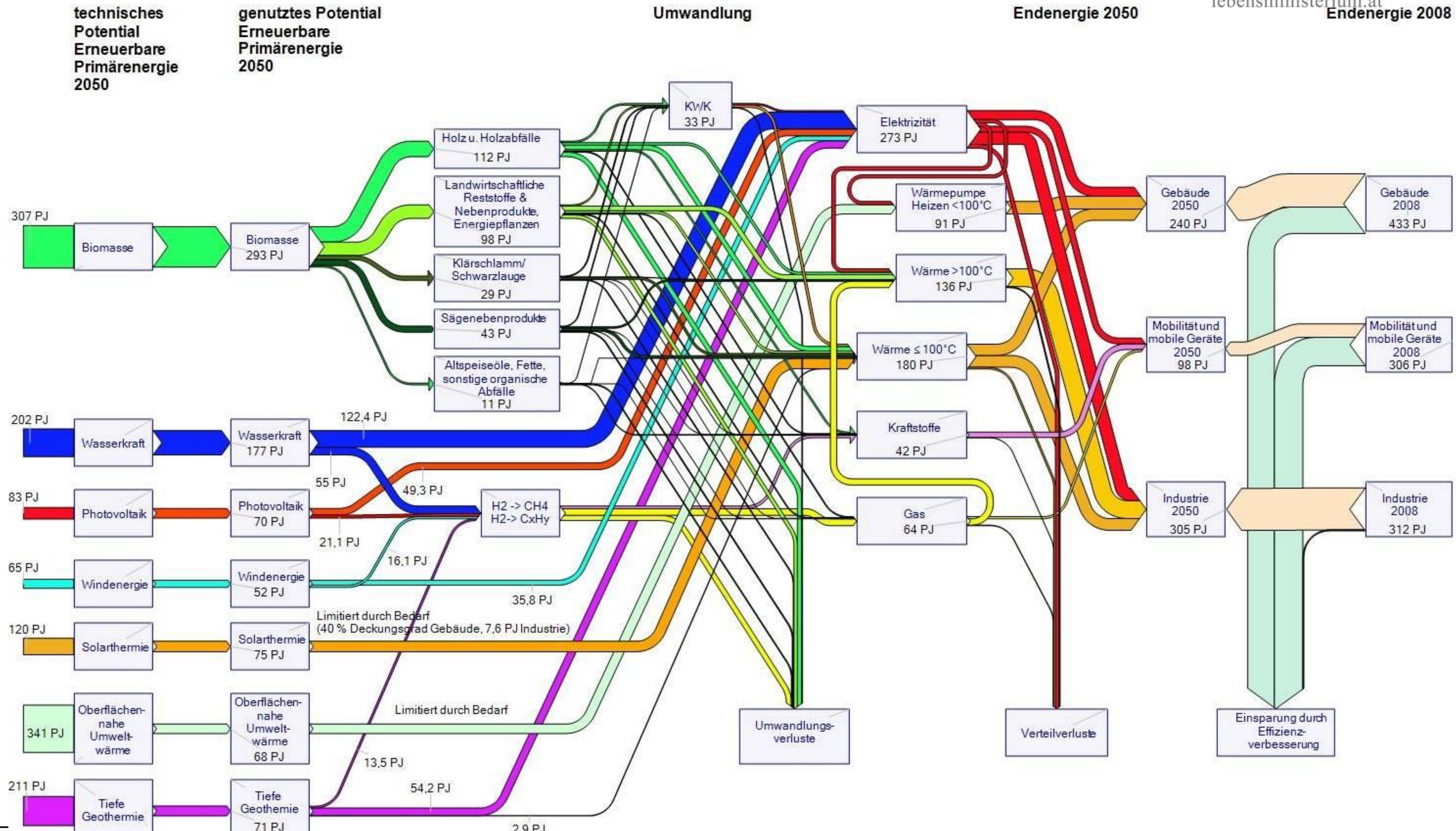



# Solutions:

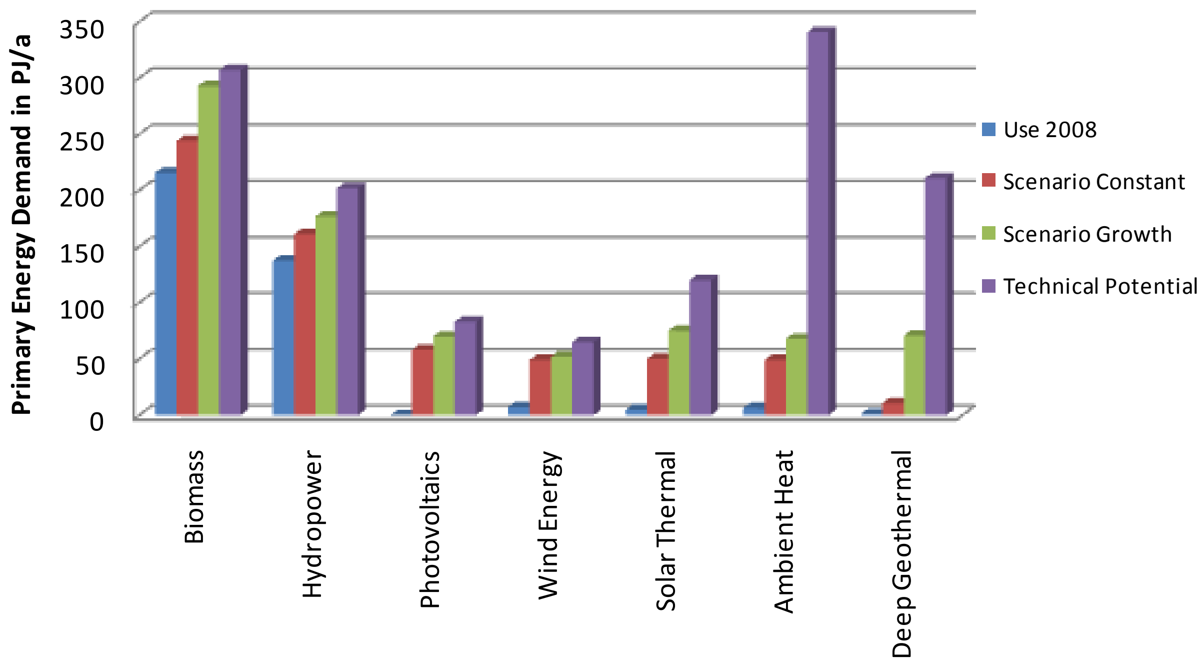
Reduction of the Energy Demand in Industry

- European Union Energie Efficiency Directive = 1 %/a Increase of Efficiency per Country
- Technological Progress

Energieflussbild Österreich 2050 100 % energieautark
Wachstum der Energiedienstleistung um 0,8 %/a

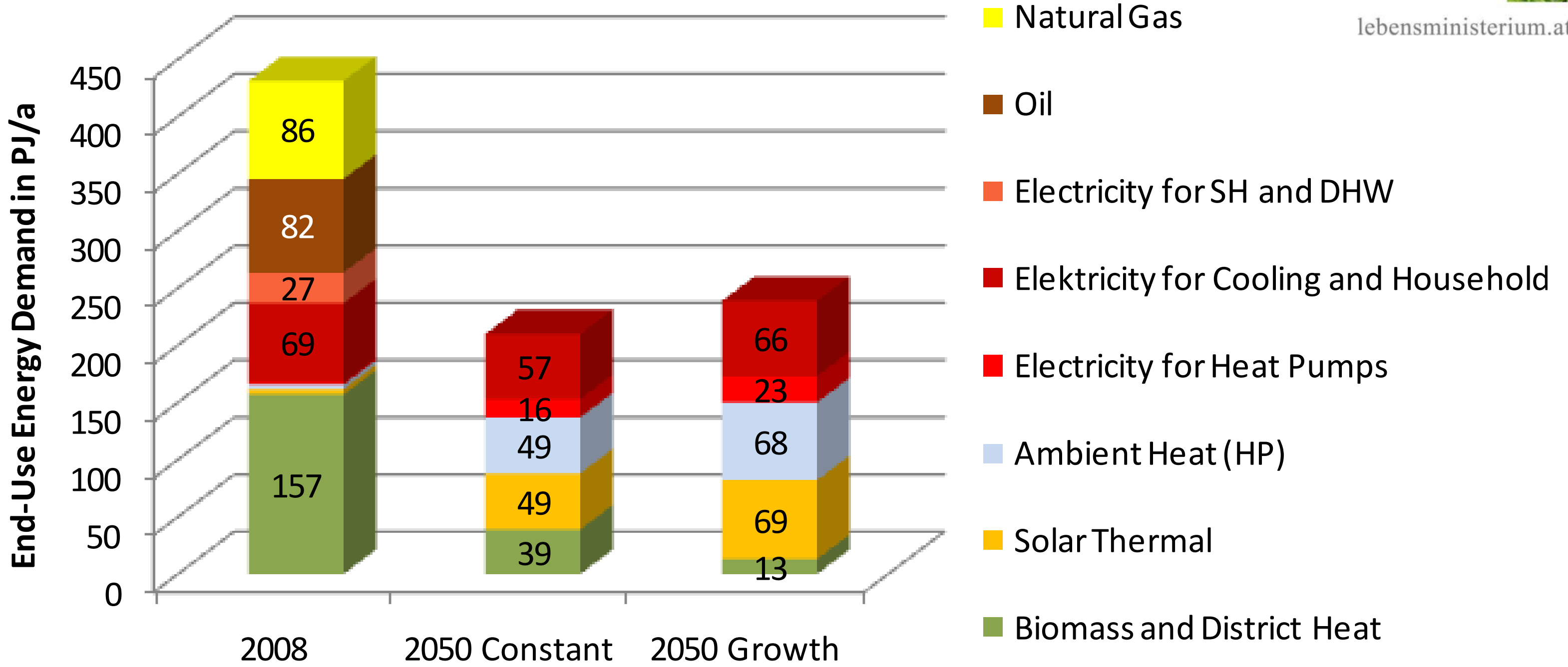


# Results: Primary Energy Renewable Energy Carriers




- **Potentials are nearly used up in the Growth Scenario**
- **Strong Increase for PV, Wind, Solar Thermal, Ambient Heat, Deep Geothermal**
- **Increase of the power of Pumping Power Stations by 85 % bzw. 130 %**

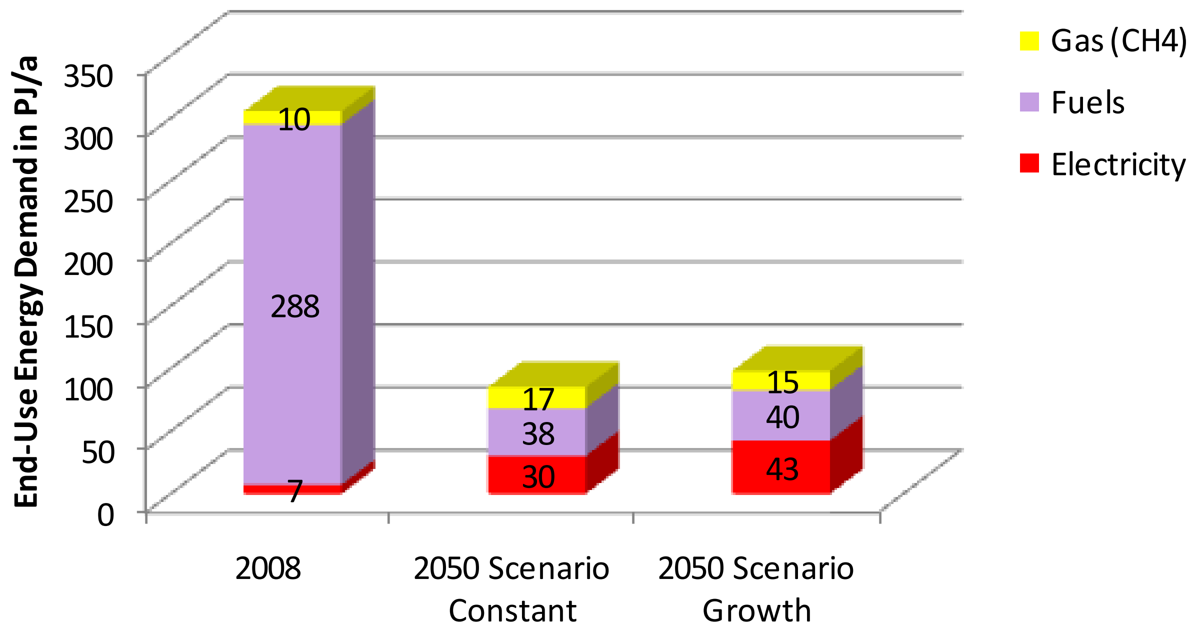
# Results Buildings




- **Ca. 50 % Energy Demand Reduction =>**
  **High Level Thermal Renovation of Old Buildings, New Buildings as Passive Houses**

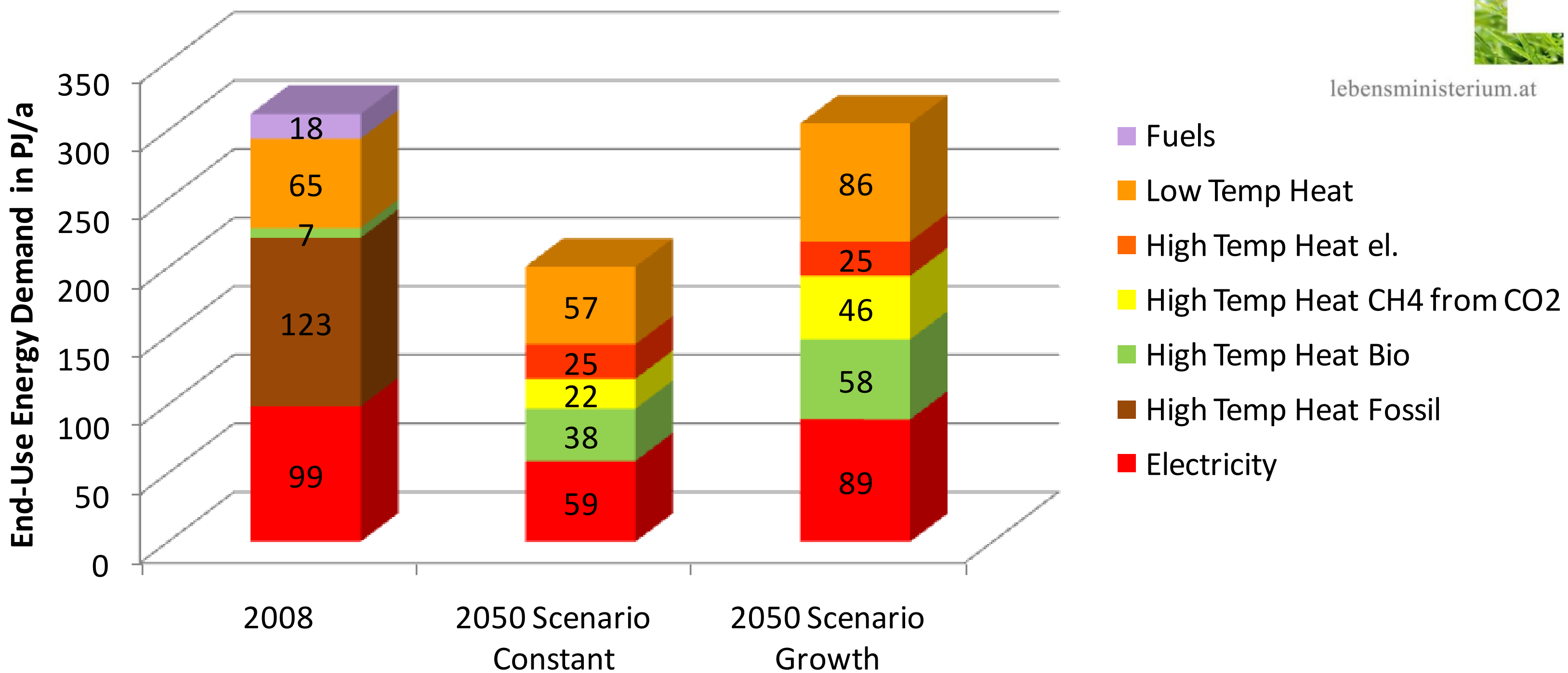
- **Switch to Solar Thermal, Heat Pumps, Reduction of Househol Electricity Demand**
  **(Biomass is used mainly in Mobility and Industry, especially in the Growth Scenario**

# Results Mobility




- **Ca. 70 % Reduction of Energy Demand =>**
  **Non Motorized Individual Traffic, Public Transportation, E-Vehicles (lightweight) 12 kWh/100km), Cars < 3 ltr/100 km, Long Distant Good Transport 100 % on Rail**
- **Strong Increase of Public Transportation (Infrastructure)**
- **Fuels and $CH_4$ from Biomass as well as $CO_2$ from Athmosphere and $H_2$ from water (Fischer Tropsch)**

# Results Industry




- **Ca. 35 % reduction (Constant-Scenario) e.g. constant demand (Growth Scenario) => this equals the EU Energy Efficiency Directive**
- **Low Temperature heat also from Solar Thermal, High Temperature Heat from $CH_4$ (from El. + $CO_2$) , Biomass, Electricity**

# Results

- Energy Autarky is Theoretically Possible Without a Reduction of the Energy Services
- For a growth of the Energy Services (due to an increase of the population or an increase per person) over 0,8 %a a complete coverage of the energy demand will need additional effort in energy demand reduction
- The Needed Increase of the Energy Efficiency for the Scenarios of this Study already imply a Crucial Change of the Energy System and the form of the Energy Services
- The Degree of Freedom is Relatively Small, as the Potentials of Renewable Energy Carriers have to be Used Nearly Completely
- The Electricity Economy has to be seen always in a European Context
- To be able to Reach Energy Autarky in 2050 the Political Framework Conditions have to be set already Today