Low Chilled-Water ΔT: Extra Flow and Pump Energy

Extra chilled-water flow and pumping energy when the coil temperature difference falls below design, for the same cooling load, with the annual cost.

Method: Sensible heat balance of the chilled-water loop with pump affinity; ASHRAE Handbook of Fundamentals (ASHRAE)

Input parameters

Unit system: SI

Parameter	Value	Unit
Cooling load	2,000.0	kW
Design temperature difference	6.0000	K
Actual temperature difference	4.0000	K
Pump power at design flow	30.000	kW
Pump power exponent on flow (3 ideal, 2–2.5 with fixed head)	2.5000	
Hours per year at this condition	3,000.0	h
Electricity price per kWh	0.12000	

Calculated results

Parameter	Value	Unit
Design flow	286.13	m³/h
Actual flow	429.20	m³/h
Flow increase	50.000	%
Pump power at actual flow	82.670	kW
Extra pump energy per year	158.01	MWh
Extra cost per year	18,961	

Notes for this case

• Same load at a lower ΔT needs proportionally more flow (water at 10 °C from IAPWS-IF97); pump power rises roughly with flow to the power n. Low ΔT also forces extra chillers on line; common causes are open bypasses, three-way valves, dirty coils and low supply set-points.

Formula and method

$$\dot{V} = \frac{\dot{Q}}{\rho c_p \Delta T}, \quad P_a = P_d \left(\frac{\dot{V}_a}{\dot{V}_d} \right)^n$$

Variables

$\dot{Q}$	Cooling load	W
ΔT_d	Design temperature difference	K
ΔT_a	Actual temperature difference	K
P_d	Pump power at design flow	W
n	Pump power exponent on flow (3 ideal, 2–2.5 with fixed head)	-
t	Hours per year at this condition	s
c_e	Electricity price per kWh	-
$\dot{V}_d$	Design flow	m³/s

$\dot{V}_a$	Actual flow	m³/s
$\Delta\dot{V}$	Flow increase	-
P_a	Pump power at actual flow	W
ΔE	Extra pump energy per year	J
ΔC	Extra cost per year	-

Method and standards

ΔT penalty.

Assumptions and limits

- Constant load; water properties at 10 °C.

References

Sensible heat balance of the chilled-water loop with pump affinity, ASHRAE Handbook of Fundamentals (ASHRAE)

Report details

Report reference	FCC-Y9ZA-B9PX (the same inputs always give the same reference)
Generated	23 November 2026, 18:09 UTC
Calculator	Low Chilled-Water ΔT: Extra Flow and Pump Energy
Method last reviewed	17 November 2026
Software release	FireCAD Calc, release of 22 November 2026
Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/hvac/chillers/chilled-water-low-delta-t

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.