# Energy Exchange℠

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# Making a Splash: Targeting Water Saving Measures for the Highest Impact

NREL ESIF Data Center Water Use Reductions

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# NREL Data Center

## Showcase Facility

- ESIF 182,000 ft.$^2$ research facility
- 10,000 ft.$^2$ data center
- 10-MW at full buildout
- LEED Platinum Facility, **PUE ≤ 1.06**
- NO mechanical cooling (*eliminates expensive and inefficient chillers*)


*Utilize the bytes and the BTUs!*

## Data Center Features

- Direct, component-level liquid cooling, 24ºC (75ºF) cooling water supply
- 35-40ºC (95-104ºF) return water (waste heat) is captured and used to heat offices and lab space
- Pumps more efficient than fans
- High-voltage, 480-VAC power distribution directly to high power density 60- to 80-kW compute racks

## Compared to a Typical Data Center

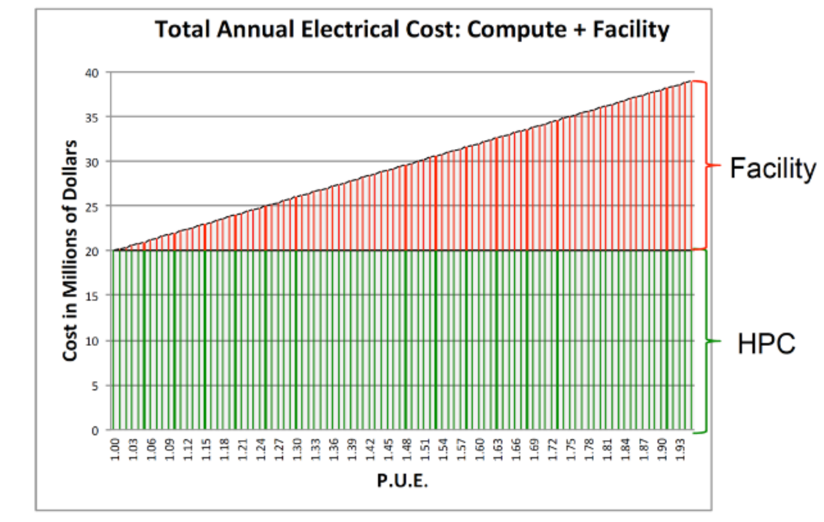
- Lower CapEx—costs less to build
- Lower OpEx—efficiencies save

*Integrated "Chips-to-Bricks" Approach*

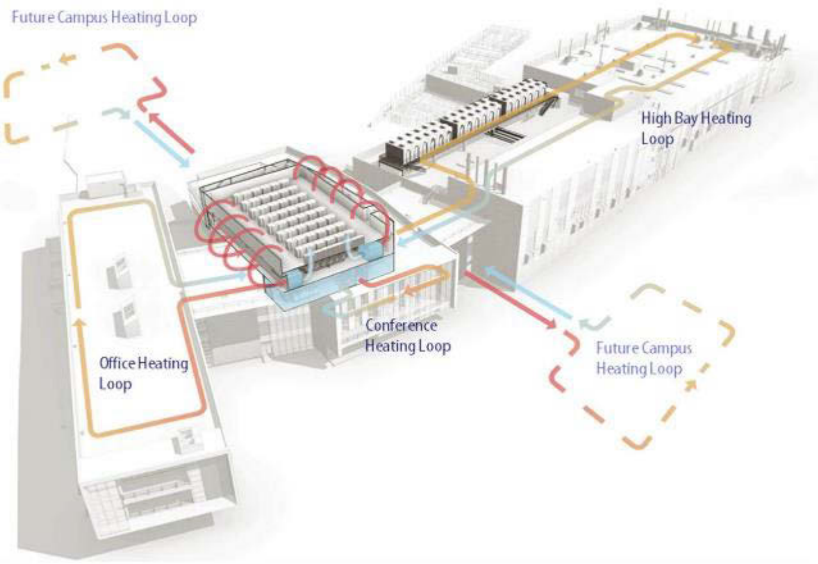
# Metrics

$$PUE = \frac{\text{"Facility energy"} + \text{"IT energy"}}{\text{"IT energy"}}$$

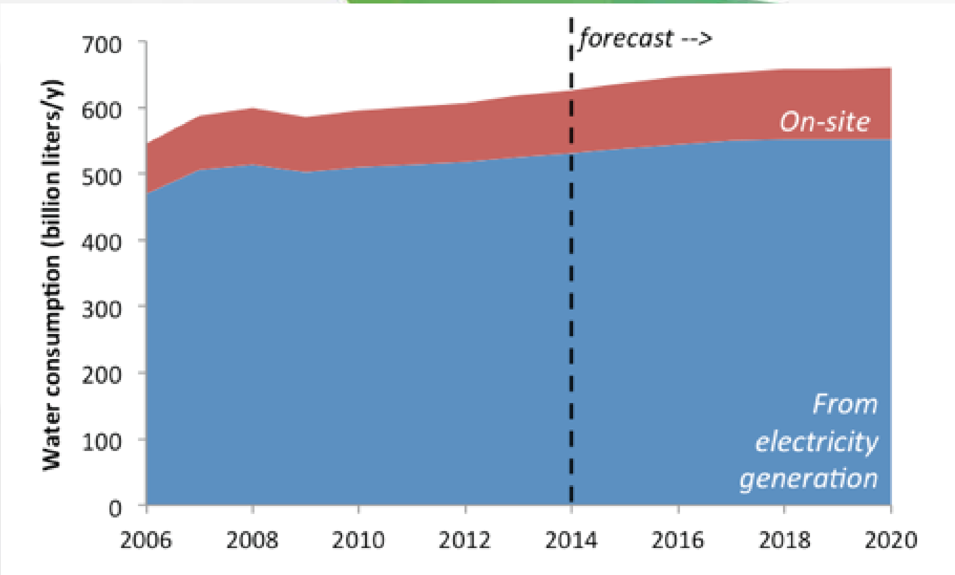
$$ERE = \frac{\text{"Facility energy"} + \text{"IT energy"} - \text{"Reuse energy"}}{\text{"IT energy"}}$$




Assume ~20MW HPC system & $1M per MW year utility cost.



# Metrics




$$WUE = \frac{\text{“Annual Site Water Usage”}}{\text{“IT energy”}}$$

*the units of WUE are liters/kWh*

$$WUE_{SOURCE} = \frac{\text{“Annual Site Water Usage”} + \text{“Annual Source Energy Water Usage”}}{\text{“IT energy”}}$$

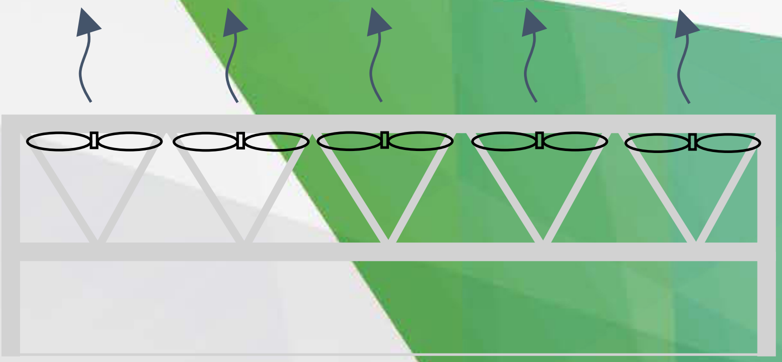
$$WUE_{SOURCE} = \frac{\text{“Annual Site Water Usage”}}{\text{“IT energy”}} + [EWIF \times PUE]$$

*where EWIF is energy water intensity factor*

# Air- and Water-Cooled System Options

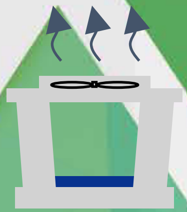
**Air-Cooled System**

- Design day is based on **DRY BULB** temperature
- Consumes no water (no evaporative cooling)
- Large footprint/requires very large airflow rates



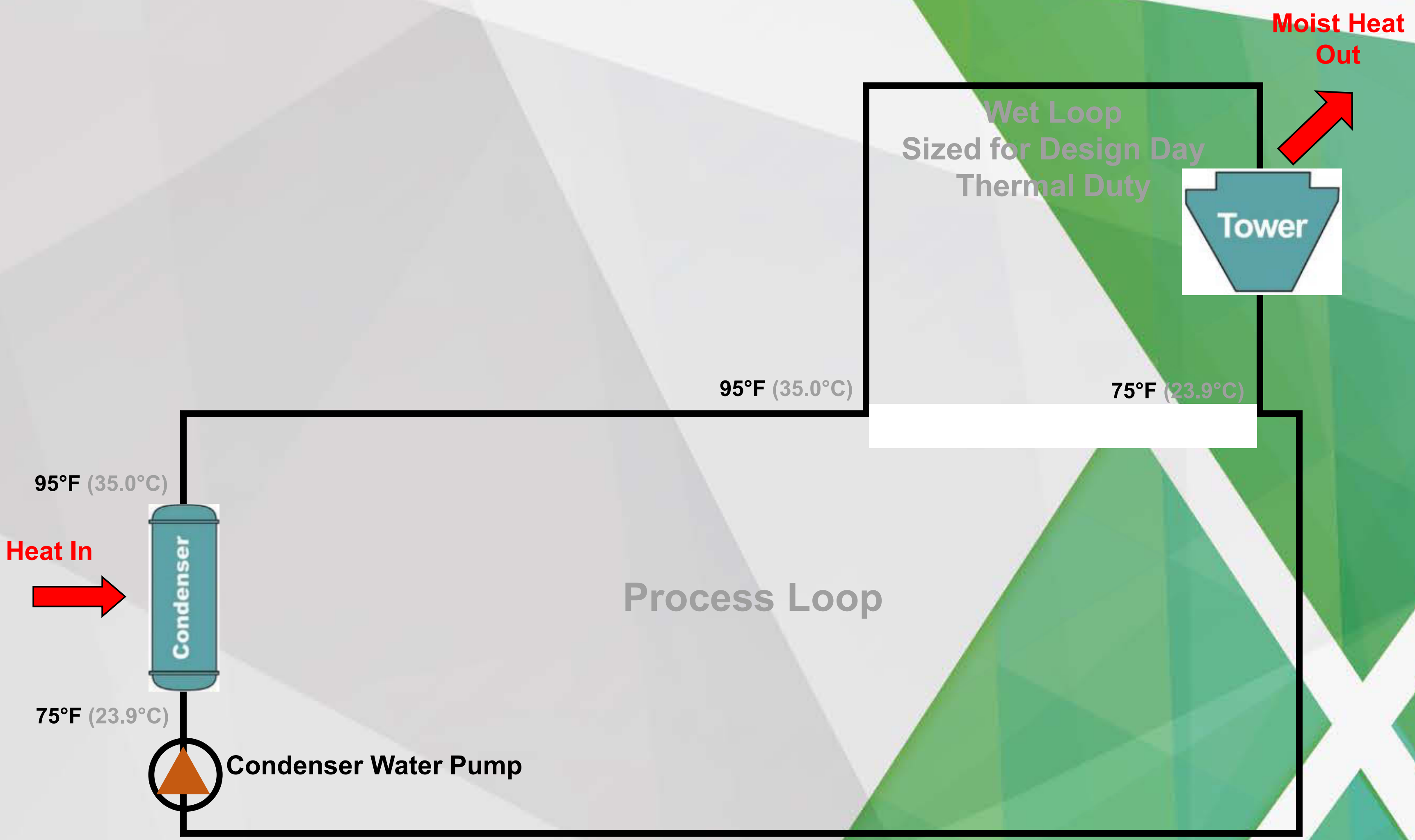
**Water-Cooled System**

- Design day is based on the lower **WET BULB** temperature
- Evaporative cooling process uses water to improve cooling efficiency
  - **80% LESS AIRFLOW → lower fan energy**
  - Lower cost and smaller footprint.
- Colder heat rejection temperatures improve system efficiency

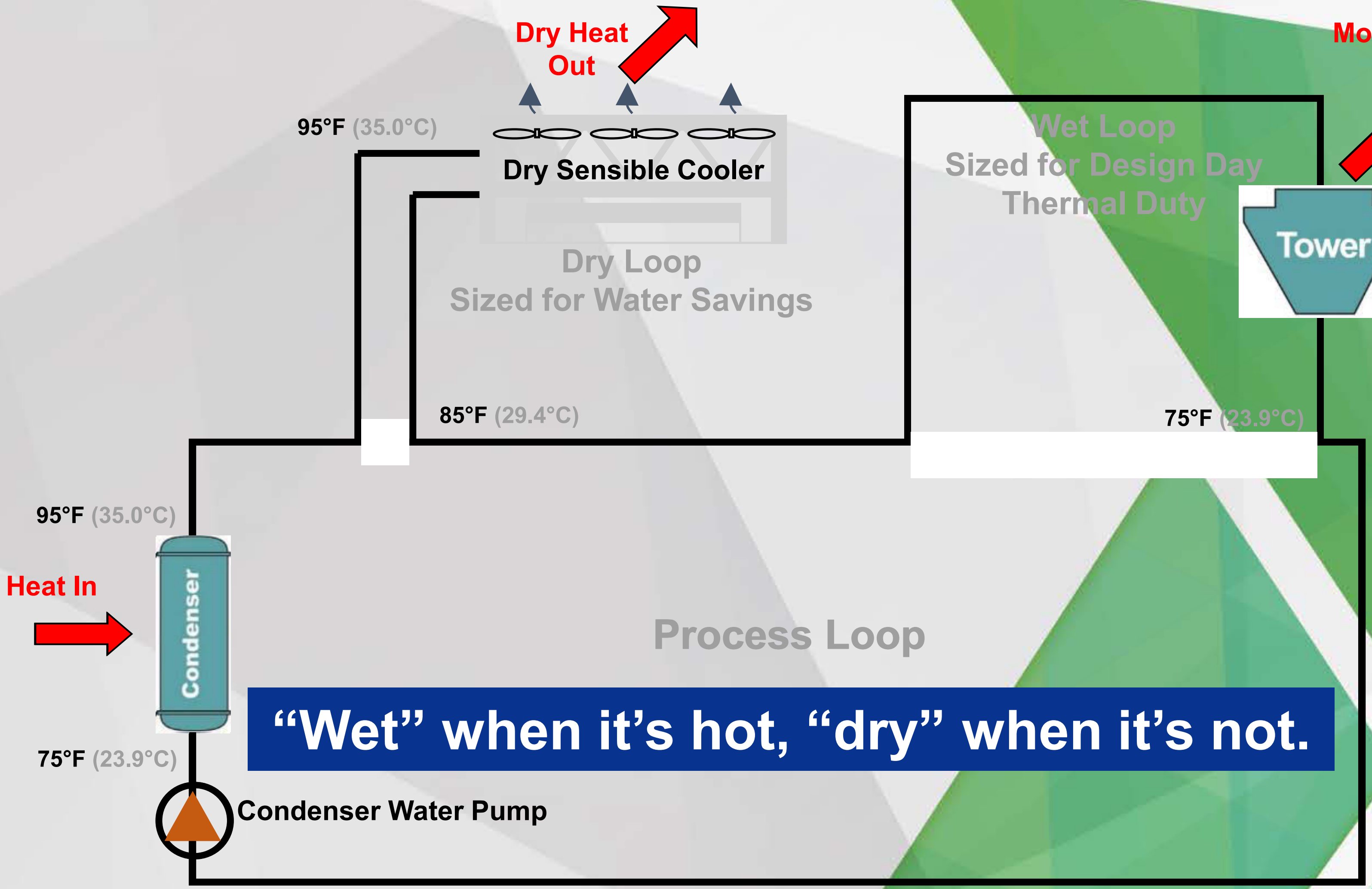


*However, water-cooled systems depend on a reliable, continuous source of low-cost water.*

# Traditional Wet Cooling System

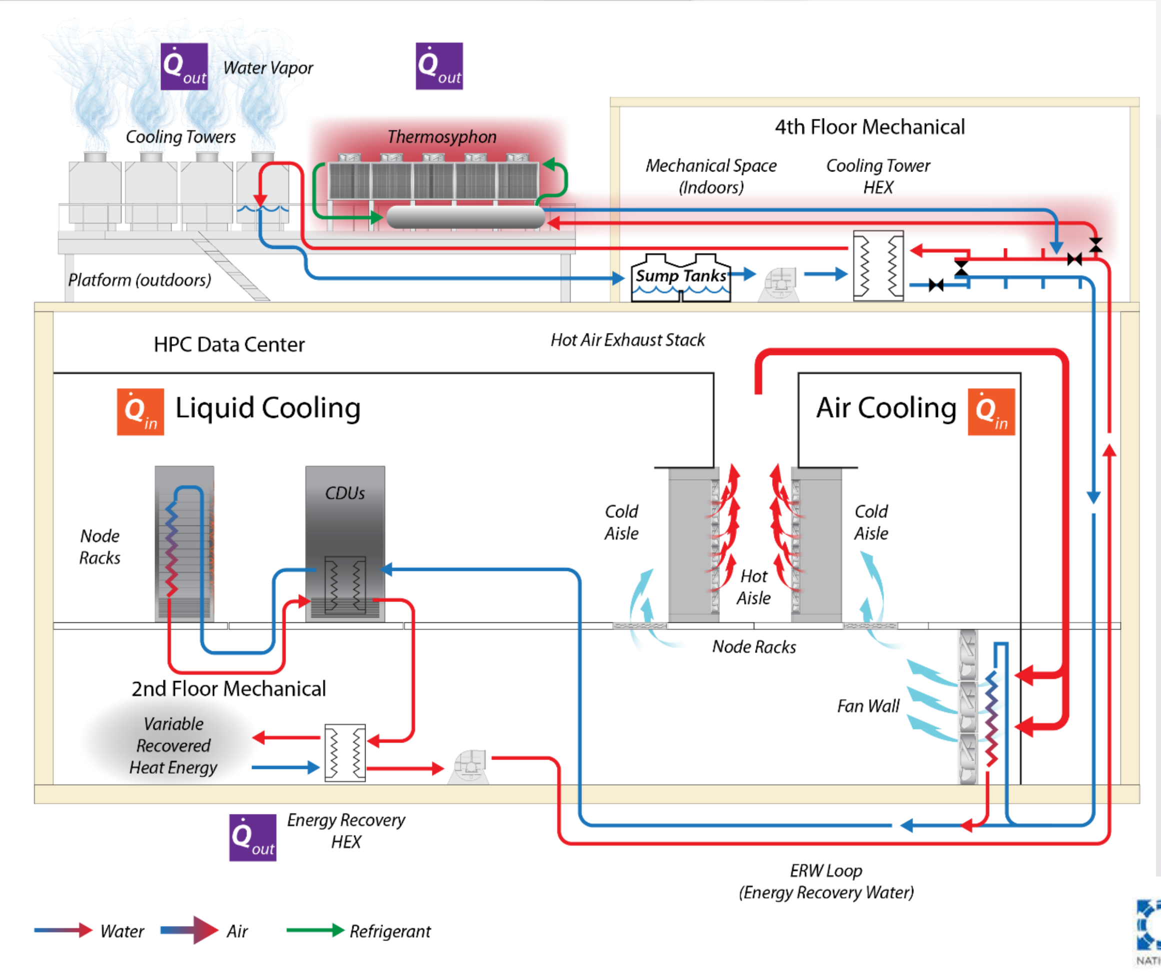


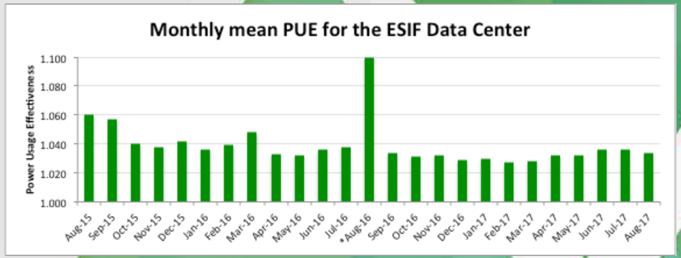
# Basic Hybrid System Concept




**“Wet” when it’s hot, “dry” when it’s not.**

# Improved WUE—Thermosyphon



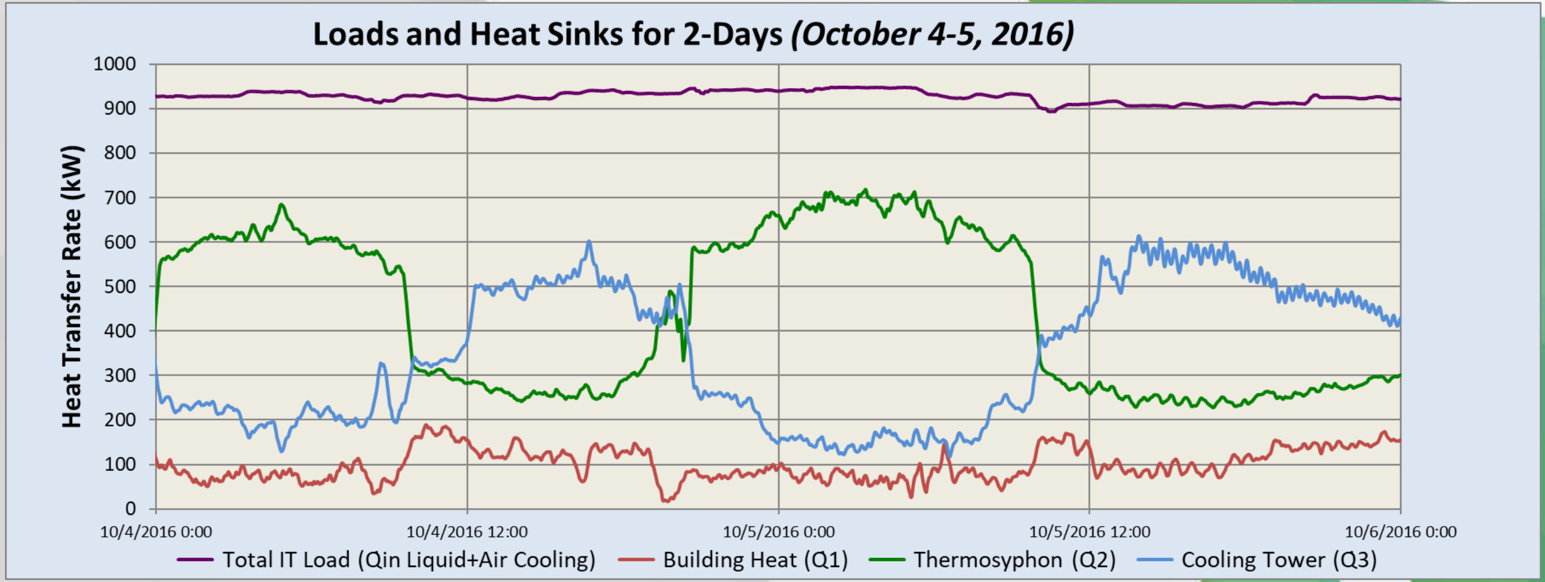
# Applications

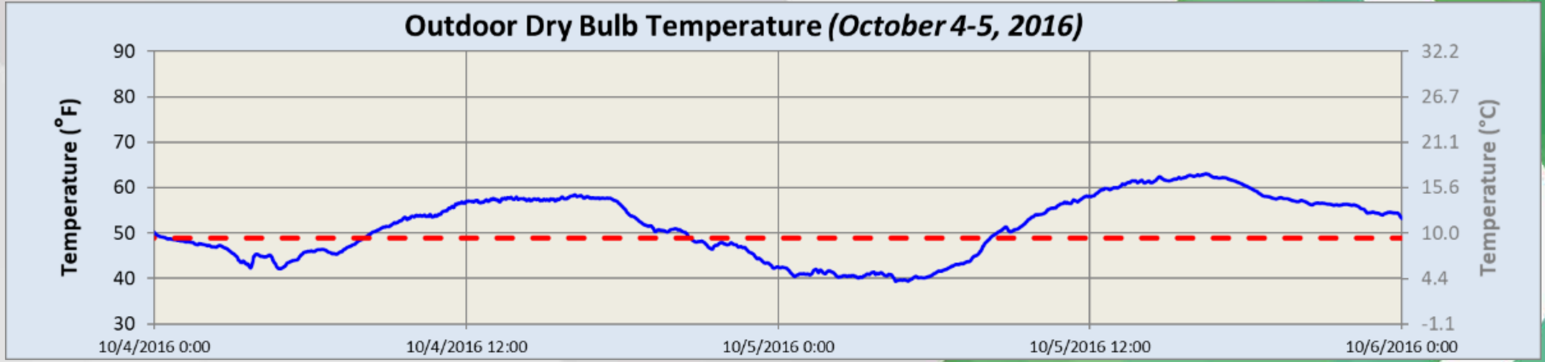
Any application using an open cooling tower is a potential application for a hybrid cooling system, but certain characteristics will increase the potential for success.

## Favorable Application Characteristics

- Year-round heat rejection load (24/7, 365 days is best)
- Higher loop temperatures relative to average ambient temperatures
- High water and wastewater rates or actual water restrictions
- Owner's desire to mitigate risk of future lack of continuous water availability (water resiliency)
- Owner's desire to reduce water footprint to meet water conservation targets

# Sample Data: Typical Loads and Heat Sinks



# Data Center Metrics

## First year of TSC operation (9/1/2016–8/31/2017)

*Hourly average IT Load = 888 kW*

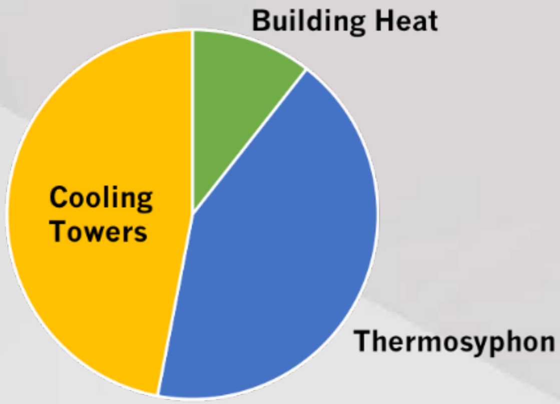
*PUE = 1.034*

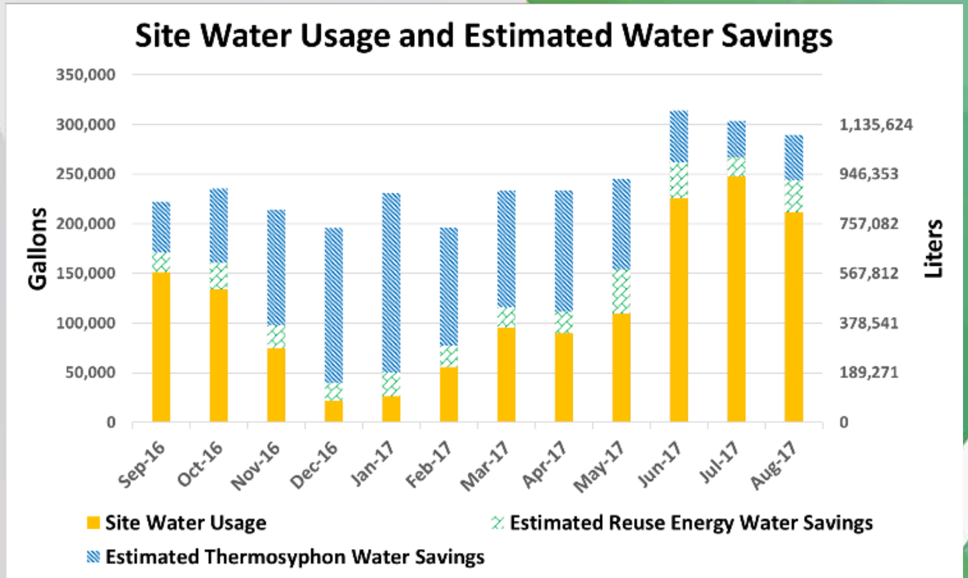
*ERE = 0.929*

*WUE = 0.7 liters/kWh*

*(with only cooling towers, WUE = 1.42 liters/kWh)*

Annual Heat Rejection




*$WUE_{SOURCE}$ = 5.4 liters/kWh*
*$WUE_{SOURCE}$ = 4.9 liters/kWh if energy from 720 kW PV (10.5%) is included*

*using EWIF 4.542 liters/kWh for Colorado*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# Notice

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