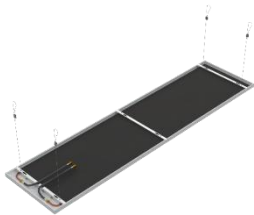


Cooling Capacity and Dimensioning:

IDA ICE Modeling Options

Jahutuse päev, 9. juunil 2026



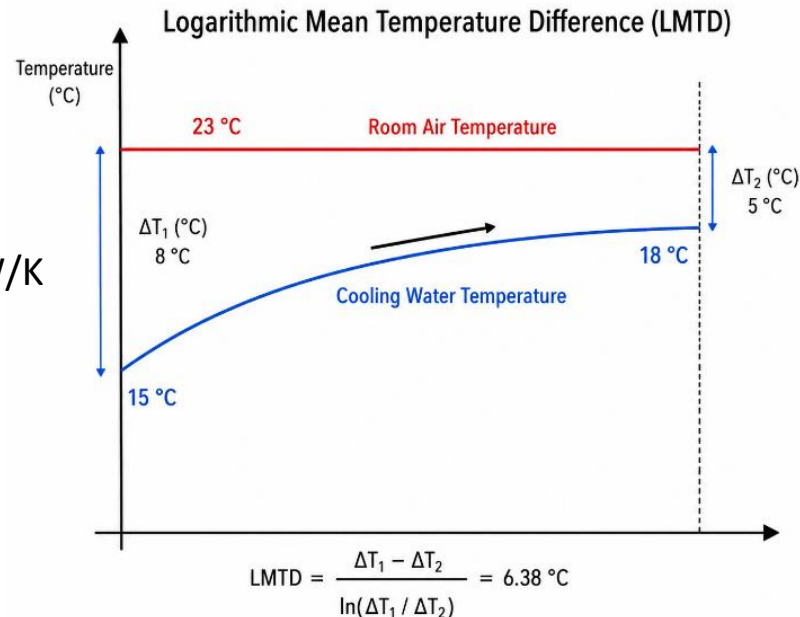
Cooling Capacity

- A cooling panel (radiant cooling panel) cools the room by:
 - Natural convection & Radiant heat transfer
- Cooling capacity depends on room and water temperature levels

- **Cooling Capacity:** $\phi = G \cdot (dT_{ln})^n$
 - G = panel conductance at design conditions, W/K
 - dT_{ln} = logarithmic mean ΔT (LMTD), K
 - n = exponent, typically around 1.1 for ceiling-mounted cooling panels

- **Water-side Cooling Capacity:**

$$\phi = c_p \dot{m} (T_{return} - T_{supply})$$



Capacity and Operation Conditions

Case	Room Temp	Supply / Return	Mass flow	Cooling Capacity	Change vs. Catalog
Catalog	23 °C	15 / 18 °C	-	400 W	-
Example 1 Higher Room Temp. (variable flow)	<u>25</u> °C	15 / 18 °C	Increased	542 W	+ 35 %
Example 2 Higher Room Temp. (constant flow)	<u>25</u> °C	15 / <u>18,8</u> °C	Constant	508 W	+ 27 %
Example 3 Dew point control	23 °C	<u>17</u> / 19,2 °C	Constant	293 W	- 27 %

Example 1 – Higher room temperature

(Variable Mass Flow)

Catalog

- $T_{room} = 23\text{ °C}$
- $T_{supply} / T_{return} = 15 / 18\text{ °C}$
- $\phi = 400\text{ W}$

$$G = \frac{\phi}{dT_{ln}^n} = 400\text{ W} / (6,38\text{ K})^{1,1} = 52,09\text{ W/K}$$

Example 1 Operation conditions:

- $T_{room} = 25\text{ °C}$
- $T_{supply} / T_{return} = 15 / 18\text{ °C}$
- Mass flow increased

- LMTD (catalog): $dT_{ln} = \frac{8-5}{\ln \frac{8}{5}} = 6,38\text{ K}$
- LMTD (Ex 1): $dT_{ln} = \frac{10-7}{\ln \frac{10}{7}} = 8,41\text{ K}$
- Ex 1 operating cooling capacity:
$$\phi_1 = (8,41 / 6,38)^{1,1} \cdot 400$$
$$= 542\text{ W}$$

Higher room temperature increases the temperature difference
→ higher operating cooling capacity

$$G = \frac{\phi}{dT_{ln}^n} = 400\text{ W} / (6,38\text{ K})^{1,1} = 52,09\text{ W/K}$$

$$\phi_1 = G \cdot dT_{ln}^n = 52,09\text{ W/K} \cdot (8,41\text{ K})^{1,1} = 542\text{ W}$$

Example 2 – Higher room temperature

(**Constant** Mass Flow)

panel heat transfer and the water-side cooling capacity must be equal, and the return water temperature appears in both equations, the solution is conveniently obtained iteratively.

Catalog

- $T_{room} = 23 \text{ }^{\circ}\text{C}$
 - $T_{supply} / T_{return} = 15 / 18 \text{ }^{\circ}\text{C}$
 - $\phi = 400 \text{ W}$
- $$G = \frac{\phi}{dT_{ln}^n} = 400 \text{ W} / (6,38 \text{ K})^{1,1} = 52,09 \text{ W/K}$$

Example 2 Operation conditions:

- $T_{room} = 25 \text{ }^{\circ}\text{C}$
- $T_{supply} = 15 \text{ }^{\circ}\text{C}$
- **Constant mass flow**

$$\dot{m} = 400 \text{ W} / (4186 \text{ J/(kg K)} \cdot 3 \text{ K}) = 0,0319 \text{ kg/s}$$

- Iterate → Return temperature:

$$T_{return} = 18,815 \text{ }^{\circ}\text{C}$$

- Ex 2 operating cooling capacity:

$$\phi_2 = 0,0319 \cdot 4186 \cdot (18,815 - 15) \\ = 508 \text{ W}$$

With constant mass flow, return water temperature rises and capacity increases moderately

$$\phi_2 = G \cdot dT_{ln}^n = 52,09 \text{ W/K} \cdot (7,9 \text{ K})^{1,1} = 508 \text{ W}$$

Example 3 – Dew point control

(**Constant** Mass Flow)

panel heat transfer and the water-side cooling capacity must be equal, and the return water temperature appears in both equations, the solution is conveniently obtained iteratively.

Catalog

- $T_{room} = 23\text{ °C}$
 - $T_{supply} / T_{return} = 15 / 18\text{ °C}$
 - $\phi = 400\text{ W}$
- $$G = \frac{\phi}{dT_{ln}^n} = 400\text{ W} / (6,38\text{ K})^{1,1} = 52,09\text{ W/K}$$

Example 3 Operation conditions:

- $T_{room} = 23\text{ °C}$
- **$T_{supply} = 17\text{ °C}$** (Dew point control!)
- **Constant mass flow** (0,0319 kg/s)

- Iterate → Return temperature:

$$T_{return} = 19,2\text{ °C}$$

- Ex 3 operating cooling capacity:

$$\phi_2 = 0,0319 \cdot 4186 \cdot (19,2 - 17) \\ = 293\text{ W}$$

Raising supply water temperature
reduces cooling capacity.

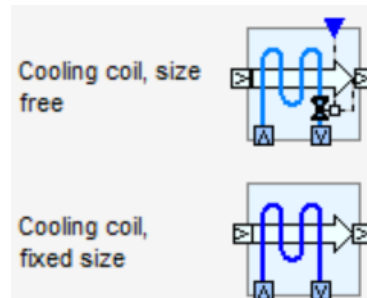


Moisture loads and dew point control
should be considered in design!

$$\phi_3 = G \cdot dT_{ln}^n = 52,09\text{ W/K} \cdot (4,7\text{ K})^{1,1} = 293\text{ W}$$

IDA ICE - Components

- Room units:
 - Ideal cooler
 - Cooling device
 - Heating/cooling panel
 - Simple fan coil
 - Active beam
 - Floor heating/cooling
 - Fan coils & Air to air, air conditioning (HP)
- Air handling units
 - Cooling coil, size free
 - Cooling coil, fixed size



--- Room units

- * Ideal cooler
- o Ideal heater
- o Simple fan coil
- o Fan coil
 - o CAV fan coil
 - o VAV heating fan coil
 - o VAV cooling fan coil
 - o Air to air, non-ducted, air conditioner
 - o Air to air, non-ducted, heat pump
- o Cooling device
- o Hot object
- o Electric radiator
- o Water Radiator
- o Heating/cooling panel
- o Active beam
- o Reheat coil
- o Electrical reheat coil
- o Swegon beam

Simple fan coil



- Design power (catalog cooling capacity) temperature levels may be defined
- Can be utilized for defining water-side cooling capacity for other devices than fan coil

Simple fan coil: object in building2.Vyöhyke (General)

General Outline Annotations

Simple fan coil

Waterborne heating

Electrical heating

Energy meter: n.a.

No heating

Design power

Cooling*	Heating**	Unit
2000.0	2300.0	W
190.3	218.8	W/m²

Fan power***: 3 %

Energy meter: [Default] LVI sähkö

Controller: PI

Water circuit: [Default] cold: 15.0 °C [Default] heat: 20.0 - 45.0 °C

* @ 7/12/27°C RH 50%; of the total approx 80% is sensible
 ** @ 50/40/20°C
 *** as a percentage of cooling power (heating if cooling is zero)

Simple fan coil: object in building2.Vyöhyke (General)

General Outline Annotations

Name	Value	Unit	Description
Controller	PI		
Heating type	Waterbor...		
Energy meter	n.a.		
Cooling power	2000.0	W	
Heating power	2300.0	W	
dT liquid-air cooling	17.5		Average temperature difference between coolant and room air at design power
dT liquid-air heating	25.0		Average temperature difference between hot water and room air at design conditions
dT liquid cooling	5.0		Temperature rise of coolant at design power
dT liquid heating	10.0		Temperature drop of hot water at design power
Fan power (%)	3.0	%	Fan power given as fraction of coil power
Sensor	Air tempe...		
Energy meter for ...	[Default] ...		
Water circuit (cooling)	[Default] ...		
Water circuit (heating)	[Default] ...		

Ex Daikin FWC-DT fan coil:

Jäähdytysteho (vakio-olosuhteet)=-
 Kokonaisteho, 2-putkinen=-Pieni=-kW

kW

4.06

(1) - Jäähdytys: ilma 27°CDB, 19°CWB; tuleva vesi 7°C; poistuva vesi 12°C

Active beam

Beam: a device in building1.Zone (General)

General Outline CFD Annotations

Simplified input data to chilled/heated beam

☐ Use manufacturer's data
☒ Simplified model:

	Cooling	Heating	
Power at design air flow	0.0	0.0	W
Power at zero air flow	0.0	0.0	W
Design air flow	0.0		L/s

Design conditions

	Cooling	Heating	
dT(coolant - zone air) at max power	8.5	20	°C
dT(coolant) at max power	3	10	°C

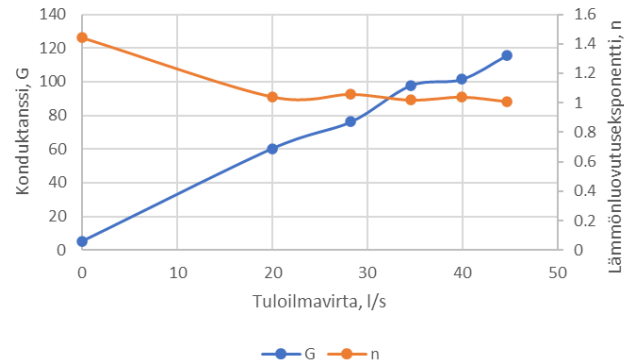
Controller: PI

Sensor: Air temperature

Water circuit

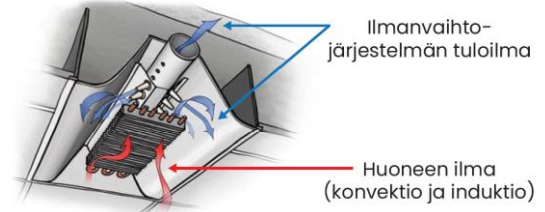
Cooling: [Default] Cooling

Heating: [Default] Heating

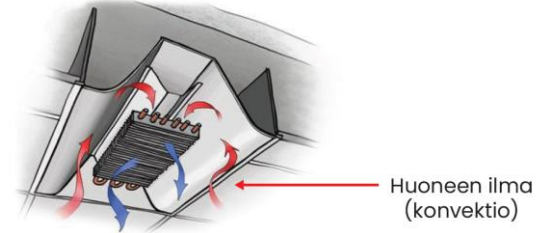


To edit manufacturer's data, switch to the outline tab.

In the simplified model, the power parameters are user-supplied. No manufacturer-supplied data are used.



A) Aktiivinen palkki (active chilled beam)



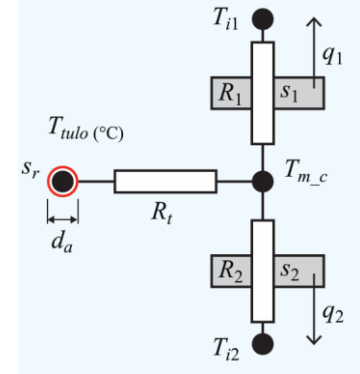
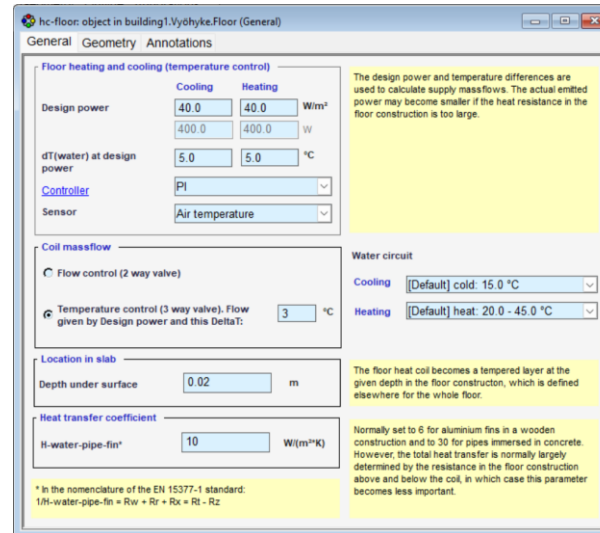
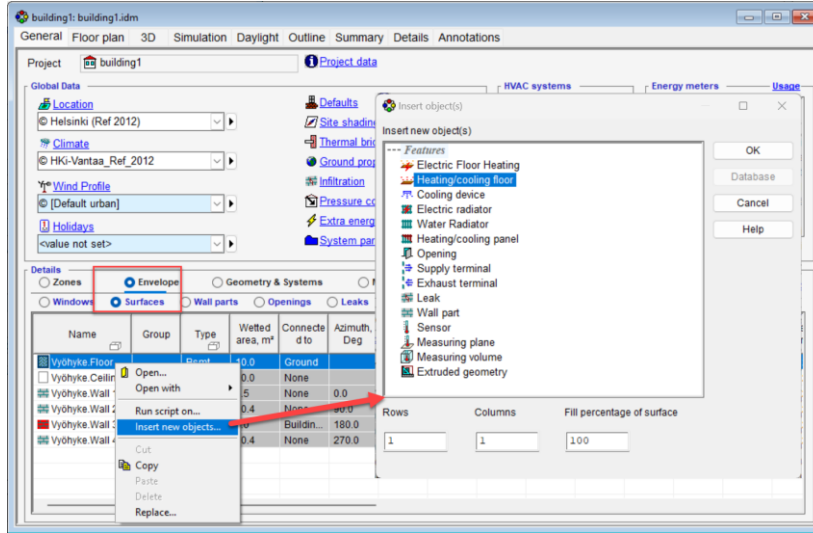
B) Passiivinen palkki (passive chilled beam)

Kuvalähde: AHRI

NOTE: the specified cooling capacity in IDA ICE is the water-side cooling capacity, not the total cooling capacity.

Floor cooling

- The supply water temperature for radiant floor cooling is typically around 16–17 °C, and the supply/return water temperature difference is usually approximately 3 °C.
- The system is generally designed so that the floor surface temperature does not fall below 20 °C.
- NOTE: pay attention to the internal floor / ground floor structure and other input parameters.



IDA ICE - Zone Models

- **Energy model**

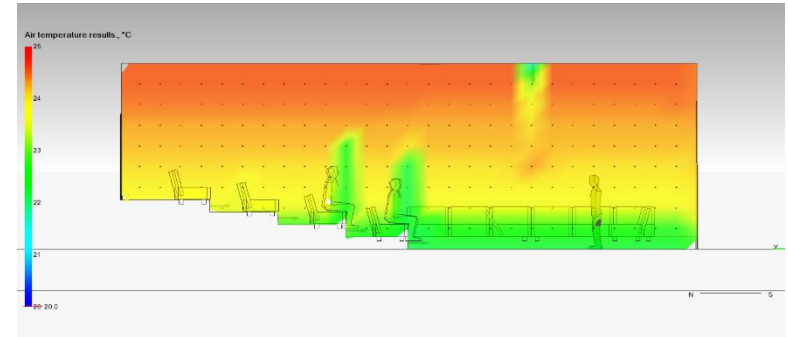
- **Purpose:** Energy and load calculations
- Simpler physical model with conventional level of accuracy (faster simulation)
- Based on mean radiant temperature
- Does not calculate direct operative temperature at specific locations
- Well-mixed zone assumption

- **Climate model**

- **Purpose:** Indoor climate and thermal comfort
- More detailed physical model of the zone
- More accurate radiation and view factor calculations (operative temperature at specific points)
- Moderate increase in simulation time

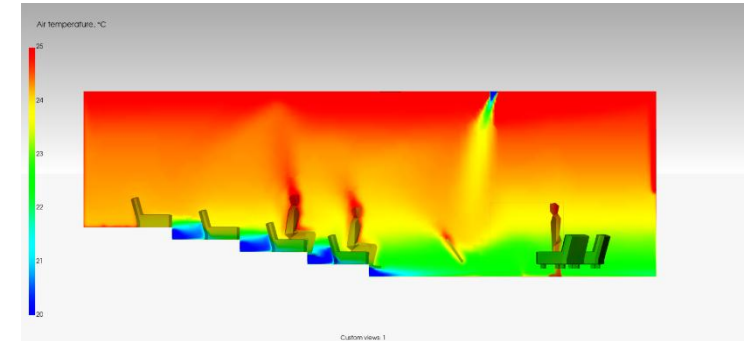
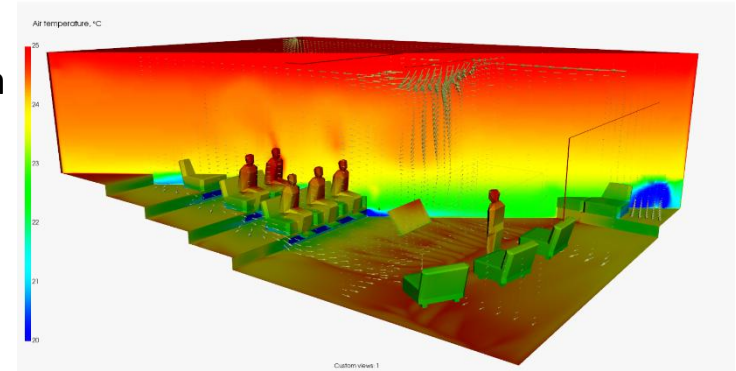
- **Climate model with stratification**

- **Purpose:** Indoor climate & TC with stratification
- Includes vertical air temperature stratification
- Simulation accuracy depends on no. of layers
- Captures effects of: Terminal & internal load locations, Vertical temperature gradients
- Most suitable for high-ceiling spaces and scenarios with significant stratification



IDA ICE - CFD

- Boundary condition inputs from dynamic simulation
- Mesh automatic creation based on settings and mesh refinement volumes
- CFD simulation with OpenFOAM
- Post-processing variables:
 - Air speed
 - Air temperature distribution
 - Draught rate (DR) – ISO 7730
 - Age of air
 - IDA ICE 5.2: CO₂ concentration
- Results from measuring volumes, sensor locations, whole zone volume and animations



IDA ICE – Climate Design Days

- Climate file: Annual or custom, example EST 2025:
- Synthetic climate
 - Periodic simulation to produce power requirements or similar.
 - Defined under location and in the cooling design / overheating simulation setups
 - Repeating either heating or cooling design day

Design day data

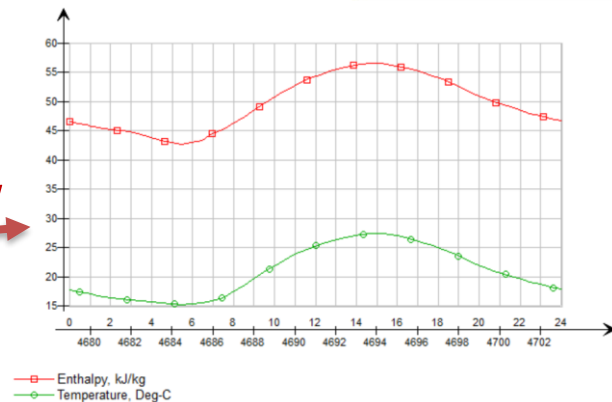
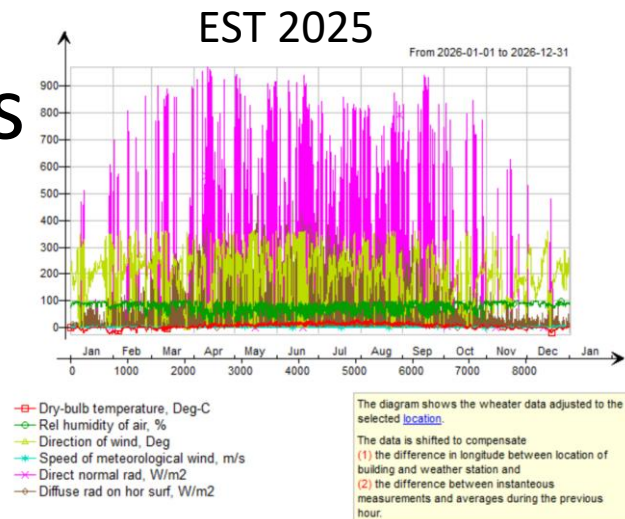
Design data file

ASHRAE 2021\260380.tbl

User-defined design days

	Winter	Summer	
Dry-bulb min	-18.5	15.2	°C
Dry-bulb max	-13.2	27.4	°C
Wet-bulb max	-14.4	19.7	°C
Wind direction	130	50	°
Wind speed	2.3	3.0	m/s
Clear-sky tau_b	0.309	0.385	
optical depth tau_d	2.182	2.409	

ASHRAE 2021, 2 %
July dimensioning day



Challenges in Cooling Dimensioning



Weather Data

Design day selection
Current / future /
realized climate



Building Properties

Structures
Building orientation
Window areas & glazing
Solar shading



Internal Heat Gains

Number of occupants
Equipment & lighting
Moisture loads
Occupancy profiles



HVAC

Supply air
AHU cooling coil
Dewpoint
Space cooling
Plant dimensioning



Ctrl and setpoints

Cooling setpoint
Allowed maximum temp.
Hysteresis and delay
Designed vs. actual use



Dimensioning target

Maximum temperature
Degree hours
Indoor climate standards
EN 16798 / ISO 7730

The most difficult part is not the simulation but defining the target and the scenario.

Challenges in Cooling Dimensioning



Dynamic phenomena

- Structural thermal mass dampens peak loads
- Peak load $\neq$ Peak temperature
- Temperature peaks occur with a time delay

~~Static methods~~



Iteration

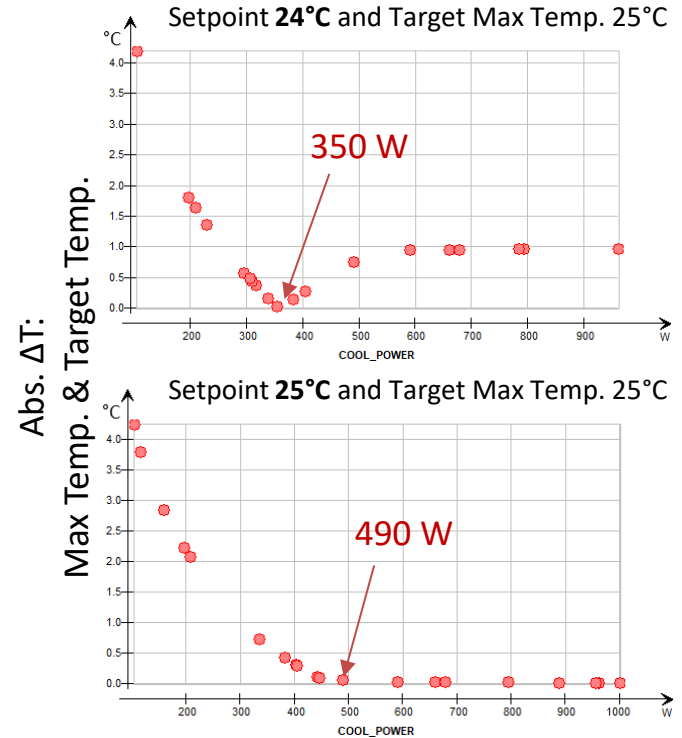
- , when cooling setpoint $\neq$ target temperature (max)
- Cooling capacity affects room temperature...and room temperature affects the required cooling capacity
- Requires iteration (root-finding)
- Traditionally manual work $\rightarrow$ IDA ICE ZoneSizing

IDA ICE ZoneSizing



IDA ICE ZoneSizing Cooling Capacity Dimensioning

- Dynamic dimensioning using a lower setpoint than the target temperature
- Ideal cooler and Simple fan coil template
- Parallel simulation of multiple zones
- Iterative root-finding (root-finding) → Smallest cooling capacity at which the maximum temperature criterion is met



How to avoid oversizing cooling power?

Use a setpoint offset from the target temperature

