LAY OUT OF SYSTEMS

High-flow and low-flow systems

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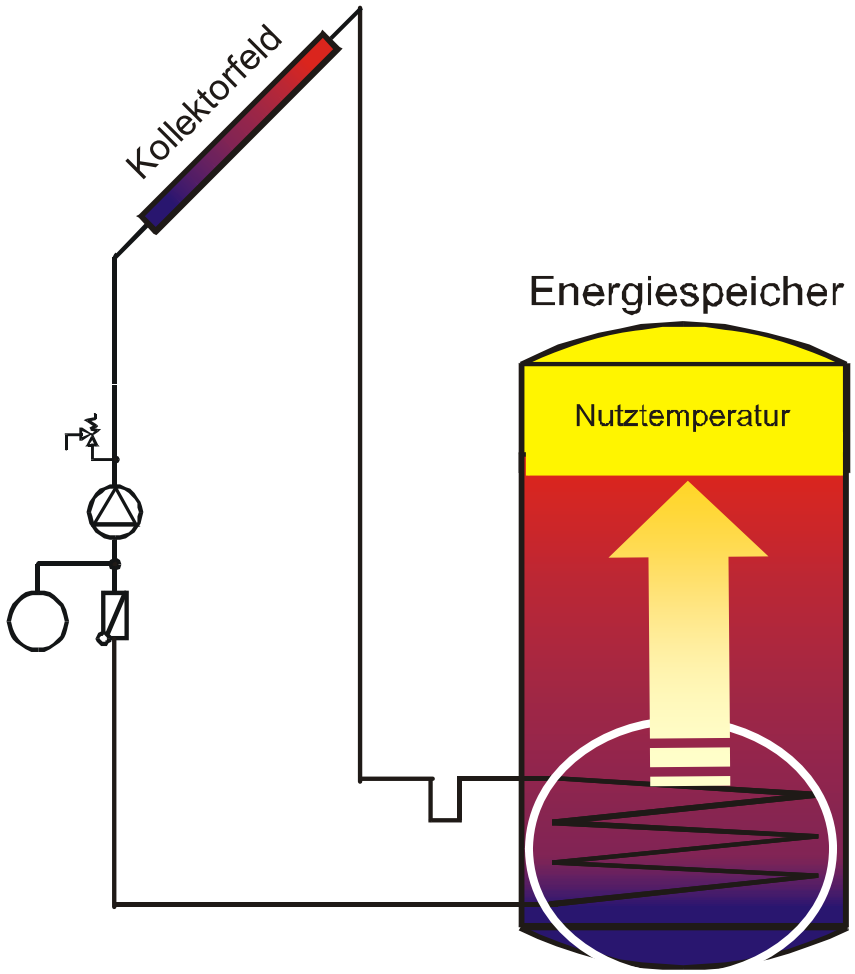
Mode of Operation – high-flow

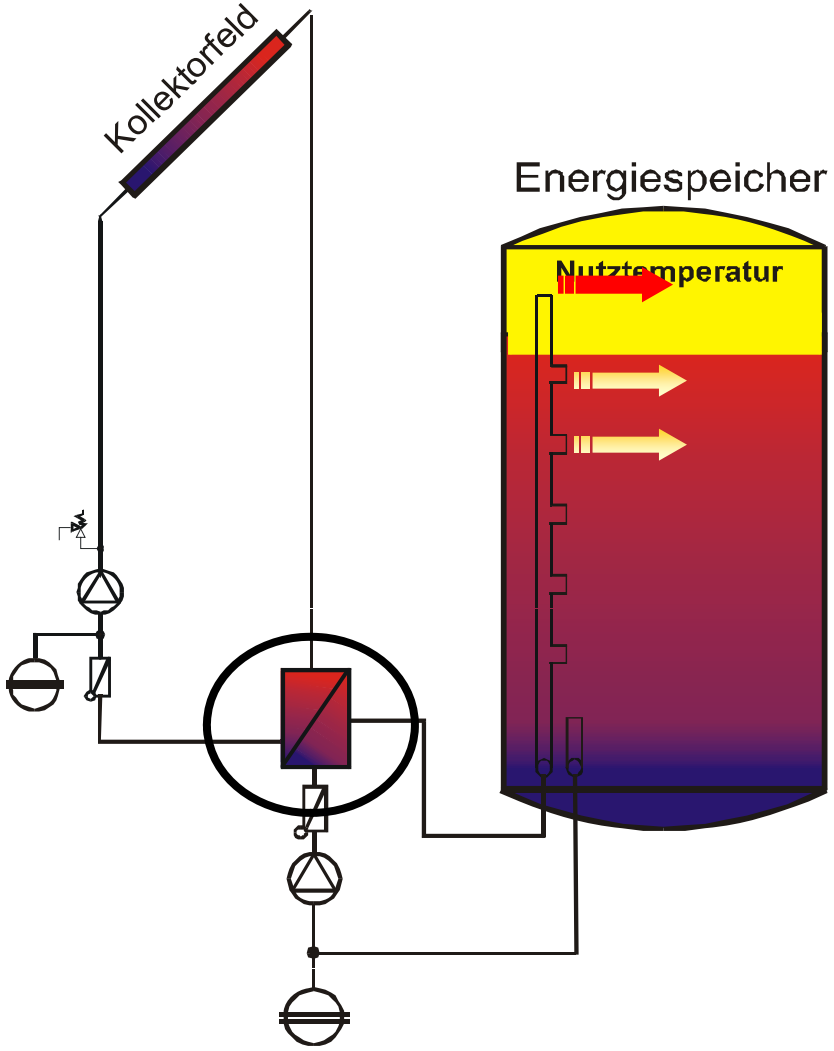


Typical mass flow: (21) 40 to 70 kg/m²h

Temperature increase per pass:
10 -15 K at 800W/m²

Collector areas up to 25 m²

Mode of Operation – low-flow

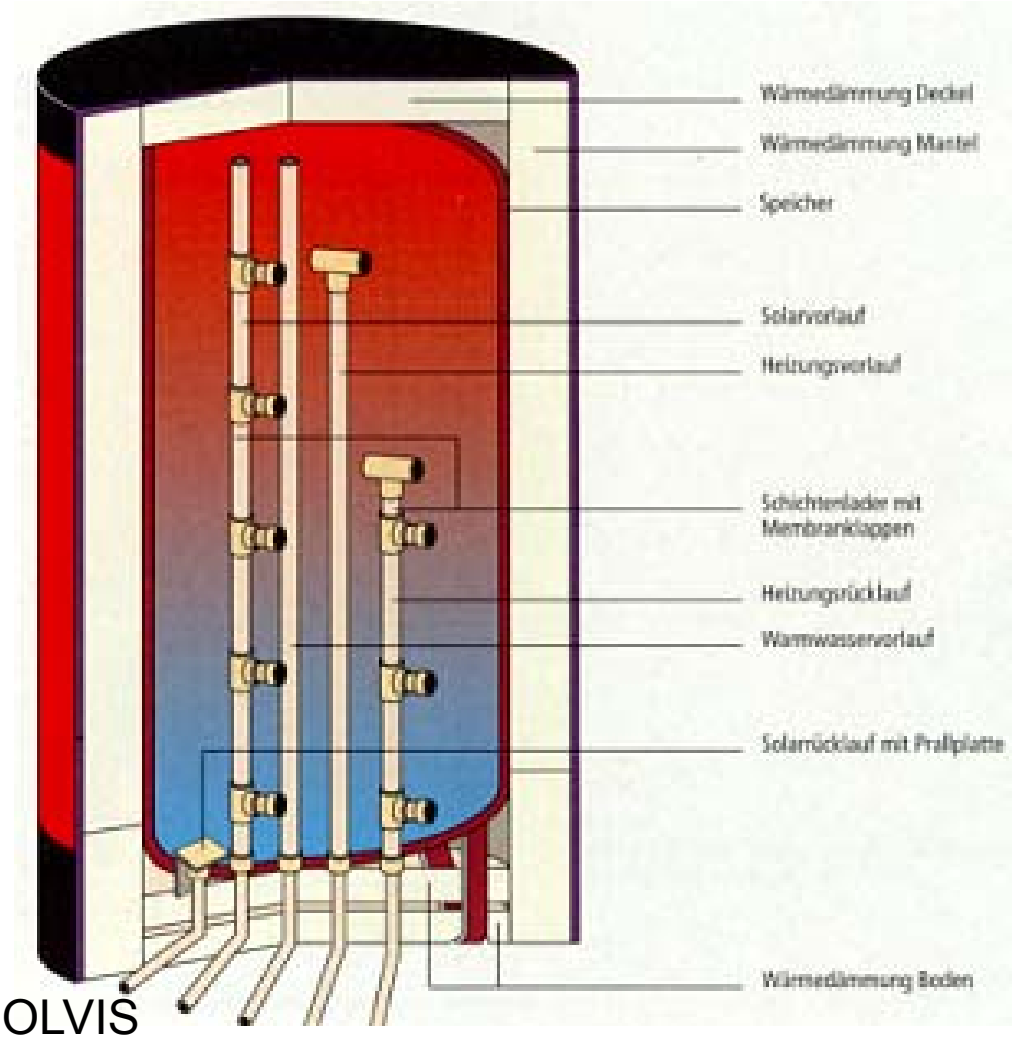


Typical mass flow: 5 to 20 kg/m²h

Temperature increase per pass:
55 K at 800W/m²

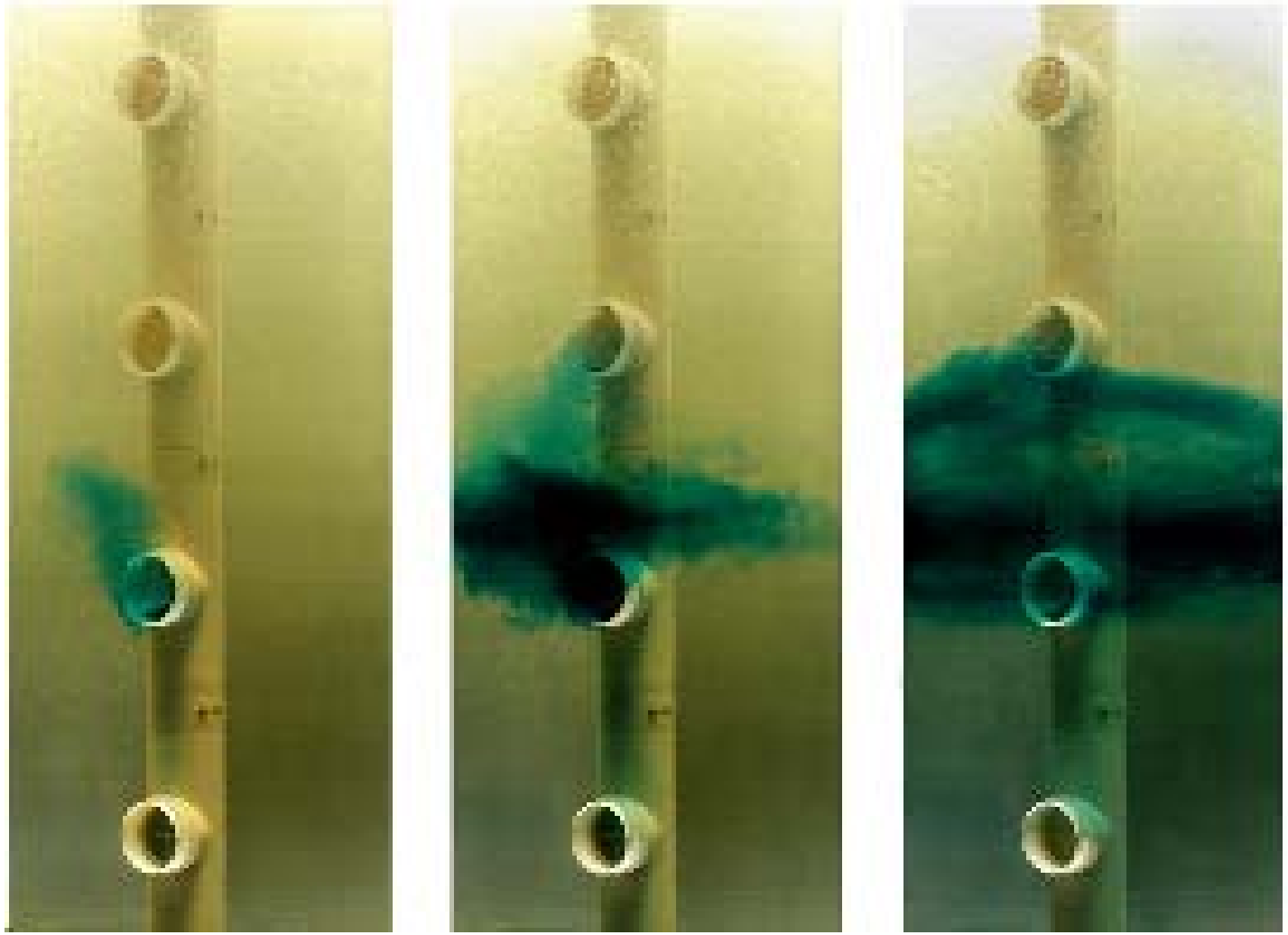
Collector areas > 15 m²

Stratified charging of the storage tank



Source: SOLVIS

Stratified charging of the storage tank



Source: SOLVIS

„Low-Flow“ Systems versus „High-Flow“

Type of operation	Specific mass flow	Example: mass flow at 50 m² collector area
Low-Flow	5 - 20 kg/m²h	12 kg/m²h => 600 kg/h
High-Flow	21 - 70 kg/m²h	45 kg/m²h => 2,250 kg/h
Low-Flow – r.p.m. controlled	5 - 20 kg/m²h	250 to 1,000 kg/h

„Low-Flow“ Systems versus „High-Flow“

$$\dot{m}_{primary} = A_{collector} \cdot \dot{m}_{specific} \quad [kg/h] \qquad \text{(equation 1)}$$

$\dot{m}_{primary}$	mass flow of the primary circuit of the solar thermal system	[kg/h]
$A_{collector}$	collector area (aperture area)	[m²]
$\dot{m}_{specific}$	specific mass flow for the primary circuit of the solar thermal system	[kg/m²h]

„Low-Flow“ Systems versus „High-Flow“

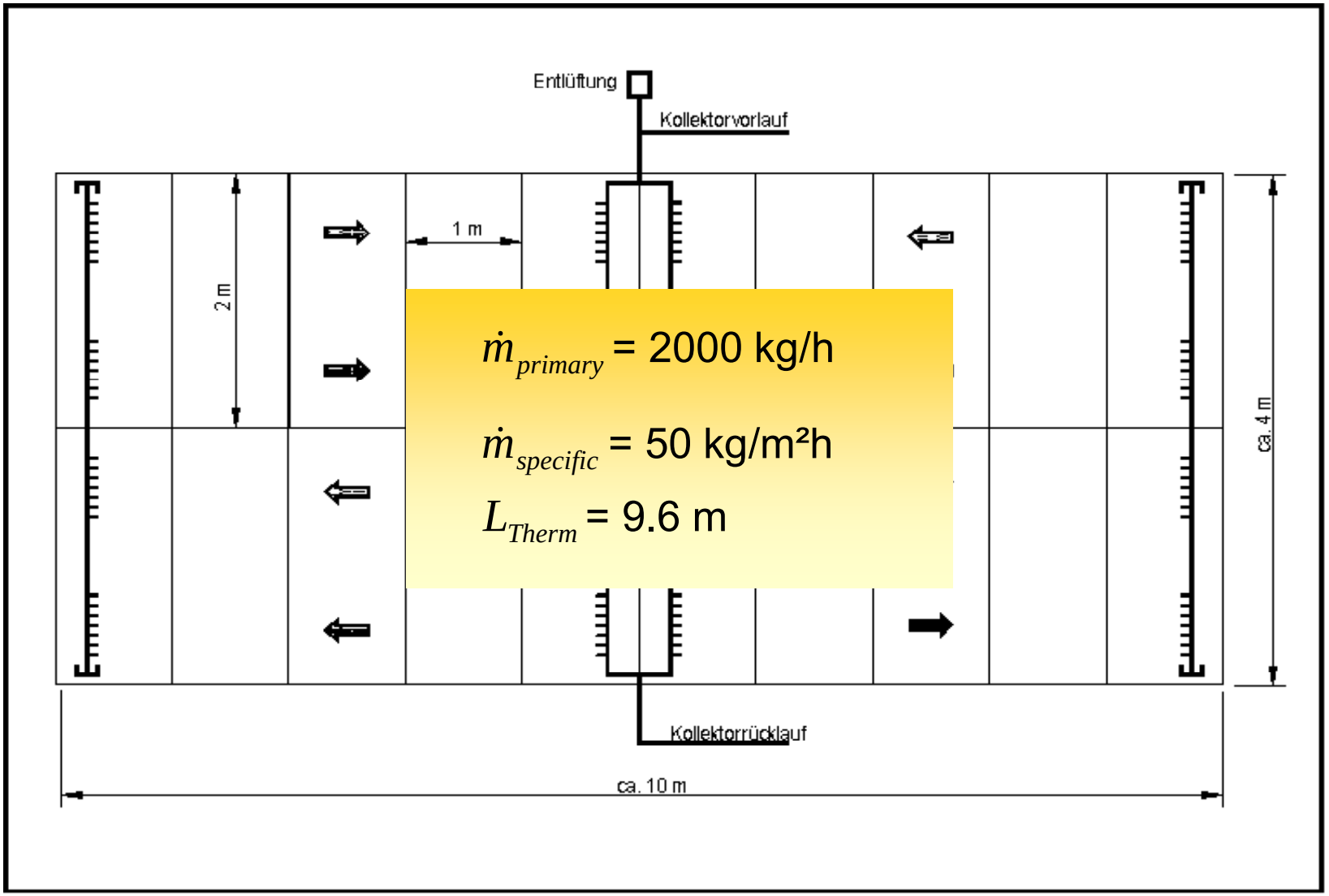
Comparison of a low-flow and high-flow system by the means of:

- Collector hydraulics
- Efficiency of the collector
- Pressure drop of the collector and the system
- Hydraulic efficiency and electrical pump efficiency

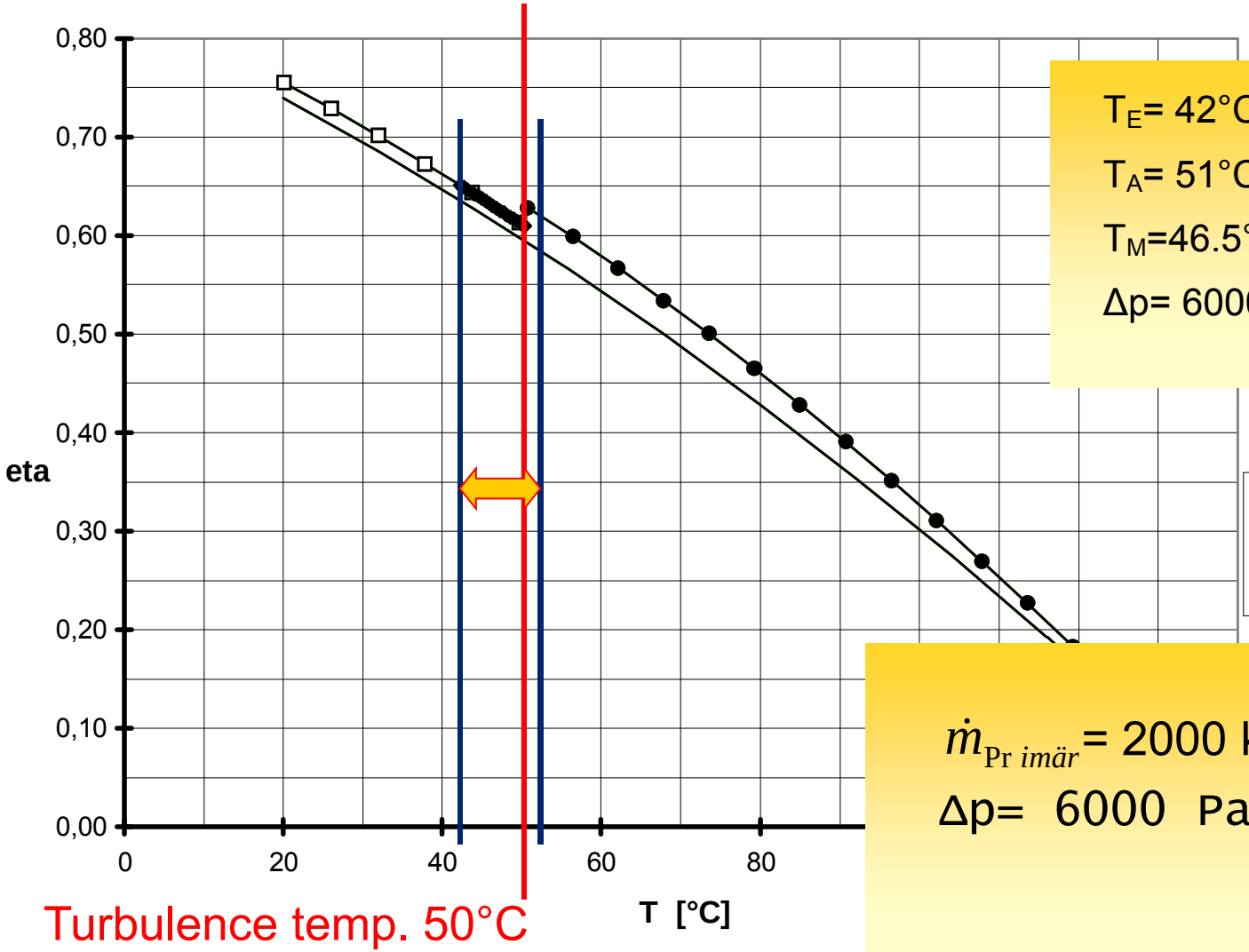
The boundary conditions for the comparison are:

- Gross collector area: 40 m² (10 m x 4 m)
- Collector values: c_0=0.77, c_1=3.33 W/m²K, c_2=0.012 W/m²K²
- Inner diameter of the absorber pipe: 8.25 mm
- Ambient temperature: 20 °C
- Irradiation on the collector area: 800 W/m²
- Average collector temperature: 46.5°C (for both systems)

High-Flow System



Efficiency curve - High-Flow System



T_E= 42°C

T_A= 51°C => ΔT von 9K

T_M=46.5°C

Δp= 6000 Pa (0.6 mWS)

$\dot{m}_{Pr\ imär}$= 2000 kg/h

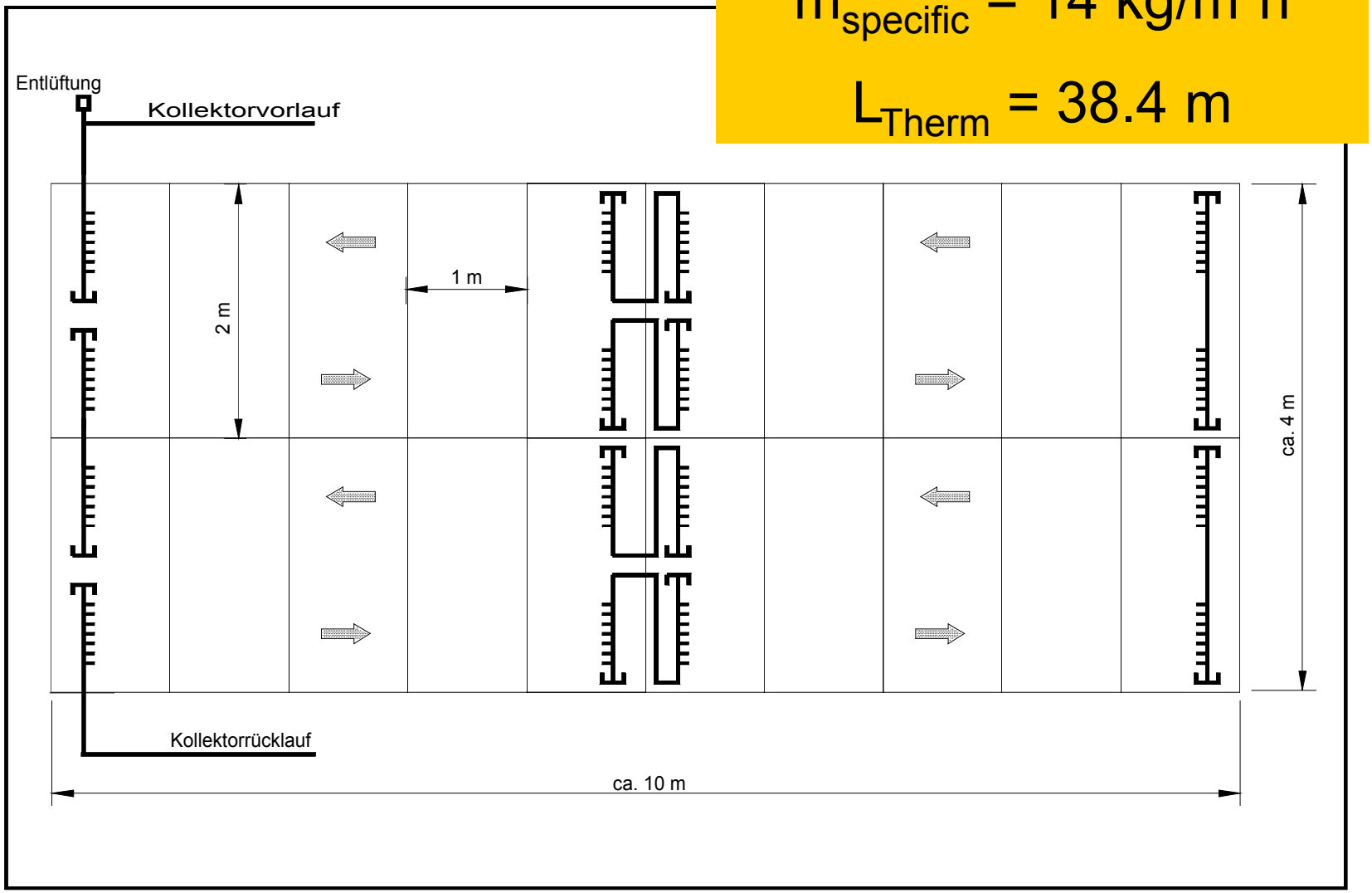
Δp= 6000 Pa (0,6 mWS)

Low-Flow System

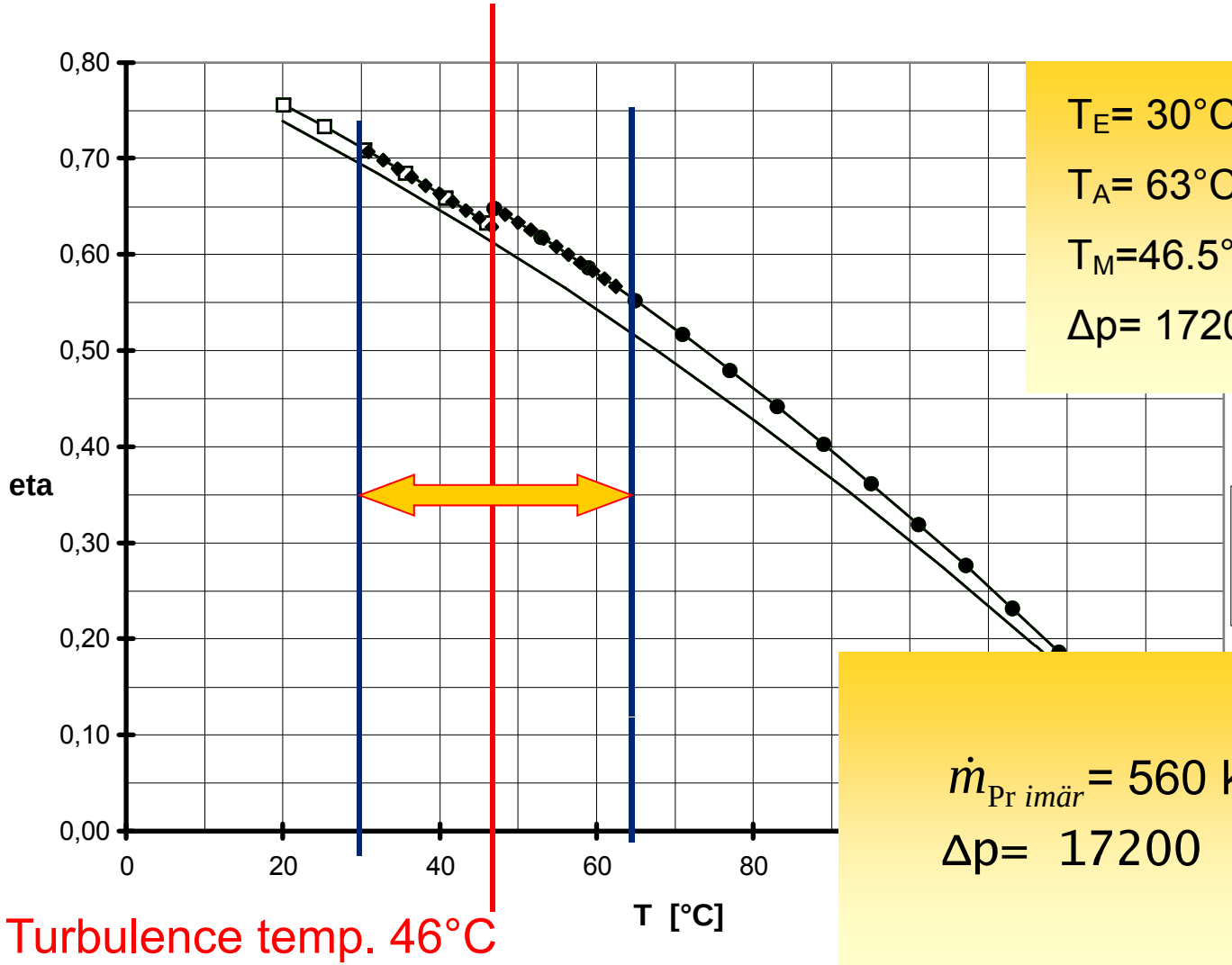
$m_{primary}$ = 560 kg/h

$m_{specific}$ = 14 kg/m²h

L_{Therm} = 38.4 m



Efficiency curve - Low-Flow System



Turbulence temp. 46°C

T_E= 30°C

T_A= 63°C => ΔT von 33K

T_M=46.5°C

Δp= 17200 Pa (1,7 mWS)

$\dot{m}_{Primär}$= 560 kg/h

Δp= 17200 Pa (1,7 mWS)

Comparison of the pressure drops

Pressure drop of the High-Flow System (2000 kg/h)

Component	Pressure drop [Pa]
37.03 net absorber area, high flow connected	6,000
Flat plate heat exchanger SWEP B25-30	16,700
Pipes – collector loop 5/4”	6,080
Other components of the system (flap trap, fittings, etc.)	4,000
Total	**32,780**

Pressure drop of the Low-Flow System (560 kg/h)

Component	Pressure drop [Pa]
37.03 net absorption area, low flow connected	17,200
Flat plate heat exchanger 2 x SWEP B15-20 in series	12,200
Pipes – collector loop 3/4”	6,000
Other components of the system (flap trap, fittings, etc.)	4,000
Total	**39,400**

Hydraulic efficiency of two systems:

$$P_{system} = \frac{\dot{m} \Delta p_{system}}{\rho \cdot 3600}$$

P_{system}	hydraulic efficiency	W
$\dot{m}$	mass flow	kg/h
Δp_{system}	pressure drop of the system	Pa
ρ	average density of the medium	kg/m³

Hydraulic efficiency of two systems:

Hydraulic efficiency high-flow system:

$$P_{system\_HF} = \frac{2037 \cdot 32780}{1039 \cdot 3600} = 18W$$

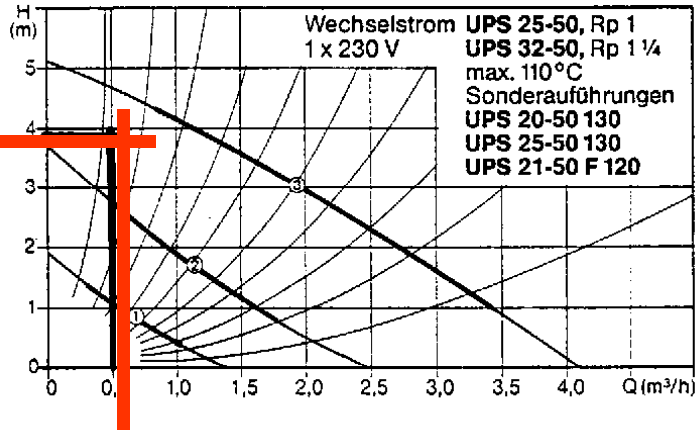
Hydraulic efficiency of the low-flow system:

$$P_{system\_LF} = \frac{555 \cdot 39400}{1039 \cdot 3600} = 6W$$

Determination of the pump

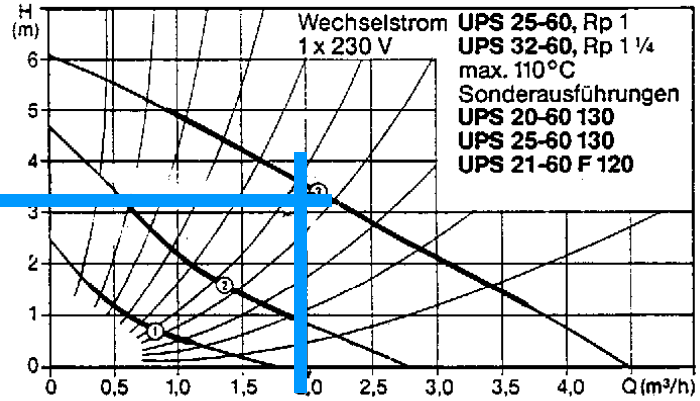
Low Flow System:

UPS 25-50, Stufe 3



High Flow System:

UPS 25-60, Stufe 3



Elektrische Daten

Typ	Stufe Drehzahl n [min⁻¹]	Leistungsaufn. P_1 [W]
UPS 25-20 UPS 32-20	3-2500 2-2050 1-1450	65 40 25
UPS 25-40 UPS 32-40	3-1850 2-1200 1- 750	75 50 30
UPS 25-50 UPS 32-50	3-1700 2-1050 1- 650	85 60 35
UPS 25-60 UPS 32-60	3-1800 2-1100 1- 700	100 65 40

⇒ **Efficiency of the pump <20%**

⇒ **Power of the pump of this Low Flow System is ~ 15% lower**

„Low-Flow“ Systems versus „High-Flow“

The low-flow operation of a system leads to smaller dimensions of the tubes. This causes lower investment costs for the whole solar thermal system.

Low-flow systems demand (and enable) a big thermal length in the collector (this means a long serial connection of the pipes). Therefore a collector area of 80 to 100 m², which is connected in series, can be realised depending on the geometry of the absorber and the resulting pressure drop. This leads to a significant reduction of the piping, as there is only one flow and return tube necessary for the whole collector field. For high-flow systems the maximum collector area, which can be connected in serial is 25 m² (depending on the geometry of the absorber and the resulting pressure drop). This advantage of low-flow systems reduces the investment costs (tubing, insulation material, man power) significantly.

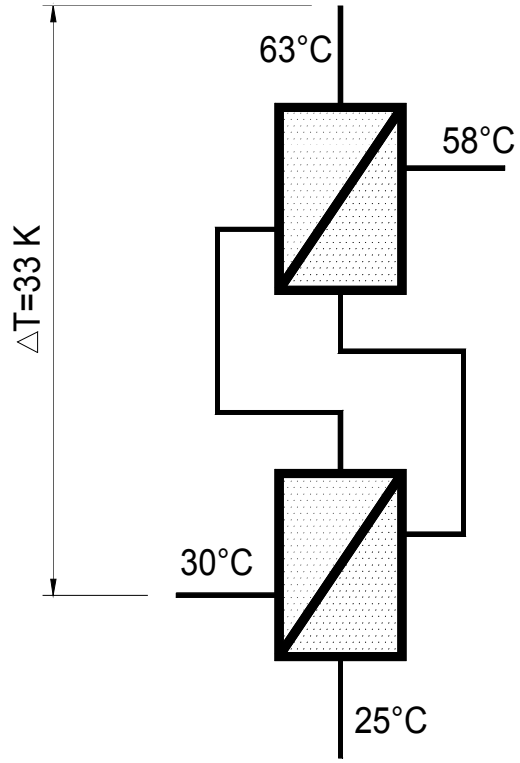
„Low-Flow“ Systems versus „High-Flow“

Due to the reduction of the tubing on the one hand and the smaller tube diameter on the other hand the heat loss at a low-flow system can be reduced and the annual efficiency of the system can be risen significantly compared to a high-flow system.

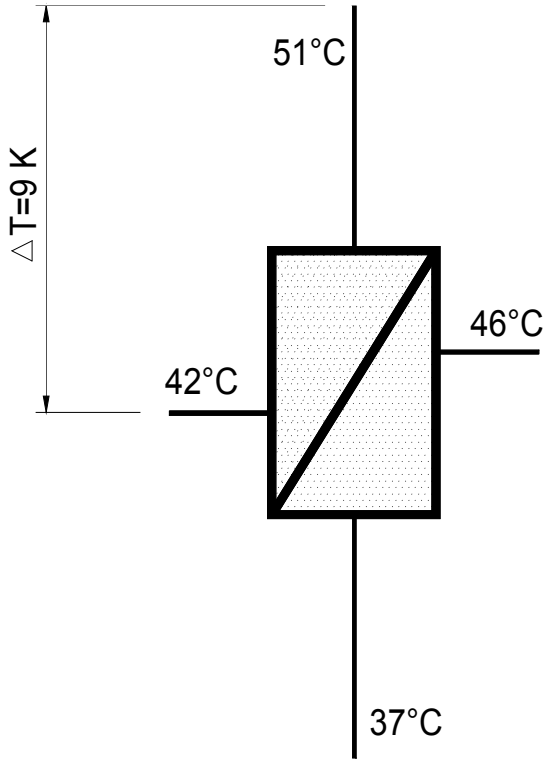
At low-flow systems the reduced mass flow leads to lower hydraulic performances and to a lower demand of electrical energy for the pumps.

The demand for auxiliary heating is reduced significantly at low-flow systems because a high temperature level can be provided for the user very quick.

For the heat exchanger applies the same as for the collector!



Sekundärseite: $\dot{m}$= 494 kg/h
2 x SWEP B15-20 in Serie



Sekundärseite: $\dot{m}$= 1811 kg/
SWEP B25-30

$\dot{Q}$= 18,9 kW