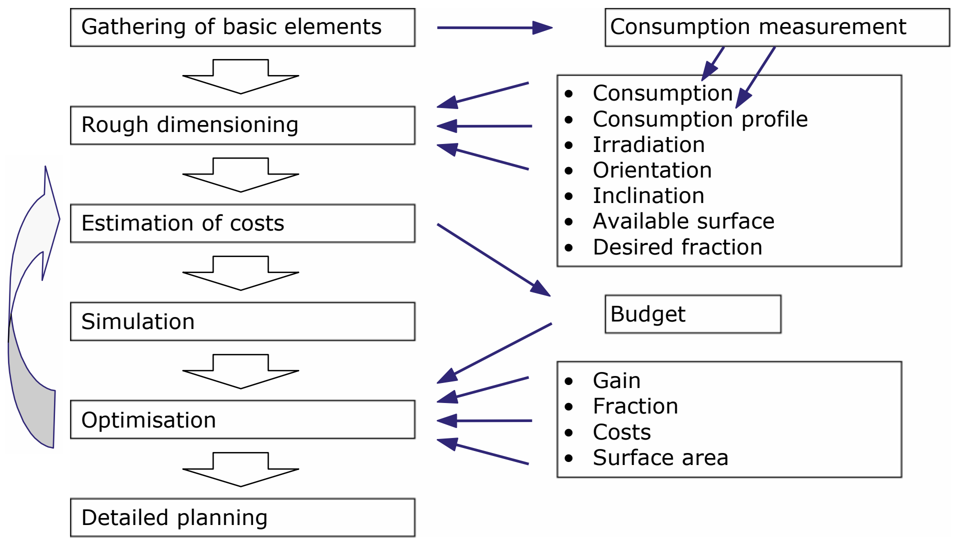
Planning steps and planning process



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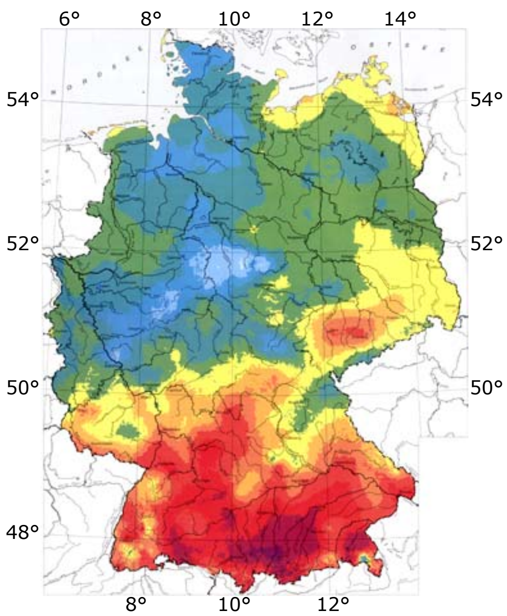
Global radiation on the horizontal level in Germany

(please adapt chart according to the situation in your country)



Total annual average 1981–1998 [kWh/(m²·a)]

- > 1,150
- 1,125 – 1,150
- 1,100 – 1,125
- 1,075 – 1,100
- 1,050 – 1,075
- 1,025 – 1,050
- 1,000 – 1,025
- 975 – 1,000
- 950 – 975
- 925 – 950
- 900 – 925
- < 900

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Consumption measurement

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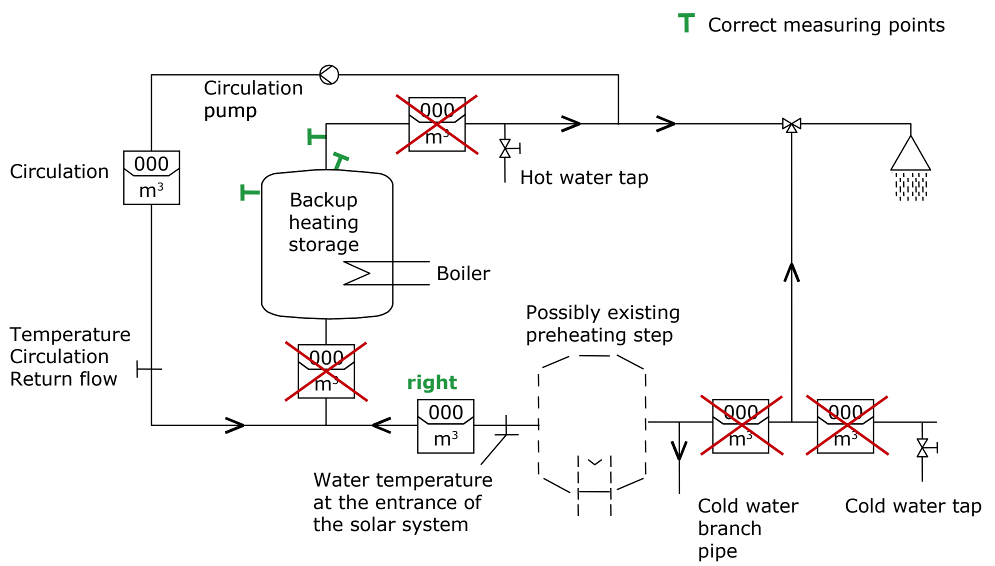

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Conversion of consumption data at different temperatures

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$$V_{60} = \frac{V_{meas} \cdot (t_{meas} - t_{cw})}{60\ °C - t_{cw}}$$

V_{60}	Consumption at 60 °C	[l]
V_{meas}	Measured consumption	[l]
t_{meas}	Measured temperature	[°C]
t_{cw}	Cold water temperature	[°C]

$$V_x = \frac{V_{60} \cdot (60\ °C - t_{cw})}{t_x - t_{cw}}$$

V_x	Consumption at temperature x °C	[l]
t_x	Desired temperature	[°C]

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Typical key figures for consumption

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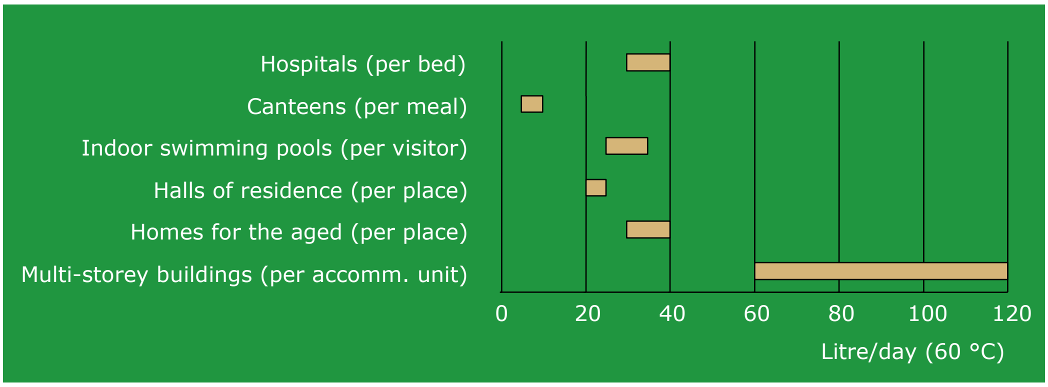
Hot water consumption in different institutions



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Circulation losses

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Example of a circulation pipe with a single length of 24 m

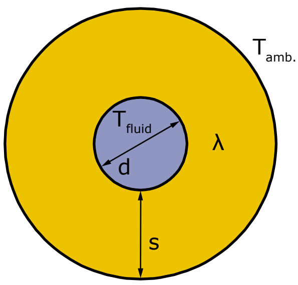
$\Delta T(F/R) = 5$ K

$T_{feed\ flow} = 55$ °C

$T_{amb.} = 20$ °C

Suspension of circulation:

22^{00}–6^{00}



Pipe: 28 x 1,5

Insulation: 100 %

λ = 0.05 W/(m·K)

Theoretic linear pipe losses:	0.2 W/(m·K)
Realistic linear losses:	0.5 W/(m·K)
Thermal energy:	4.5 MWh/a

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Dimensioning of the collector surface

Capacity utilisation	Institution	Collector surface	
30–50 l/(m²·d)	One family house	4–8	m²
40–70 l/(m²·d)	Small multiple family dwelling	2–4	m² / accomm. unit
60–80 l/(m²·d)	Large multiple family dwelling	1–1.5	m² / accomm. unit
60–80 l/(m²·d)	Residential homes	0.5–0.8	m² / place
60–80 l/(m²·d)	Hospital	ca. 1	m² / bed
60–80 l/(m²·d)	Hotel	0.5–1.5	m² / bed
60–80 l/(m²·d)	Youth hostel	0.5–1	m² / bed
60–80 l/(m²·d)	Canteen (kitchens)	ca. 1	m² / 10 meals

These indications are benchmarks for a rough dimensioning that is later tested and optimised through simulating calculations.

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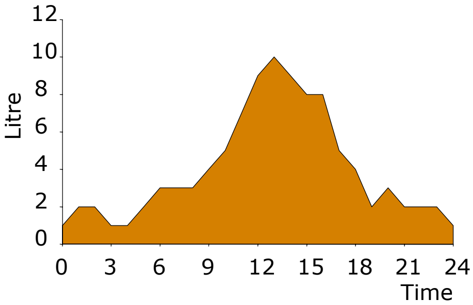
Dimensioning of the storage tanks

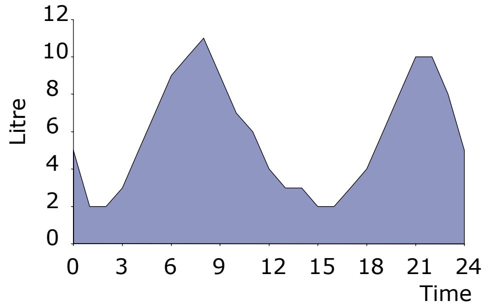
Benchmark: ≥ 50 litres per m² collector surface

Depending on
- the type of storage tank
- the maximum storage temperature
- the consumption profile
- the aspired solar fraction

Consumption profile



Maximum at noon



Maximum in the morning & evening

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Dimensioning of volumetric flow rates in the collector loop

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Specific flow rate

Flow variant	Spec. volumetric flow rate	Heating at 1,000 W/m² *
High flow	40–60 l/(m²·h)	13– 8.6 K
Medium flow	20–40 l/(m²·h)	26–13 K
Low flow	12–20 l/(m²·h)	43–26 K

* at 60 % efficiency

Total volumetric flow rate in the collector loop:

$$\dot{V} = \text{specific volumetric flow rate} \cdot \text{collector surface}$$

Dimensioning of pipes (I)

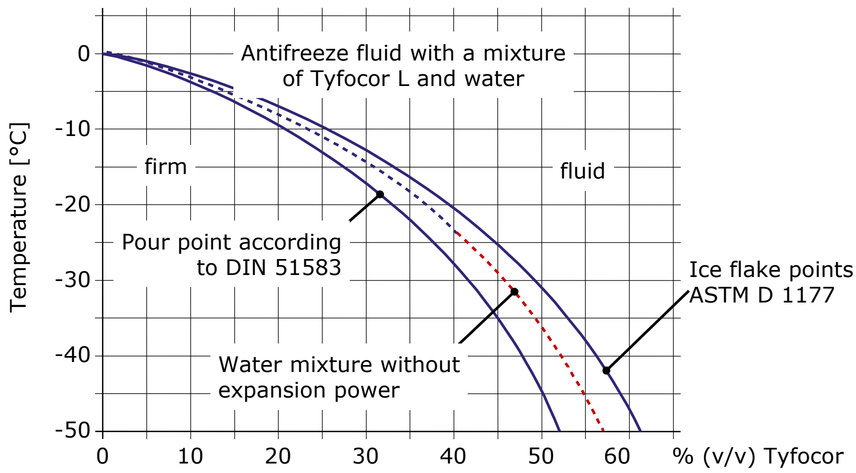
SOLARGE

Adjustment of the collector circuit

- Mixture water/glycol:
  appropriate dosage, in order to resist the norm outside temperature (-25 °C)
  $T_{Calculation}$ – 10 °C
- Low flow: 12 … 20 l/(m²·h)
- Copper pipes:

Flow [l/h]	Outer diameter x thickness [mm]
600 – 900	28 × 1.5
800 – 1,500	35 × 1.5
1,500 – 2,000	42 × 1.5
2,000 – 3,200	54 × 2
3,200 – 5,000	64 × 2
5,000 – 7,000	76.1 × 2
7,000 – 10,000	88.9 × 2

Antifreeze



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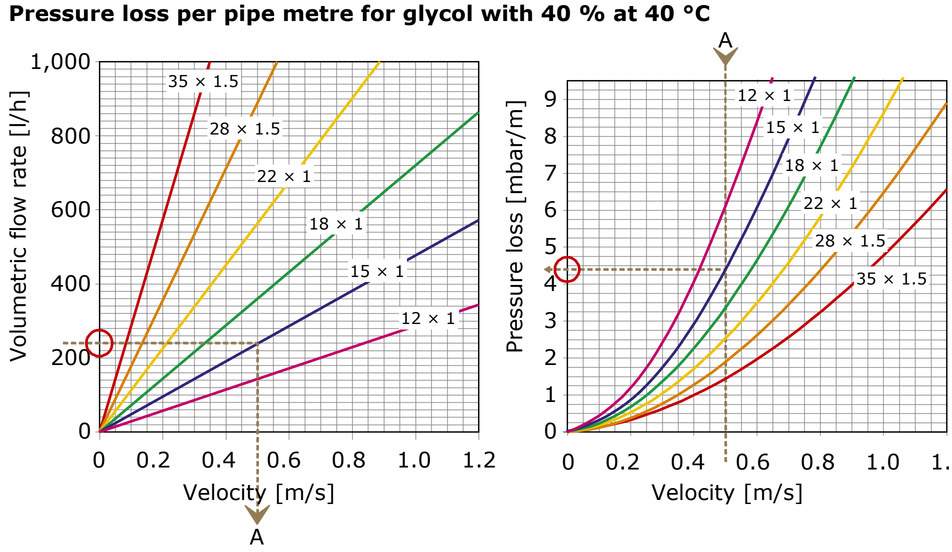
Dimensioning of pipes (II)

Pressure loss per pipe metre for glycol with 40 % at 40 °C



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Dimensioning of heat exchangers (I)

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Plate heat exchanger, counter flow (without heat losses)

$$\dot{Q} = (k \cdot A) \cdot \Delta T_m$$

$$\dot{Q} = \dot{m}_1 \cdot c_{p,1} \cdot (T_{1,in} - T_{1,out}) = \dot{m}_2 \cdot c_{p,2} \cdot (T_{2,out} - T_{2,in})$$

with $\dot{m}_1 \cdot c_{p,1} = \dot{m}_2 \cdot c_{p,2}$ follows $\Delta T_m = (T_{1,in} - T_{2,out}) = (T_{1,out} - T_{2,in})$

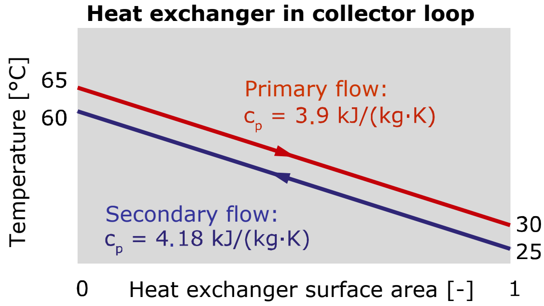
Nominal capacity of collector field

$$\dot{Q} = \eta_{Coll.} \cdot 800\ W/m^2 \cdot A_{Coll.}$$

with $\eta_{Coll.} = \eta_{Coll.}\ (800\ W/m^2, 30\ K)$

$\Delta T_{log} = 5\ K$ (selected)

Heat exchanger in collector loop



Dimensioning of heat exchangers (II)

SOLARGE

Price of usable solar heat

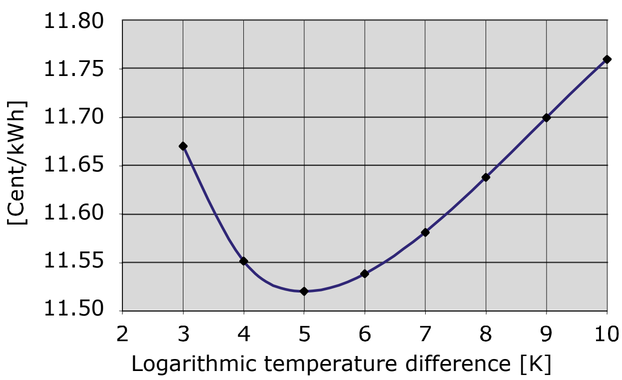


Photo: Ambiente Italia

Dimensioning of heat exchangers (III)

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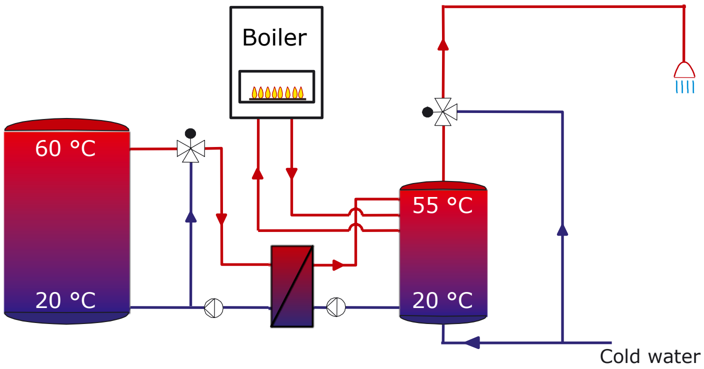
- Boiler performance according to appropriate calculation methods
- $P_{Heat\ exchanger} = P_{Boiler}$
- $\Delta T_{log} = 5\ K$



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Pressure losses in the collector loop

SOLARGE

Example: Calculation of the pressure loss in the collector loop

Collectors (4 modules, 70 mbar each)	280 mbar
Pipes (Copper, 35 x 1.5, l = 60 m)	54 mbar
Heat exchanger	100 mbar
Mountings etc. (10 % pipes)	5 mbar
Total	**439 mbar**

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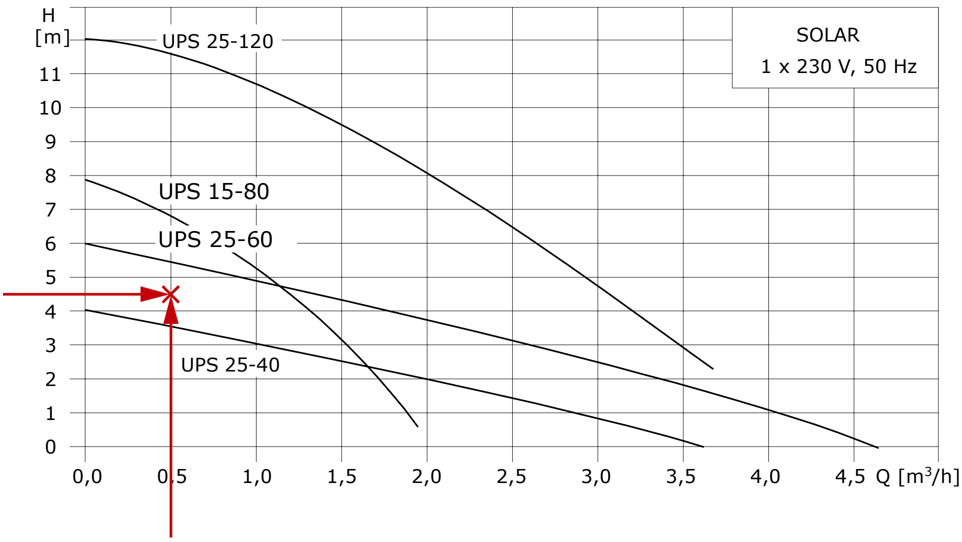
Dimensioning of the pumps



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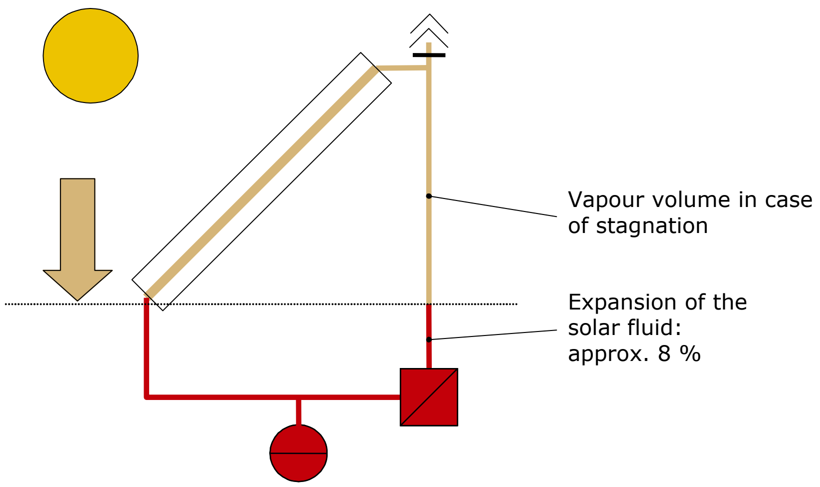
Dimensioning of the diaphragm expansion tank (I)

Identification of the expansion volume



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Dimensioning of the diaphragm expansion tank (II)

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Adjustment of pressure in the collector loop

	recommended
p_i (inital) = mm of water + 0.5 bar	2.5 bar up to 20 m difference of height
p_{DET} (Pre-pressure of diaphragm expansion tank) = p_i – ca. 0,5 bar	2 bar
p_f (final) = 5.5 bar	5.5 bar
p_{SV} (Safety valve) = p_f + 0.5 bar	6 bar

- Check, that $(p_f - p_i) / (p_f + 1\ \text{bar})$ not >> 0.5!
- All building components / circuit components should be dimensioned for 7 bar

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Dimensioning of the diaphragm expansion tank (III)

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Dimensioning of the expansion tank

Content of the collector loop:	$V_{fluid} = V_{Coll.}$	(Collector)
	$+ V_P$	(Pipes)
	$+ V_{HE}$	(Heat exchanger)
	$+ V_{oth.}$	(other components)
Thermal expansion:	$\Delta V_{fluid} = e \cdot V_{fluid}$	(e = 0.045 water; 0.07 mixture)
Useable volume:	$V_{use} = (\Delta V_{fluid} + V_{Coll.}) \cdot (1{,}5 \ldots 2{,}0)$	(safety factor)
Nominal volume:	$V_{nom.} = V_{use} \cdot (p_f + 1) / (p_f - p_i)$	

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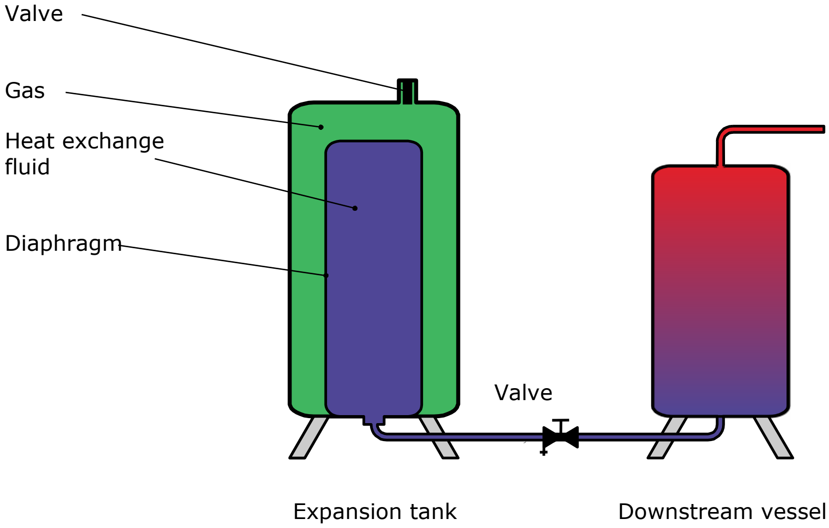
Infeed tanks



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Safety valves

maximum pressure p_{max} = 6 bar

T_{sv} = T' (7 bar_{abs}) = 165,3 °C

$\dot{Q}_{sv}$ = $\eta_{Coll.}$ 1.100 W/m² · $A_{Coll.}$

mit $\eta_{Coll.}$ = η_{Coll} (1.100 W/m², 135 K)

Diameter

Capacity [kW]	50	100	200	350	600	900
Diameter DN [mm]						
Inlet	15	20	25	32	40	50
Outlet	20	25	32	40	50	65

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Control unit

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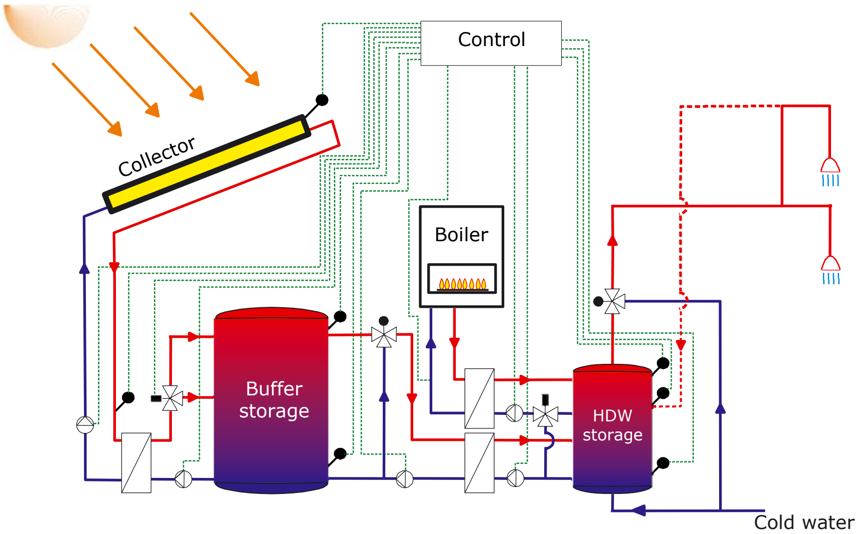

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Sensor

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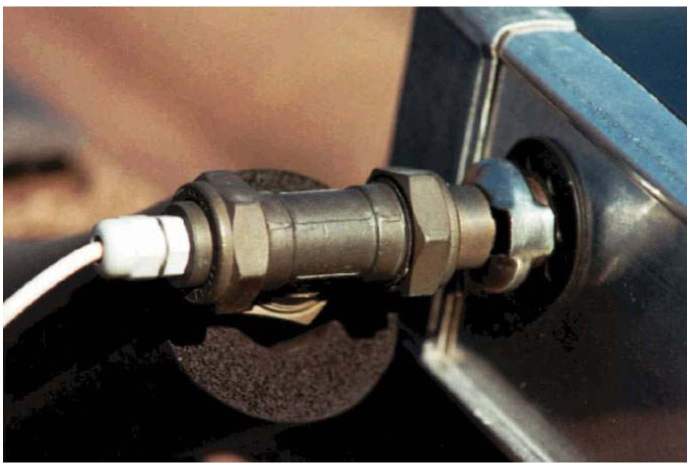

Heat insulation?

Sensor length?

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