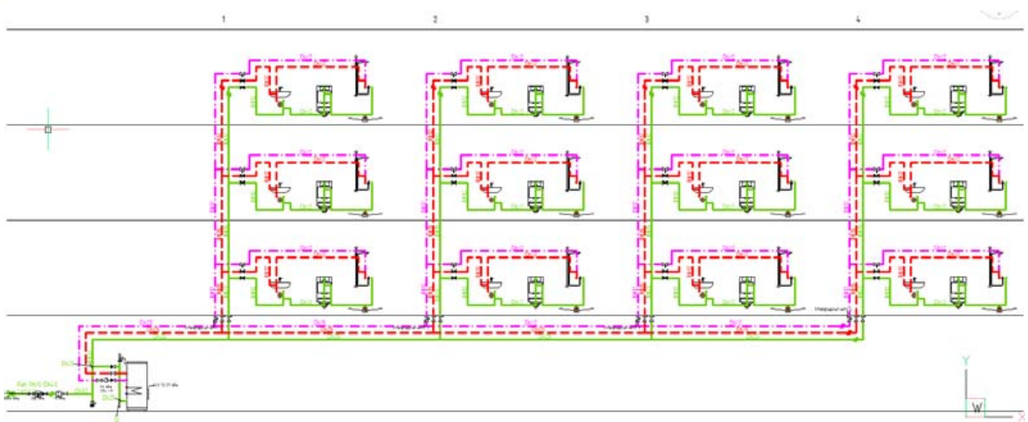
Hot Water Return (HWR): Benefits, Design & Technologies



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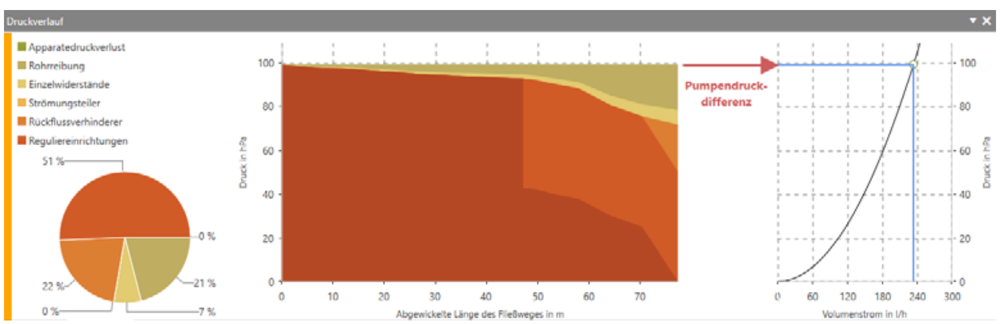
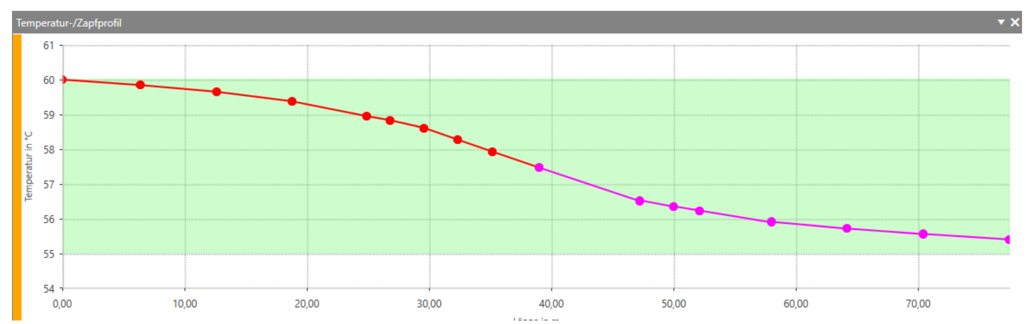




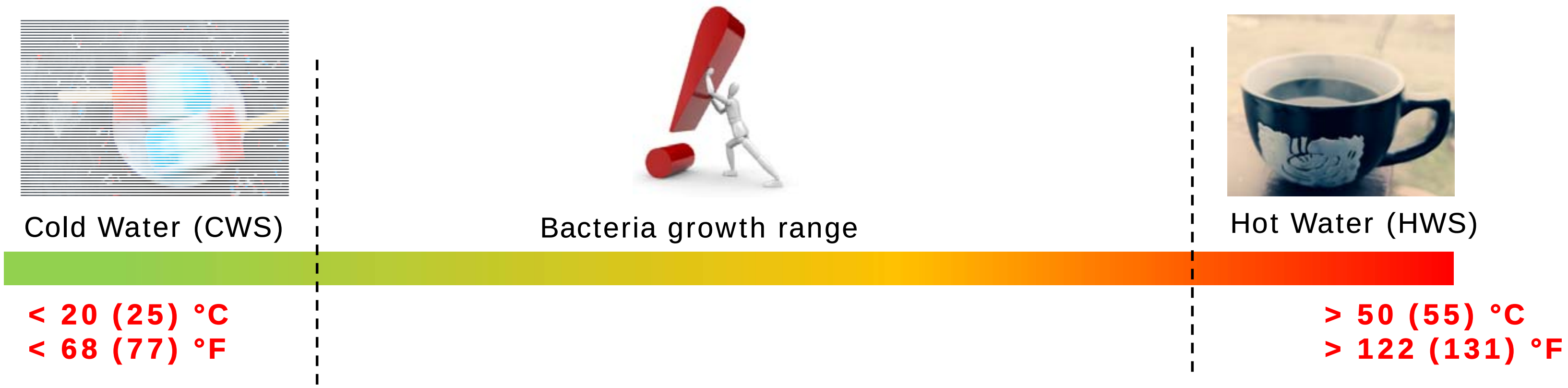
Content

- Benefits of HWR systems
- HWR system approaches
- HWR design & calculation
- Comparison of HWR systems

Benefits of HWR installations

- Instant hot water

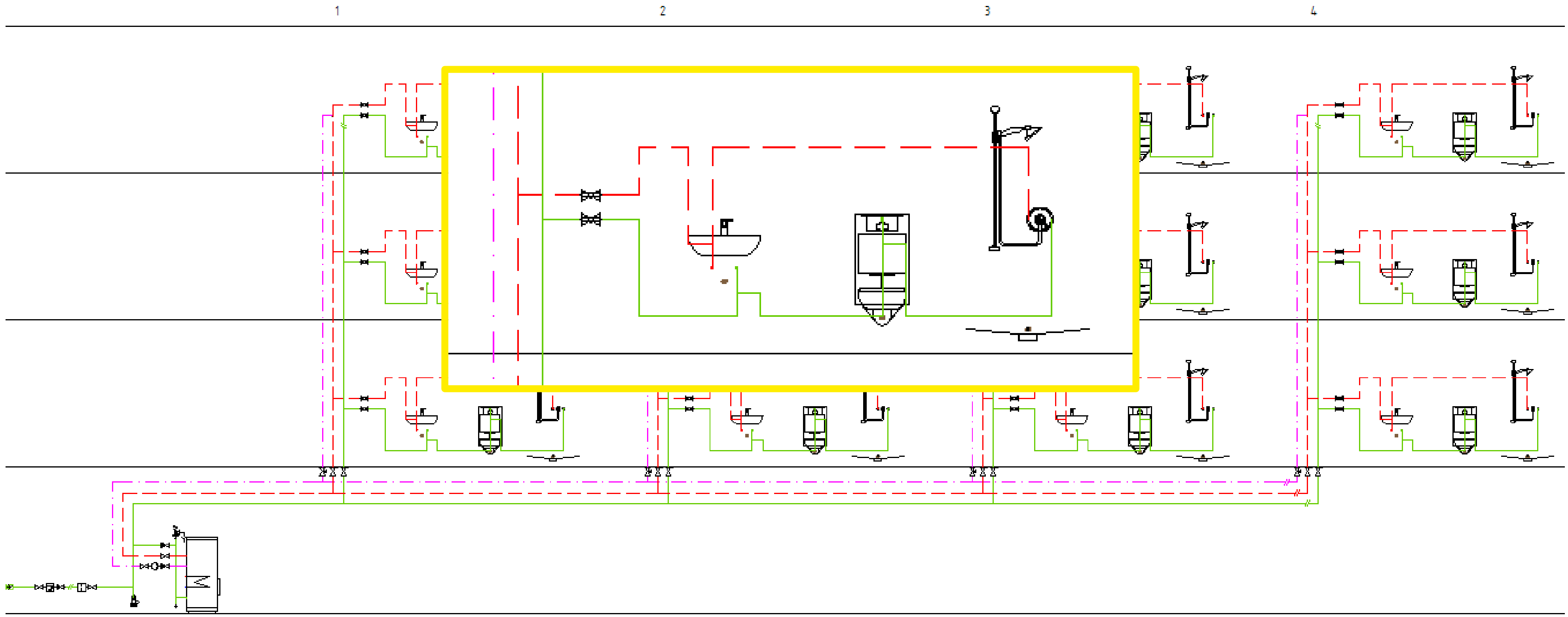
- Maintaining the water quality



HWR approaches

Time to tap: how long do you want to wait for HW?

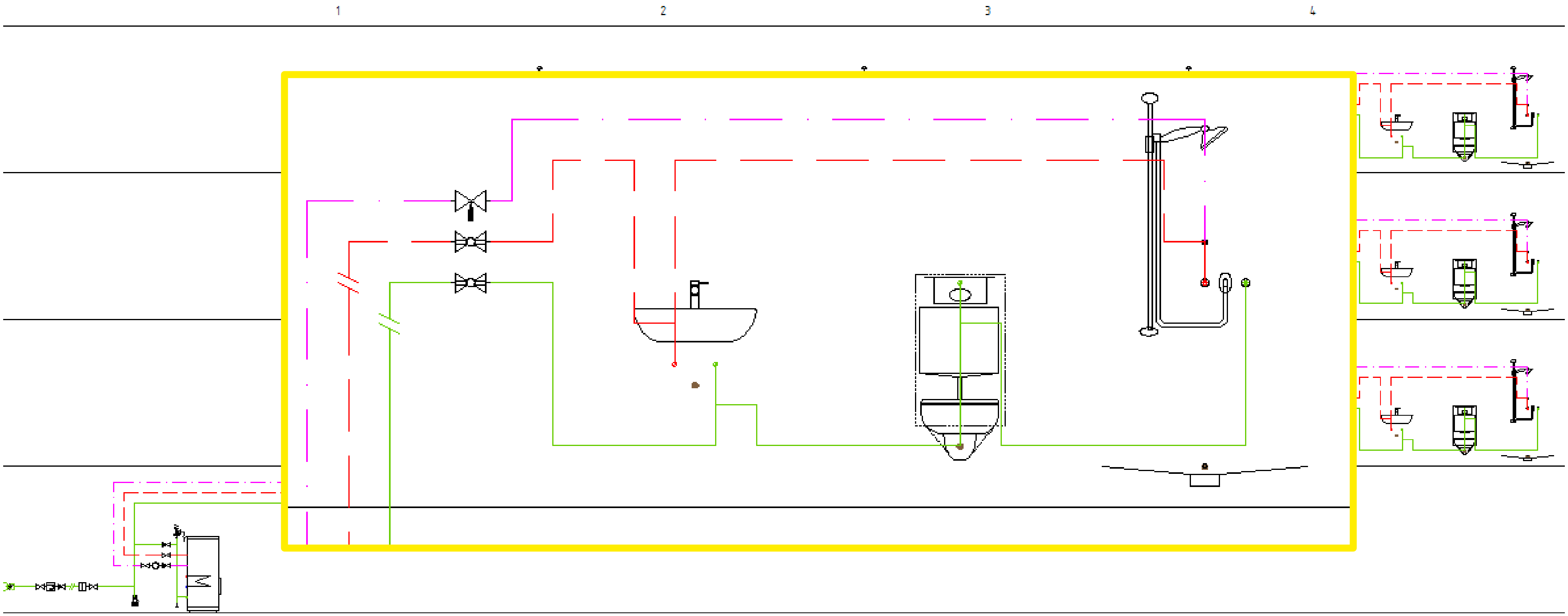
Example 1: circulation only in riser



HWR approaches

Time to tap: how long do you want to wait for HW?

Example 2: circulation in every room / as close to fixtures as possible



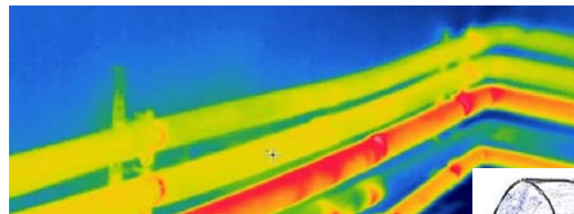
General design recommendations

- Simple & symmetric pipe routing
  (hydraulic balancing by clever pipe routing)
- Minimize branching
  (as less branches as possible, but as many as required)
- Compact system design
  (HWR/HWS ratio)
- Separate hot and cold pipe traces / risers
  (keep the heat away from cold pipes)

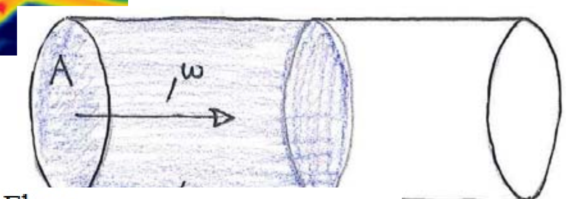
HWR design calculations

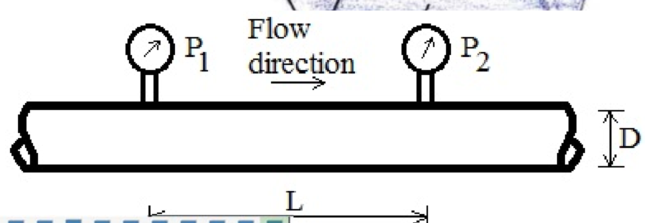
Four steps to design & size a HWR installation:

Step 1 – calculation of heat loss



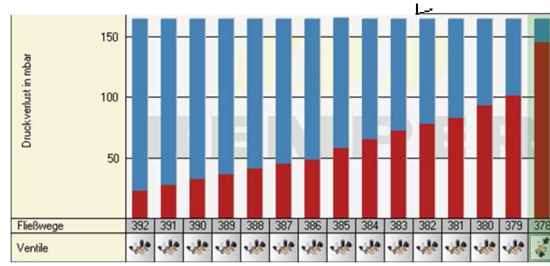
Step 2 – calculation of circulation flow rate





Step 3 – calculation of pressure loss

Step 4 – hydraulic balancing

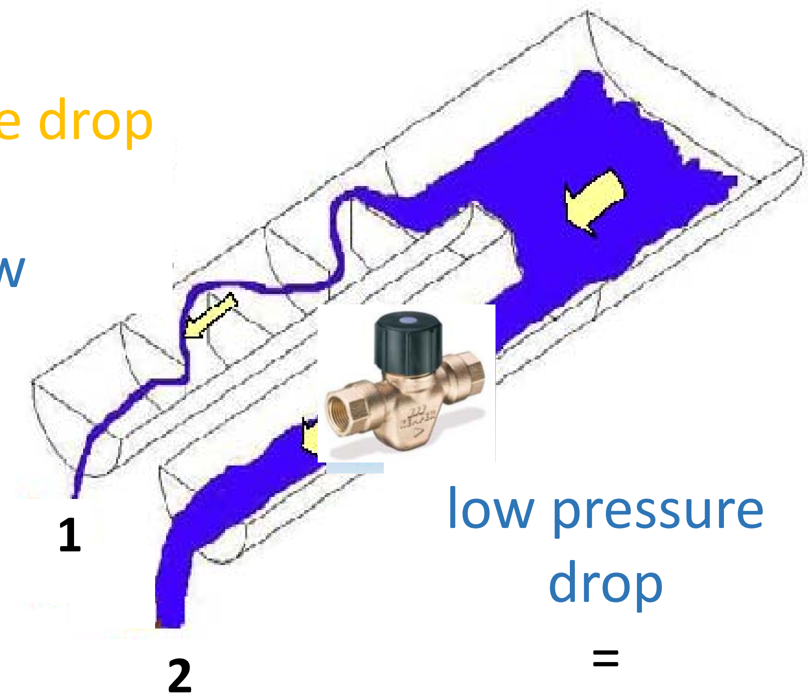


HWR design calculations

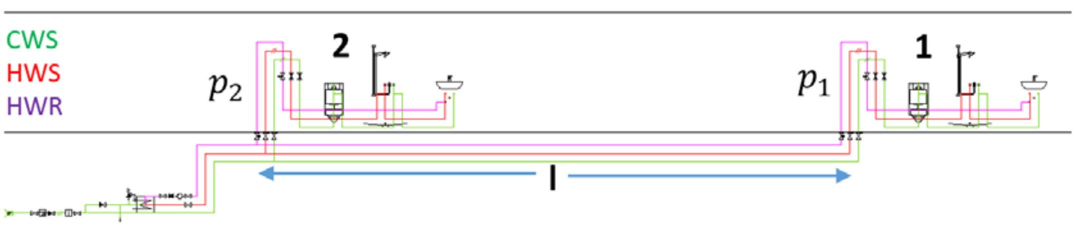
Step 4 – hydraulic balancing

the problem to solve:

high pressure drop
=
low flow

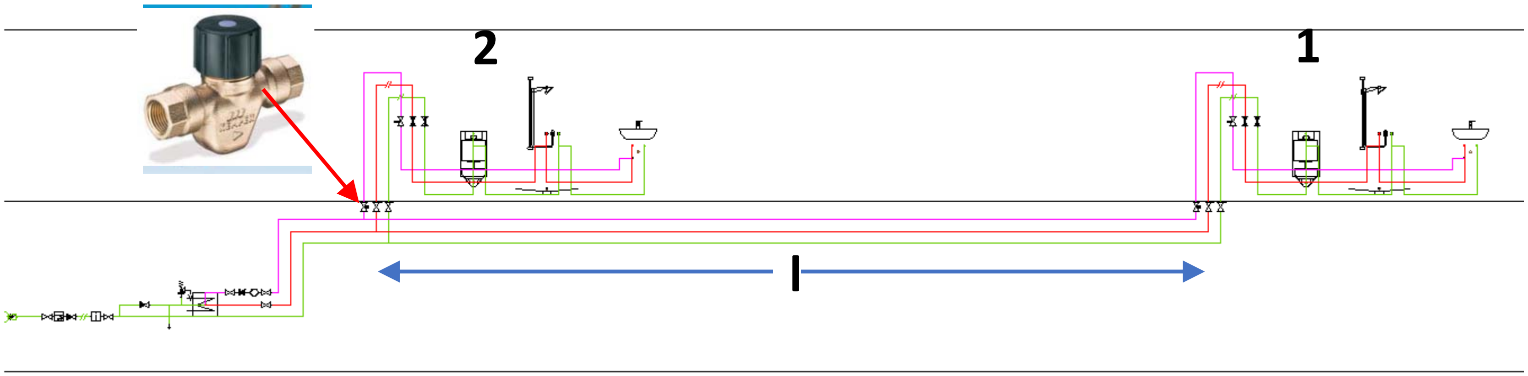


low pressure drop
=
high flow



HWR design calculations

Step 4 – hydraulic balancing



Operating point for hydraulic balancing valve: $\Delta p_{valve} = p_1 - p_2$

$\dot{V}_2$

The required operating point of a HWR balancing valve is defined of the required HWR flow rate of the branch and the required „additional“ pressure drop of the balancing valve that depends on the pressure loss of the index run (critical flow path).

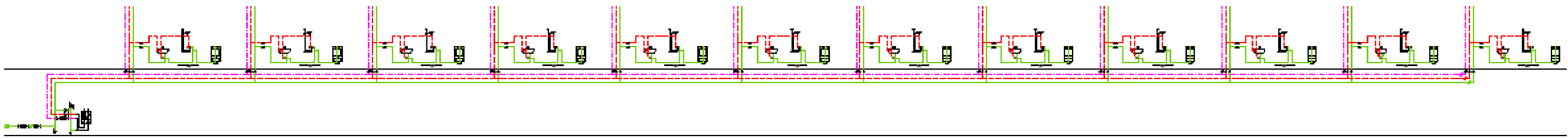
HWR design calculations

HWR Example: Hotel with 96 rooms

HWR design calculations

HWR Example – Calculation Results (steps 1 – 3)

Riser	1	2	3	4	5	6	7	8	9	10	11	12
HWR flow rate [l/h]	62	63	63	65	66	67	68	69	71	74	93	**97**
pressure loss pipework [hPa]	18	24	30	35	40	51	60	67	72	76	83	**88**
pressure loss other components [hPa]	62	62	62	62	62	62	62	62	62	62	62	**62**
pressure loss HWR balancing valve [hPa]												**70**
total pressure loss [hPa]	80	86	92	97	102	113	122	129	134	138	145	**220**



- Total pressure drop must be eqal in each riser, riser 12 is the index run → **total pressure drop must be 220 hPa through all risers (flow paths)**!
- **The missing pressure loss has to be „produced“ by the balancing valves @ a required flow rate**

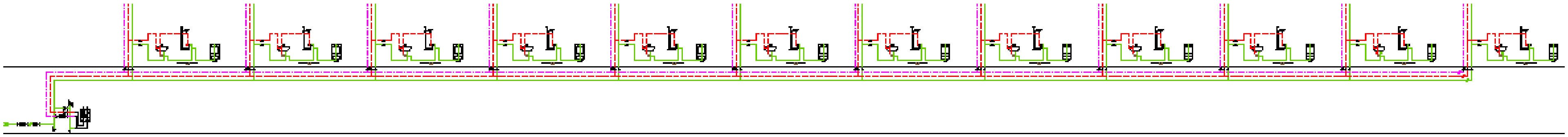
HWR design calculations

HWR Example – Step 4: hydraulic balancing

HWR design calculations

HWR Example – Step 4: hydraulic balancing

Riser	1	2	3	4	5	6	7	8	9	10	11	12
HWR flow rate [l/h]	62	63	63	65	66	67	68	69	71	74	93	**97**
pressure loss pipework [hPa]	18	24	30	35	40	51	60	67	72	76	83	**88**
pressure loss other components [hPa]	62	62	62	62	62	62	62	62	62	62	62	**62**
pressure loss HWR balancing valve [hPa]	140	134	128	123	118	107	98	91	86	82	75	**70**
total pressure loss [hPa]	220	220	220	220	220	220	220	220	220	220	220	**220**



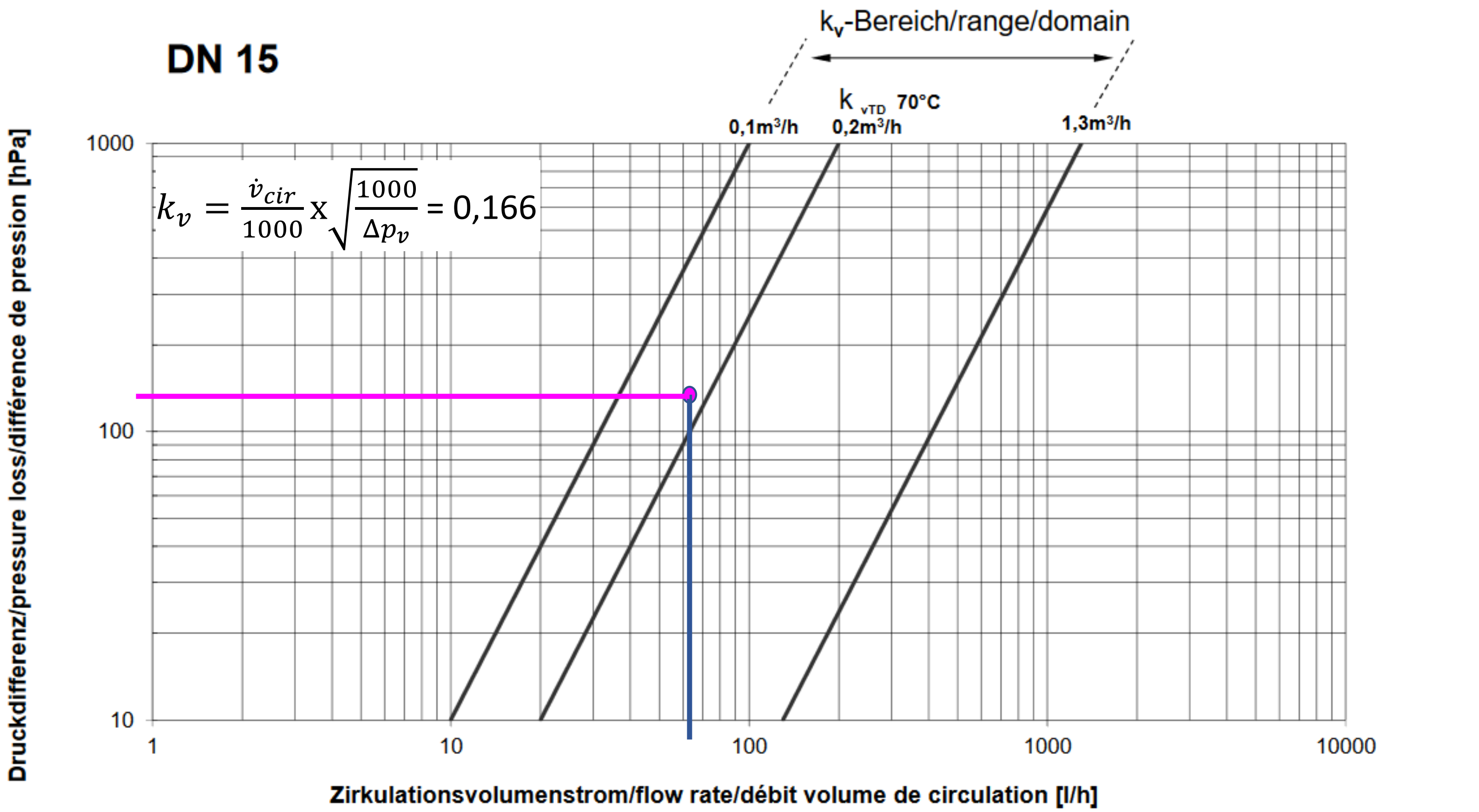
- Total pressure drop must be eqal in each riser, riser 12 is the index run → **total pressure drop must be 220 hPa in all risers**!
- **The missing pressure loss has to be „produced“ by the balancing valves @ a required flow rate**

HWR design calculations

HWR Example – Step 4: Valve Selection

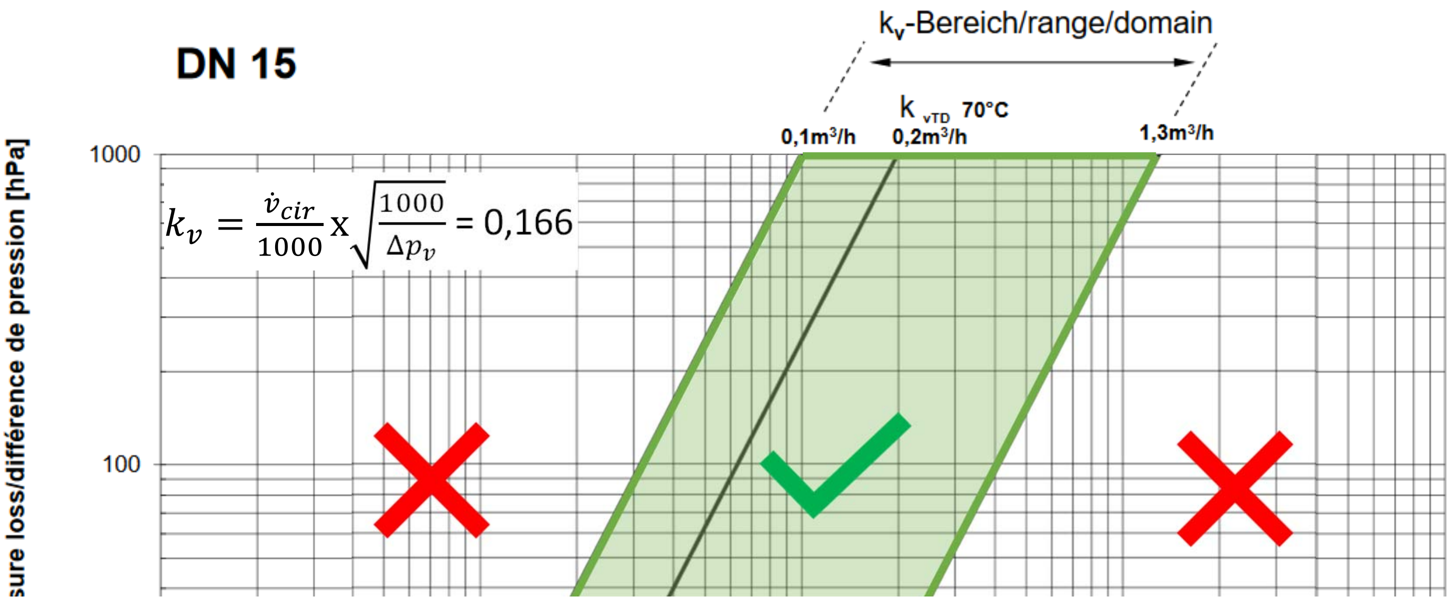
Riser	1
HWR flow rate [l/h]	62
pressure loss pipework [hPa]	18
pressure loss other components [hPa]	62
pressure loss HWR balancing valve [hPa]	140
total pressure loss [hPa]	220

$$k_v = \frac{\dot{v}_{cir}}{1000} \text{x} \sqrt{\frac{1000}{\Delta p_v}} = 0{,}166$$



HWR design calculations

HWR Example – Step 4: Valve Selection

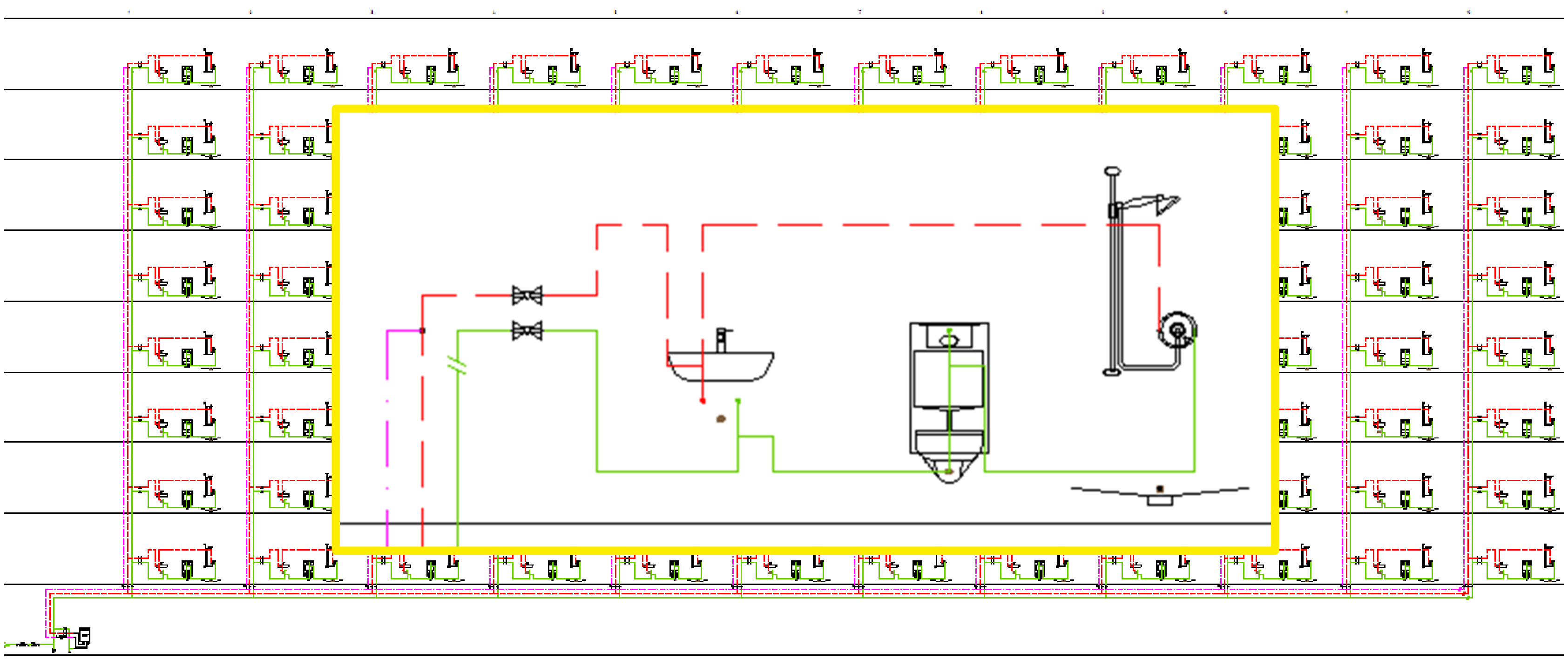


$$k_v = \frac{\dot{v}_{cir}}{1000} \text{x} \sqrt{\frac{1000}{\Delta p_v}} = 0{,}166$$

- (Automatic) Thermostatic balancing valves can only balance within their hydraulic operating range!
- It has to be checked if the calculated hydraulic operating point is within the operating range of the valve.

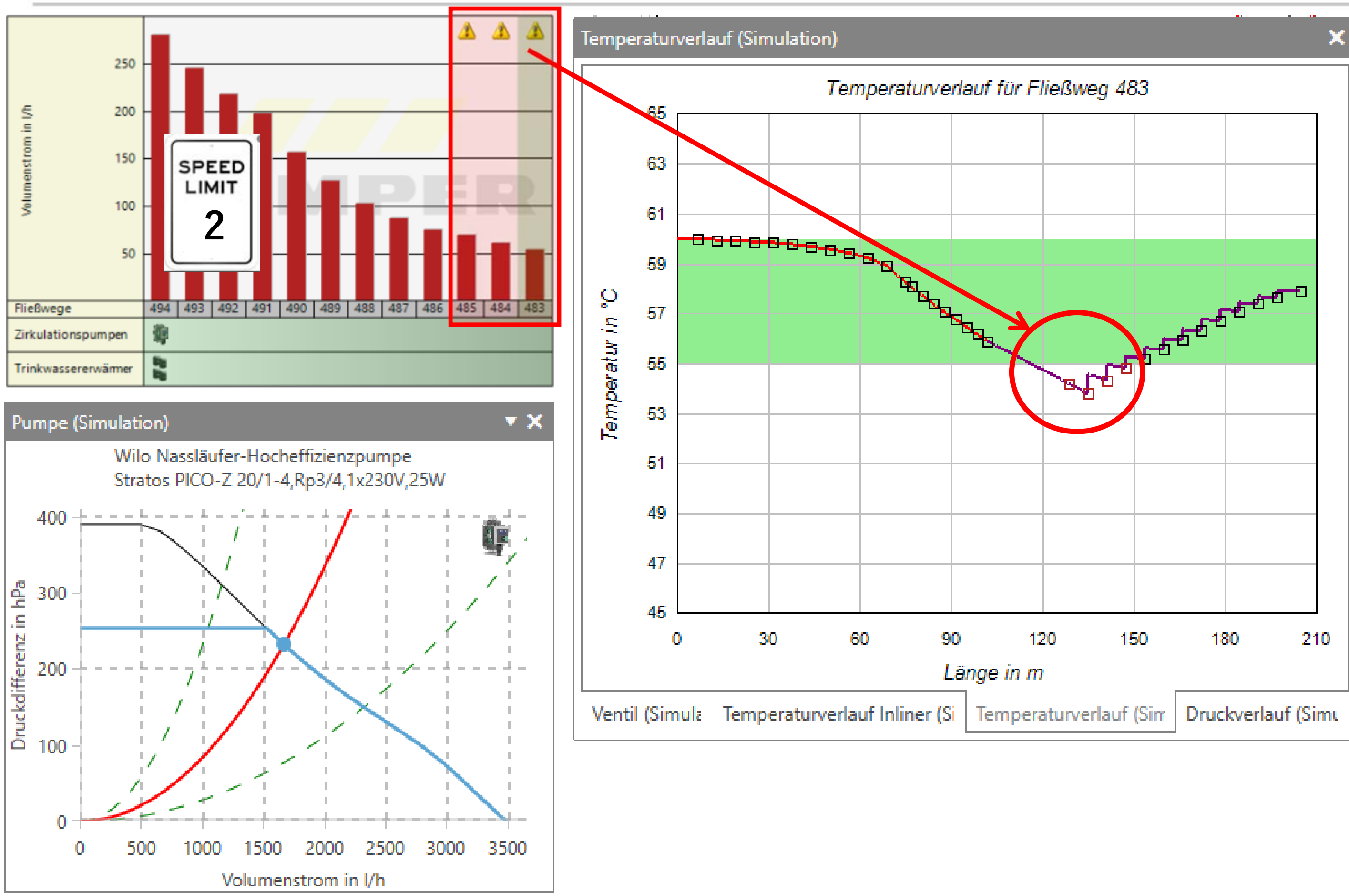
Comparison of HWR principles

Example 1: Hotel with 96 rooms – HWR connection at top of riser



Comparison of HWR principles

Example 1: Hotel with 96 rooms – HWR connection at top of riser



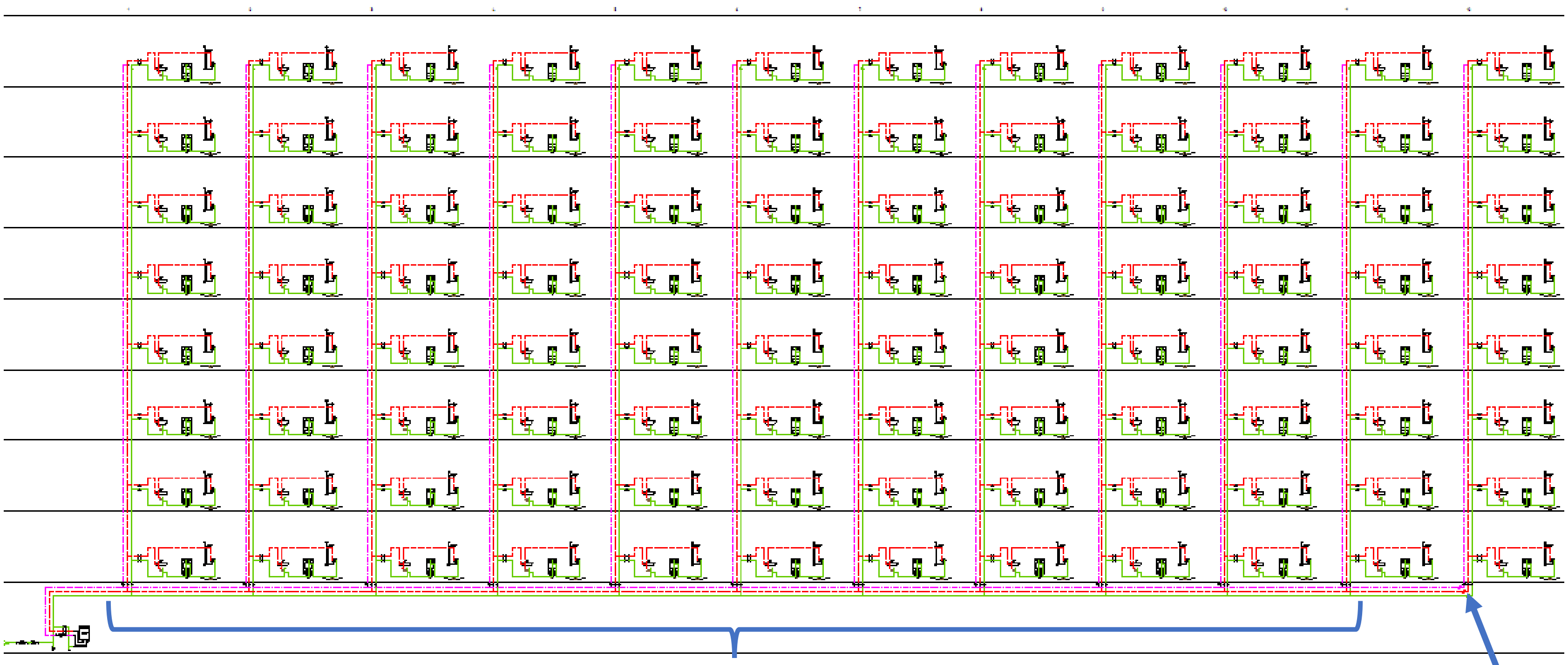
<u>Hydraulically unbalanced system</u>

Malfunctions:

- Excessive flow through first risers – waste of energy & risk of material damage
- Low temperatures in last risers – lack of comfort & health risk

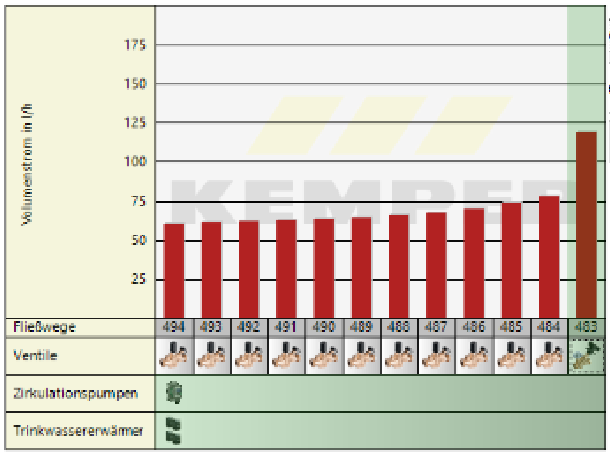
Comparison of HWR principles

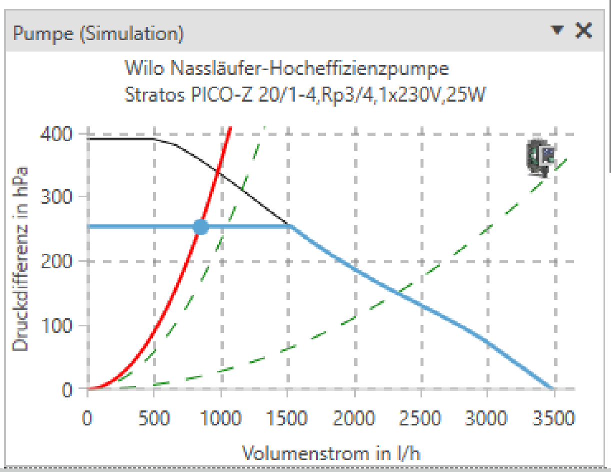
Example 1: Hotel with 96 rooms – HWR connection at top of riser

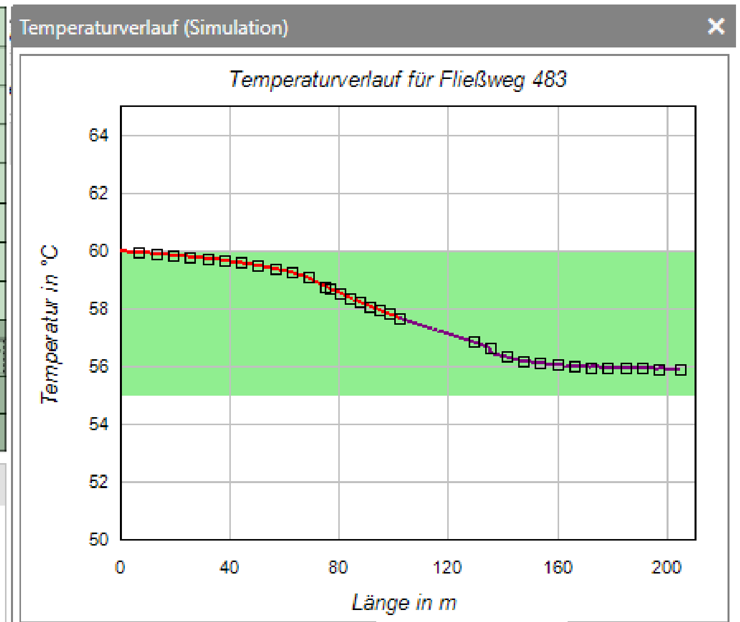


Comparison of HWR principles

Example 1: Hotel with 96 rooms – HWR connection at top of riser







<u>Hydraulically balanced system</u>

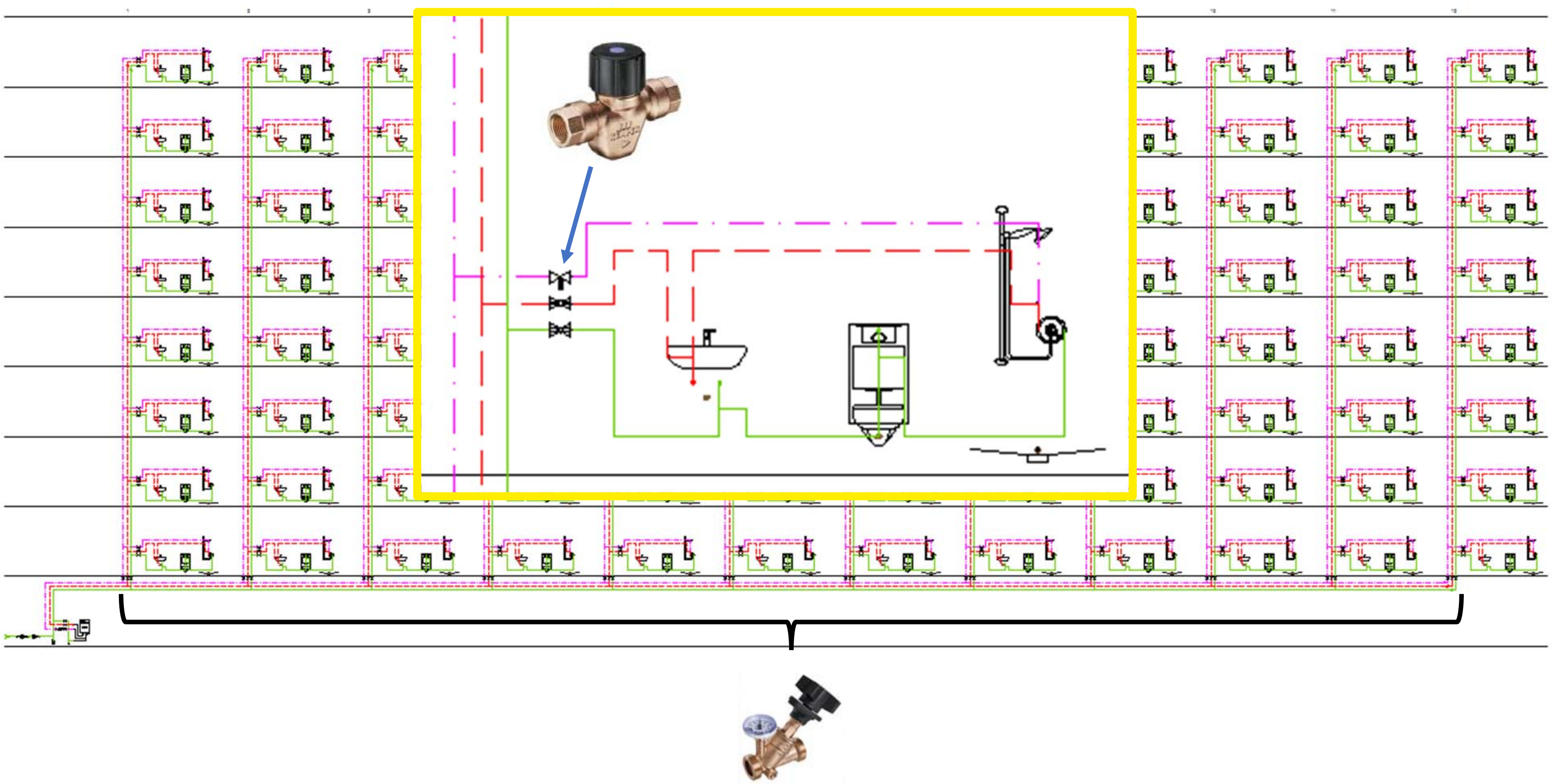
Temperature maintanance in entire HW installation with low flow rates:

- energy efficient
- increased comfort

<u>Higher comfort and lower risk of bacteria growth still possible.</u>

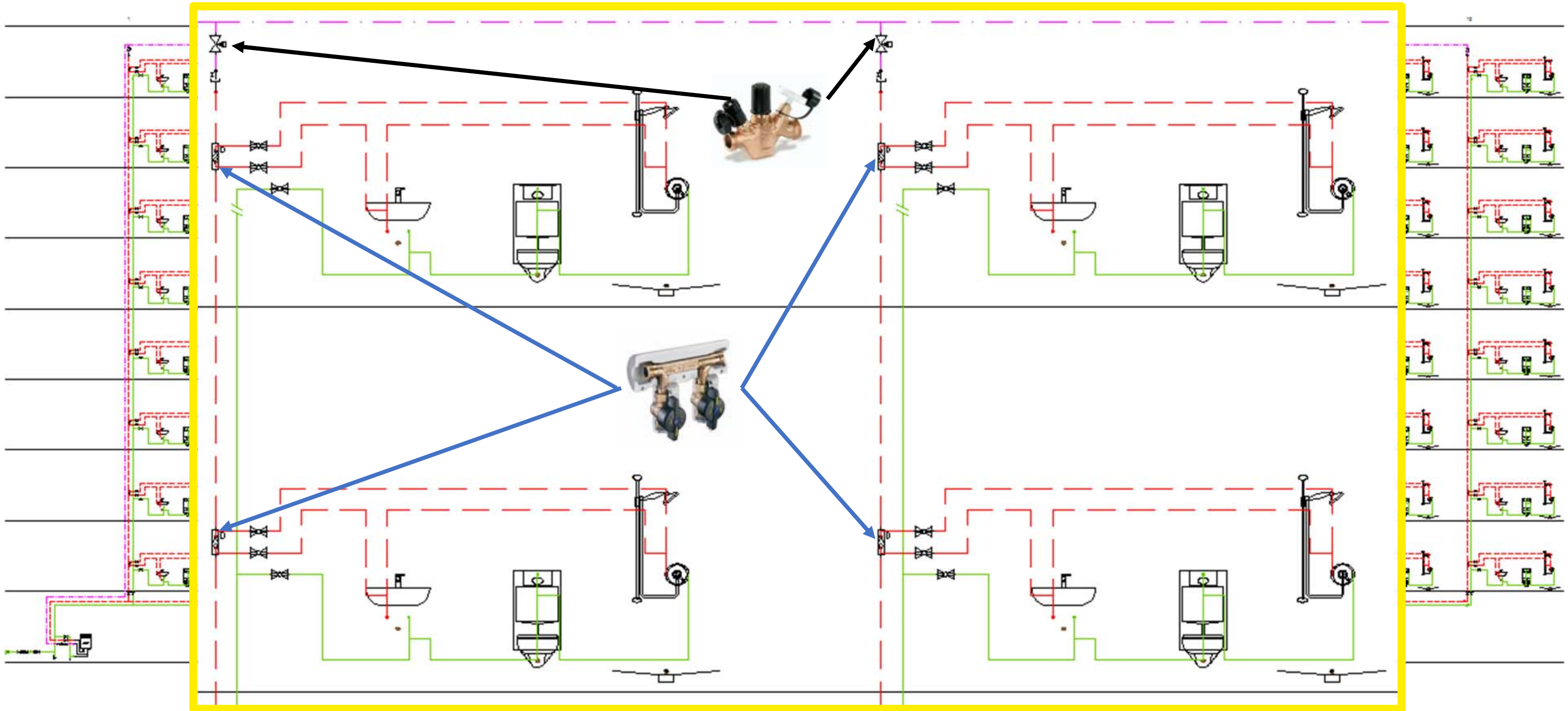
Comparison of HWR principles

Example 2: Hotel with 96 rooms – HWR connection at last fixture of each room



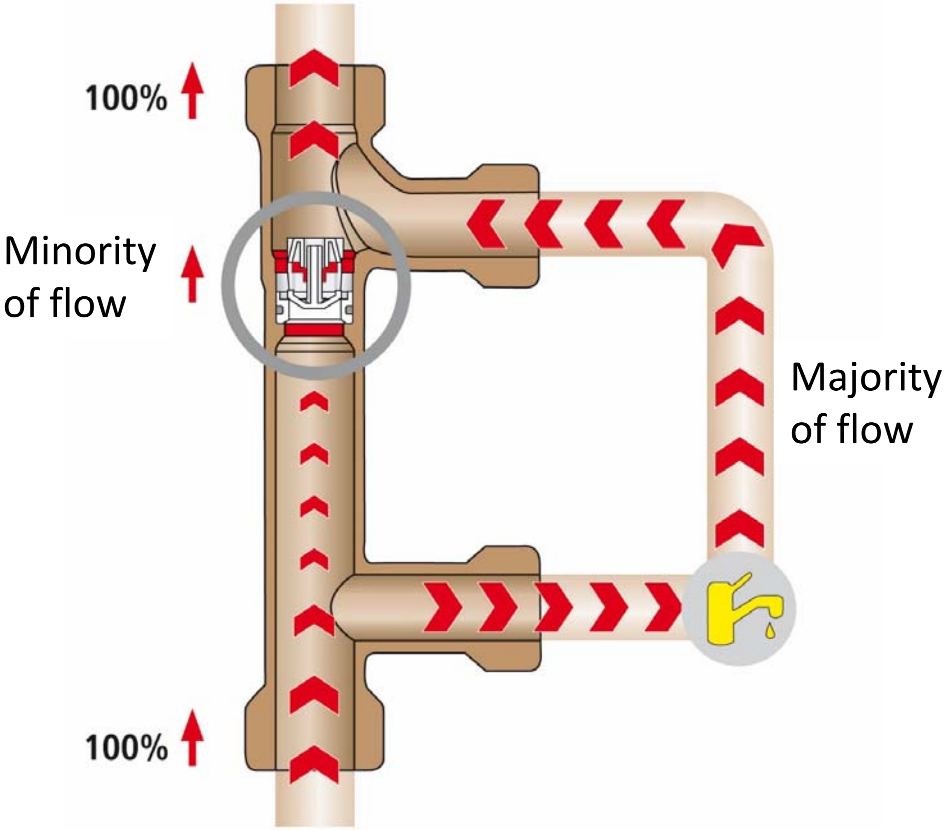
Comparison of HWR principles

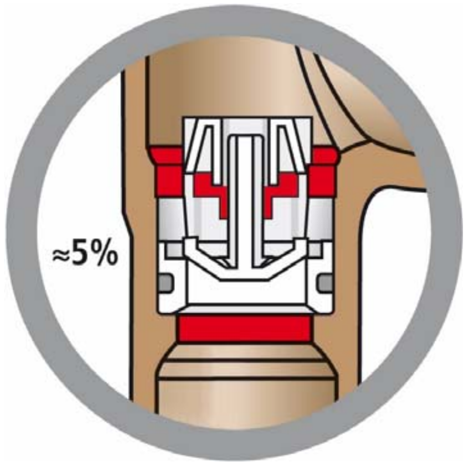
Example 3: Hotel with 96 rooms – HWS with Flow-Splitters for rooms



Principle of the Flow-Splitter

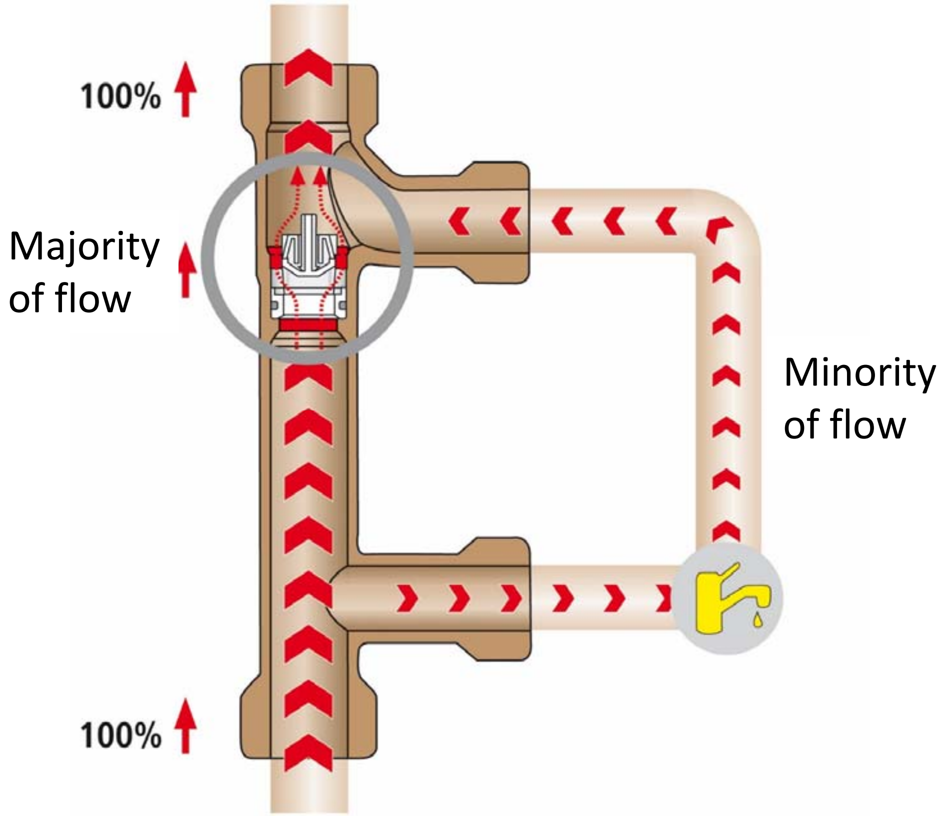
Operation Case: HWR circulation only – no hot water consumption

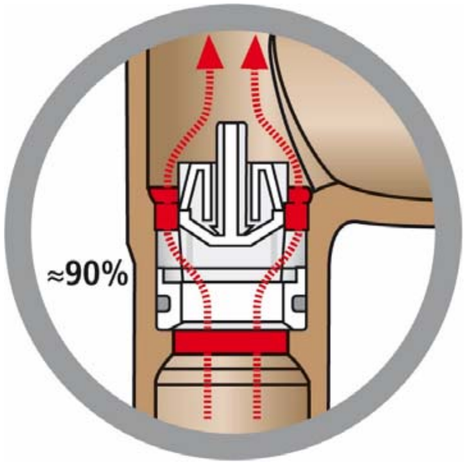




Principle of the Flow-Splitter

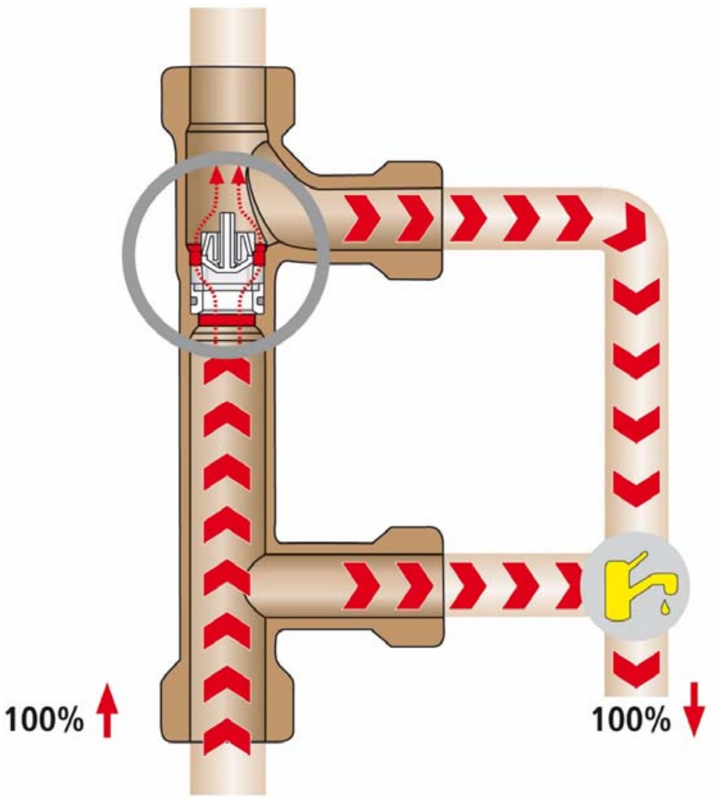
Operation Case: high downstream HW consumption (peak flow)

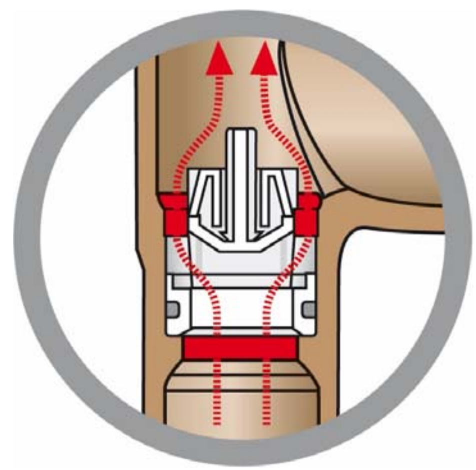




Principle of the Flow-Splitter

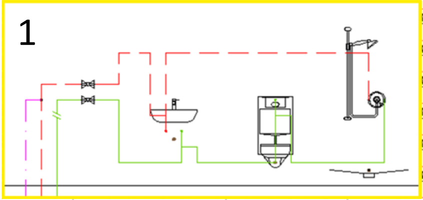
Operation Case: water usage at a fixture in the loop

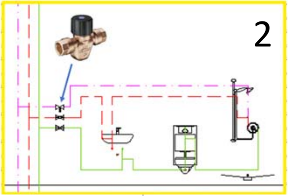


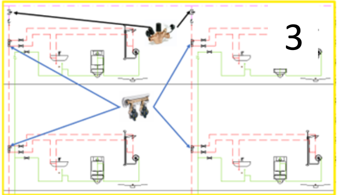


Comparison of HWR principles

Results



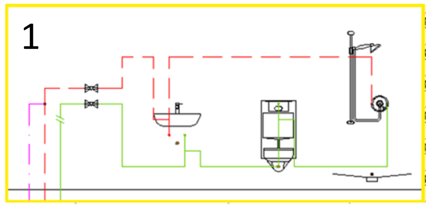


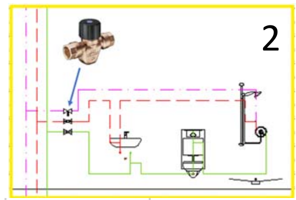


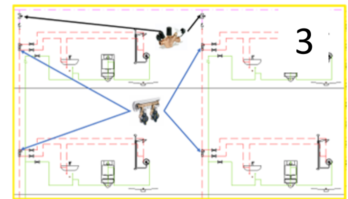
	HWR connection at riser		HWR connection at last fixture	HW with KHS Flow-Splitter
	unbalanced	balanced	balanced	balanced
Efficiancy / comfort class	Malfunctions: * low temperatures * waste of energy * risk of damage	*medium comfort *medium health protection	*highest comfort *no stagnation *energy efficient	*highest comfort *no stagnation *energy saving *lowest installation effort

Comparison of HWR principles

Results







	HWR connection at riser				HWR connection at last fixture		HW with KHS Flow-Splitter	
	unbalanced		balanced		balanced		balanced	
Efficiancy / comfort class	Malfunctions: * low temperatures * waste of energy * risk of damage		*medium comfort *medium health protection		*highest comfort *no stagnation *energy efficient		*highest comfort *no stagnation *energy saving *lowest installation effort	
HWR flow rate	1671 l/h	441,4 gal/h	850 l/h	224,5 gal/h	2176 l/h	574,8 gal/h	1834 l/h	484,5 gal/h
annual power consumption pump	111 kWh/a		62 kWh/a		194 kWh/a		180 kWh/a	
annual electric cost pump **	**35 €/a**	**38 $/a**	**20 €/a**	**21 $/a**	**62 €/a**	**66 $/a**	**57 €/a**	**61 $/a**
heat loss HWS & HWR pipework	4234 W		4179 W		9630 W		8360 W	
annual heat loss HWS & HWR	37090 kWh/a		36608 kWh/a		84359 kWh/a		73234 kWh/a	
annual therm. Energy cost HWS & HWR *	**2225 €/a**	**2381 $**	**2196 €/a**	**2350 $**	**5062 €/a**	**5416 $**	**4394 €/a**	**4702 $**
pipe lenght HW	1074 m	3523 ft	1074 m	3523 ft	1074 m	3523 ft	1585 m	5199 ft
pipe lenght HWR	400 m	1312 ft	400 m	1312 ft	920 m	3018 ft	118 m	387 ft
rel. pipe savings HW	**26,1%**				**0,0%**		**14,6%**	

* 0,06 €/kWh th.
** 0,32 €/kWh el.

HWR Benefits, Design and Technologies

Summary

- Clever pipe routing / system design is essential.
- Hydraulic balancing calculations are mandatory (HWR flow rates, Δp_{valve}, c_v).
- Every balancing valve has its **hydraulic** operating range which must be respected. Select accordingly!
- Choose the best system design and components for your unique project and project requirements.

HWR Design & Balancing