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Technical Installations in Passive Houses
Part 2: Heating Systems

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Heating Systems for Passivehouses

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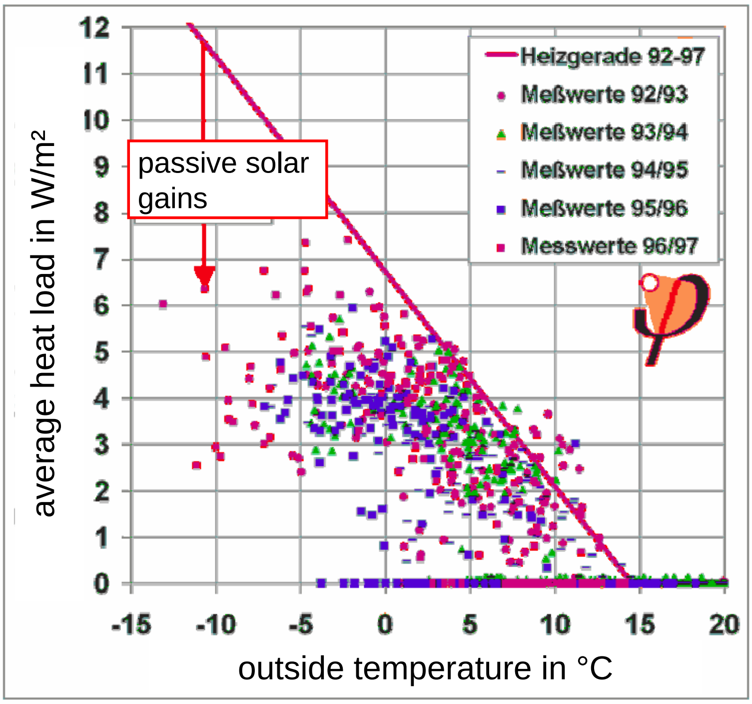
1. Heating Load
2. Room Heating Systems
3. Heat Generation



Messergebnisse zur aufgetretenen Heizleistung *im Passivhaus Darmstadt Kranichstein; die Heizleistung hat 7,4 W/m² zu keinem Zeitpunkt überschritten, auch nicht im ganz besonders kalten Winter 1996/1997 (vgl. dazu auch [Feist 1997b]).*

„Heizlast im Passivhaus“ – Bisanz Fachinformation PHI 1999/2

- International Standards (EN 12831) lead to heating loads, which are 2,5 times the measured values
- Applying dynamical simulation the „real“ heating loads for passivehouses were determined

- Influence considered from:
  - Internal heat gains
  - Solar heat gains
  - Response Time of the building

- A simple stationary method for calculating the heating load for passivehouses should be found

Heating Load in Passivehouses
Calculation Method of PHPP

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Method in PHPP:

- The heating load is calculated for a cold, clear and moderate cold, overcast day
- The maximum of both values is used as heating load
- Transmission heat losses:
  - Calculation under stationary conditions
  - Cold basements are assumed to have 10°C
- Ventilation heat losses
  - effective air change rate
  - air change rate due to infiltration according to EN 832 is multiplied by 2.5
- Internal heat gains
  - in general 1,6 W/m² (for dwellings)
- Solar heat gains
- Local weather conditions: Have to be calculated with dynamical simulation software

Heating Load in Passivehouses
Calculation Method of PHPP

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SPECIFIC SPACE HEATING LOAD

Building: End-of-Terrace Passive House Kranic… …lling

Location: Darmstadt Kranichstein — Interior Temperature: 20

Climate (HL): Standard Germany

2 weather situations

	Design Temperature		Radiation: North	East	South	West	Horizontal	
Weather Condition 1:	-10,6	°C	10	30	90	35	40	W/m²
Weather Condition 2:	-1,2	°C	5	5	10	5	10	W/m²
Ground Design Temp.	9,6	°C						

	Building Element	Temperature Zone	Area m²		U-Value W/(m²K)		Factor Always 1 (except "X")		TempDiff 1 K		TempDiff 2 K		P_T 1 W		P_T 2 W
1.	Exterior Wall - Ambie	A	184,3	*	0,138	*	1,00	*	30,6	or	21,2	=	774	or	538
2.	Exterior Wall - Groun	B		*		*	1,00	*	10,4	or	10,4	=		or	
3.	Roof/Ceiling - Ambien	A	83,4	*	0,108	*	1,00	*	30,6	or	21,2	=	274	or	191
4.	Floor Slab	B	80,9	*	0,131	*	1,00	*	10,4	or	10,4	=	110	or	110
5.		A		*		*	1,00	*	30,6	or	21,2	=		or	
6.		A		*		*	1,00	*	30,6	or	21,2	=		or	
7.		X		*		*	0,75	*	30,6	or	21,2	=		or	
8.	Windows	A	43,5	*	0,777	*	1,00	*	30,6	or	21,2	=	1033	or	718
9.	Exterior Door	A		*		*	1,00	*	30,6	or	21,2	=		or	
10.	Exterior TB (length/m)	A	116,9	*	-0,030	*	1,00	*	30,6	or	21,2	=	-106	or	-74
11.	Perimeter TB (length/m)	P		*		*	1,00	*	10,4	or	10,4	=		or	
12.	Ground TB (length/m)	B	11,4	*	0,061	*	1,00	*	10,4	or	10,4	=	7	or	7
13.	House/DU Partition Wall	I	84,8	*	0,375	*	1,00	*	3,0	or	3,0	=	96	or	96

Transmission Heat Losses P_T

Total = 2188 or 1586

Transmission heat losses

Ventilation System:

		A_{TFA}		Clear Room Height		
		m²		m		m³
Effective Air Volume, V_V		156,0	*	2,50	=	390

Efficiency of Heat Recovery of the Heat Exchanger	□$_{HR}$ 82%	Heat Recovery Efficiency SHX	93%	Efficiency SHX	□$_{SHX}$ 1: 63%	or	□$_{SHX}$ 2: 49%

	$n_{V,Res}$ (Heating Load)		$n_{V,system}$		□$_{HR}$		□$_{HR}$				
	1/h		1/h						1/h		1/h
Energetically Effective Air Exchange n_v	0,047	+	0,300	*(1-	0,93	or	0,91	) =	0,068	or	0,075

Ventilation Heating Load P_V

V_L		n_L		n_L		c_{Air}		TempDiff 1		TempDiff 2		P_V 1		P_V 2
m³		1/h		1/h		Wh/(m³K)		K		K		W		W
390,0	*	0,068	or	0,075	*	0,33	*	30,6	or	21,2	=	**266**	or	**204**

Total Heating Load P_L

		P_L 1		P_L 2
		W		W
$P_T + P_V$	=	**2453**	or	**1790**

Ventilation heat losses

	Orientation the Area	Area m²		g-Value (perp. radiation)		Reduction Factor (see Windows worksheet)		Radiation 1 W/m²		Radiation 2 W/m²		P_S 1 W		P_S 2 W
1.	North	11,0	*	0,5	*	0,5	*	10	or	5	=	25	or	13
2.	East	0,0	*	0,0	*	0,4	*	30	or	5	=	0	or	0
3.	South	30,4	*	0,5	*	0,4	*	90	or	10	=	605	or	67
4.	West	2,0	*	0,5	*	0,4	*	35	or	5	=	14	or	2
5.	Horizontal	0,0	*	0,0	*	0,4	*	40	or	10	=	0	or	0

Solar Heat Gain, P_S Total = **645** or **82**

Heat gains

Internal Heat Gains P_I

				P_I 1		P_I 2
				W		W
1,6	*	156	=	**250**	or	**250**

Heat Gains P_G

	P_G 1		P_G 2
	W		W
=	**894**	or	**332**
=	**1559**	or	**1459**

Heating load

Heating Load P_H = **1559** W

Specific Heating Load P_H / A_{TFA} = **10,0** W/m²

					°C	°C
Input Max. Supply Air Temperature	52	°C				
Max. Supply Air Temperature □$_{Supply,Max}$	52	°C	Supply Air Temperature Without Heating	□$_{Supply,Min}$	17,9	18,1

1315 W specific 8,4 W/m²

(Yes/No)

...ly Air Heating Sufficient? **No**

Can be supplied via supply air

Room Heating Systems

1. Heating with Supply Air
2. Additional Heating Systems when Using Supply Air Heating
3. Other Heating Systems
4. Different Temperatures in Different Rooms

Room Heating Systems
Heating with Supply Air

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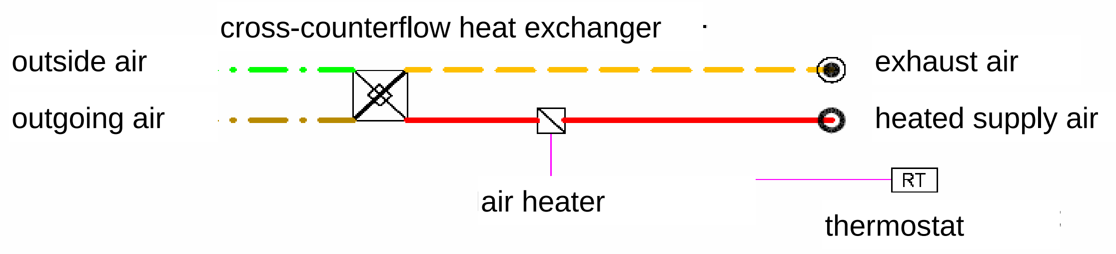
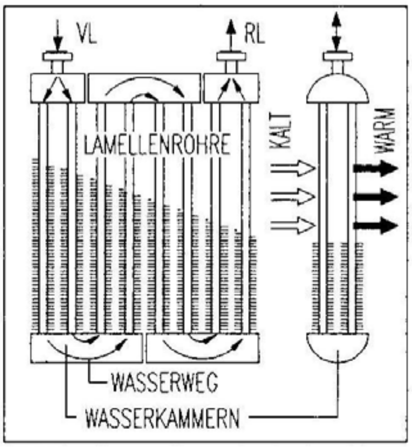
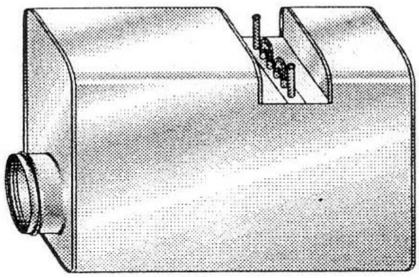
- Scheme:



- Supply air is heated by an air heater
  - max. 52 °C
  - max. 10 W/m², to avoid dry indoor air
  - Electrical heater or water based heaters available
  - One central air heater is sufficient for a single family house
  - In multifamily buildings one air heater is used for each dwelling
  - Additional heating system for bathrooms

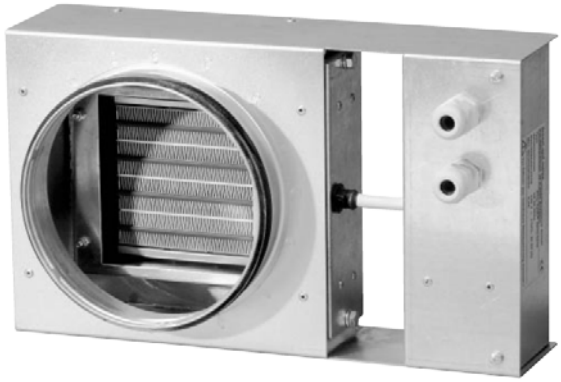
Room Heating Systems
Air Heater with Water or Electrical





PTC-Element

Elektrisches Heizelement für die selbstregelnde Nachheizung der Zuluft. Die Luft wird in Abhängigkeit von Luftmenge und Lufteintrittstemperatur auf 40 bis 50 °C erwärmt.



Das PTC-Element wird in die Zuluftleitung eingebaut. Durch den abgesetzten Elektronik-Bereich ist eine nahezu wärmebrückenfreie Dämmung des Gehäuses möglich. Durch den Selbstregeleffekt von PTC-Elementen wird das Heizelement bei Ventilatorausfall nicht überhitzt.

Room Heating Systems
Additional Heating Systems

- Bathrooms should be heated up to 24°C, therefore an additional system is necessary
- Common systems:
  - Towel radiator
  - Radiant heater
  - Floor heating system
- A combined time switch thermostat should be used

Room Heating Systems
Conventional Heating Systems

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- In general all conventional heating systems can be used in passivehouses
- Passivehouses have the advantage, that the heater can be installed in almost any position in the room

- Recommendations:
  - Use fast responding systems like radiators
  - If a water system is used, the circulation pump should be controlled according to the heat demand

- Disadvantage of conventional heating systems: Probably more expensive

- Further advantage: Decoupling of heating power and supply air change rate, usefull when a low humidity load is expected

Room Heating Systems
Aligning Room Temperatures in Dwellings

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Basic Questions:

- Room temperatures in „normal“ dwellings
- Lower temperatures in bedrooms
- Higher temperatures in bathrooms
- Rapid temperature changing
- Different temperatures in different rooms

- How to meet these demands ?
- Effects on energy consumption

Room Heating Systems
Measured Room Temperatures

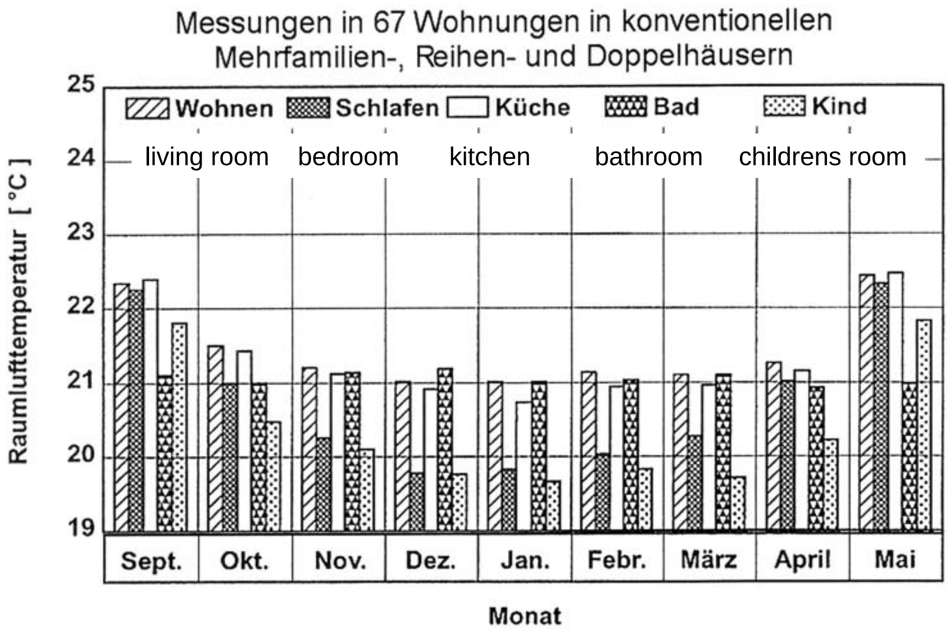

Abbildung 1: Gemessene Temperaturen in 67 Wohnungen. Die Räume waren jeweils mit Heizkörpern und Thermostatventil ausgestattet. Grafik aus [Reiß 2003].

Room Heating Systems
Lower Temperatures in Bedrooms

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Applying dynamic simulation methods: Different possibilities to achieve lower temperatures in bedrooms were investigated:

- Window opened over night (tilted): 45 m^3/h from 22 to 7
- Window opened over night in such a way, that temperature is between 16 and 18 °C
- Windows completly open for a short time before sleeping
- No heated supply air
- Night time heating reduction

Ref.:
Jürgen Schnieders: Temperaturdifferenzen gezielt herstellen – wie geht´s, Protokollband 25, PHI

Room Heating Systems
Lower Temperatures in Bedrooms

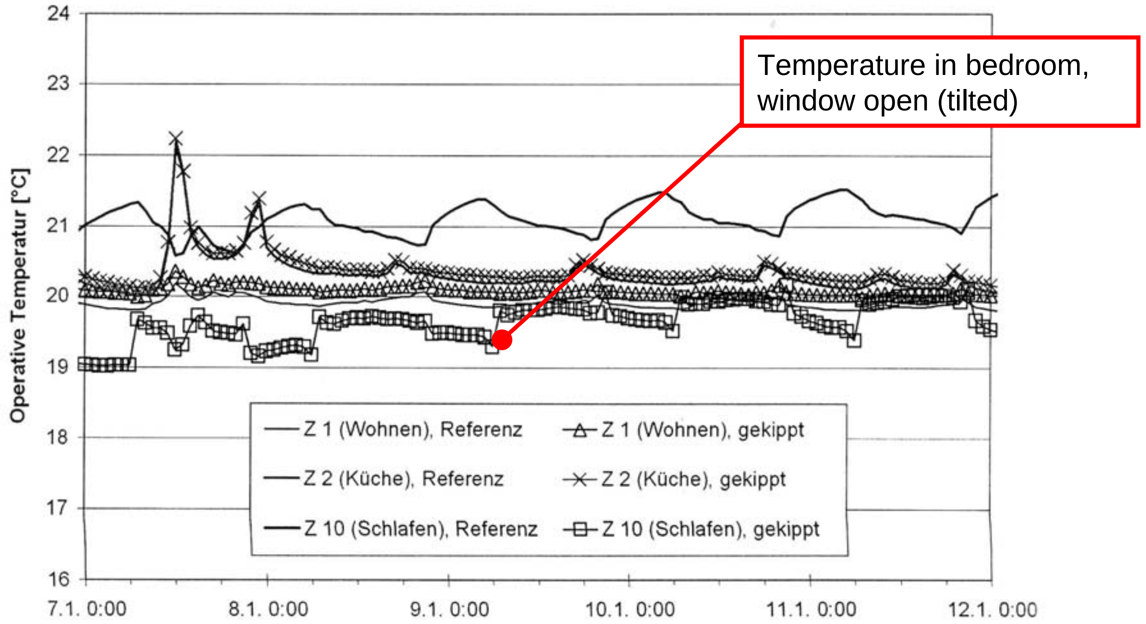

Abbildung 2: Auswirkungen eines nachts gekippten Schlafzimmerfensters.

Room Heating Systems
Lower Temperatures in Bedrooms

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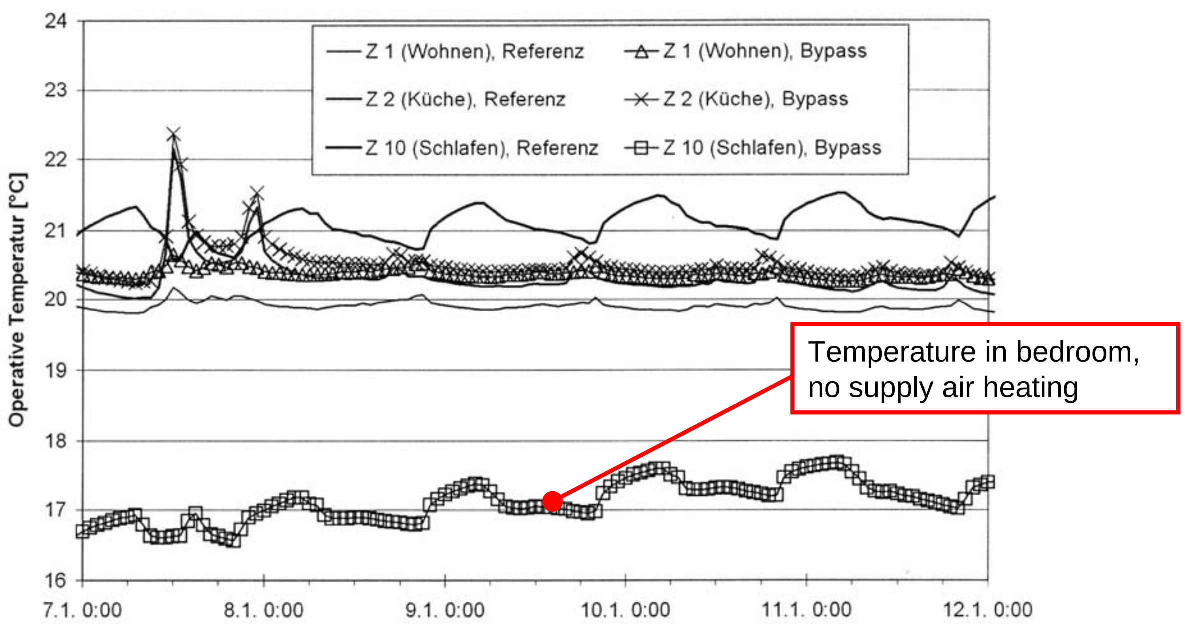

Abbildung 6: Temperaturen bei fehlender Beheizung des Schlafzimmers.

Room Heating Systems
Lower Temperatures in Bedrooms

Bedroom Temperatures and Effects on Energy Consumption

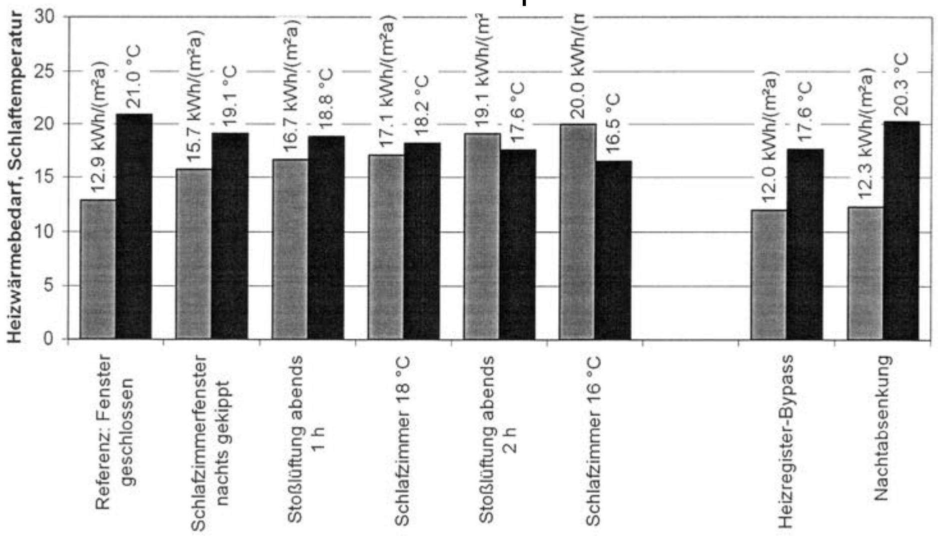

Abbildung 10: Heizwärmebedarf bei kaltem Schlafzimmer in verschiedenen Varianten. Als zweite Säule ist jeweils die mittlere Temperatur des Schlafzimmers von November bis Februar zwischen 22 und 7 Uhr aufgetragen.

Room Heating Systems
Higher Temperatures in Bathrooms

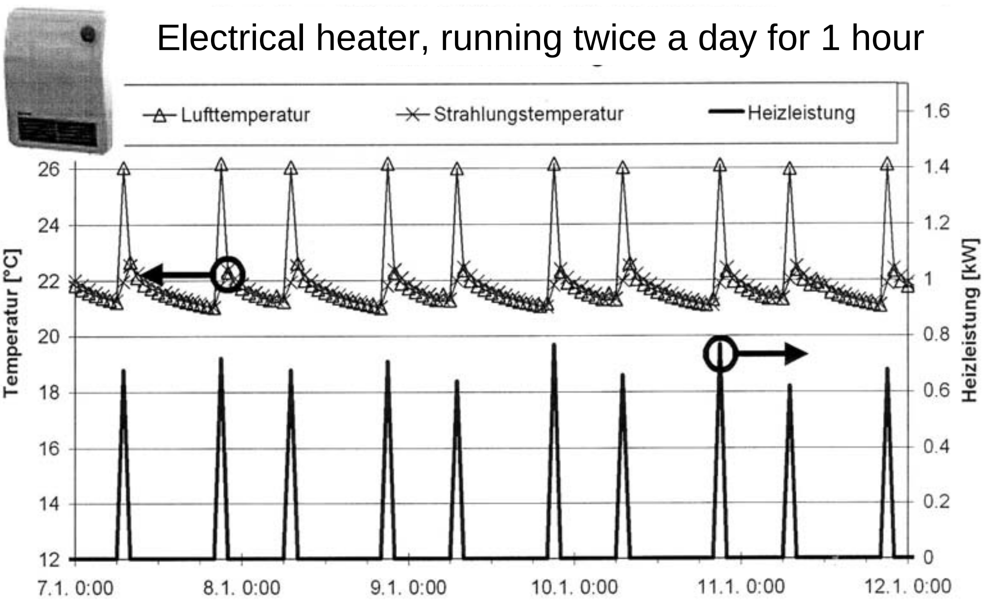

Abbildung 14: Stundenmittelwerte der Luft- und Strahlungstemperatur sowie Leistung der Zusatzheizung im Bad, wenn die Zusatzheizung auf die Raumluft wirkt (2-mal täglich 24 °C operative Temperatur im Bad).

Room Heating Systems
Higher Temperatures in Bathrooms

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Bathroom Heating and Effects on Energy Consumption

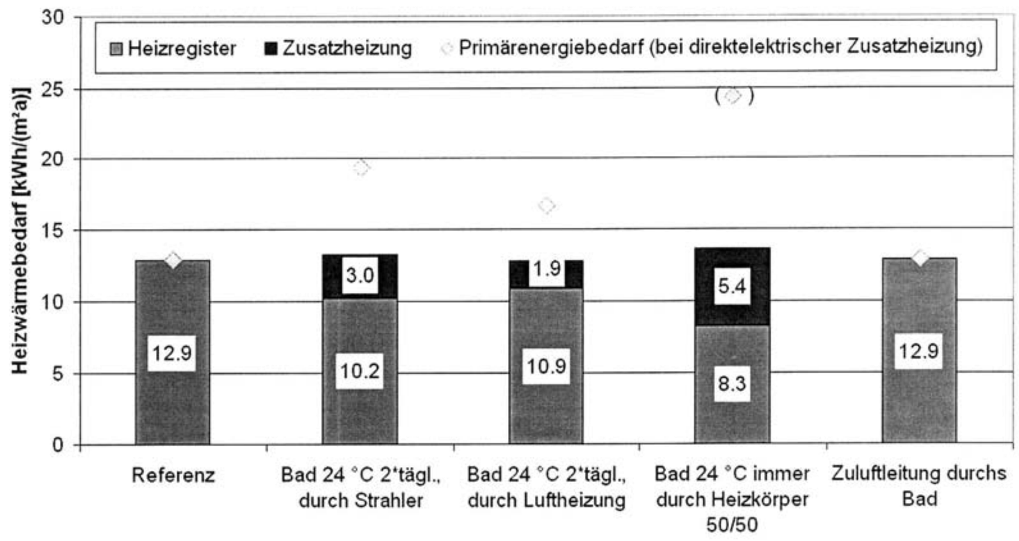

Abbildung 18: Heizwärme- und Primärenergiebedarf für die Fälle, in denen im Bad höhere Temperaturen erreicht werden. Eine kontinuierliche Zusatzheizung im Bad sollte nicht direktelektrisch betrieben werden.

Room Heating Systems
Recommendations

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- Cool bedroom is achievable in a passivhouse:
  - Tilted window
  - Bedroom without supply air heating
  - Own experience: window tilted, closed supply air inlet
- Additional heating in bathrooms is necessary
  - Electrical powered: use temporarly
  - Non electrical heater: permanent heating to 24°C is possible
- Different temperatures in different rooms
  - One air heater for each floor
  - One air heater for a group of rooms
  - Use conventional room heating systems like radiators

1. Required Heating Power
2. Direct Electrical Heating (not recommended)
3. Compact Units with Heat Pumps
4. Boilers with Gas and Oil
5. Wood and Wood Pellets
6. District Heating
7. Primary and Final Energy Demand

Required Heating Power

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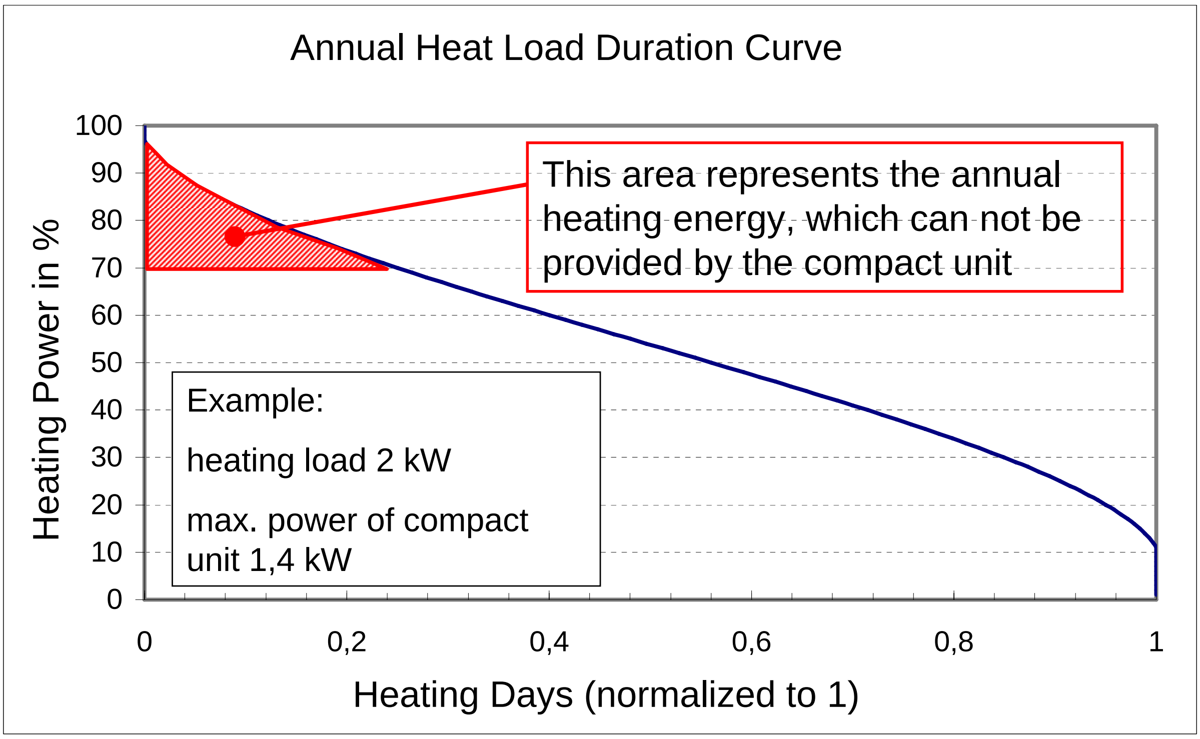
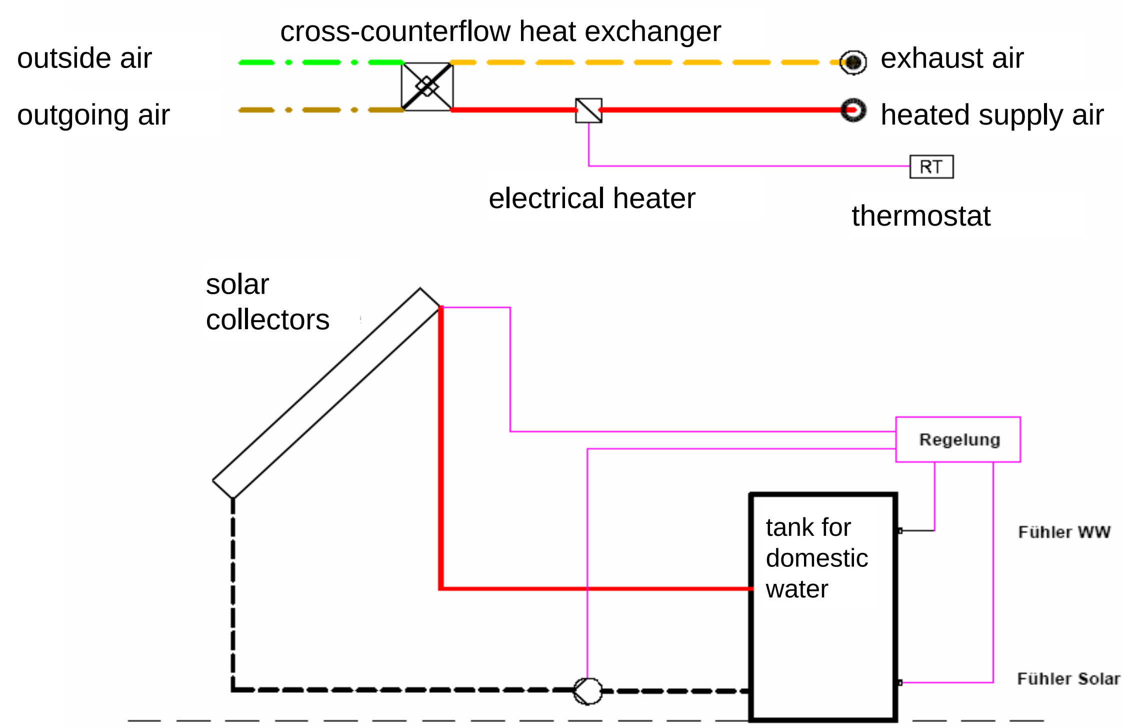


Heat Generation for Passivehouses
Direct Electric Heating



Heat Generation for Passivehouses
Compact Unit with Heat Pump Using Outside Air

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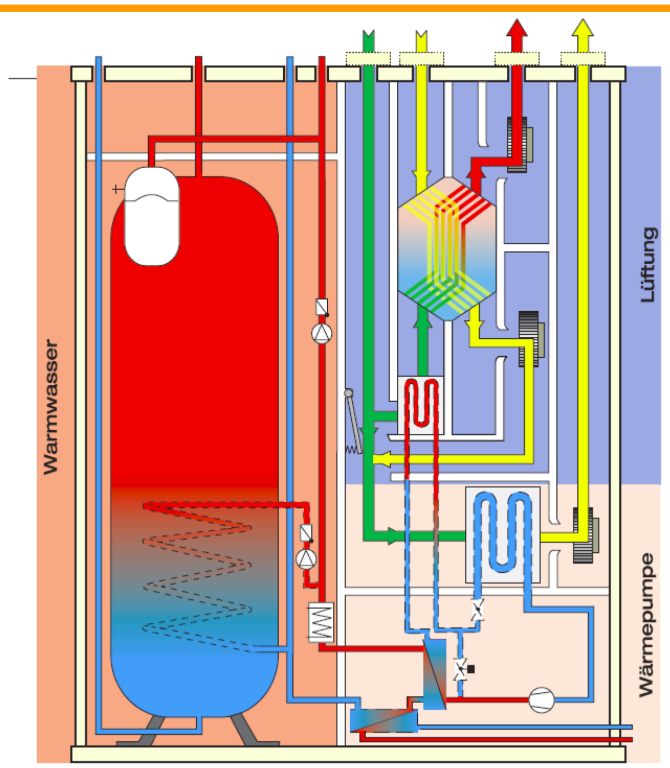
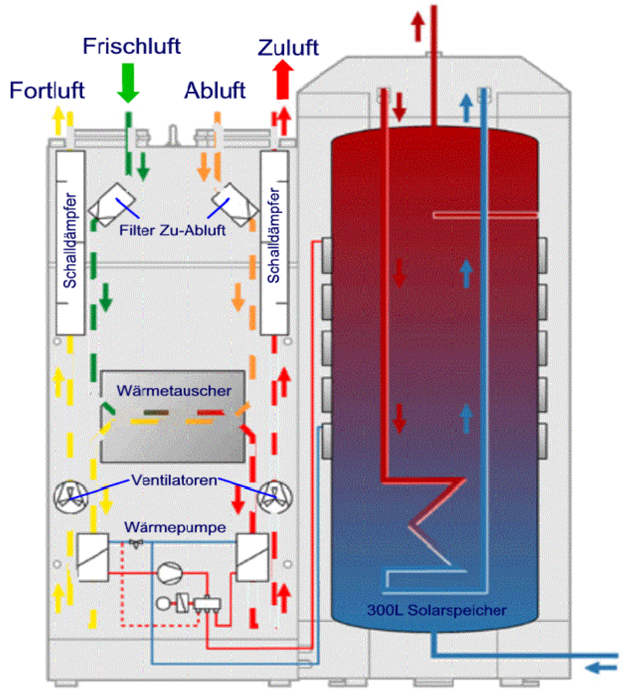


ref: tecalor.de

Compact Unit:

- Outside air heat pump
- Ventilation with heat recovery
- Additional electrical heater
- Domestic water heating
- Solar system can be integrated
- Thermal power up to 6kW
- Floor or wall heating

Heat Generation for Passivehouses „Classical“ PH Compact Unit

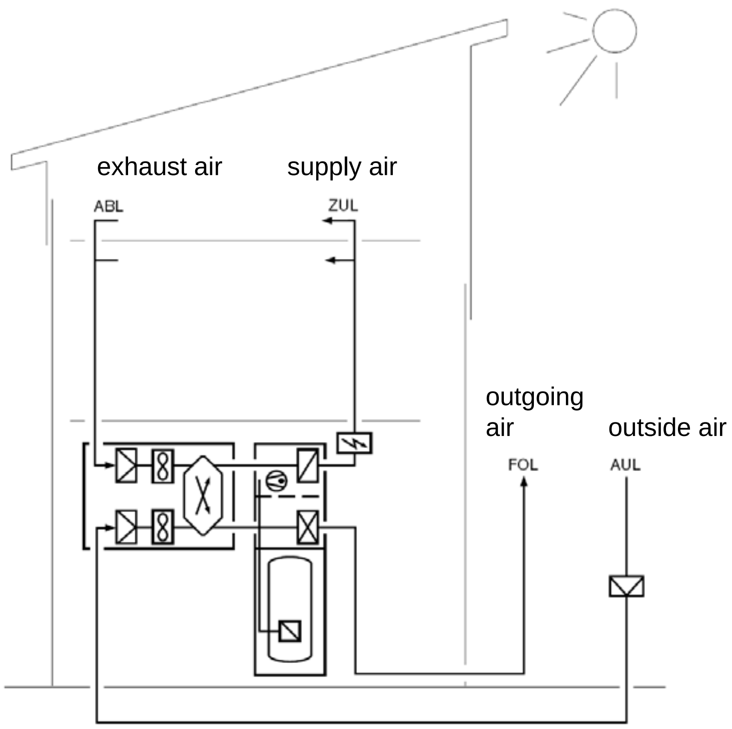


ref.: Aerex Haustechnik

Compact unit:

- Exhaust air heat pump
- Ventilation with heat recovery
- Additional electr. heater for domestic water
- Domestic water heating
- Solar system can be integrated
- Air flow rates from 125 to 225 m^3/h
- Heating power from 1,0 to 1,8 kW
- COP about 2,5

Heat Generation for Passivehouses „Classical“ PH Compact Unit – New Generation



ref.: drexel & weiss

Heat Generation for Passivehouses
PH Compact Unit with Subsoil Heat Pump

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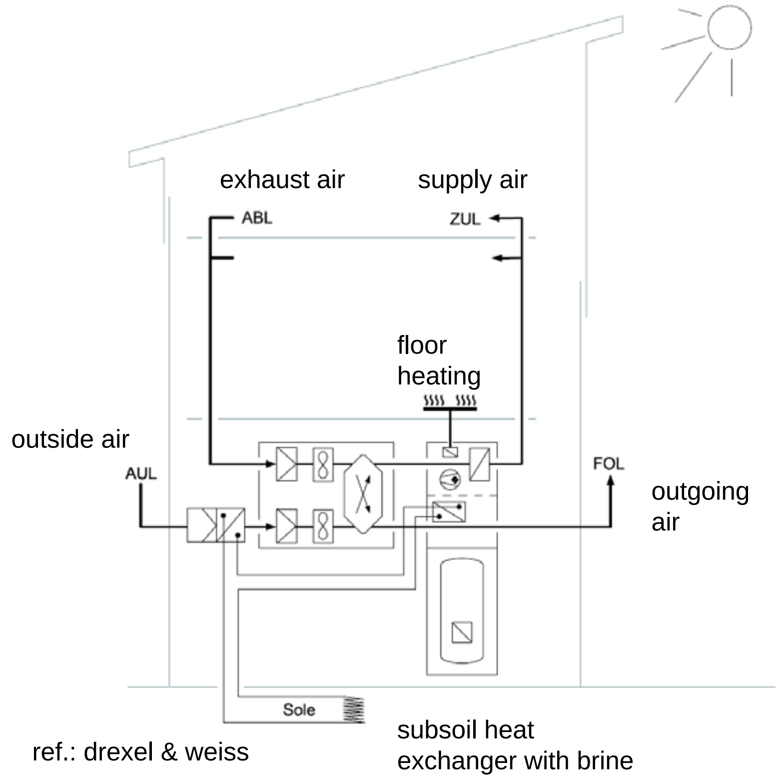

ref.: drexel & weiss

Compact Unit „Extended“:

- Heat pump with subsoil heat exchanger
- Air heating (1 kW) an floor/wall heating (2 kW)
- Ventilation with heat recovery
- Max. air flow rate 225 m³/h
- Preheating or outside air by subsoil heat exchanger
- Domestic water heating
- Solar system can be integrated
- COP up to 4

Heat Generation for Passivehouses
New Space Saving Subsoil Collectors

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(www.betatherm.de):

- Diameter top: 1,7 or 2,1 m
  Diameter bottom: 0,9 or 1,1 m
  Hight: 1,3 m or 2,6m
- Tube length: 100/300 m, PE100 PN16, DN32
- Brine volume: approx. 53l/160l
- Weight without brine: approx. 20 kg/60kg
- Thermal power: 0,7-1,0 KW / 1,6 -2,1 kW
- Optional second circuit for solar system

Heat Generation for Passivehouses
Compact Unit for Multifamily Buildings

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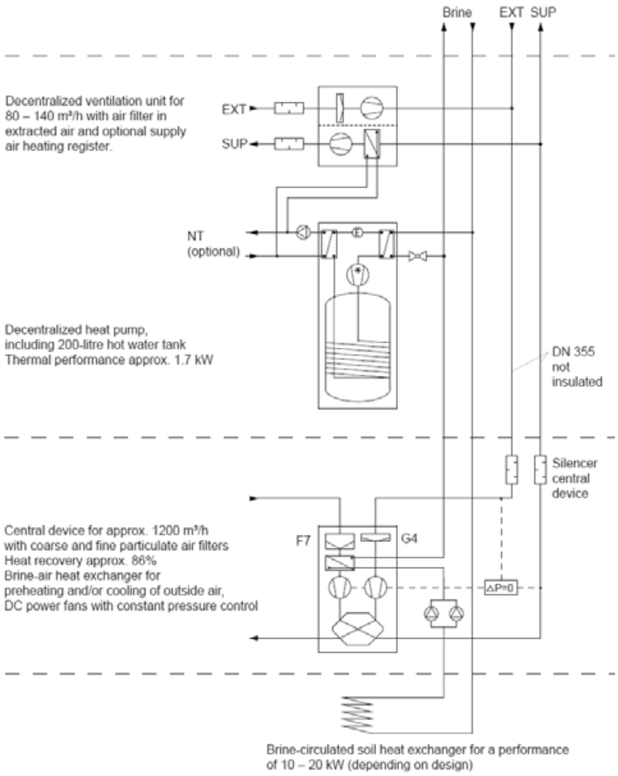

drexel & weiss

Heat Generation for Passivehouses
Compact Unit for Multifamily Buildings

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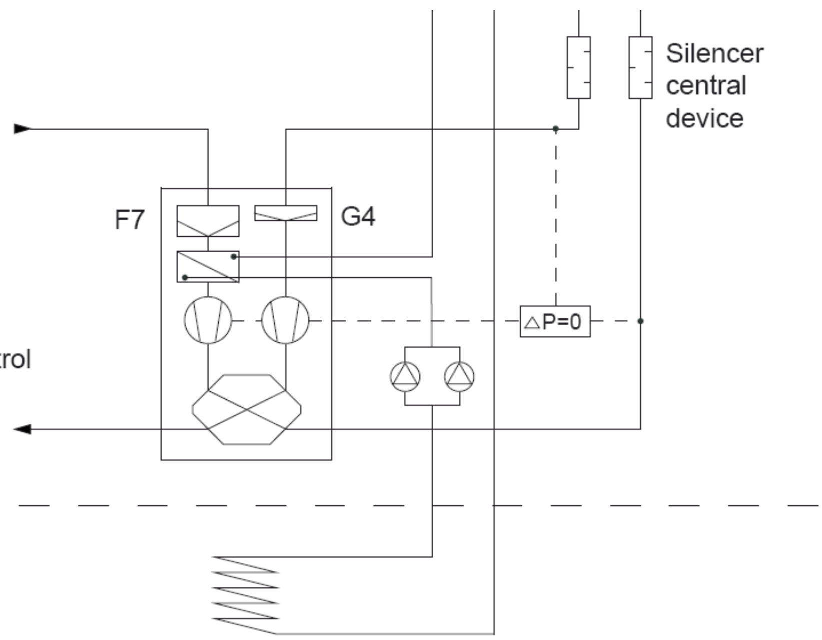
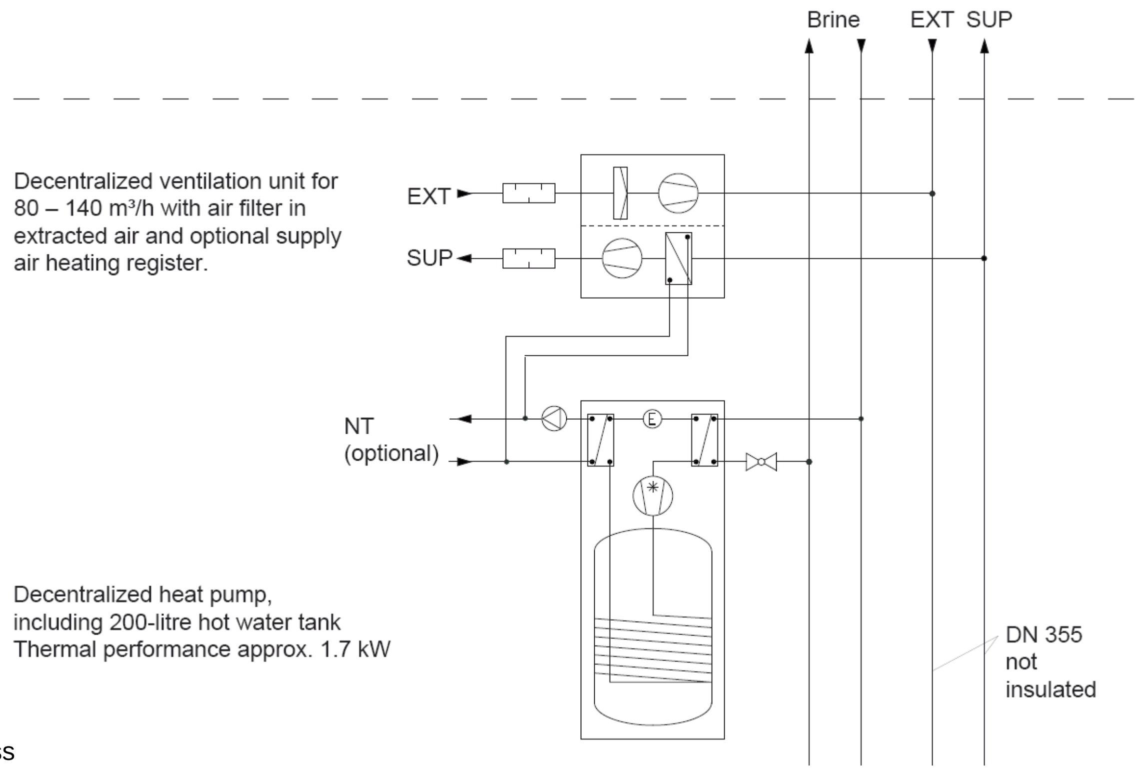
Central device for approx. 1200 m³/h
with coarse and fine particulate air filters
Heat recovery approx. 86%
Brine-air heat exchanger for
preheating and/or cooling of outside air,
DC power fans with constant pressure control



Brine-circulated soil heat exchanger for a performance
of 10 – 20 kW (depending on design)

drexel & weiss

Heat Generation for Passivehouses
Compact Unit for Multifamily Buildings



drexel & weiss

Heat Generation for Passivehouses
Wood Pellets

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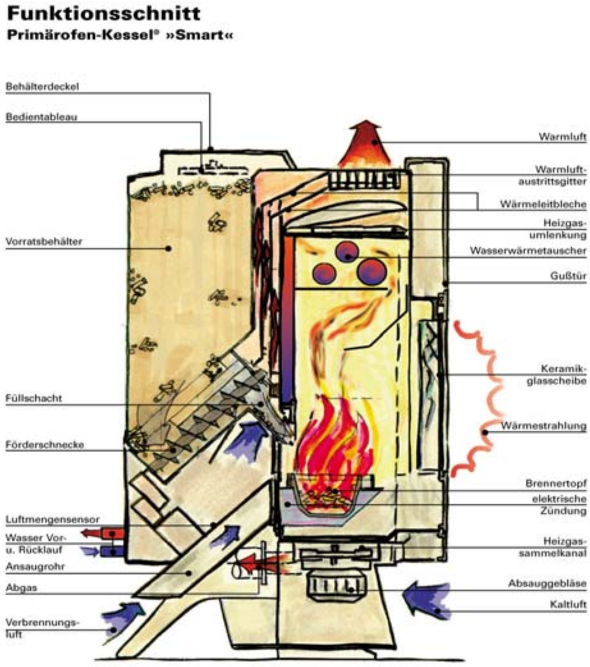
- Net calorific value approx. 5 kWh/kg, piled density ca. 650 kg/m³
- 2 kg pellets = approx. 1 liters oil
- 1 m³ pellets = 320 liters oil

Heat Generation for Passivehouses
Wood Pellets Ovens

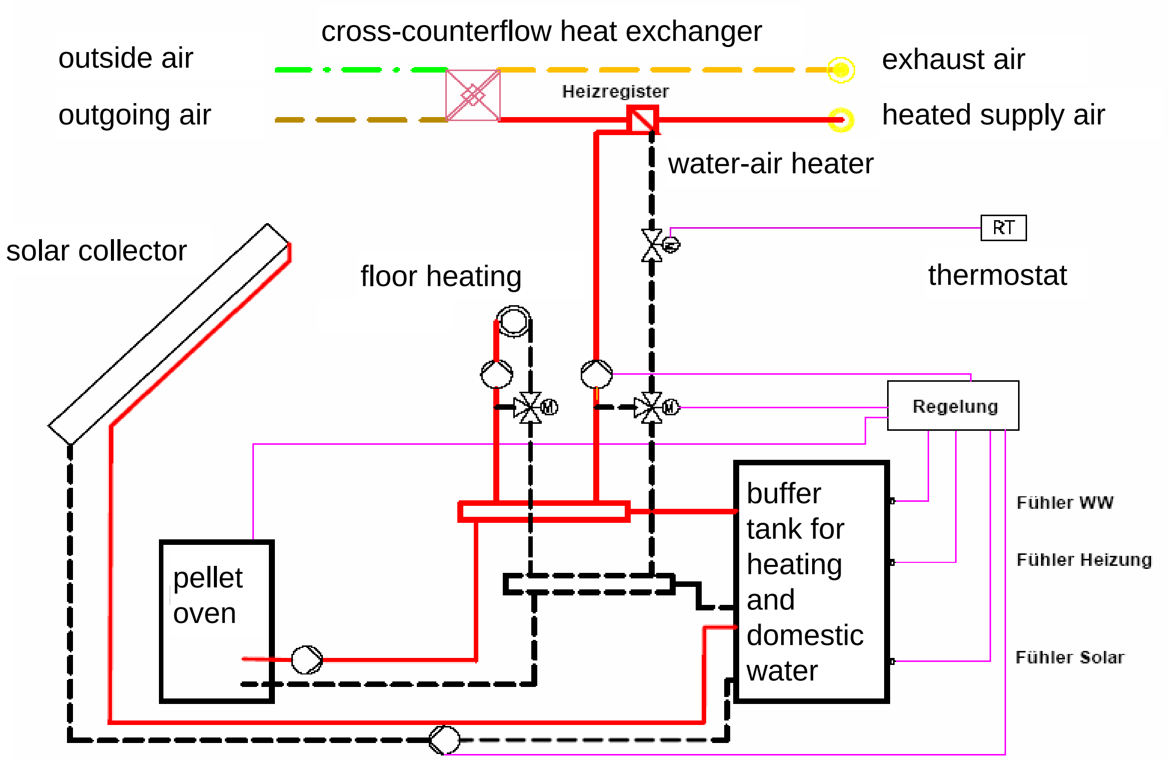


Wodkte

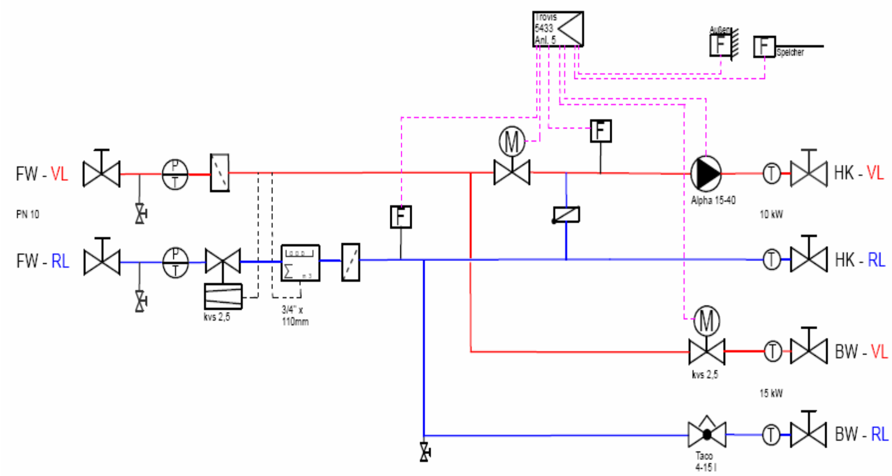
Heat Generation for Passivehouses
Wood Log Ovens

ref.: Rika.at

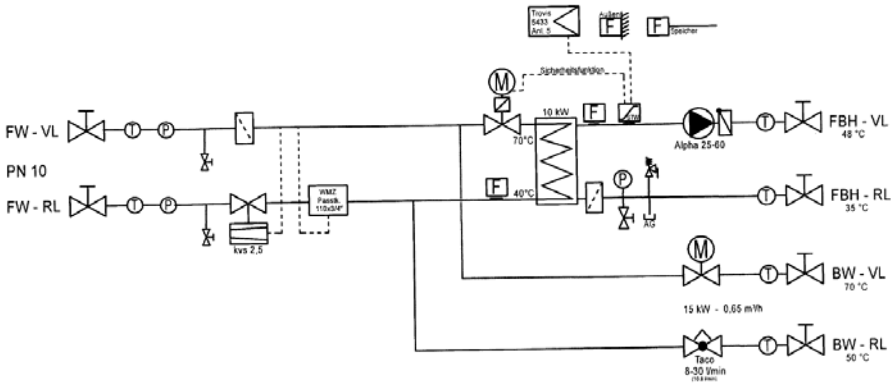
Heat Generation for Passivehouses
Hydraulic Scheme for Wood Ovens



Heat Generation for Passivehouses
District Heat Transfer Stations



Heat Generation for Passivehouses
District Heat Transfer Stations



Heat Generation for Passivehouses
Primary and Final Energy Consumption