Expanding Delta T in Enwave's Cooling System

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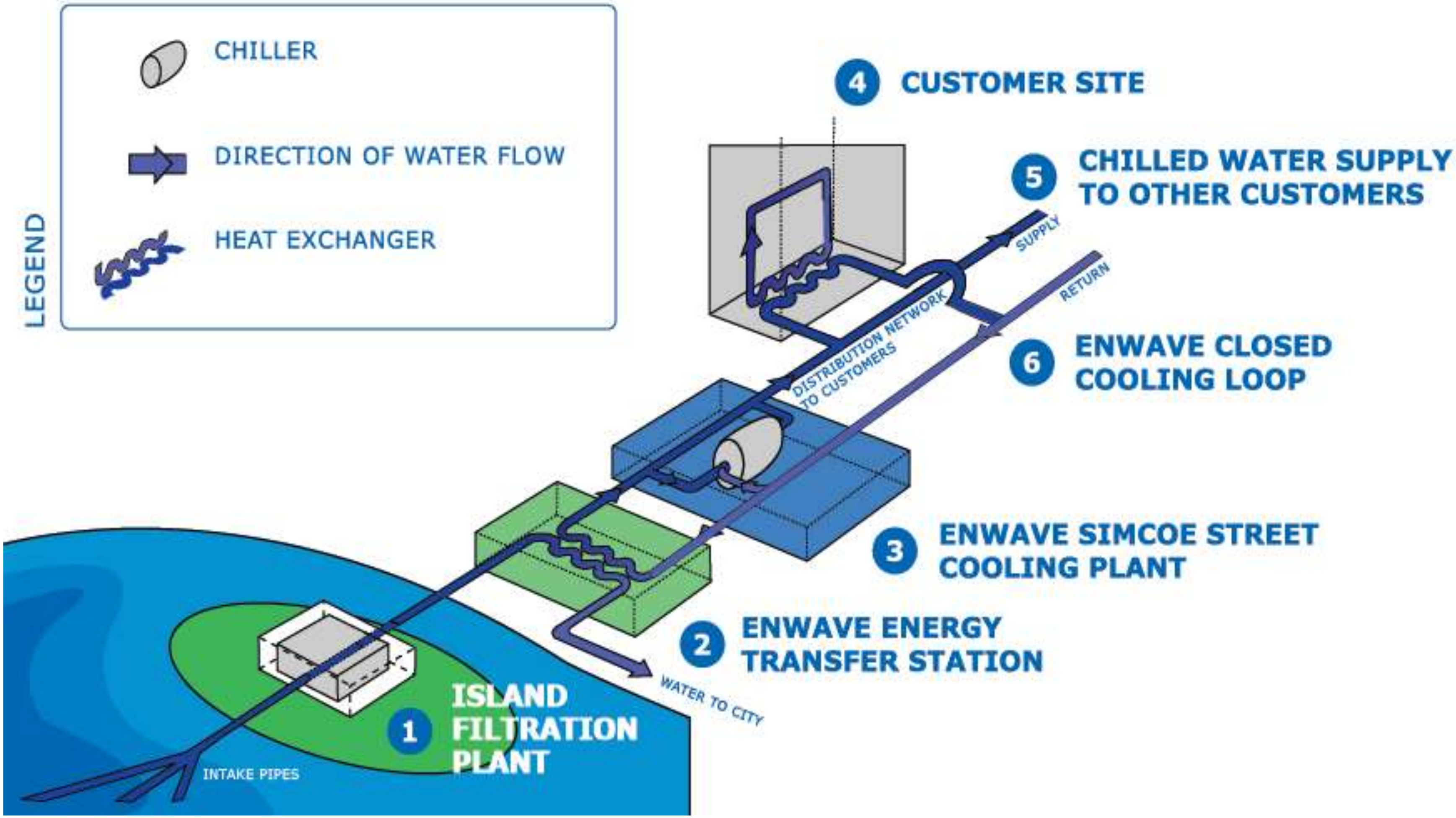
AGENDA

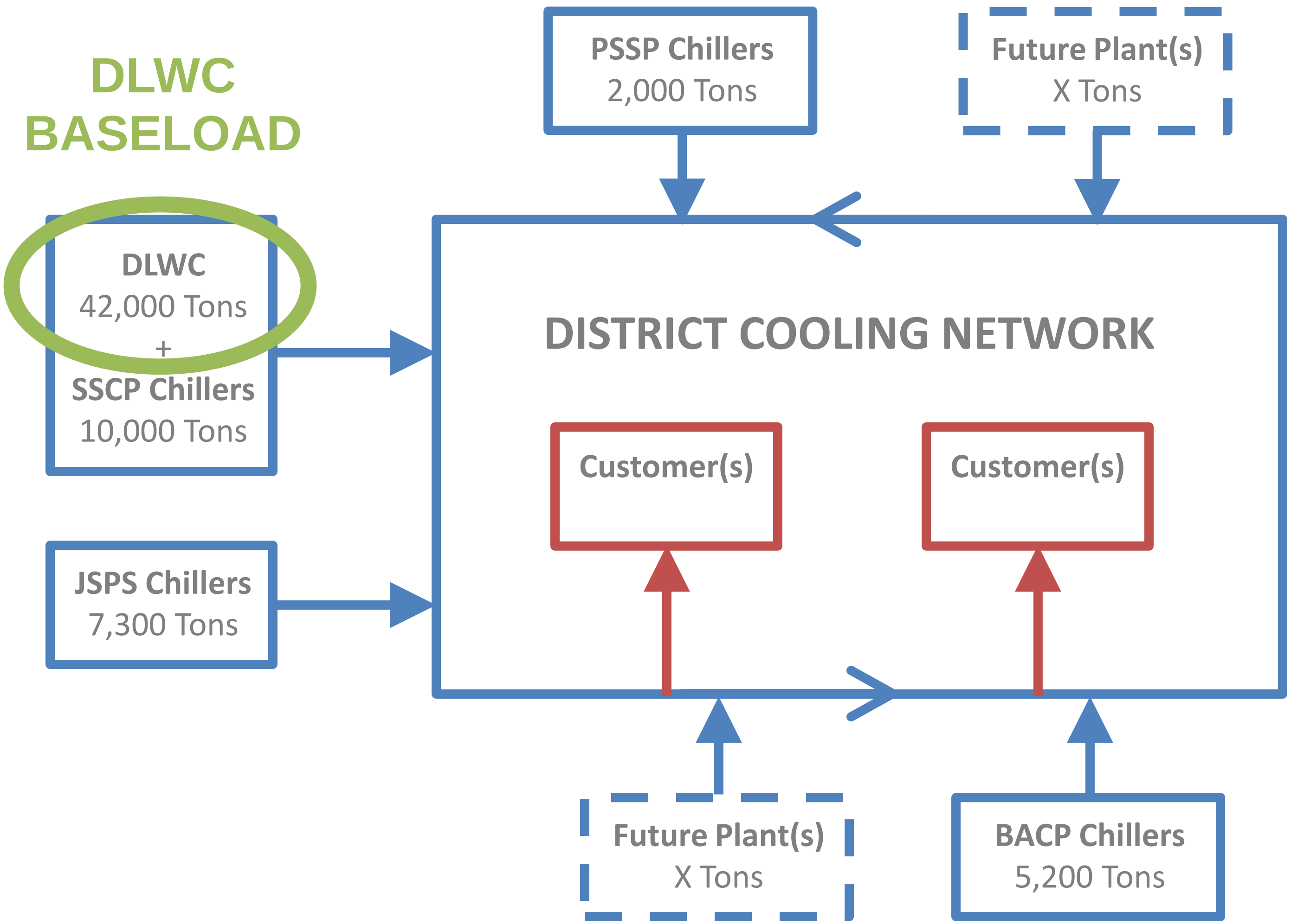
- Quick Intro to Enwave's DLWC System
- DLWC Capacity Breakdown and Constraints
- Typical Customer Site Controls
- Hybrid Control Strategy
- Summary & Other Applications

Introduction to
Deep Lake Water Cooling

DLWC & “Polishing” Chillers



The Cooling System Today



Breakdown of Deep Lake Water Cooling (DLWC) Capacity & Constraints

DLWC Nameplate Capacity

Original Nameplate Capacity	CHWR (°F)	CHWS (°F)	Flow (GPM)	Design Capacity (Tons)
DLWC Capacity	56.0	41.5	69,400	42,000

In reality, the Nameplate Capacity is rarely fully utilized in any given hour of the year

A reduction in nameplate capacity both:

- Increases Variable Operating Costs
- Reduces Total System Capacity

Season	Maximum On Peak Capacity (Tons)	Maximum Off Peak Capacity (Tons)
Summer	39,500	34,500
Spring/ Fall	37,500	27,000
Winter	21,000	17,500

these Variables

DLWC Nameplate Capacity

Original Nameplate Capacity	CHWR (°F)	CHWS (°F)	Flow (GPM)	Design Capacity (Tons)
DLWC Capacity	56.0	41.5	69,400	42,000

Determined by DLWC Heat Exchanger Approach. Influenced by:

- City Water Flow Rate
- Lake Temperature

Determined by Customer Loads (Independent)

Based on Customer Site Return Temperatures

Objective:

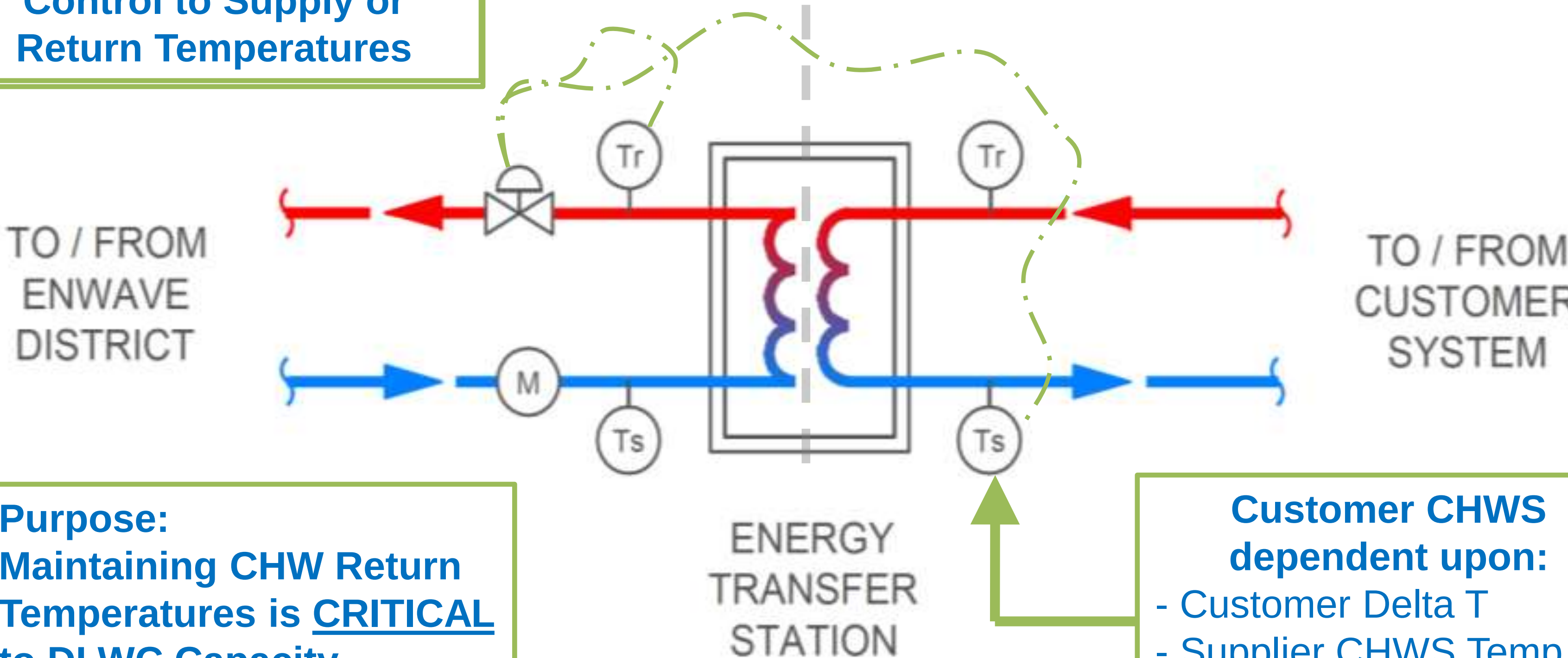
Explore Opportunities to Increase System CHWR Temperatures from Customer Sites

Typical Customer Site Control

Typical Customer Site Control

Supplier Side **Customer Side**

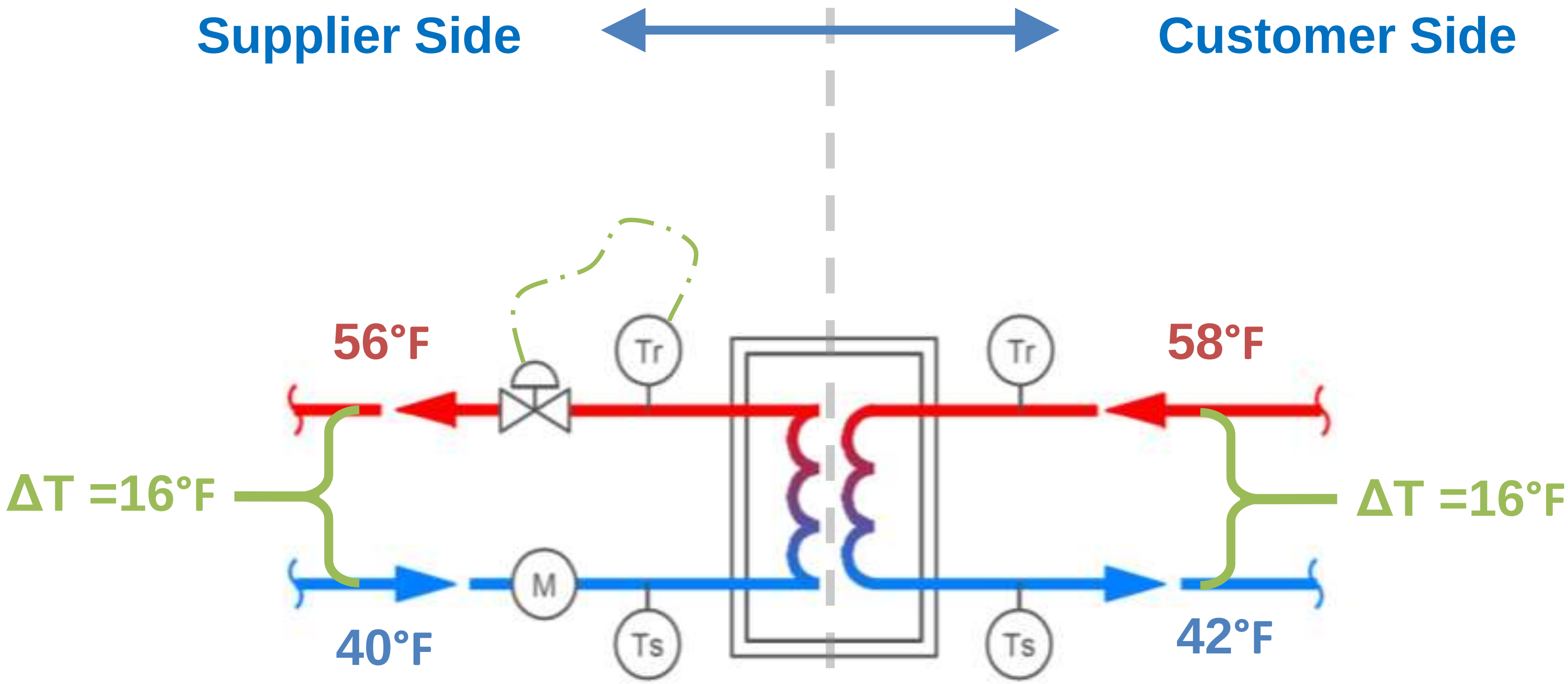
Typically, District Systems Control to Supply or Return Temperatures



Purpose:
Maintaining CHW Return Temperatures is <u>CRITICAL</u> to DLWC Capacity

Customer CHWS dependent upon:
- Customer Delta T
- Supplier CHWS Temp

Typical Customer Site Control



Systems are Operating in Harmony

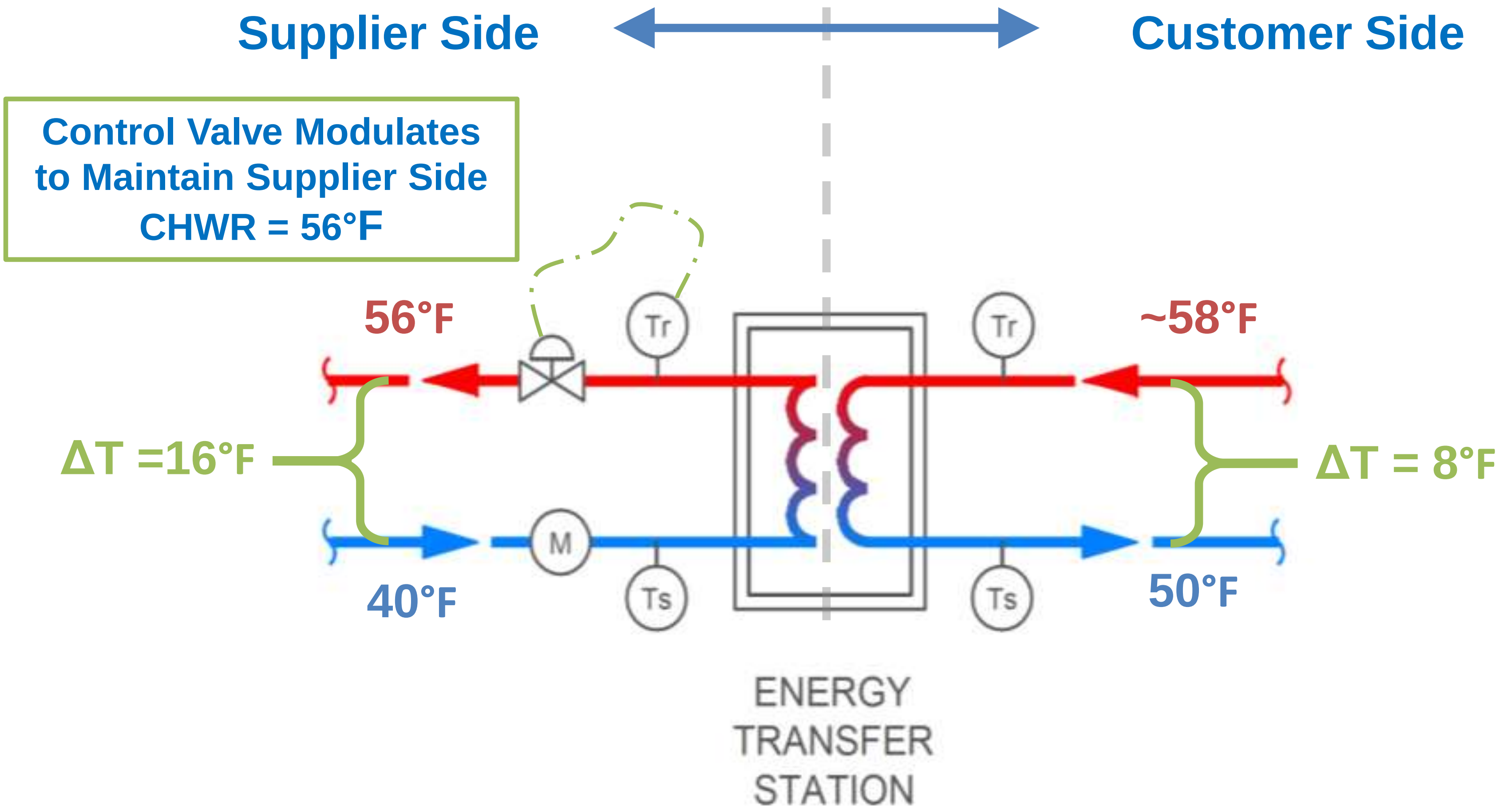
Realities of Customer Sites

- Good Performers and Bad Performers
- Variations between On-Peak and Off-Peak
- Variations Seasonally
- Buildings are Never in a Steady State
  (Valves fail, Coil & HX performance degrades, etc.)

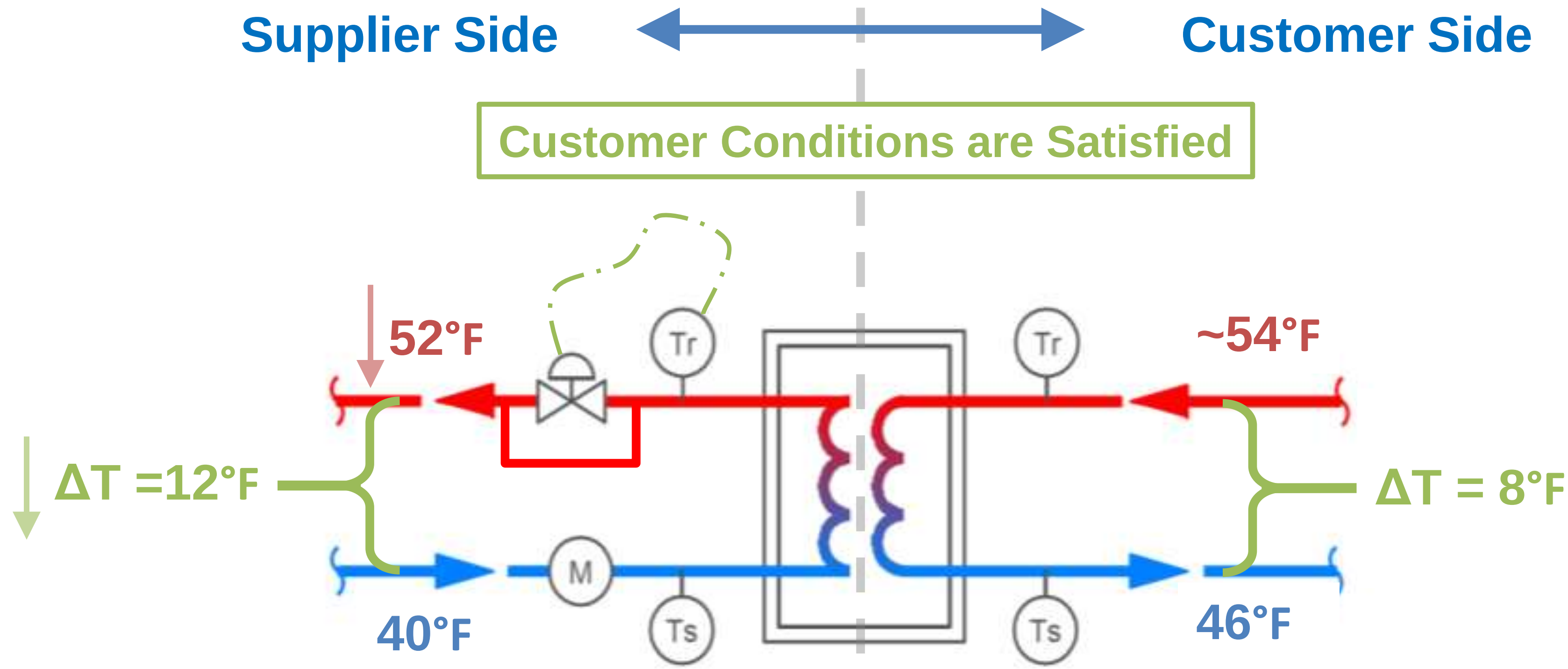
System CHWR Temperatures as a Result…

TARGET	Winter		Spring		Summer		Fall	
-	On-Peak	Off-Peak	On-Peak	Off-Peak	On-Peak	Off-Peak	On-Peak	Off-Peak
56	51	50	53	51	54	53	52	51

Realities of Customer Sites



Realities of Customer Sites



Accomplished By:
- **Resetting CHWR Setpoint Down**
- **Setting up a minimum bypass under Low Load Conditions**

Opportunities for Improvement

At Low Delta T Sites

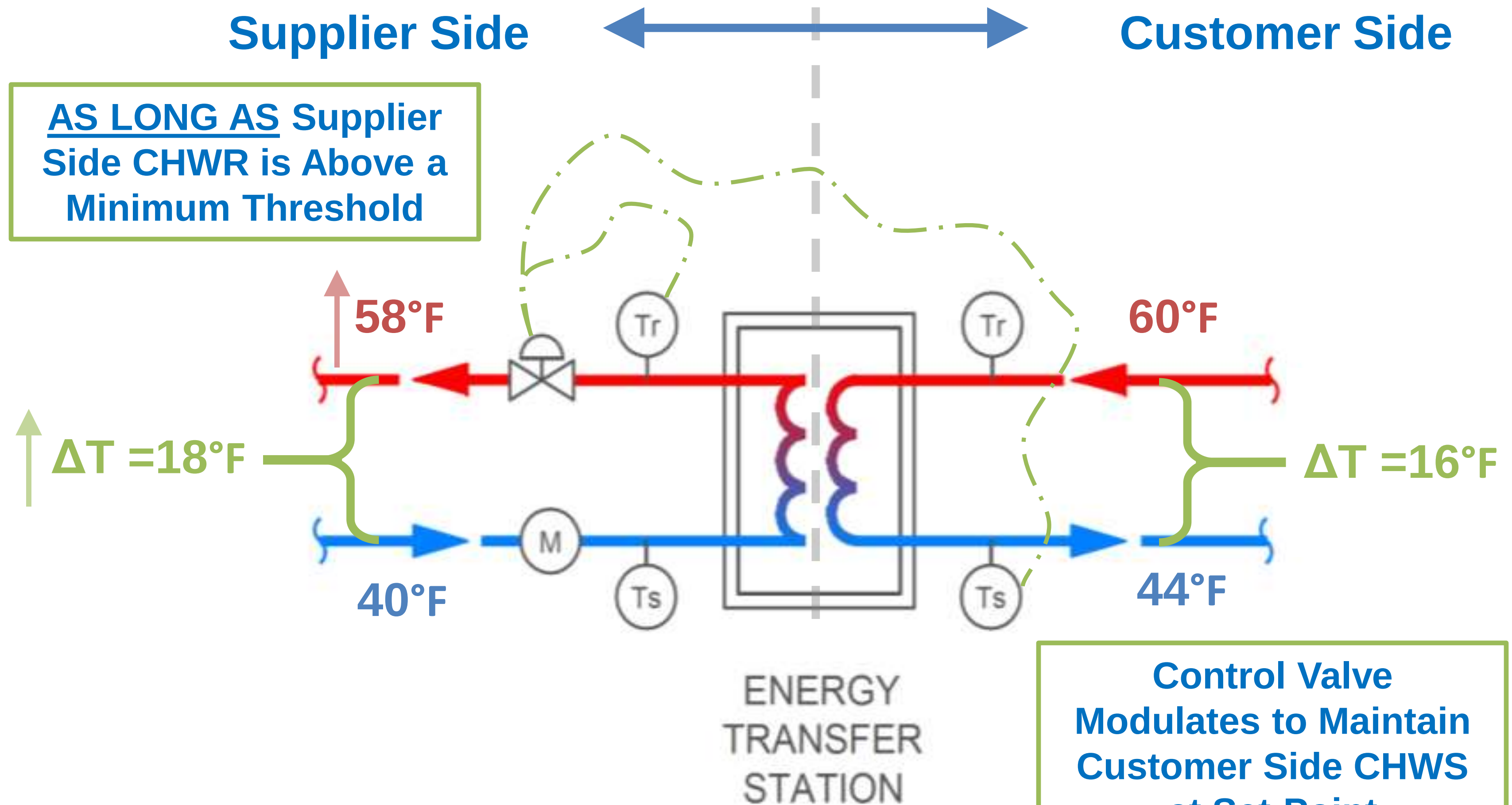
- Adjusted Set-points and Minimum Flow Bypasses are somewhat arbitrarily set to satisfy worst case conditions
- Missing out on opportunities when buildings are performing better

At High Delta T Sites

- Opportunity to realize higher CHWR temps than 56°F on Peak
- Seasonal Customer side CHWS requirements can be leveraged to drive building CHWR temperature higher

Hybrid Customer Site Control Strategy

Hybrid Control Strategy



<u>AS LONG AS</u> Supplier Side CHWR is Above a Minimum Threshold

Control Valve Modulates to Maintain Customer Side CHWS at Set-Point

Control Strategy Advantages

At <u>Low</u> Delta T Sites

- CHWR set-points below typical (ie. 56°F) become minimum thresholds instead
- The lower CHWR temperatures only occur when the building performance dictates

At <u>High</u> Delta T Sites

- Increased Supplier Side CHWR Temperatures are realized when building performance dictates

Benefits to Each Party

Customer Benefits

- Stability in Customer Side CHWS Temperatures
- Enwave has a vested interest in the delta T performance of the building
- Additional Customer Side monitoring

Supplier Benefits

- Customers CHWS temperature requirements are satisfied
- Higher CHWR temperatures are realized when available

Summary & Other Applications

In Summary…

Original Nameplate Capacity	CHWR (°F)	CHWS (°F)	Flow (GPM)	Design Capacity (Tons)
DLWC Capacity	56.0	41.5	69,400	42,000

- To maximize DLWC Capacity at all times
- Supplier Side CHWR Temperatures need to be maximized
- CHWR Temperatures can be improved through a Hybrid Control Strategy

Other Applications & Considerations

Reducing District CHWS Temperature adds Capacity

- Added benefit of realizing higher Supplier Side CHWR temperatures when the district temperature is reduced
- Due to LMTD on the heat exchanger, approach narrows between the CHWR temperatures as the CHWS temperatures part
- DLWC Capacity increases as a result

Other Applications & Considerations

Increasing Heat Recovery in Hot Water Systems

- The inverse of the control strategy can be applied to Hot Water systems coupled with heat recovery or economization sources
- HWR temperatures would be minimized while maintaining Customer HWS temperatures at setpoint

Questions?