Chilled Water Plant Optimization in Healthcare Facilities

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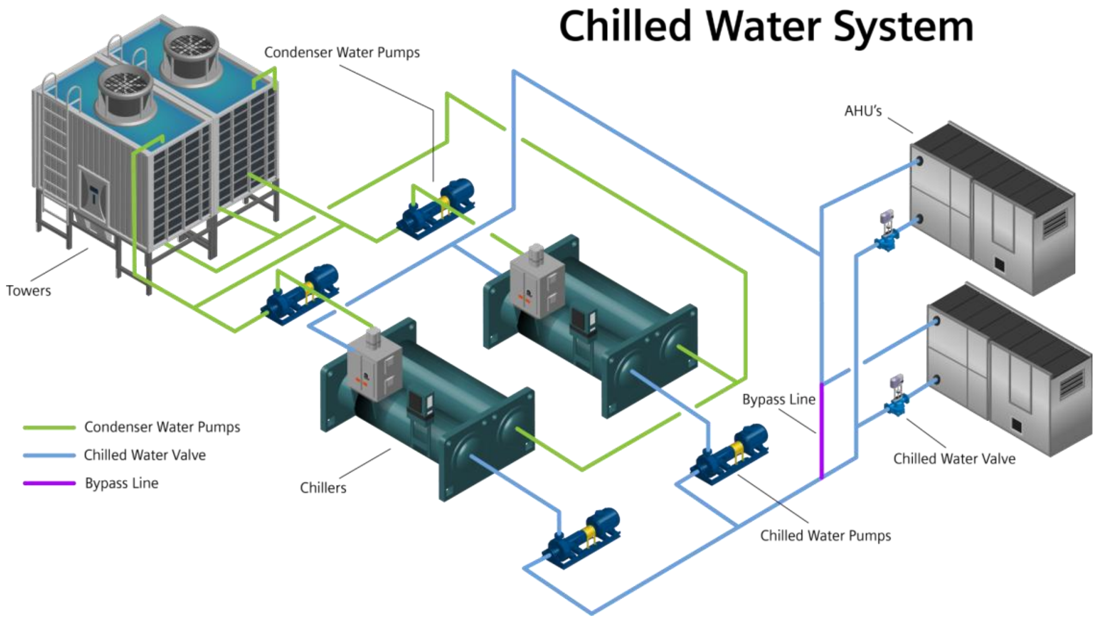
Why the chiller plant?

- HVAC cooling is a significant energy use in most buildings
- Often does not operate at peak load
- It is possible to optimize a chiller plant so that it is more efficient at low loads, but remains able to give peak performance at high loads



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Chiller Plant Optimization

Balancing efficiency and performance

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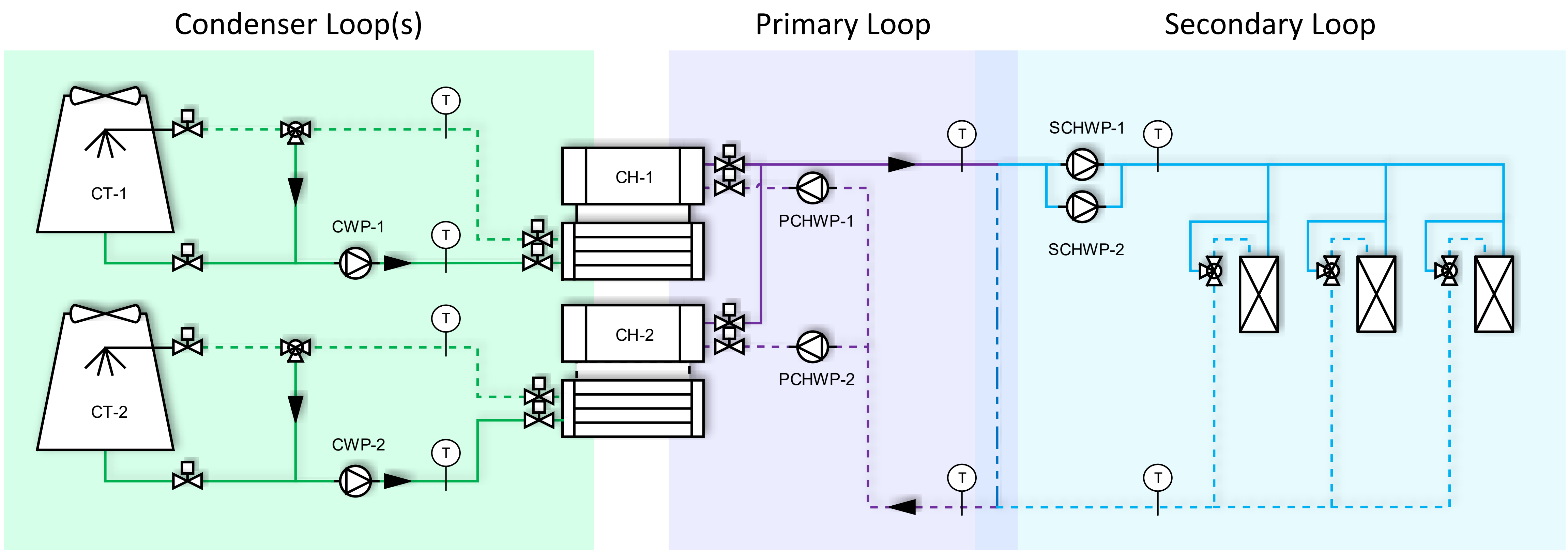
Types of chilled water plant

Primary / Secondary



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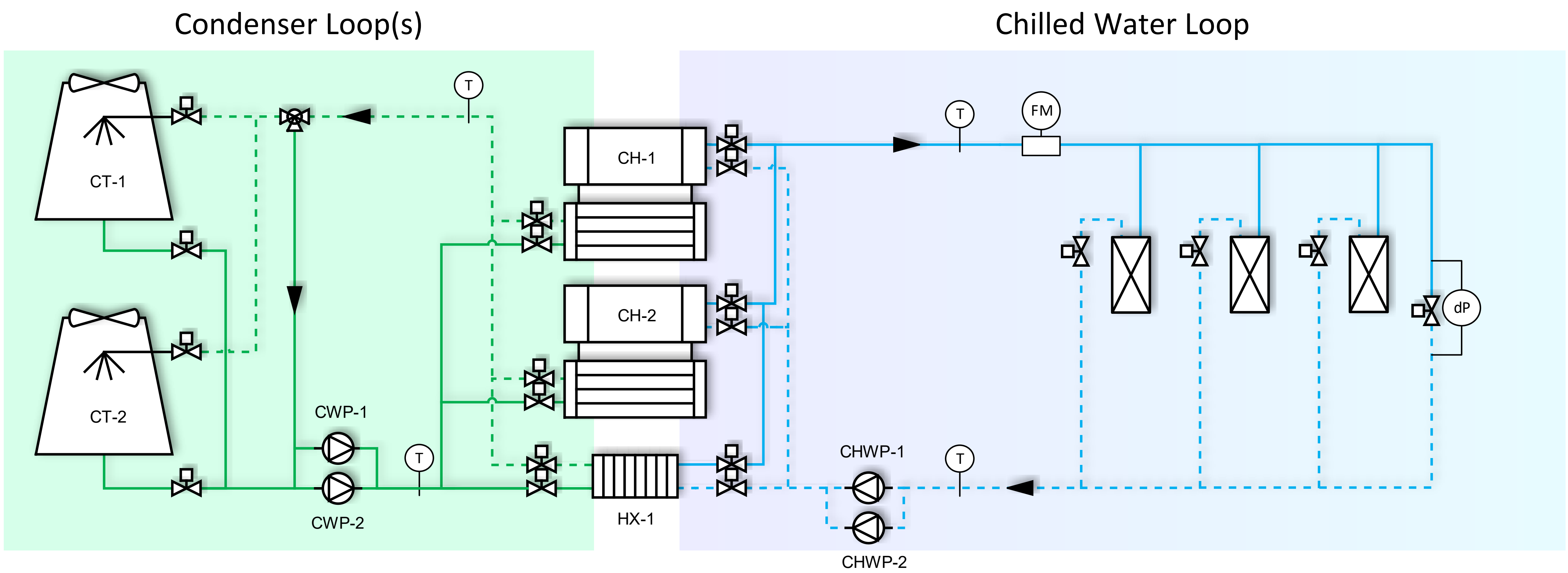
Types of chilled water plant

Primary-Only



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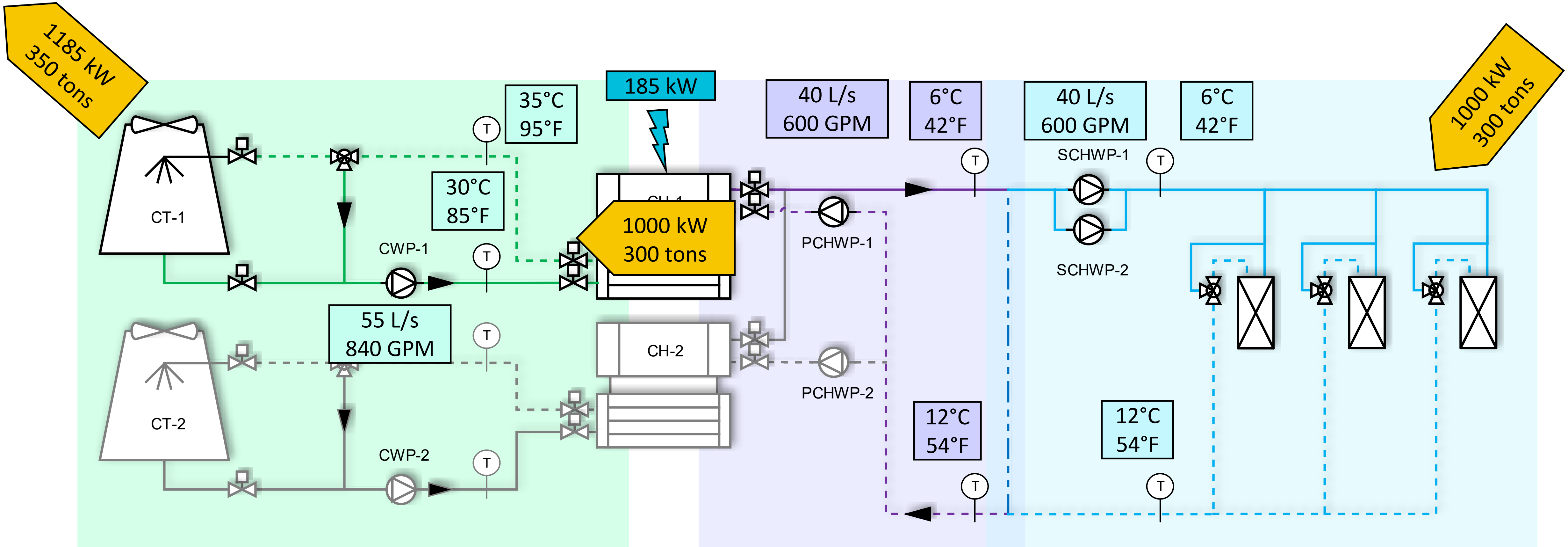
Optimization process

What does the primary/secondary plant look like at design load?



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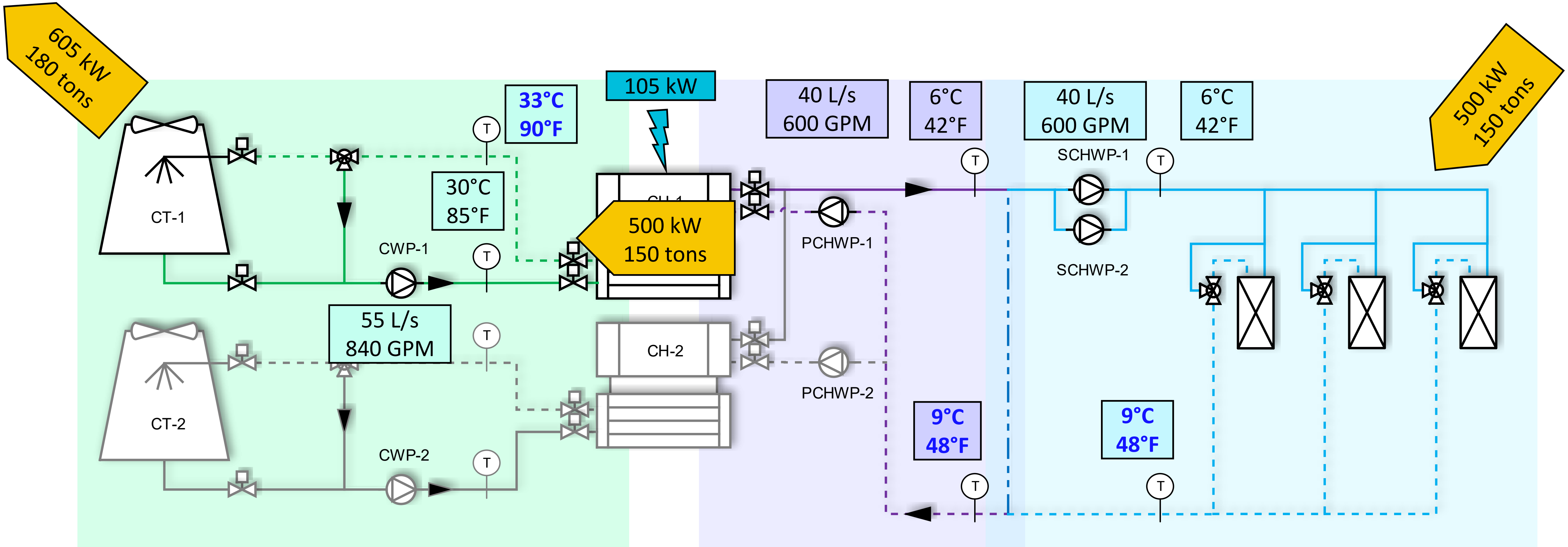
Optimization process

What does the primary/secondary plant look like at 50% load?



At lower loads, neither the pumps nor the chiller are operating at their full capacity. This gives an opportunity to change how the system operates to improve efficiency.

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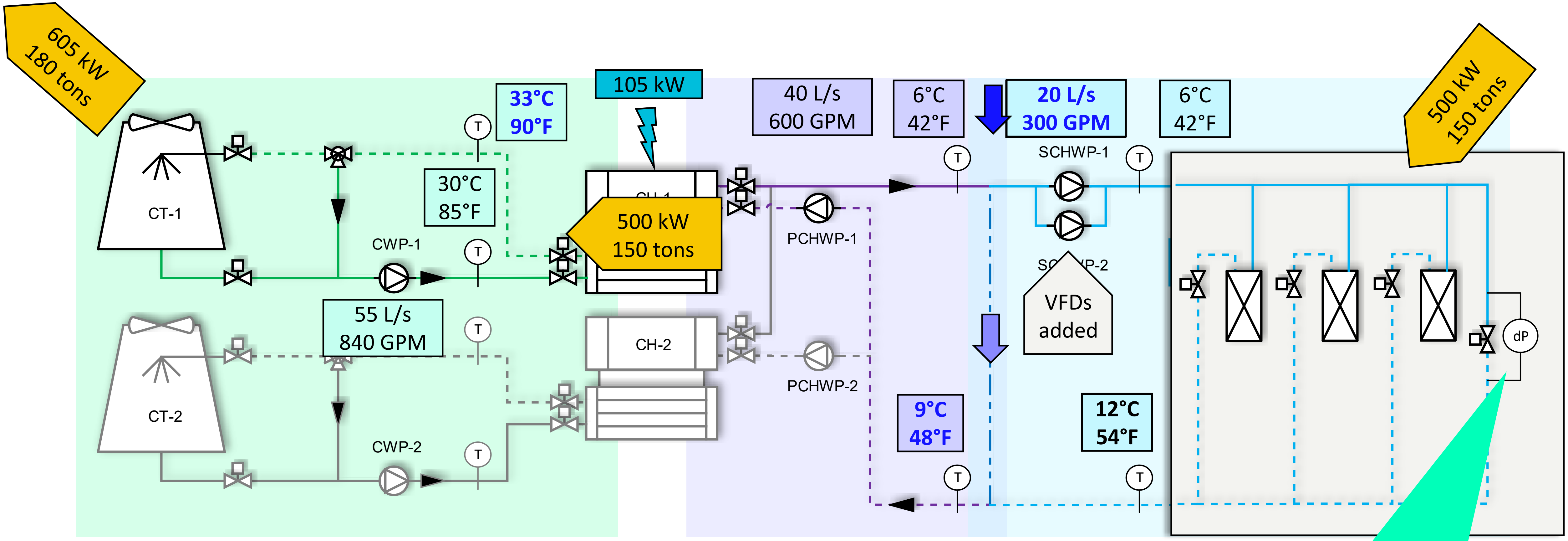
Optimization process

What 'dials' can we adjust to change the performance of the plant?

Parameter	How?
Secondary loop flow	Add VFDs to secondary pumps, convert 3-way valves to 2-way
Primary loop flow	Add VFDs to primary pumps
Chilled water temperature	Adjust chiller setpoint
# of chillers operating	Adjust chiller staging
Condenser water temperature	Adjust cooling tower / bypass valve setpoint
# of cooling towers operating	Adjust tower staging (depends on piping)
Condenser loop flow	Add VFDs to condenser pumps

Optimization process

Varying secondary loop flow:



By adding VFDs to the secondary pumps and reducing flow at lower loads, we save pumping energy without changing how the chiller operates

Adjusting differential pressure setpoint based on AHU demand helps keep pump energy to a minimum

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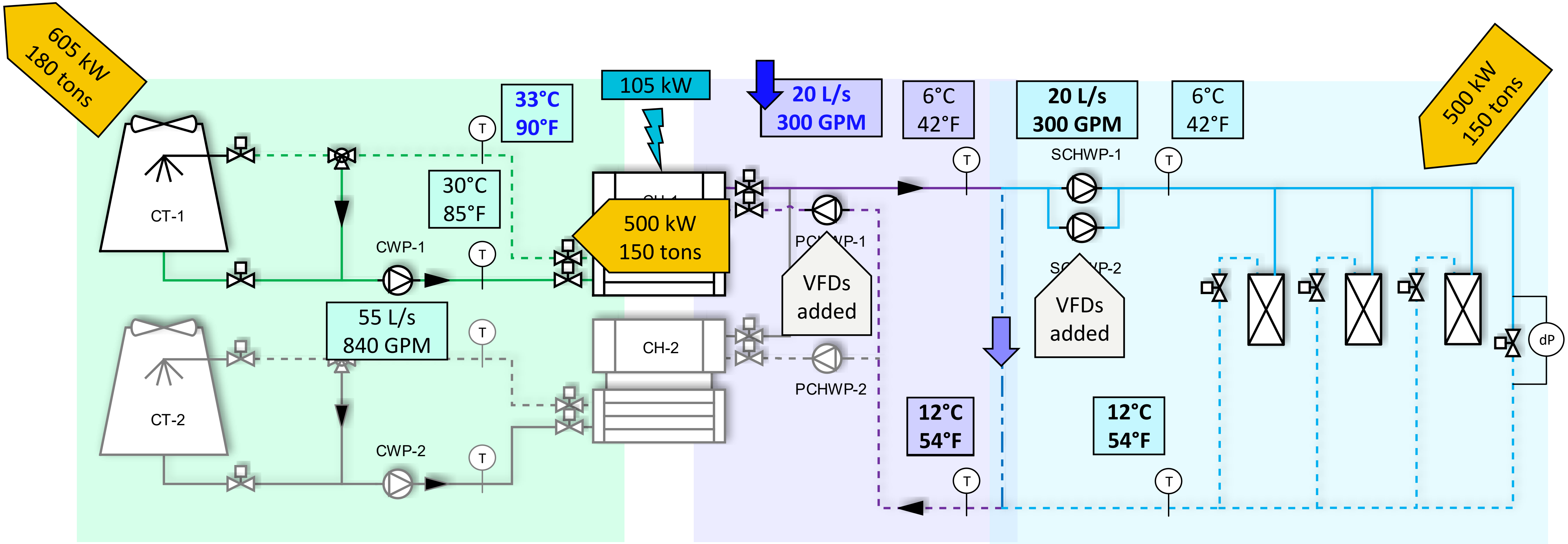
Optimization process

Varying primary loop flow:



By adding VFDs to the primary pumps and trying to match primary to secondary flow, we save more pumping energy, but need to consider how this impacts the chiller.

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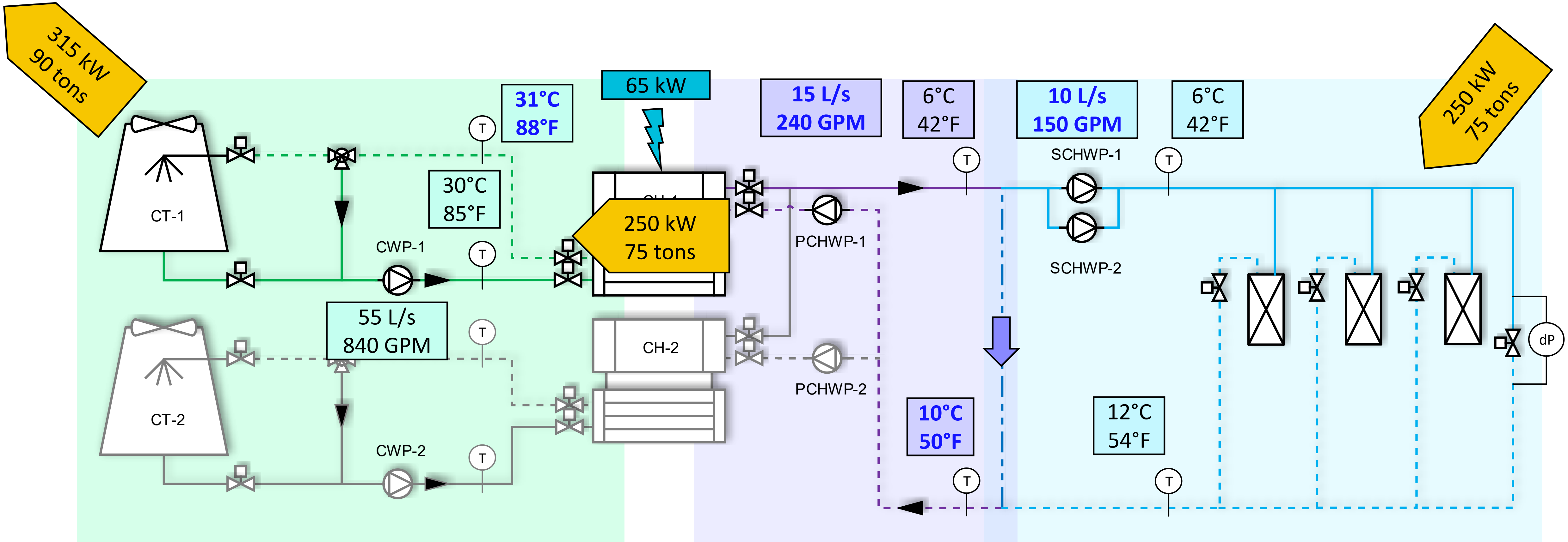
Optimization process

Why do we have separate primary/secondary pumps? System at 25% load:



At very low loads, flow in the secondary loop may fall below the minimum flow required for the chiller to operate.

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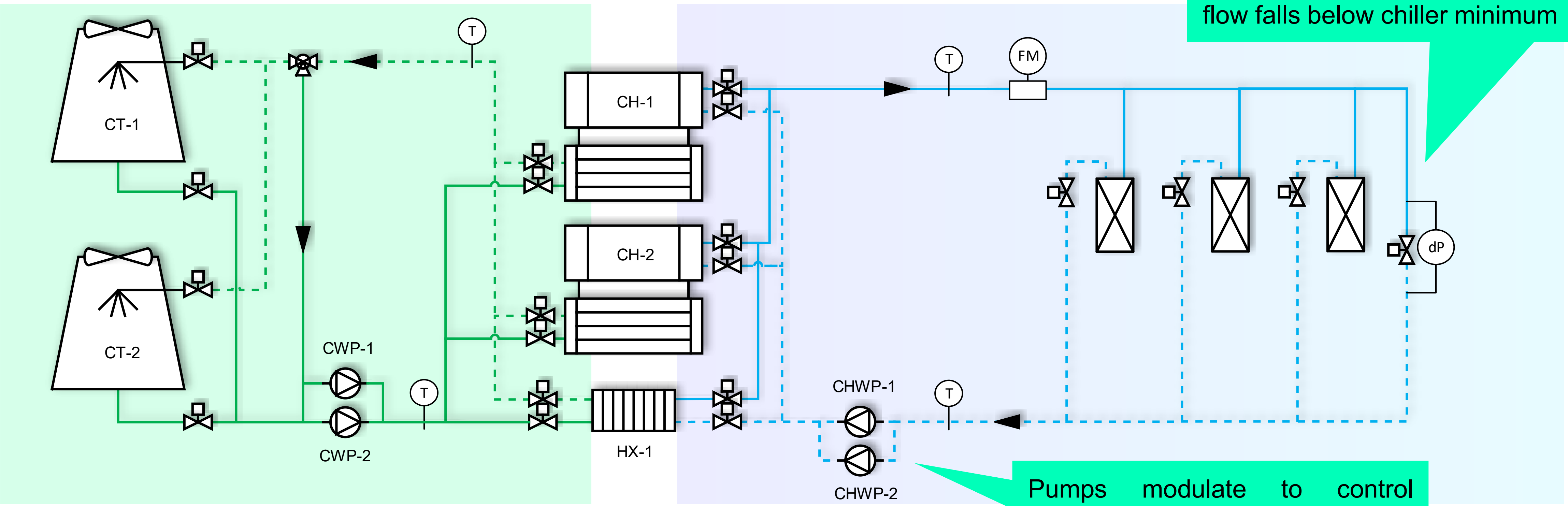
Optimization process

Varying flow in a primary-only plant



Bypass valve opens if system flow falls below chiller minimum

Pumps modulate to control differential pressure and ensure adequate flow through coils

Variable-primary can be efficient but requires good commissioning and testing to ensure reliable operation

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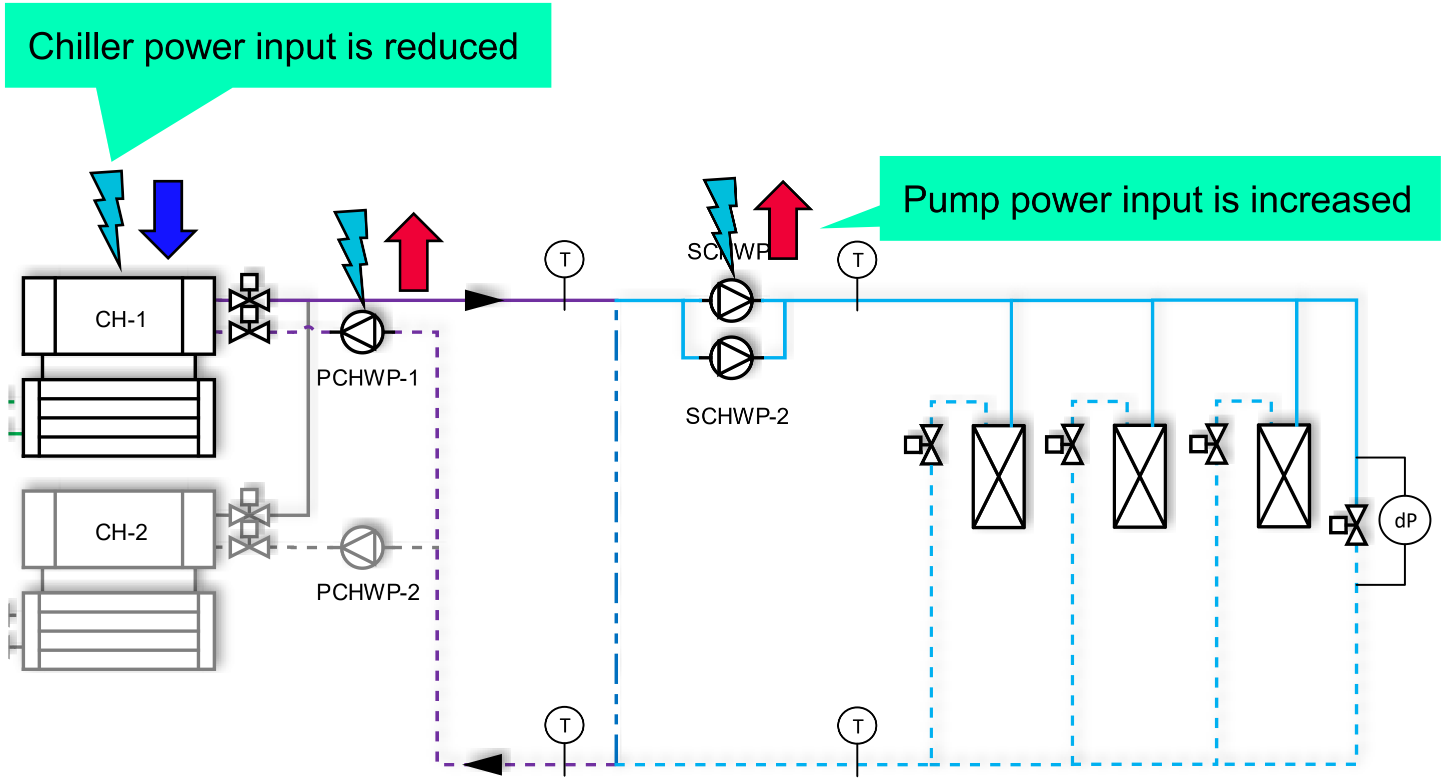
Optimization process

Raising chilled water temperature

- *Chillers operate more efficiently with higher evaporator temperature*

But…

- *AHU coils require more flow to deliver the same amount of cooling*
- Typically, temperature will be reset based on AHU demand (valve position)



Raising chilled water temperature setpoint is a balancing act between chiller efficiency and pumping efficiency

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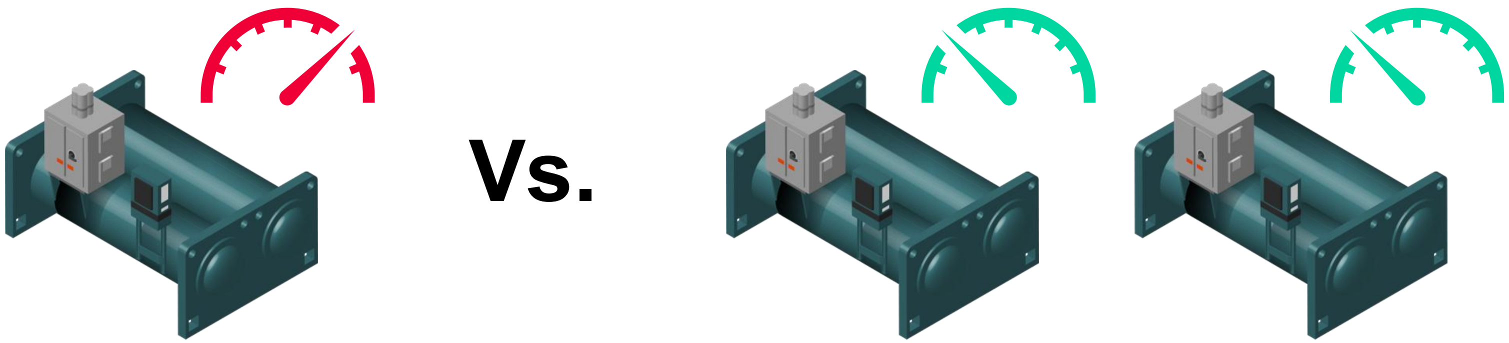
Optimization process

Chiller sequencing

- One chiller or two? It depends!
- Some types of chiller are more efficient at low loads, some are less efficient
  - For some plants, it may be more efficient to run two chillers at low load than one chiller at high load
  - For others, it will be better to wait until the first chiller is nearly at full capacity before bringing on a second chiller



Optimization process

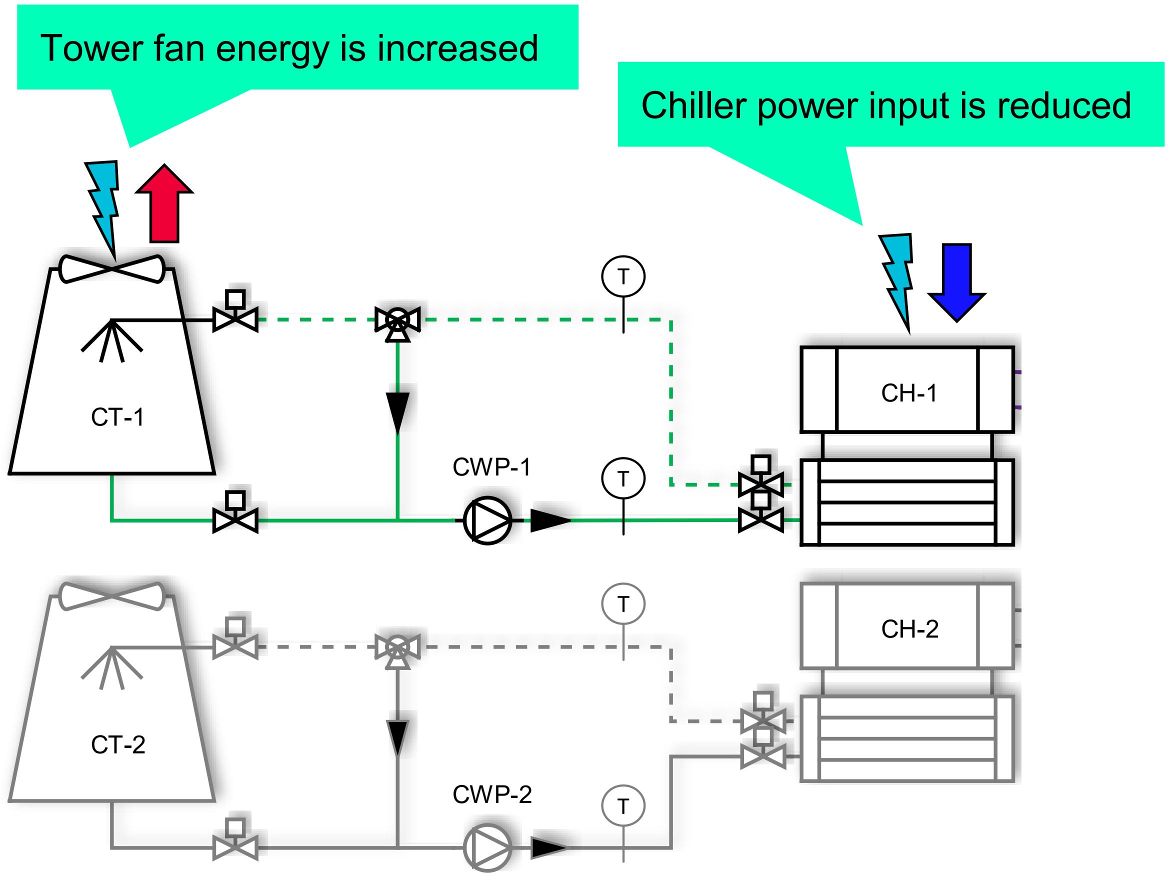
Lowering condenser water temperature

Chillers operate more efficiently with lower condenser water temperature

But…

Cooling tower fans will need to work harder to provide the same amount of cooling

- Typically, temperature will be reset based on outdoor wet bulb temperature
- Consult chiller manufacturer – different machines have different limits



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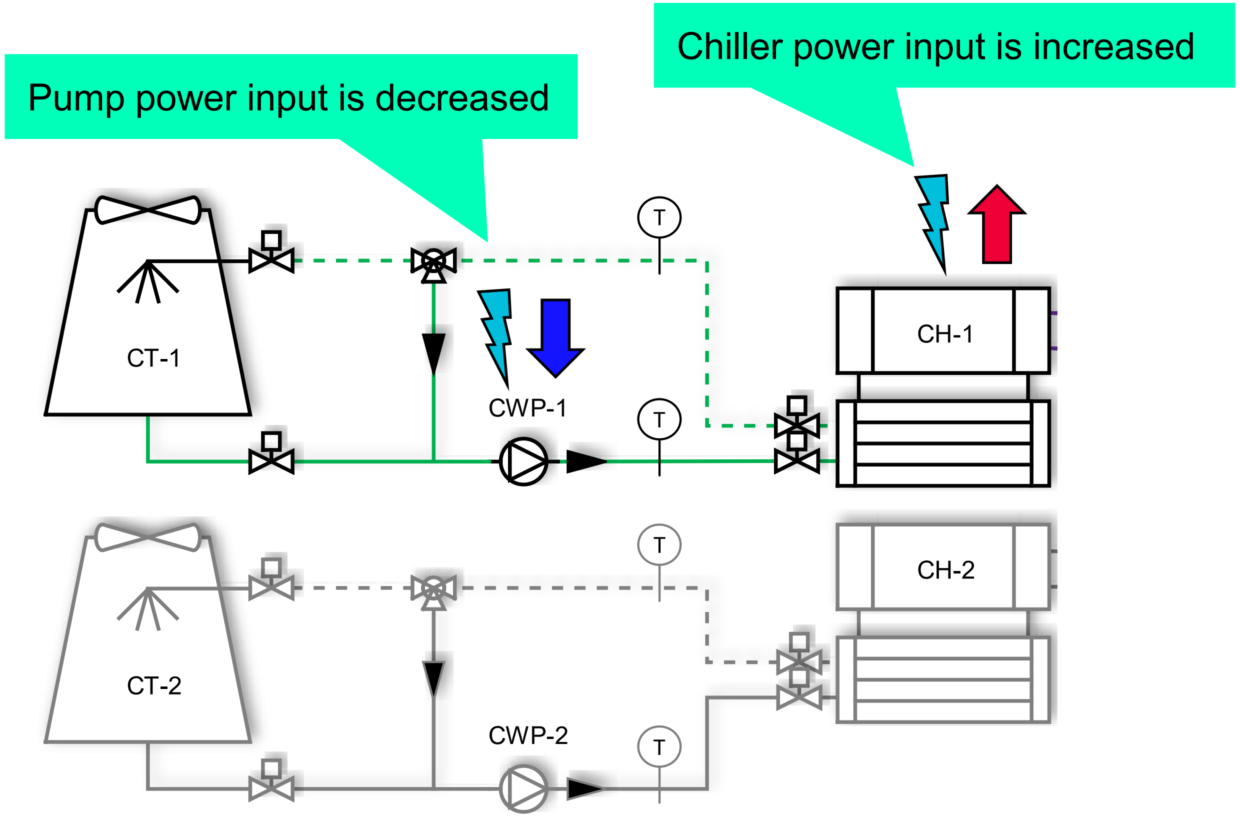
Optimization process

Varying condenser loop flow

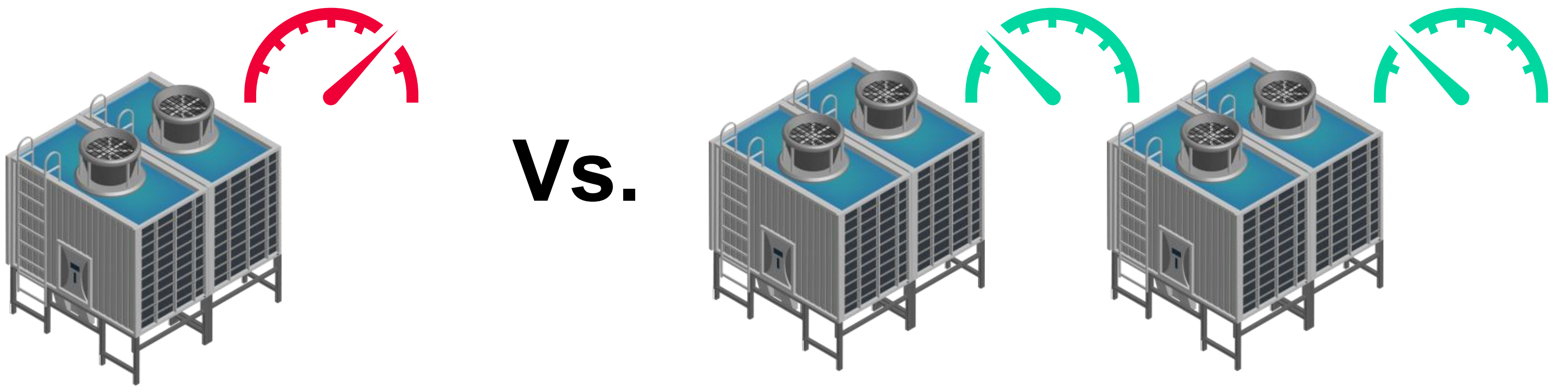
- Adding VFDs to condenser-water pumps can reduce pumping energy, but introduces complications:
  - Both chiller and cooling tower have minimum flow rates
  - Pump minimum speed needs to be high enough to raise water to the top of the tower
  - Chiller efficiency is reduced due to higher condenser leaving temperature
  - Consult manufacturer(s)!



Optimization process

Cooling tower sequencing

- Depending on piping configuration, it may be possible to run multiple cooling towers at lower fan speed than to run one tower at a higher fan speed.
- Generally, multiple towers are more efficient
- Check minimum flow for cooling towers – too low can cause scaling



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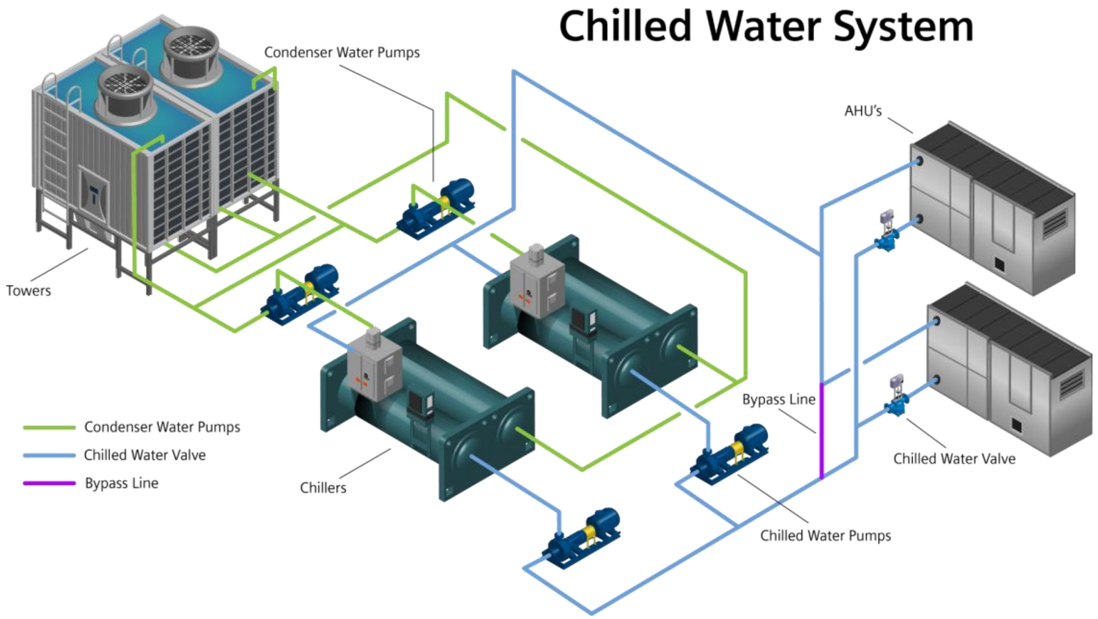
Optimization process

Putting the pieces together

- Measures can be implemented piece-by-piece, or as part of a comprehensive optimization project
- Control vendors and chiller manufacturers have various ‘packaged’ strategies
- Make sure optimization strategies account for non-HVAC loads like MRI machines
- Make sure any maintenance / operational issues are understood before embarking on an optimization project
- Collaboration between facility operations team, chiller manufacturer, and controls vendor is key!



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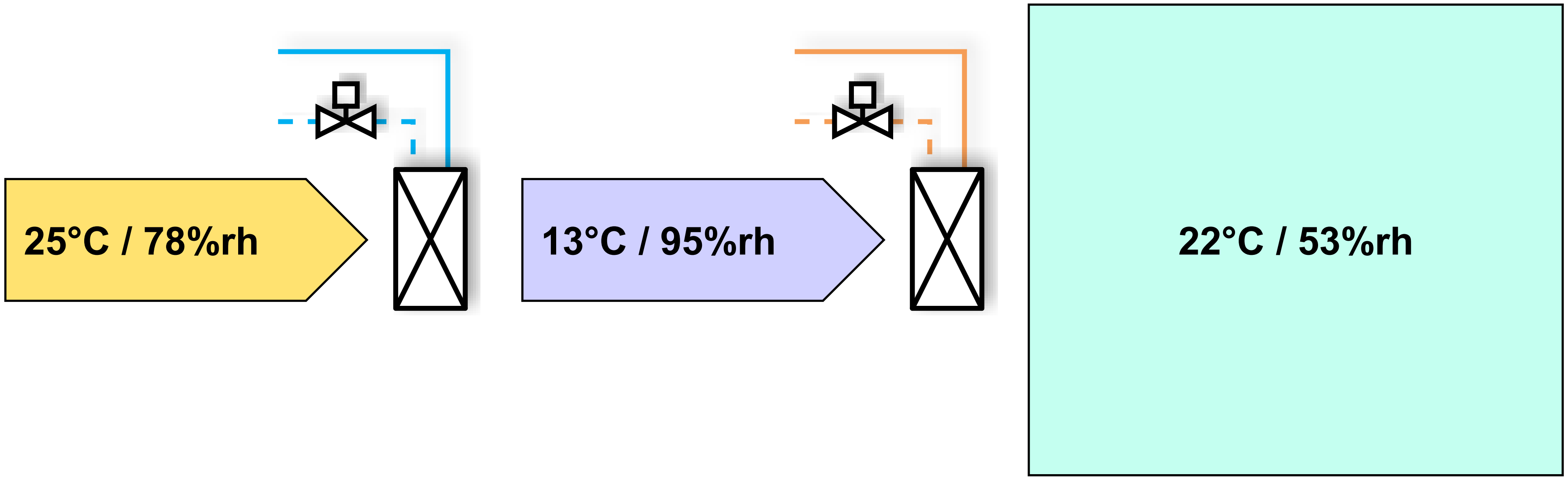
Downstream Effects

How do downstream loads affect the chiller plant?

Downstream loads

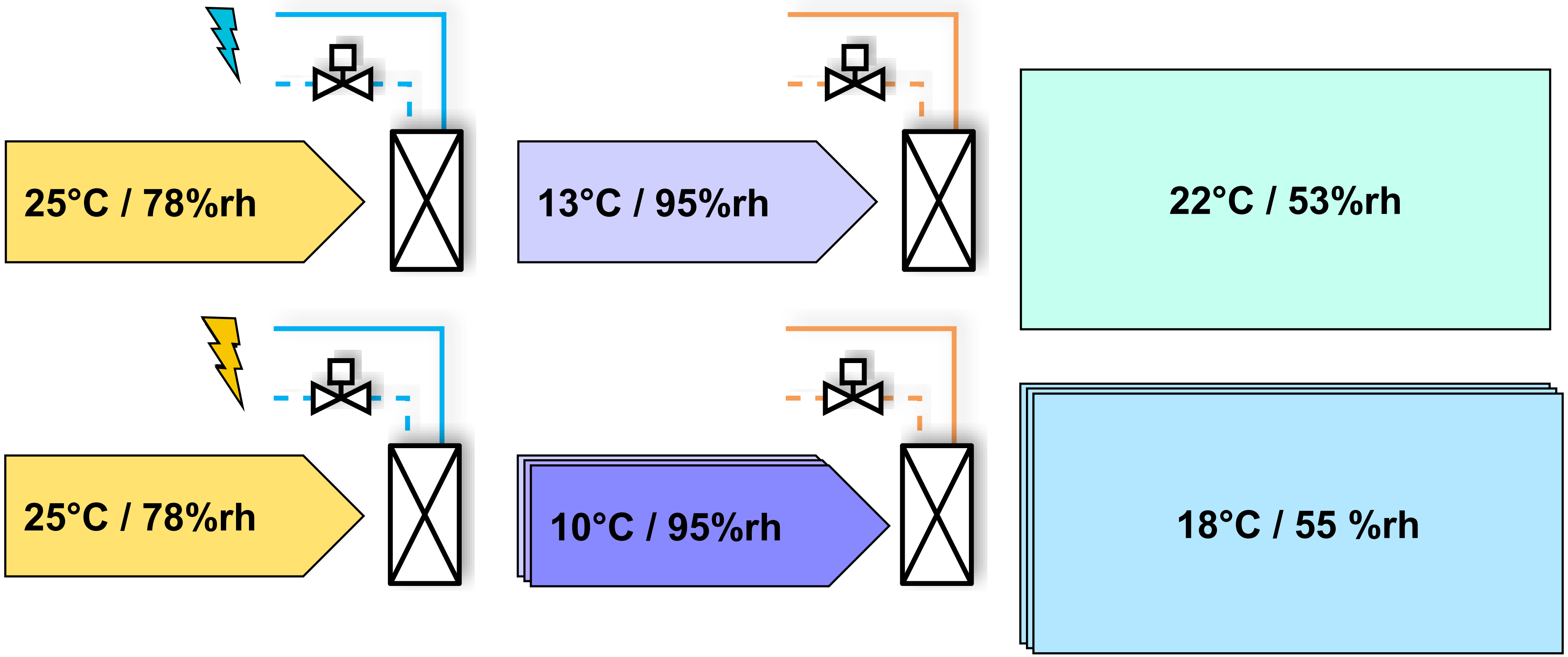
Ventilation cooling and dehumidification

- Air handling systems bring in air from outside and heat/cool it as needed to provide comfortable space conditions
- Dehumidification is a big driver of cooling load, especially in areas with strict humidity requirements



Downstream loads

How does space temperature affect dehumidification demand?

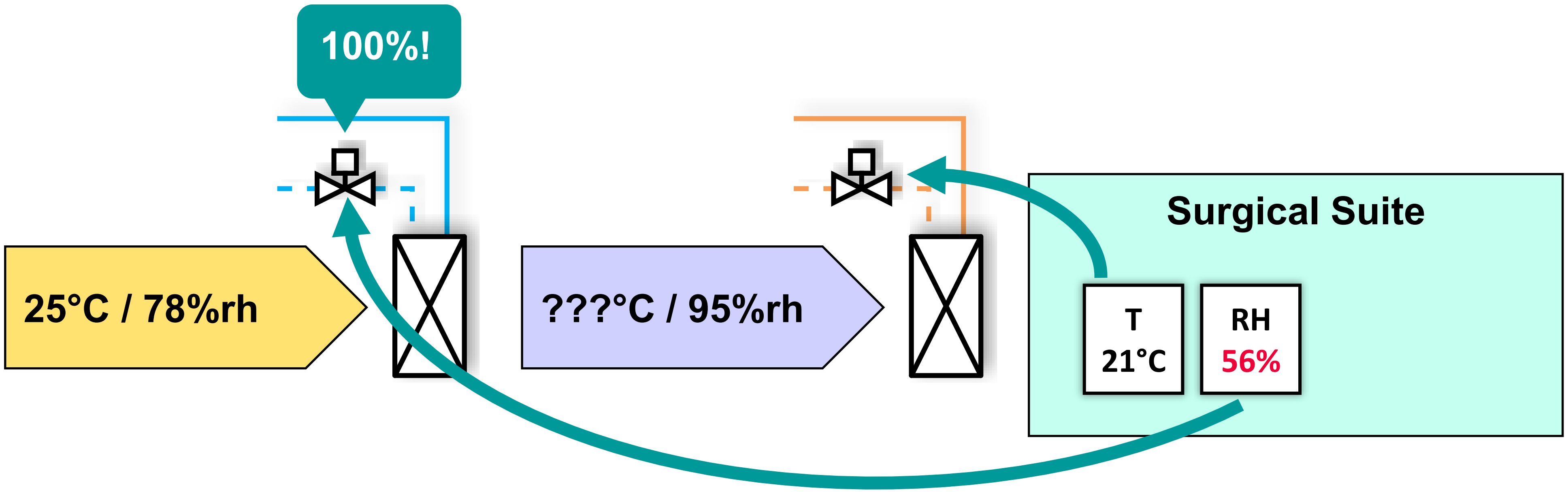


Maintaining a space at 18°C and 55% humidity can use ~25% more energy than keeping it at 22°C

Downstream loads

How should dehumidification be controlled?

- Simple way – open cooling coil valve to 100% whenever space humidity gets too high
  - Pros: simple to program
  - Cons: excessive chilled water flow for little benefit, can impact other systems



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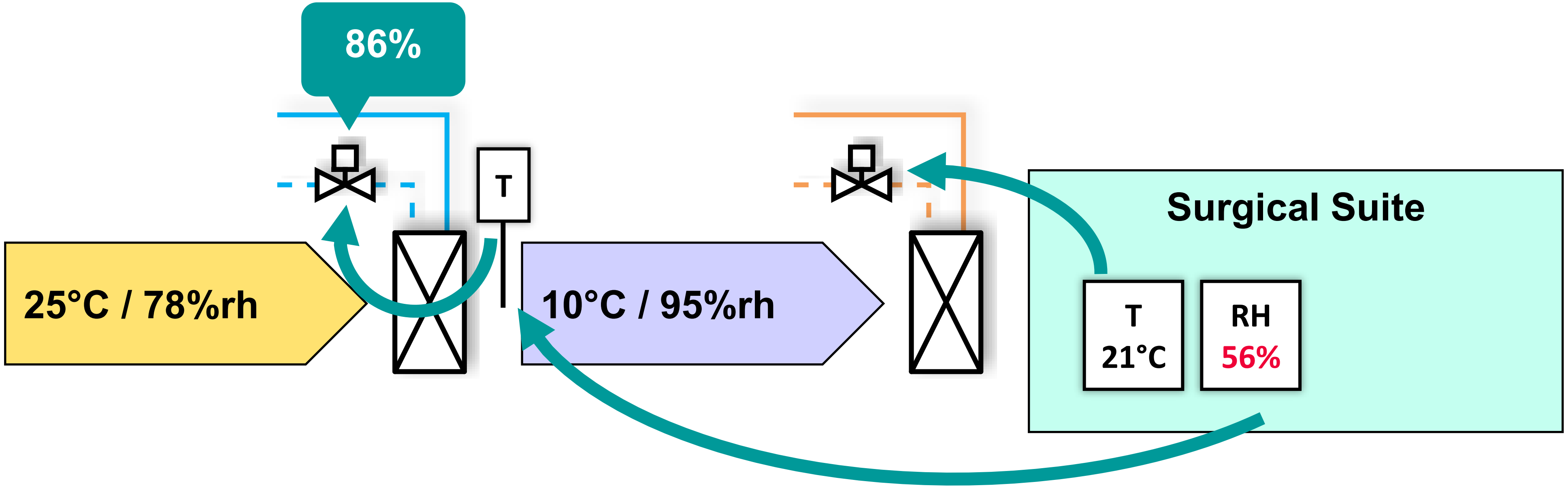
Downstream loads

How should dehumidification be controlled?

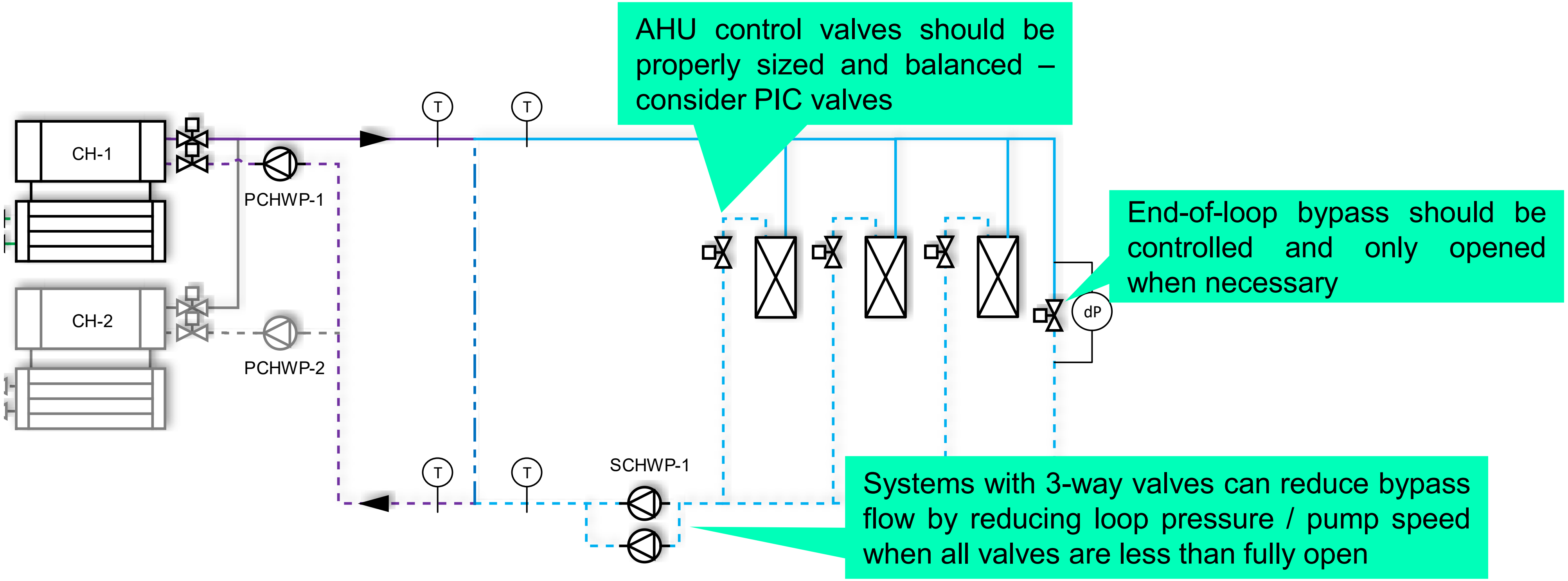
- Better way – install a temperature sensor after the cooling coil, modulate valve to control cooling coil leaving temperature
  - Low-cost upgrade
  - Reduces pumping energy
  - Prevents an air handler in dehumidification mode from impacting other systems



Downstream loads

Controlling chilled water flow is important – both for efficiency, and performance

- Excessive chilled water flow can cause chilled water temperature to rise above setpoint and require a secondary chiller to start, even if the first chiller has capacity to meet the load (low delta-T syndrome)
- Pushing excessive flow through a cooling coil to increase capacity provides diminishing returns



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Downstream loads

Keeping cooling demand to a minimum

- Many heat recovery systems will work to some extent in cooling mode
- Ensure coils and control devices are in good working order
- Look for opportunities to reduce demand
  - Occupancy-based controls for high-load areas like ORs
  - Scheduling or demand-controlled ventilation for spaces without a healthcare function (cafeterias, atria)

Measures like this can save energy at low loads and free up capacity at high loads

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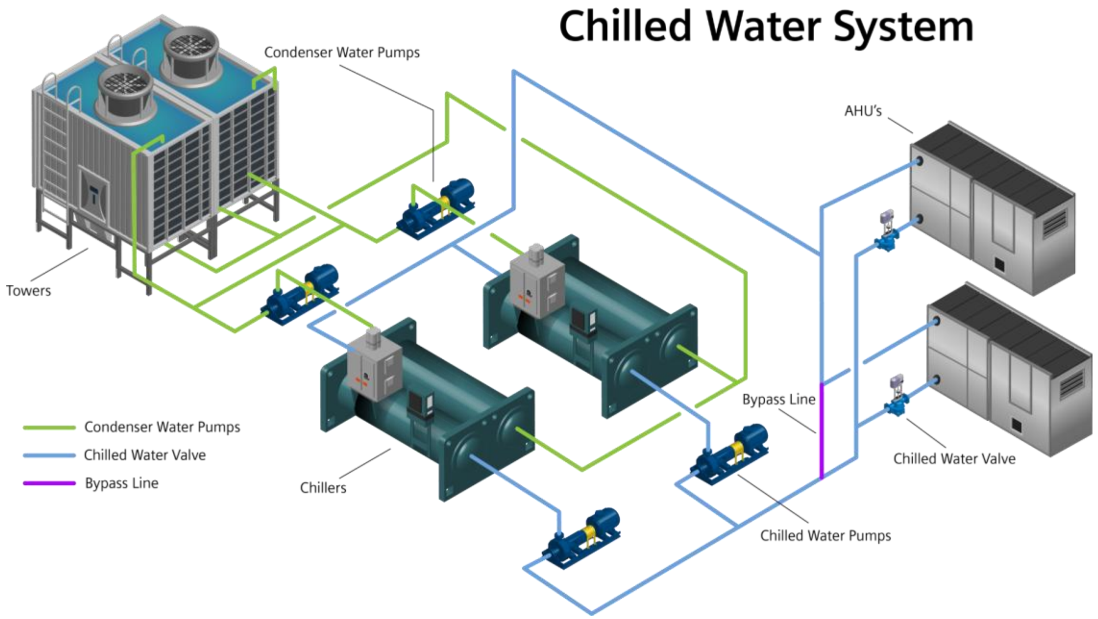
Optimization process

Putting the pieces together (again)

- Don't just look at the chiller plant in isolation!
- If the HVAC equipment served by the chiller plant is in good working order, it will have positive effects on the performance of the plant
- Poor control and performance of downstream loads will have negative effects
- Optimizing both the plant and its loads saves energy and gives your chiller plant the best shot at meeting its peak load



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Questions?

Luke Hancox P.Eng, CBCP
Energy Services Team Lead
Smart Infrastructure – Buildings | Sustainability
Halifax, NS
Canada

Mobile +1 709 740 3496

E-mail luke.hancox@siemens.com

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