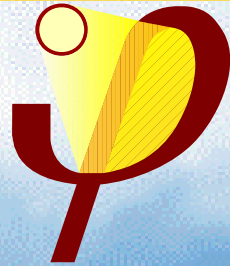
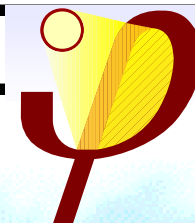


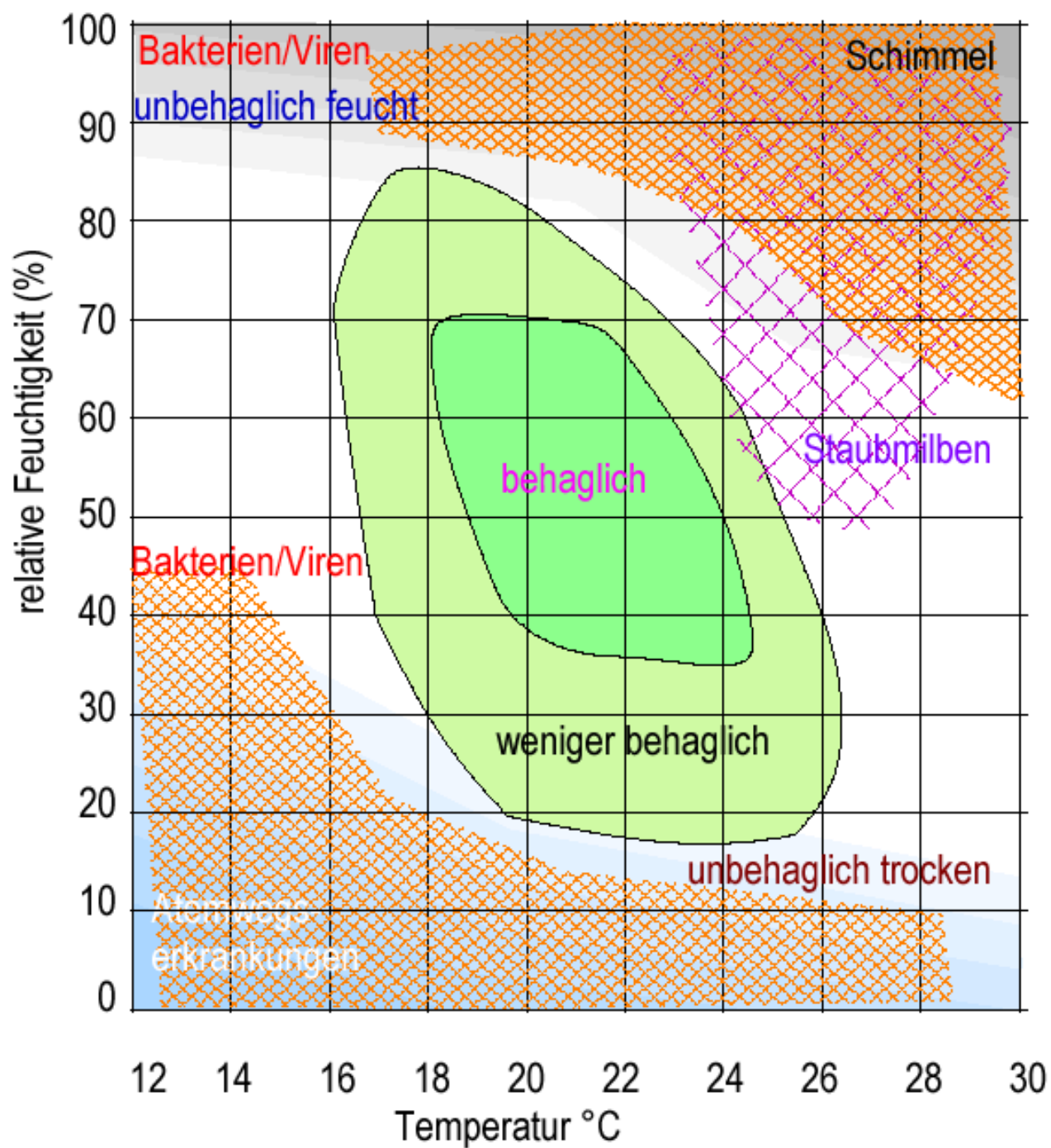
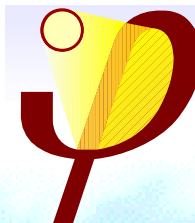
Objectives of Ventilation



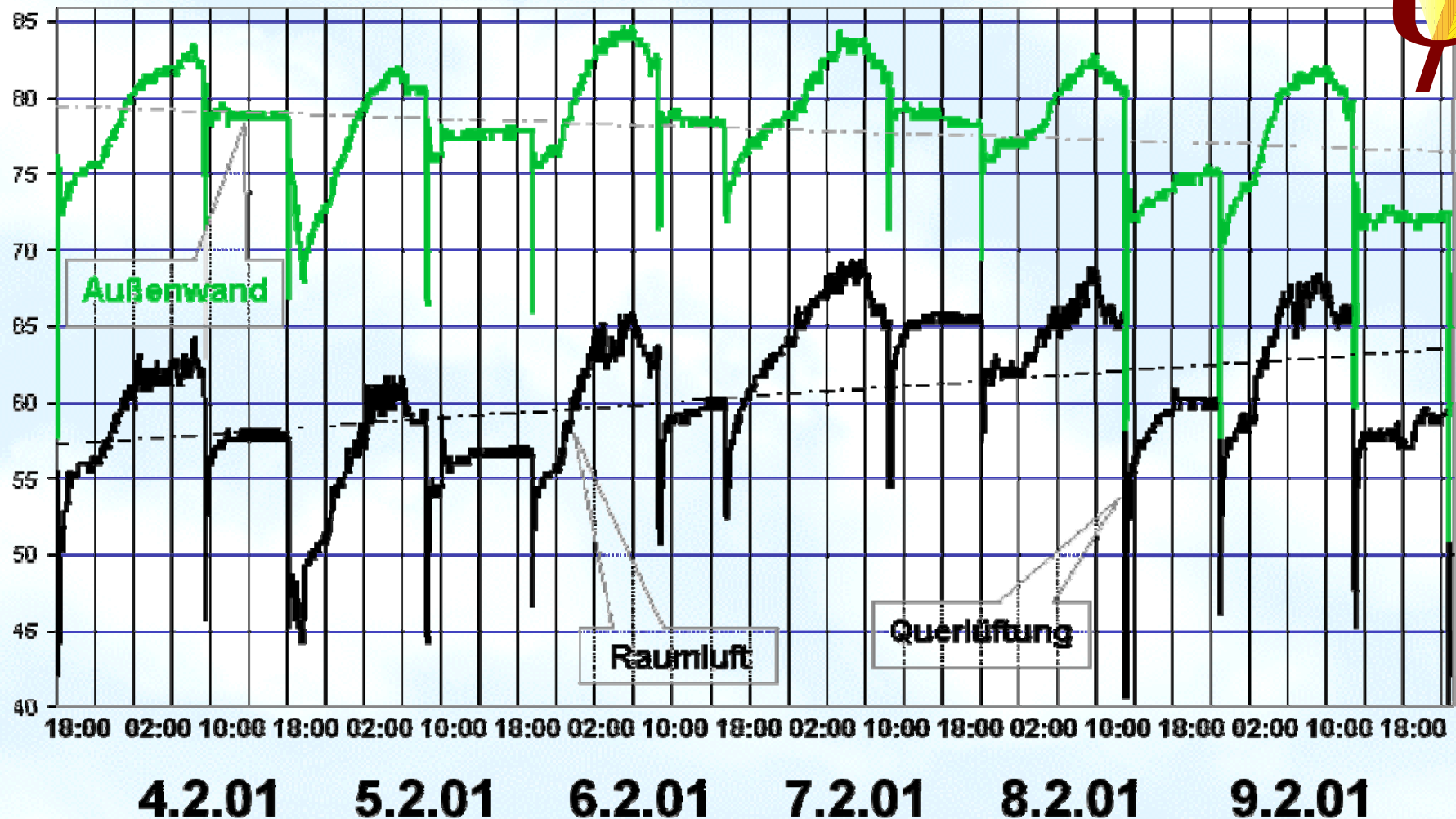
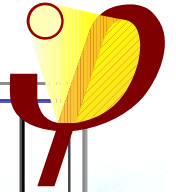
- Delivery of fresh air.
- Removal of IA Pollutants.



Schadgas	Wirkung
Schlechte Gerüche	meist harmlos aber unangenehm
H ₂ O	Zu gering: Austrocknung der Schleimhäute, verstärkter Staubanfall, zu hoch: Kondensatbildung, Schimmelpilz (über 60 %rF), Hausstaubmilbenwachstum
N ₂ O, NO, NO ₂	In hohen Konzentrationen Schädigung des Lungengewebes
Formaldehyd-dämpfe	Ab Konzentrationen von 100 µg/m ³ Beeinträchtigung der Augen u. der oberen Atemwege, in Wohnungen tolerierbar: max. 120 µg/m ³
CO	Geruchlos, sehr giftig
CO ₂	In Innenräumen sollten 1500 ppm nicht überstiegen werden [DIN 1946-2], MAK 5000 ppm
O ₃	Hochgiftig, Reizung der Schleimhäute, in hohen Konzentrationen Schädigung der Atemwege, MAK 0,1 cm ³ Ozon pro m ³ Luft
Radon, Thoron	Zerfallsprodukte lagern sich an Staubpartikel in der Luft an und sind durch Inhalation lungengängig (Gefahr von Lungenkrebs), gemessener Mittelwert der Radonkonzentration in der Raumluft von Wohnungen 50 Bq/m ³ , kritischer Wert: 500 Bq/m ³ , Beseitigung durch Lüften, vorzugsweise im Bodenbereich (Keller)



r.F. von Raumluft und Wandoberfläche im Schlafzimmer



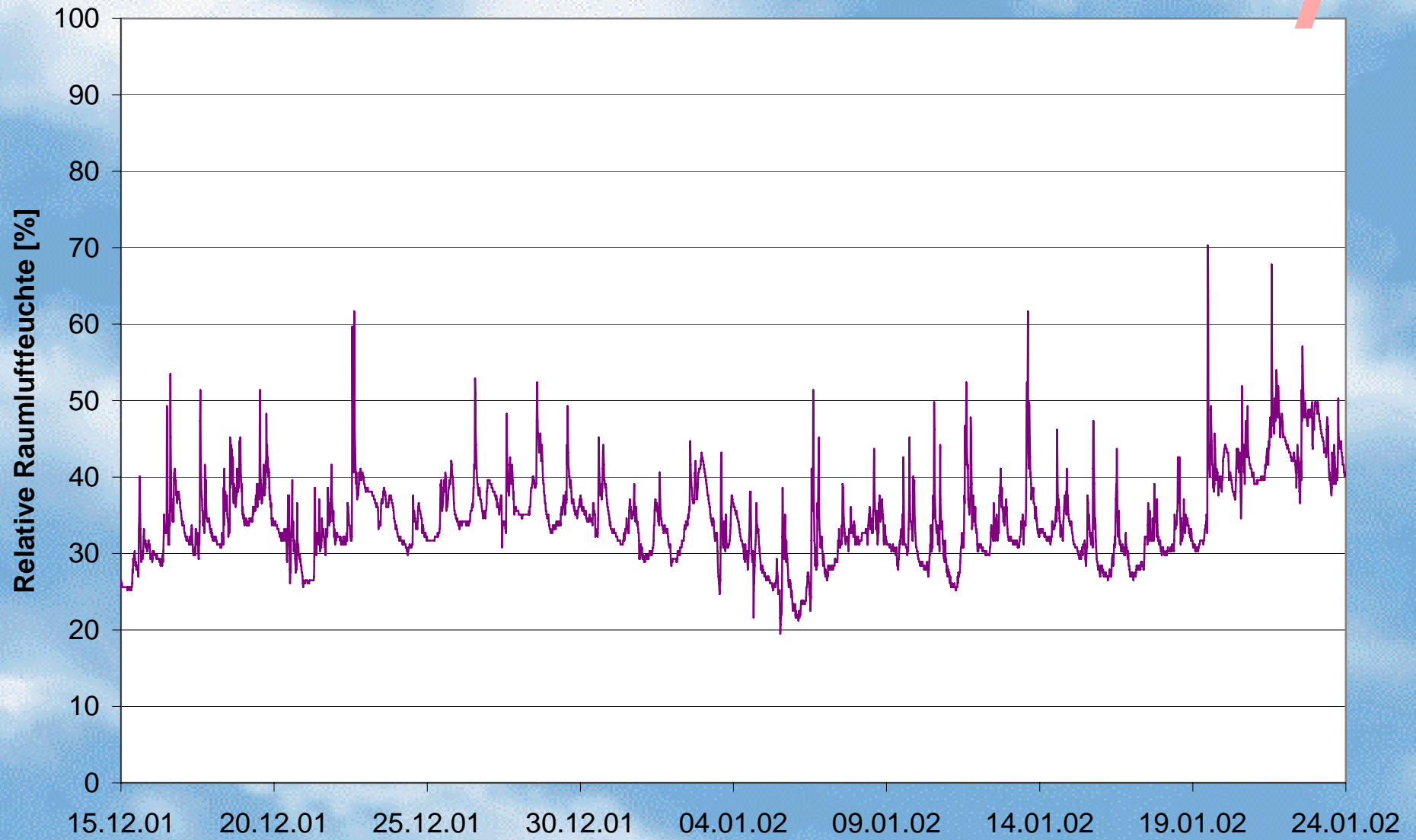
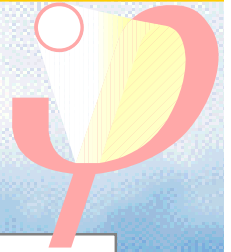
Quelle: U. Münzenberg,
Umwelt, Gebäude & Gesundheit

Grafik: Raumklimaaufnahme Altbau vom 03.2. bis 9.02.2001

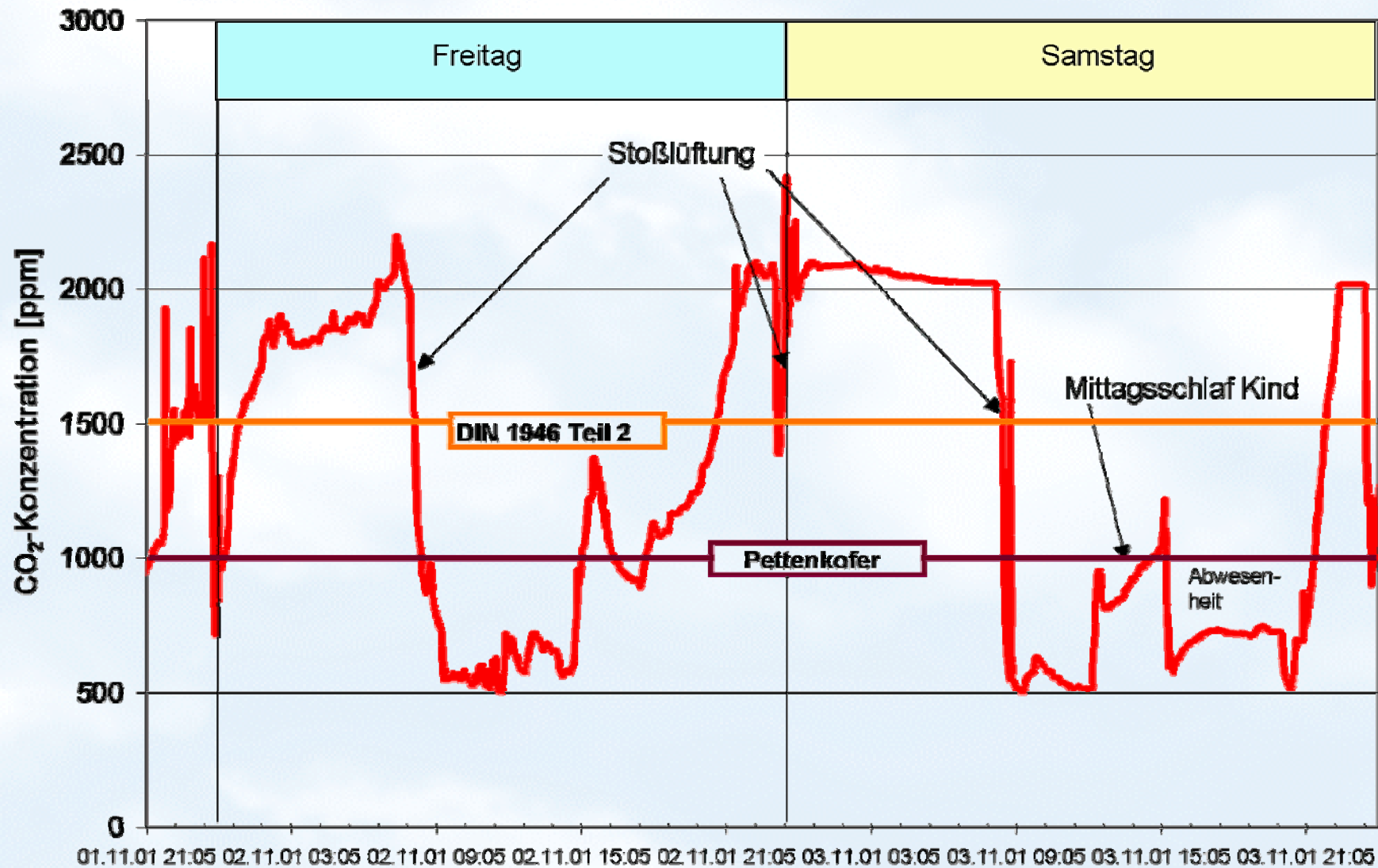
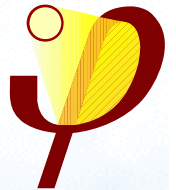
Consequence: Opening windows 2 times a day is not sufficient

Mesured Humidity in Passivhaus

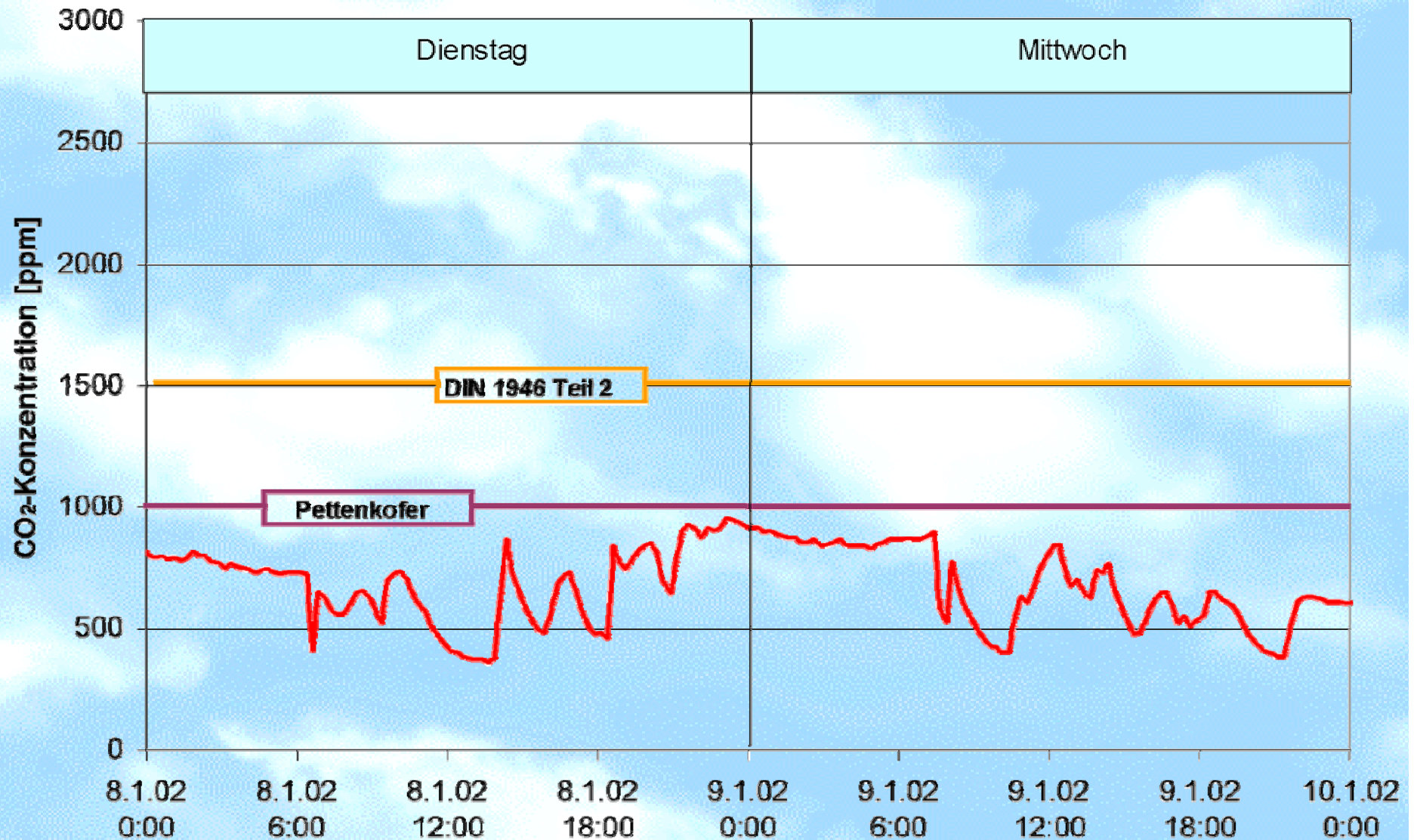
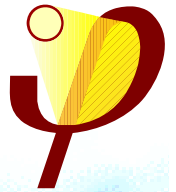
(Mesured at Kassel Marbachshöhe Winter 2001/2002)



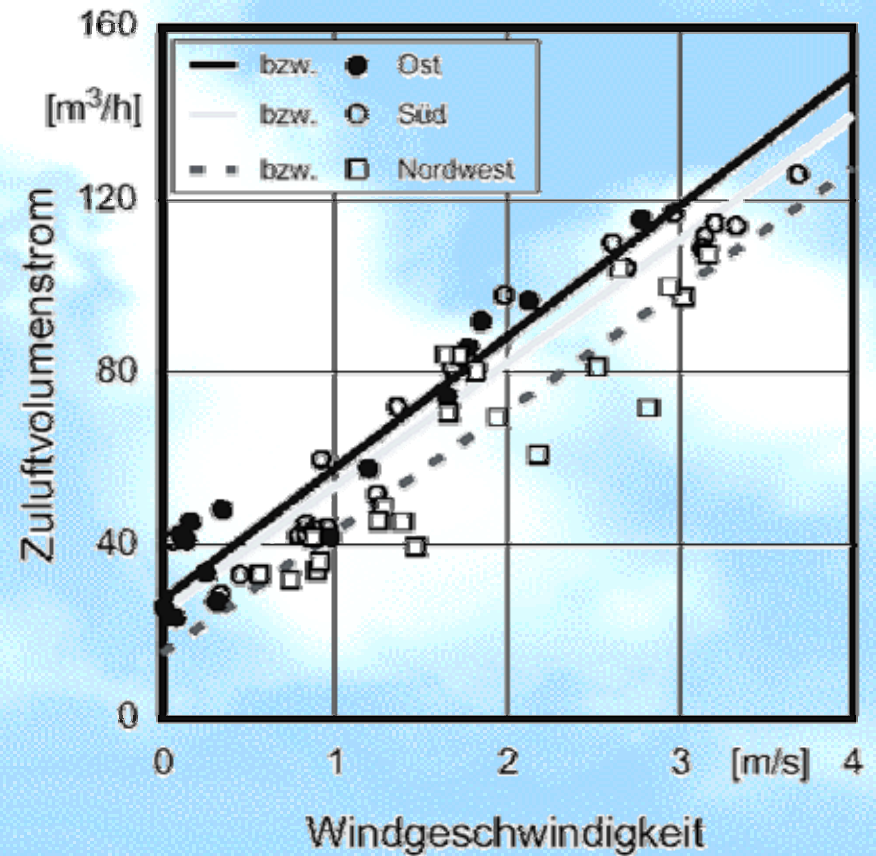
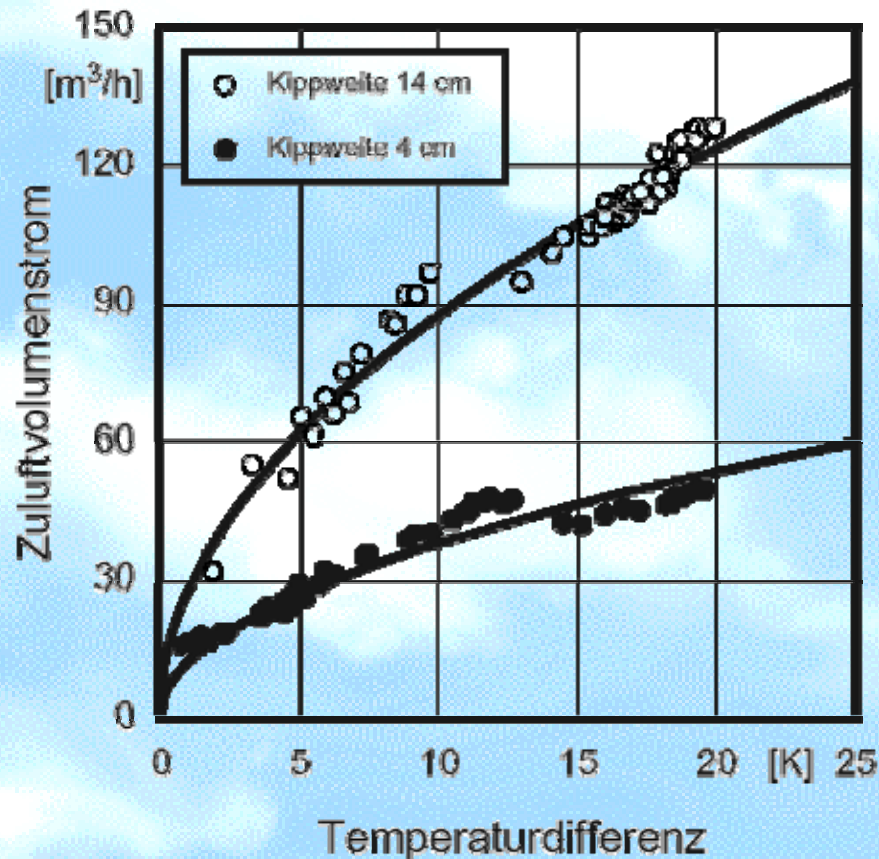
CO₂ ---- window opening



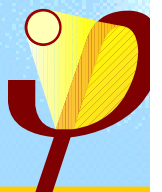
CO₂ – in a passive house (Measurements Kassel Marbachshöhe Winter 2001/2002)



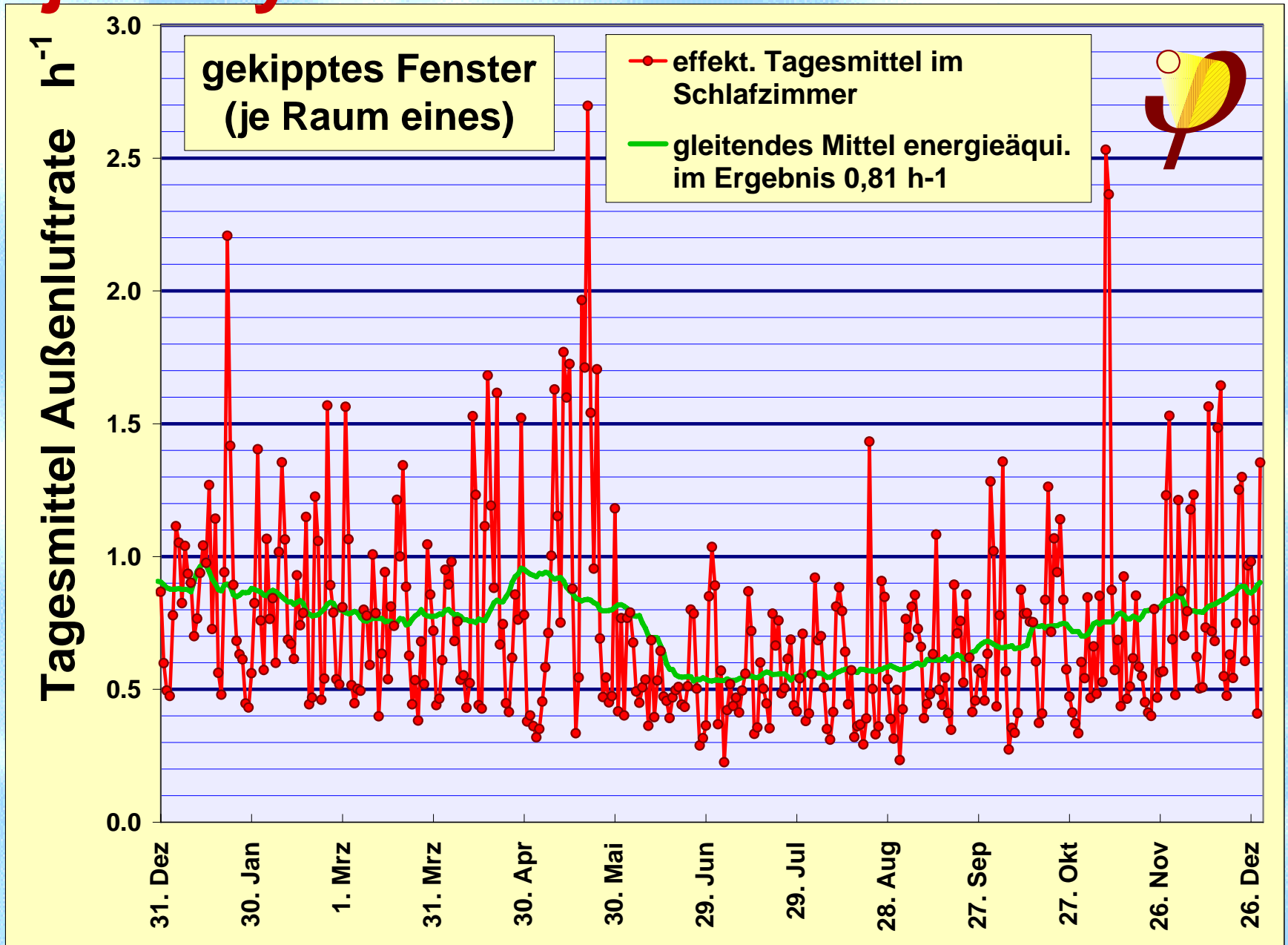
Windows: dependent from Temperature diff. and wind velocity



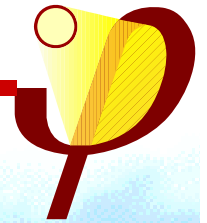
Quelle: Anton Maas,
Dissertation , Kassel, 1995



It is just by chance....

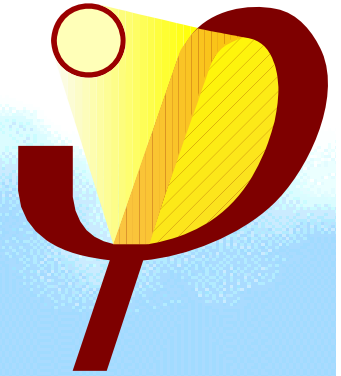


Fensterlüftung ist Zufallslüftung...



Well Working Ventilation:

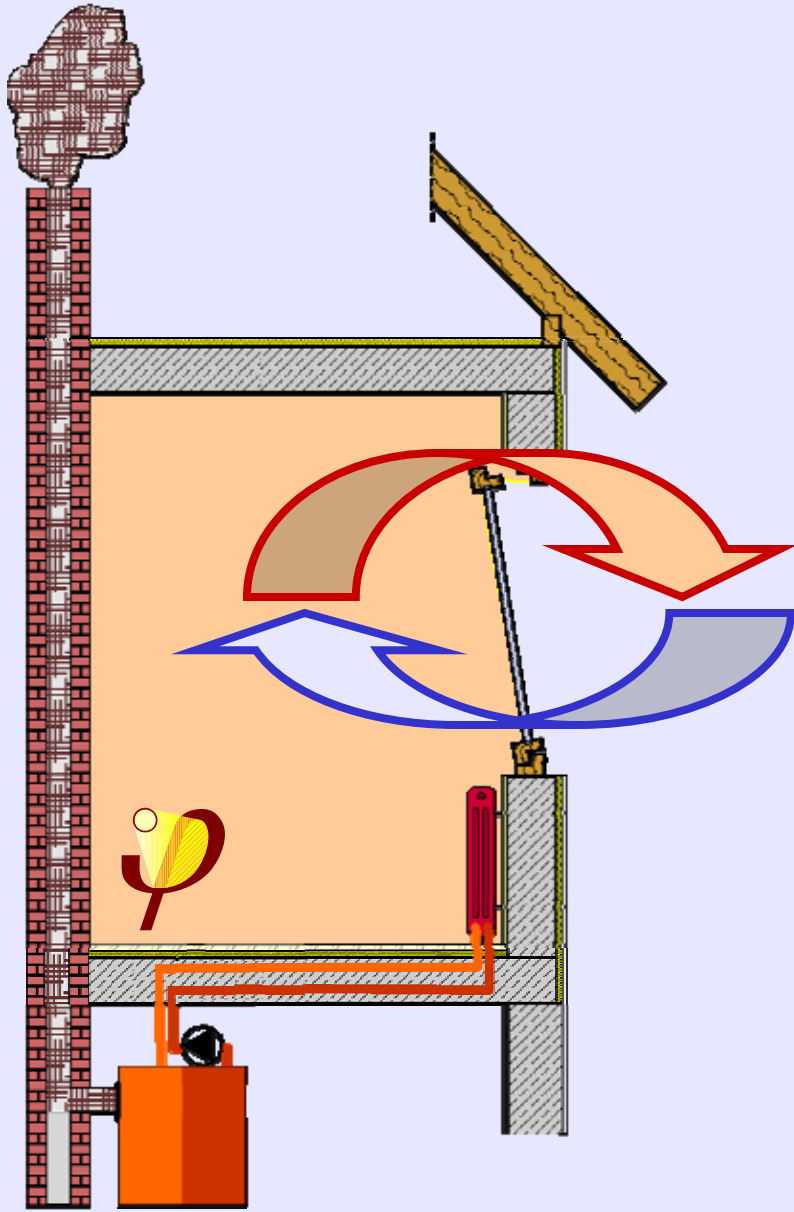
- operated by demand
- designed flow



Means: Balanced mechanical vent.

- concept and design
- supply ducts
- extract ducts
- inlets, internal flow, outlets
- IAQ, Filter
- heat recovery
- noise reduction

Ventilation is essential for indoor air quality

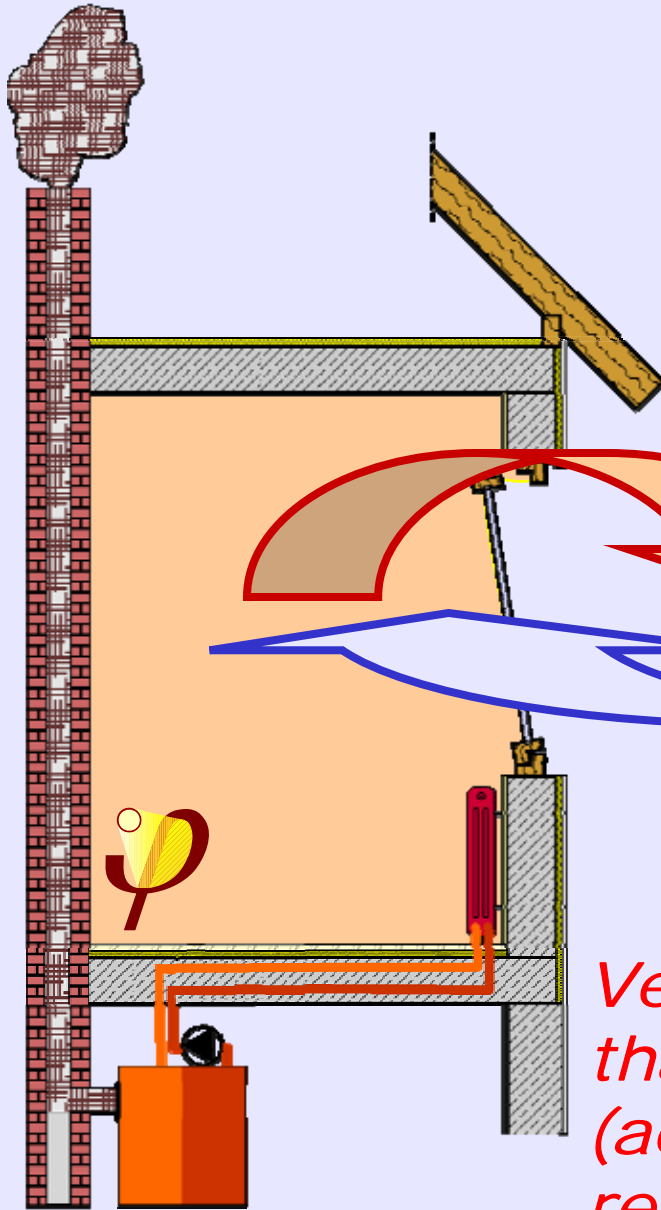


It is impossible to solve the problem by reducing the amount of fresh air delivered

- humidity
- CO₂
- VOC
- Radon
- ...

*At least:
30 m³/Person/h*

Ventilation Losses



$30 \text{ m}^3/\text{Person}/\text{h}$

$\cdot 0.33 \text{ Wh}/\text{m}^3/\text{K}$

$\cdot (20^\circ\text{C} - (-5^\circ\text{C}))$

$= 250 \text{ W} / \text{Person}$

Ventilation losses are much higher than free heat: No zero-energy (carbon) house without heat recovery in cold climates!

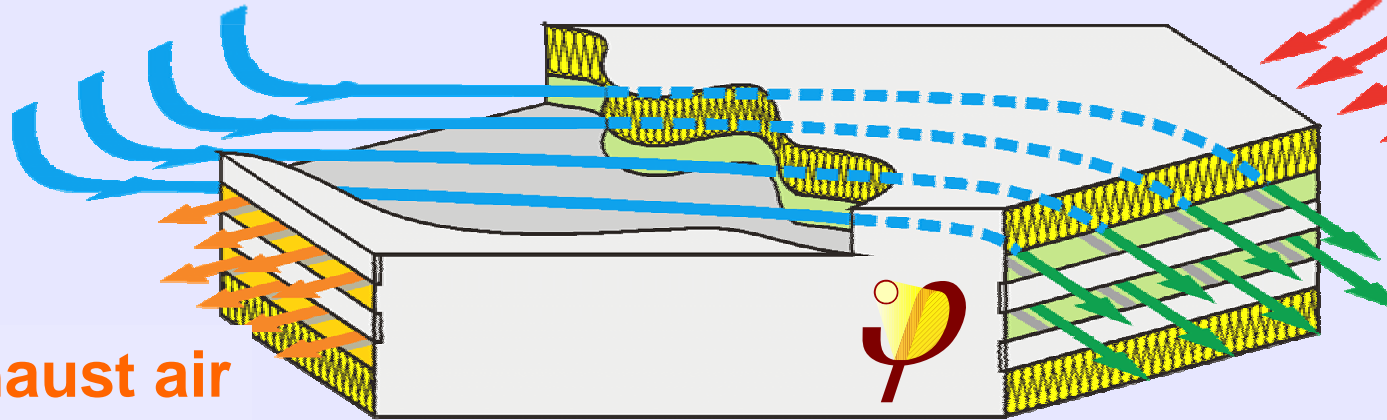
~~ventilation losses~~

Fresh air

Extract air

Exhaust air

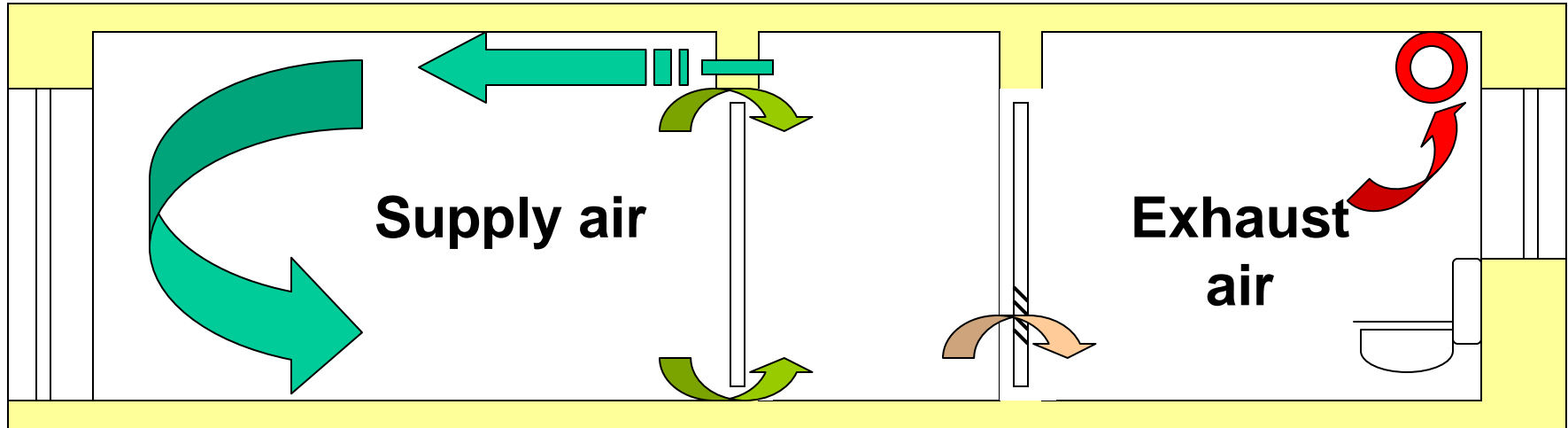
Supply air



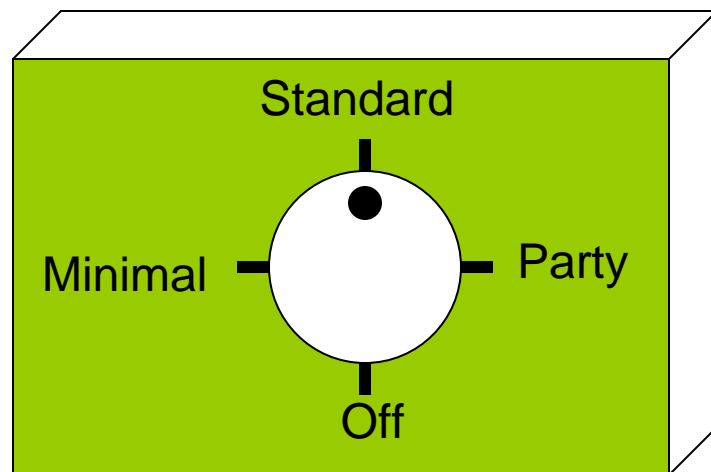
Efficient Technology:

*Ventilation with Heat Recovery.
Efficiency some 90%.*

Ventilation



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



Exhaust air demand

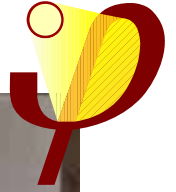
Kitchen: 60 m³/h

Bathroom: 40 m³/h

WC/other: 20 m³/h

Typical:

Home with kitchen & bath
60 + 40 = 100 m³/h



Ventilation

*→ simple
technology*

*→ small and
efficient*

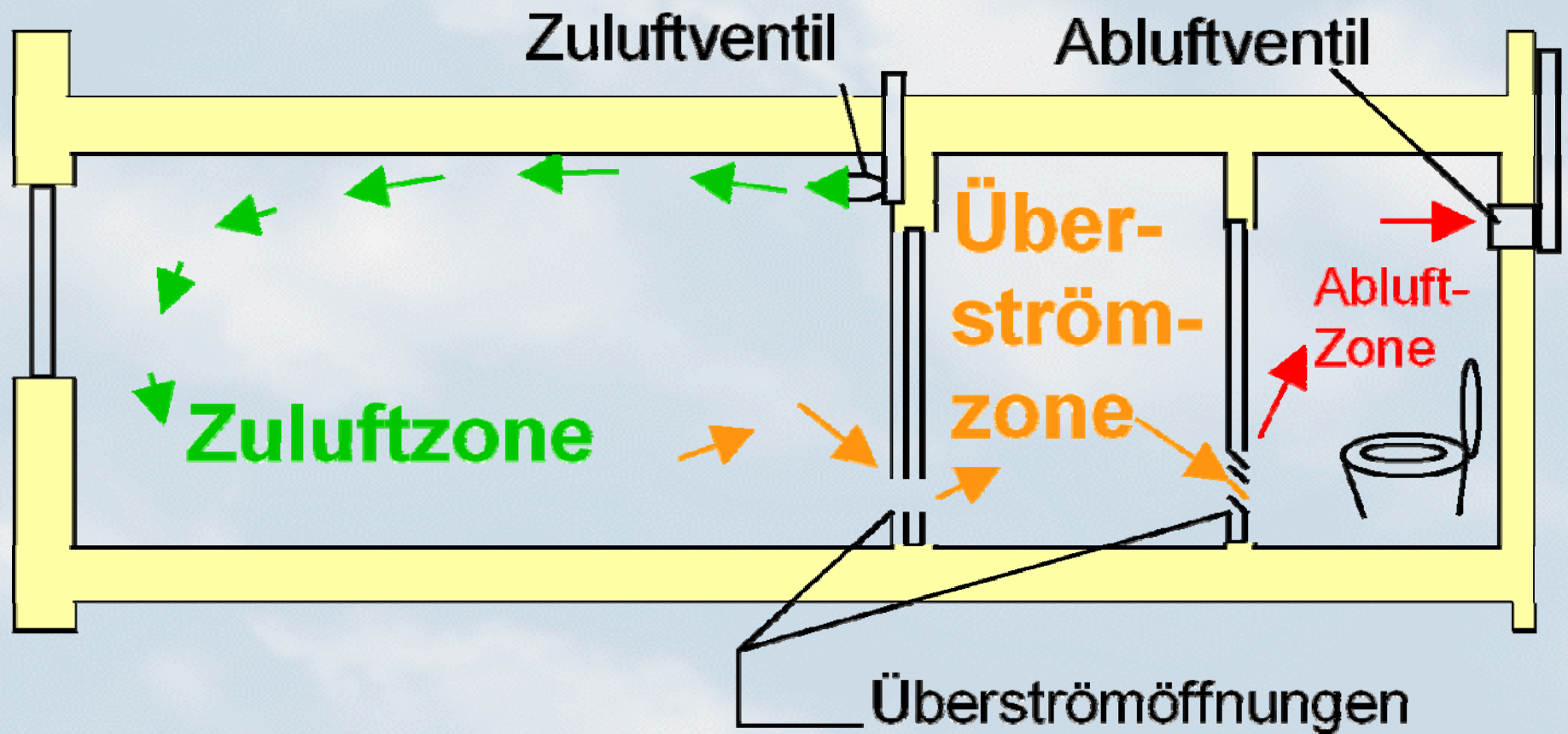


Directed flow

→ supply air

→ overflow area

→ extract air



IAQ fresh air requirement:

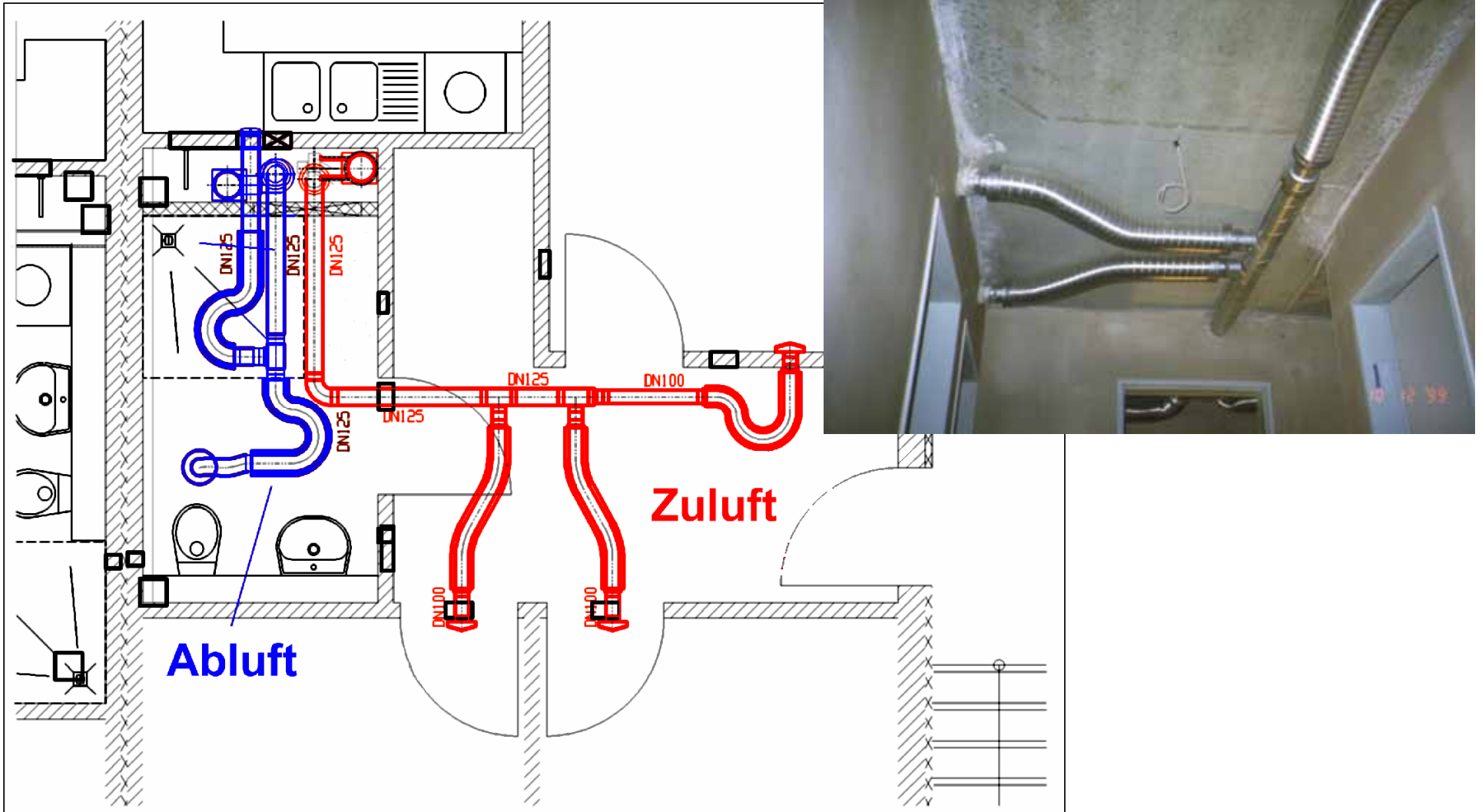


well approved: DIN 1946

Supply air: 20 to 30 m³/(person h)

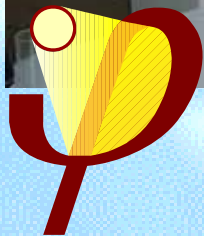
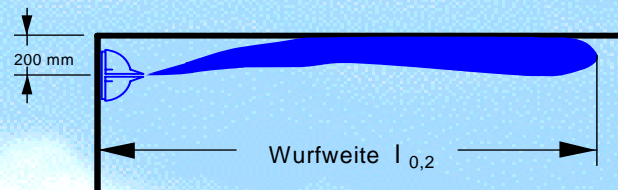
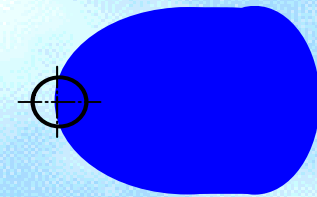
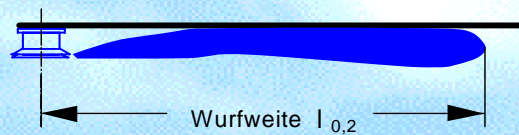
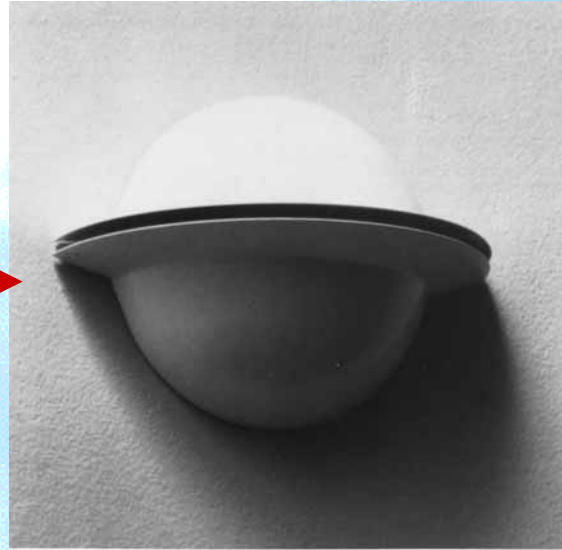
Extract air:

R o o m	M a s s f l o w
K i t c h e n	60 m³/h
B a t h r o o m s	40 m³/h
T o i l e t t e t c	20 m³/h



Example: **Passivhaus Kassel
Marbachshöhe**
design: **innovatec / Otte**

Supply air: use of Coanda effect



Weitwurfprinzip: Coanda-Effekt



**CEPHEUS-
Passive house
Wegere near
Luzern
Measurement by
Prof. Werner
Betschart
HTA Luzern**



*Frankfurt/M Germany Sophienhof
FAAG/ABG Frankfurt Architect Fuessler*

Blocks of Flats



*160 dwellings
14 767 m²
Passive House Technology*

*Extra buildings costs:
3-5% of the total b.c.*

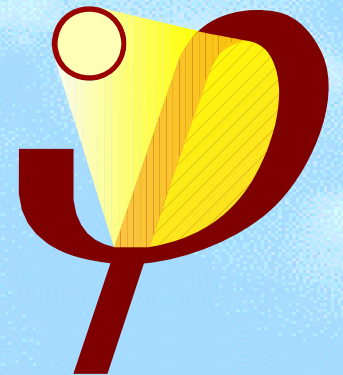
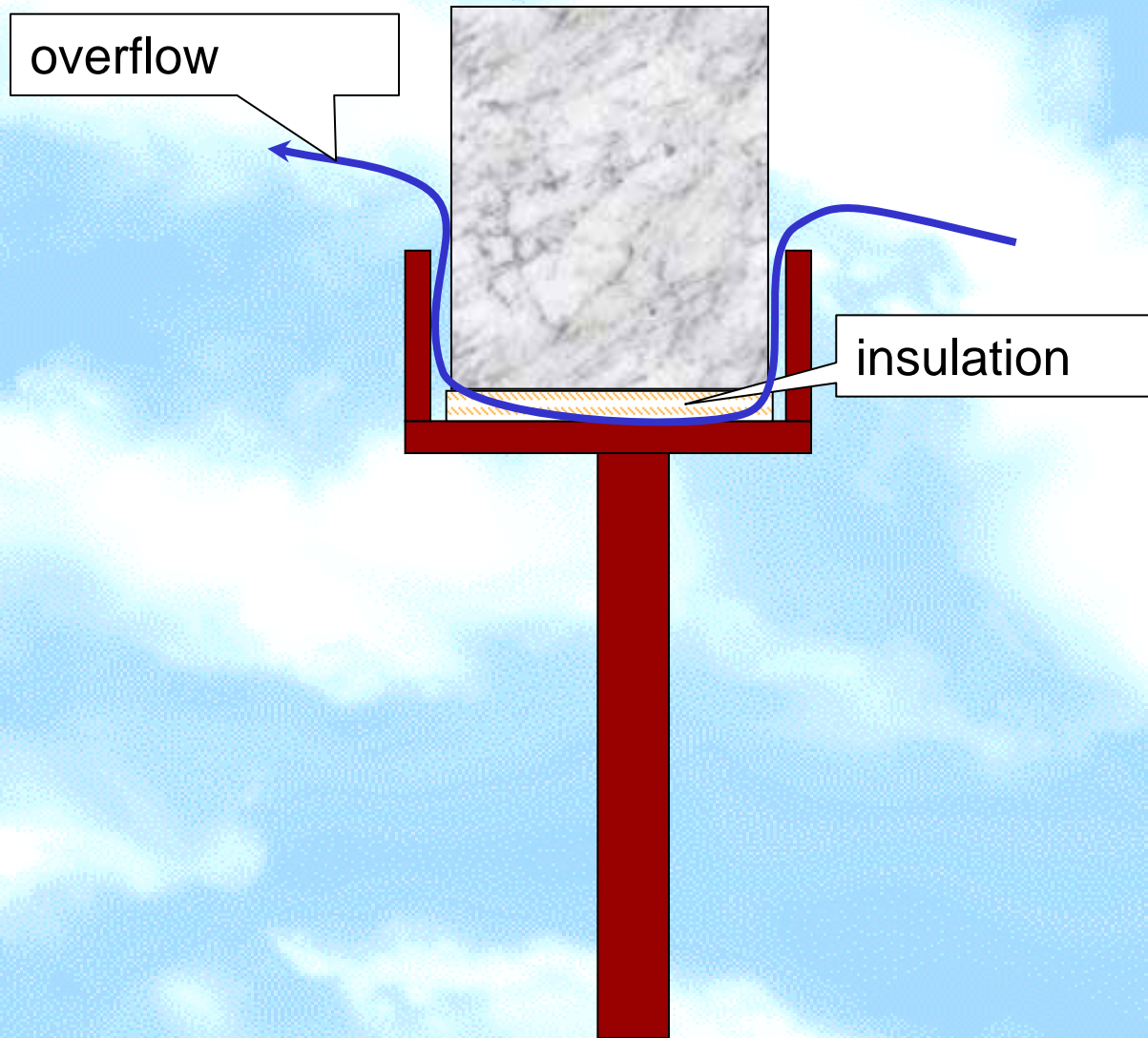


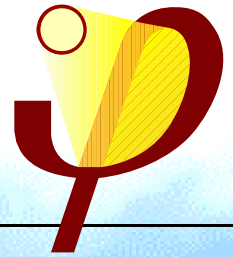




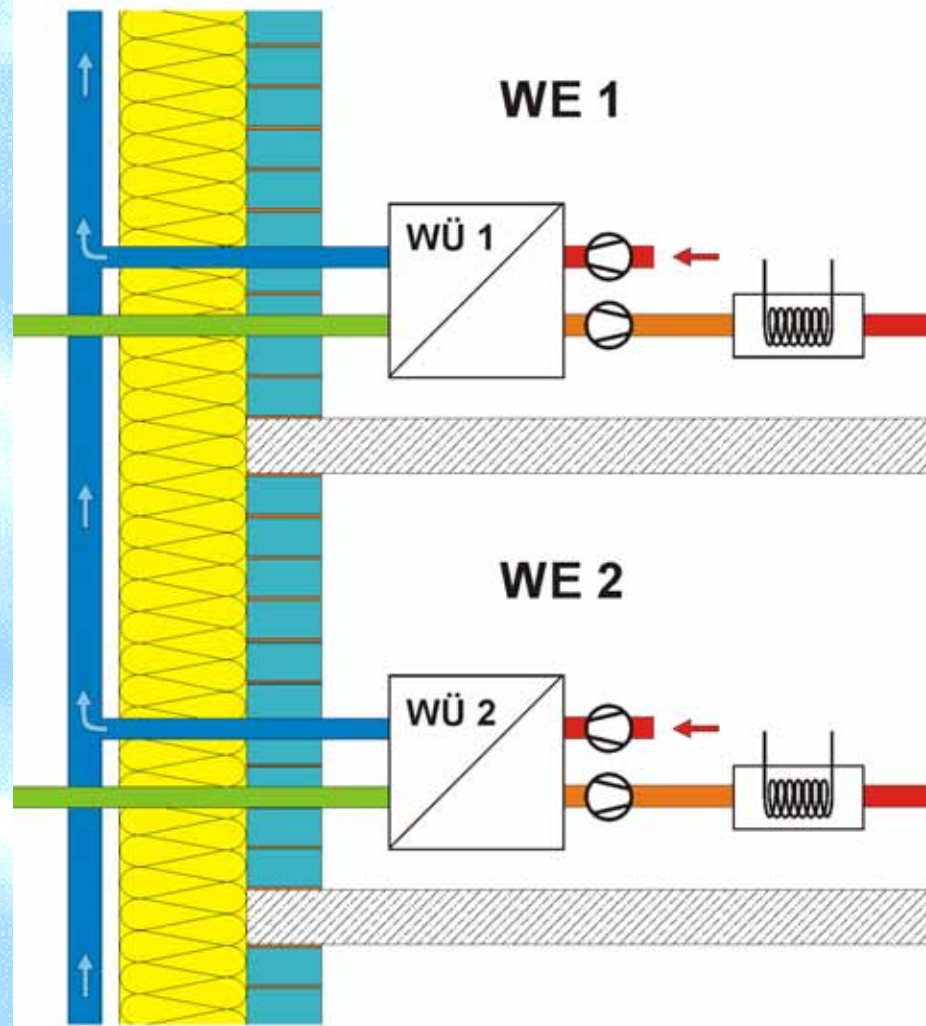
Supply air = Radiator

Internal valve

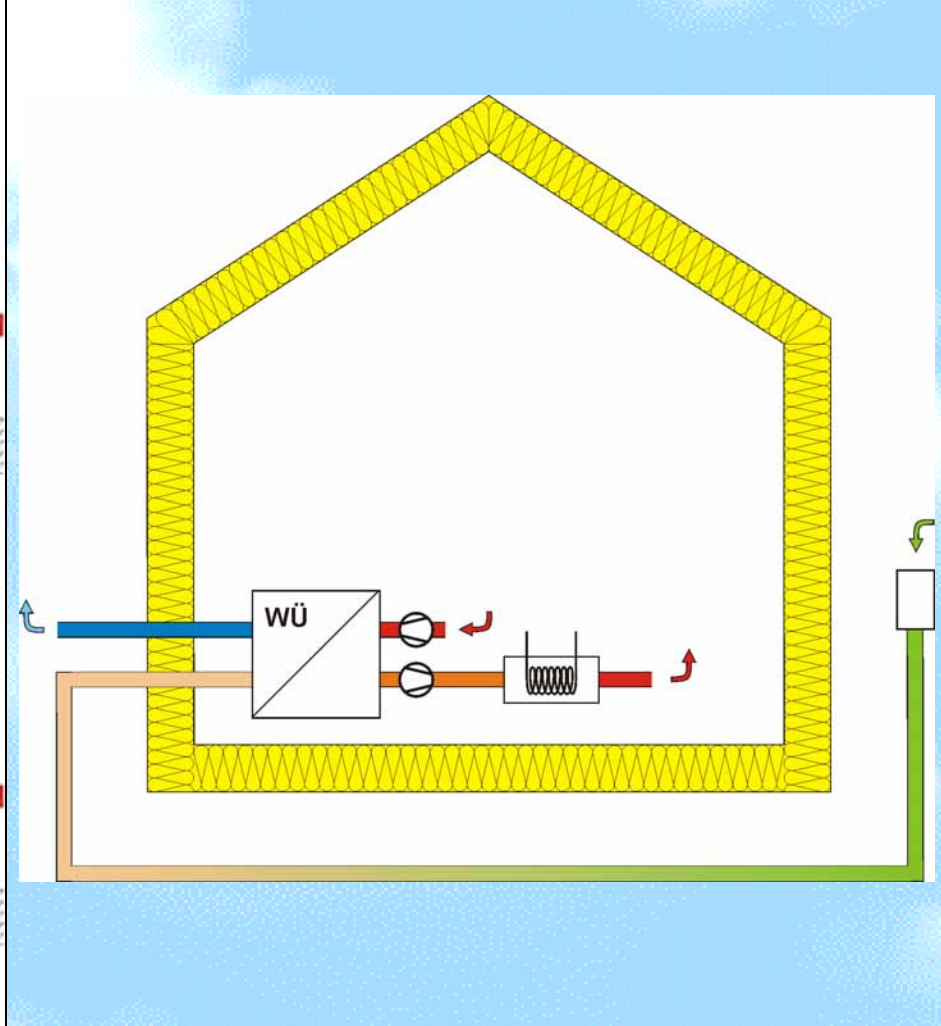




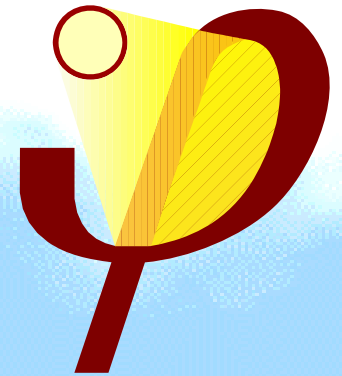
Dezentrale Anlage



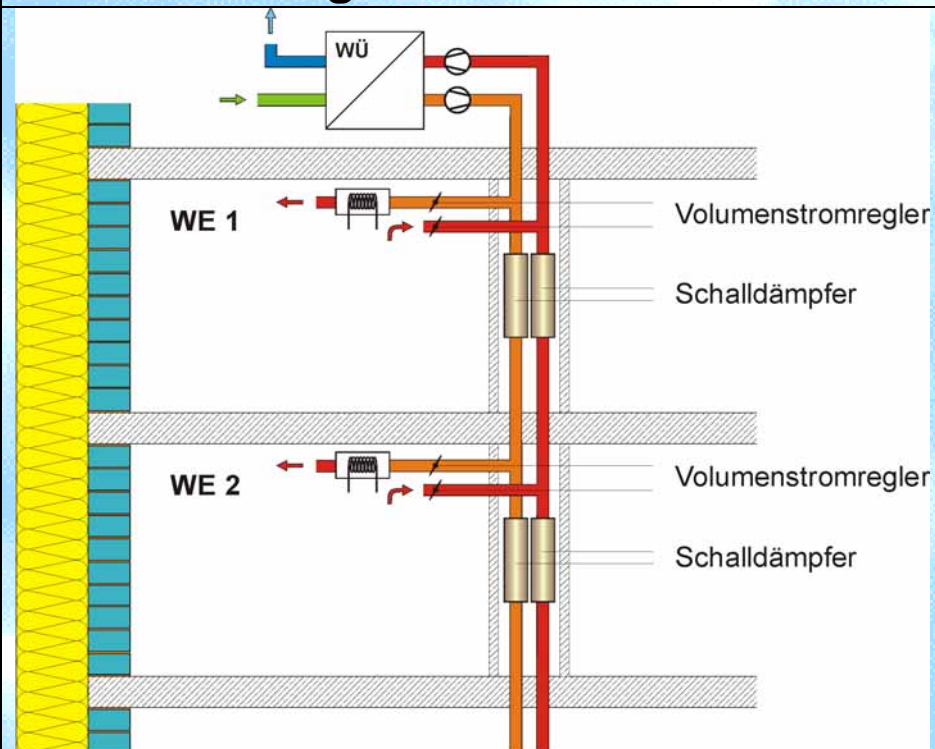
Geschoßwohnungsbau



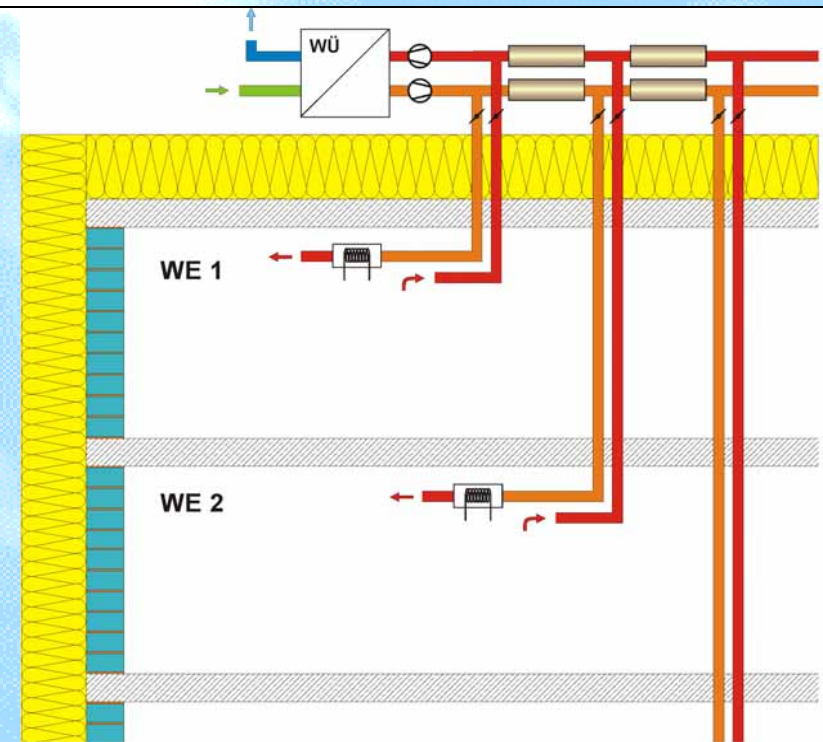
Reihen- bzw. Einfamilienhaus



Zentrale Anlage

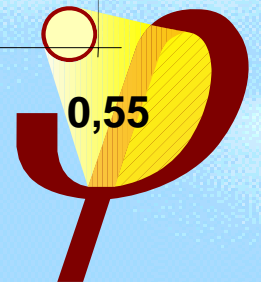
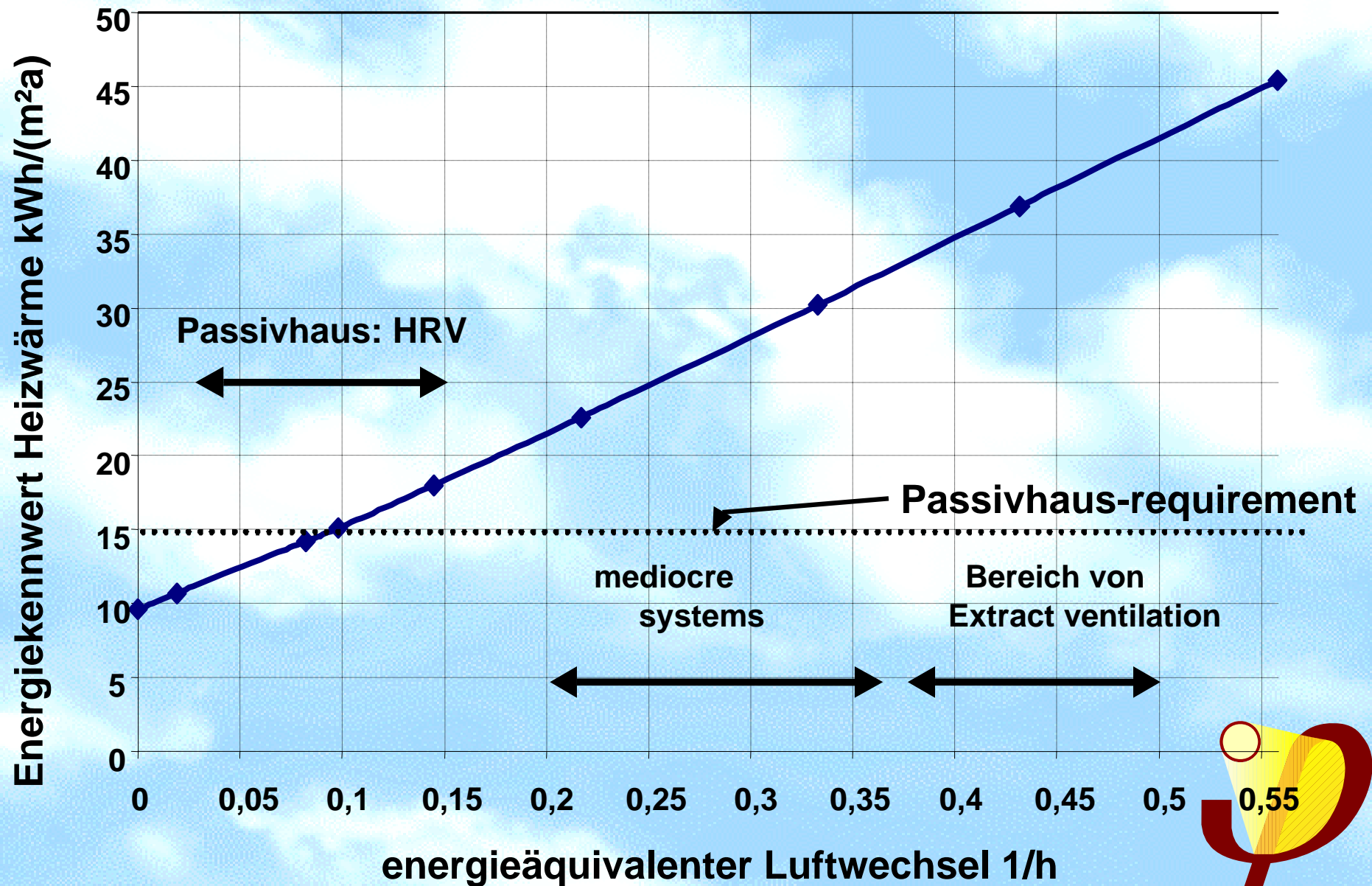


Volumenstromregelung u. Schalldämpfer
dezentral



Volumenstromregelung u. Schalldämpfer
zentral

Passivhaus: Lüftung nur mit hocheffi. WRG





WF 200502

	1. Variante häufig angetroffene Anlage	2. Variante nach DIBT zulässige Anlage	3. Variante Passivhaus geeignete Anlage	4. Variante optimiertes System im Passivhaus	
n-50-Wert	4.0	1.5	0.3	0.3	1/h
mittl. Zuluftstrom	150	140	120	120	m³/h
Wärmebereitstellungsgrad	56.0%	65.0%	85.0%	90.0%	
Jahreslüftungswärmeverlust	3248	1897	609	441	kWh/a
mittl. Ventilatorleistung	150	78	42	36	Watt
Jahresstromverbrauch	983	508	275	236	kWh/a
Jahresstromkosten	157	81	44	38	€/a
Filterkosten je Jahr	50	50	38	38	€/a
Heizkosteneinsp. je Jahr	67	161	251	263	€/a
SUMME: Jährliche Betriebskosteneinsp.	-141	30	170	188	€/a
Mehrinvestition	4000	4000	4500	4800 - 2500	€
Annuität	7.0%	7.0%	7.0%	7.0%	
annuitätische Kapitalkosten	281	281	317	162	€/a
Kosten je eingesparte kWh	51	18	11	6	€/ kWh
Jahresheizzahl	2.4	5.0	10.4	12.8	
Primärenergie-Einsparung	1210	2926	4563	4776	kWh/a

PH-Kriterien Lüftungsanlagen

1) Passivhaus-Behaglichkeitskriterium:

Minimale Zulufttemperatur 16,5°C bei -10 °C

2) Effizienz-Kriterium (Wärme):

balancierten Massenströme: $\eta_{WRG,t,eff} = 75\%$

3) Effizienz-Kriterium (Strom):

max. 0,45 W/(m³/h) geförderter Zuluftvolumenstrom

4) Dichtheit und Wärmedämmung:

Leckagerate int. und ext. max. 3%

5) Abgleich und Regelbarkeit:

Balanceabgleich auf der Außen-/Fortluftseite,
Regelbarkeit 70 / 100 / 130 %, Standby max. 1 W

6) Schallschutz:

Schalldruckpegel Aufstellraum < 35 dB(A)
Schallpegel in Wohnräumen < 25 dB(A)

7) Raumlufthygiene:

Außenluftfilter mindestens F7; Abluftfilter mindestens G4

8) Frostschutzschaltung:

Regulärer Betrieb auch bei -15 °C,
Frostschutz für Wärmeübertrager und Nachheizregister

