Thermosyphon: Improved WUE

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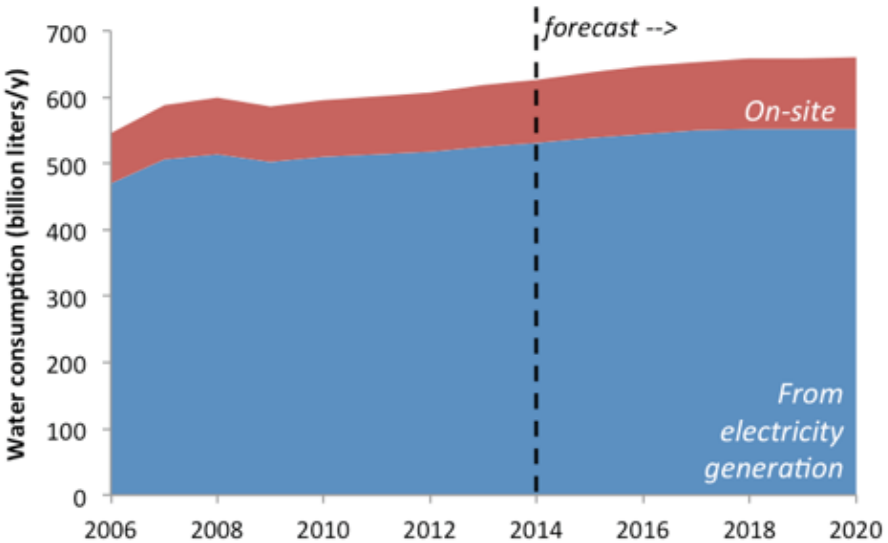
Metric – Water Usage Effectiveness



Source: Lawrence Berkeley National Laboratory

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

the units of WUE are liters/kWh

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

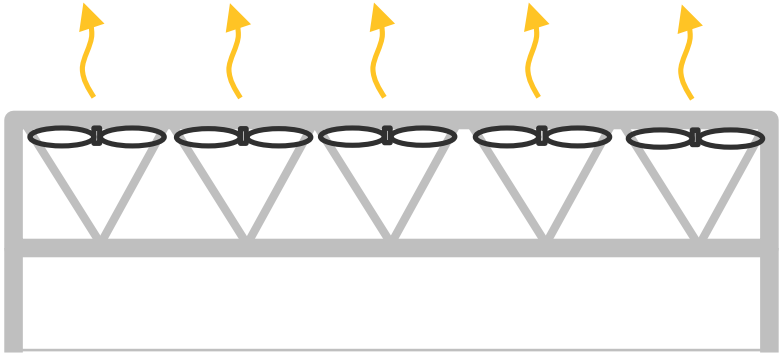
$$WUE_{SOURCE} = \frac{\text{“Annual Site Water Usage”}}{\text{“IT energy”}} + [EWIF \times PUE]$$

where EWIF is energy water intensity factor

Air- and Water-Cooled System Options

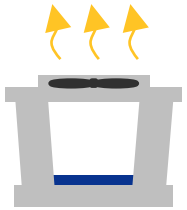
Air-Cooled System

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



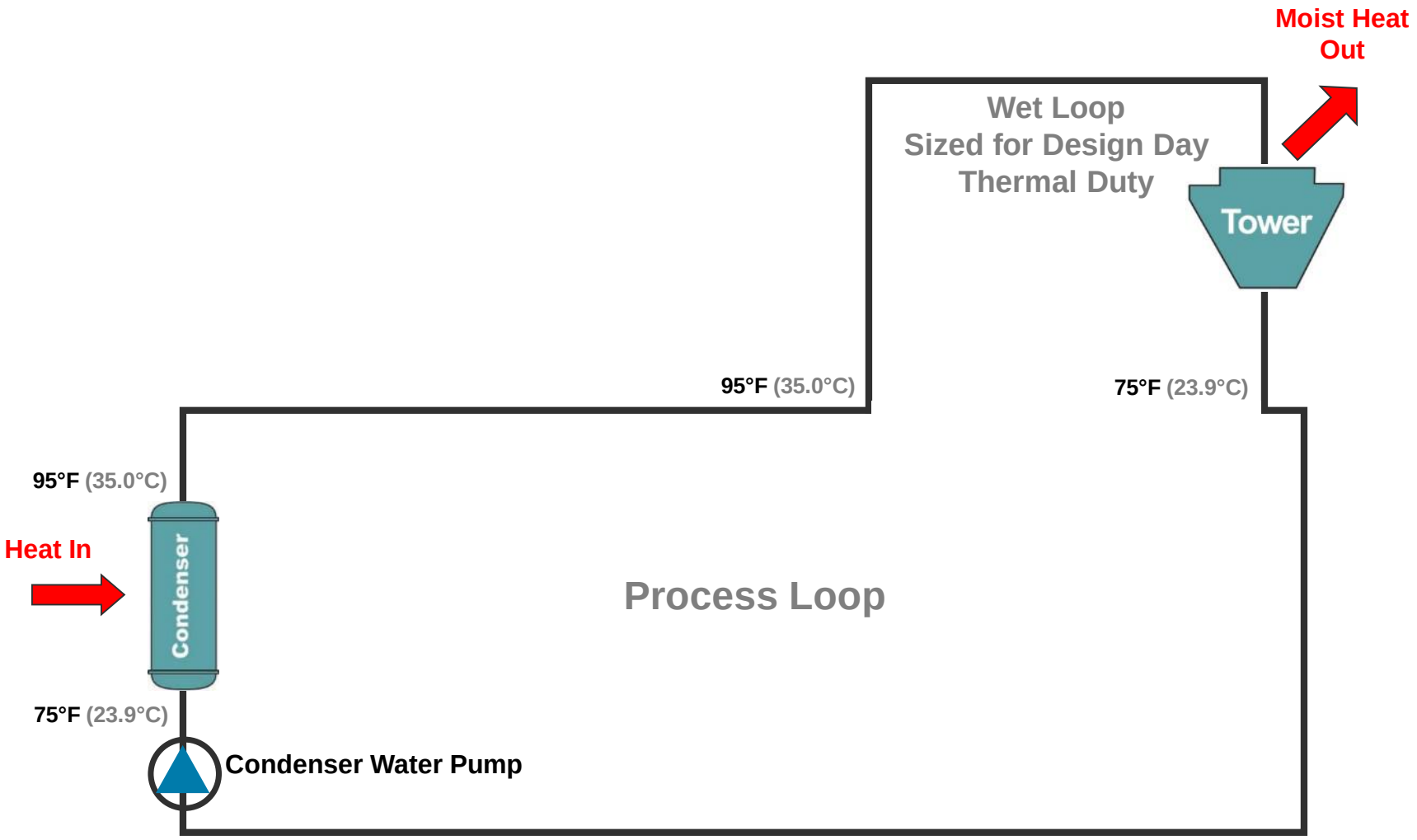
Water-Cooled System

- 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

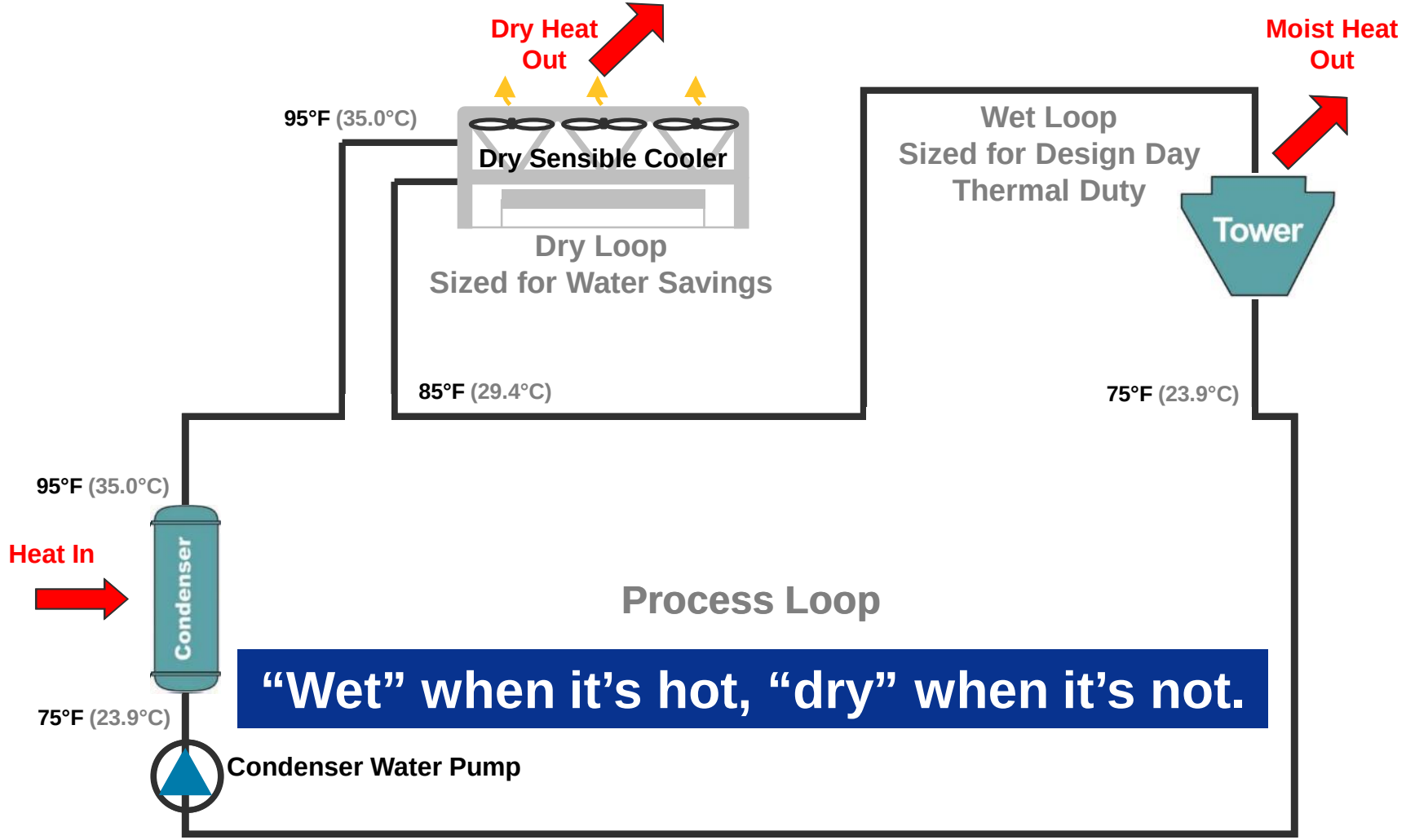


However, water-cooled systems depend on a reliable, continuous source of low-cost water.

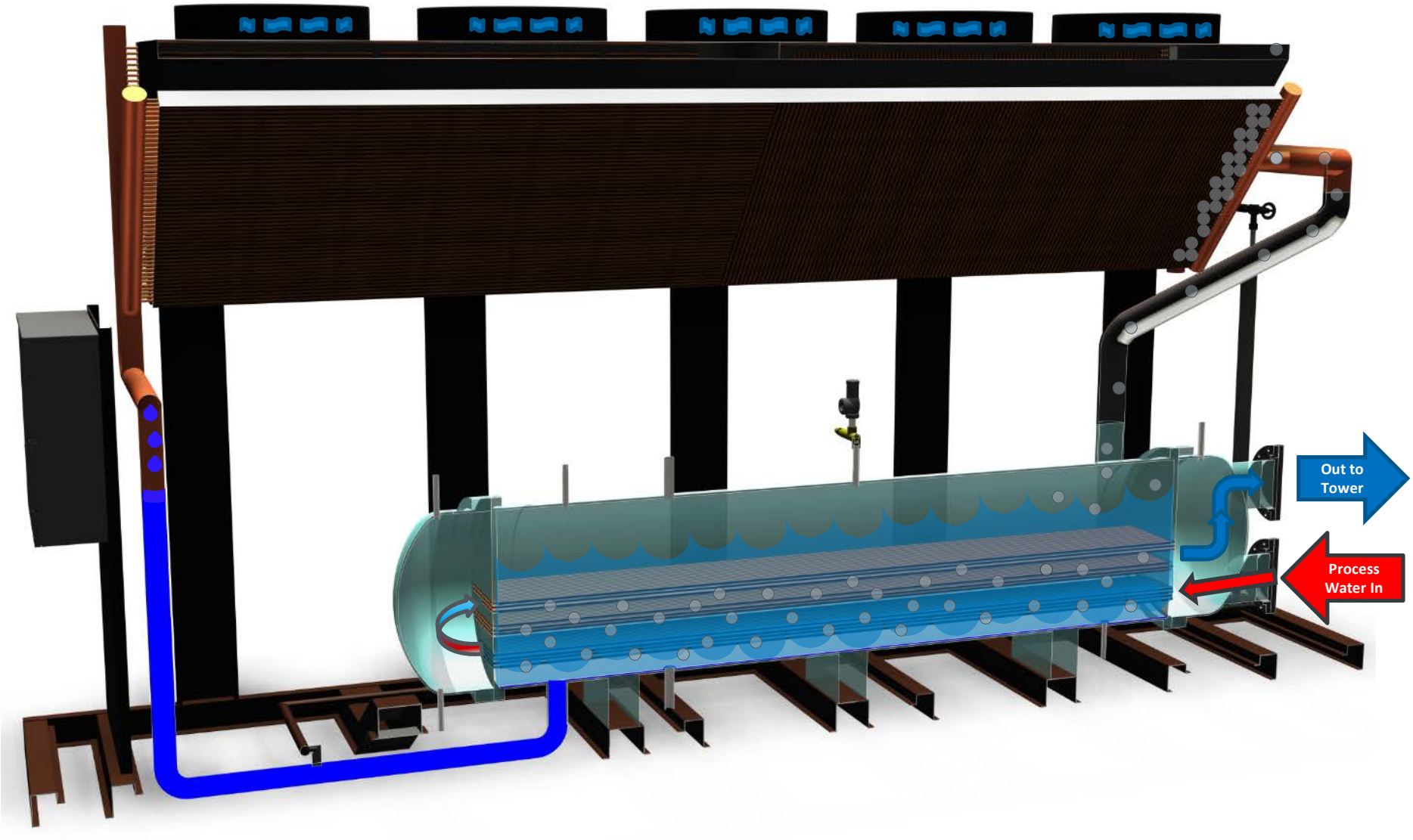
Traditional Wet Cooling System



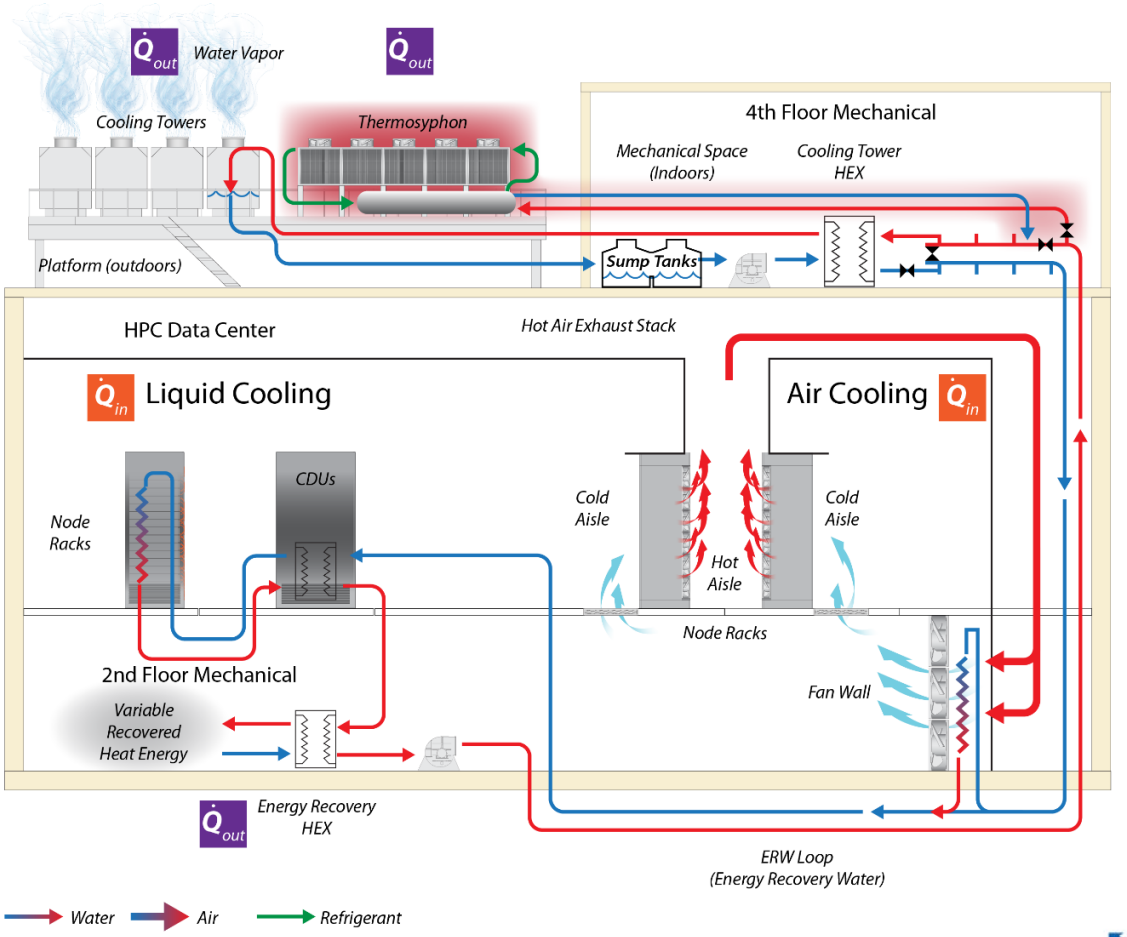
Basic Hybrid System Concept

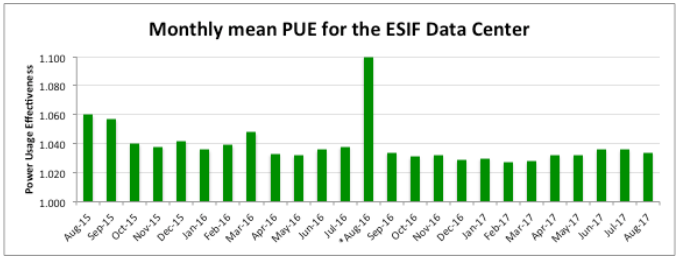


Thermosyphon Cooler



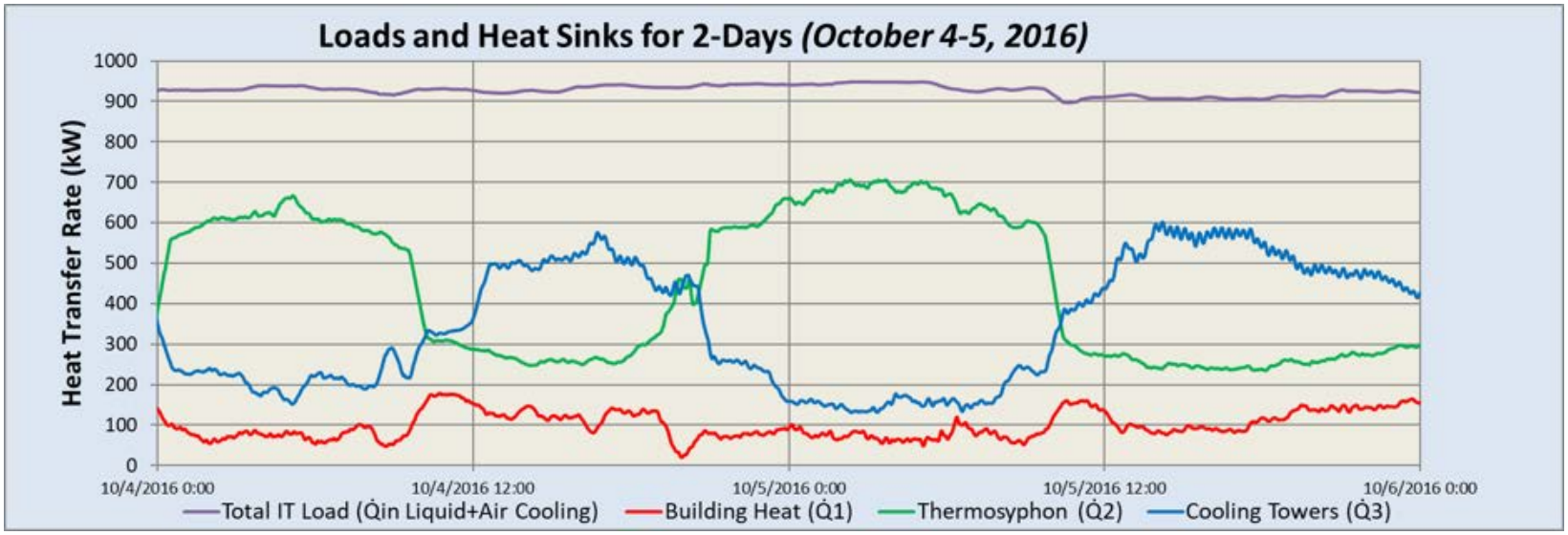
Improved WUE—Thermosyphon

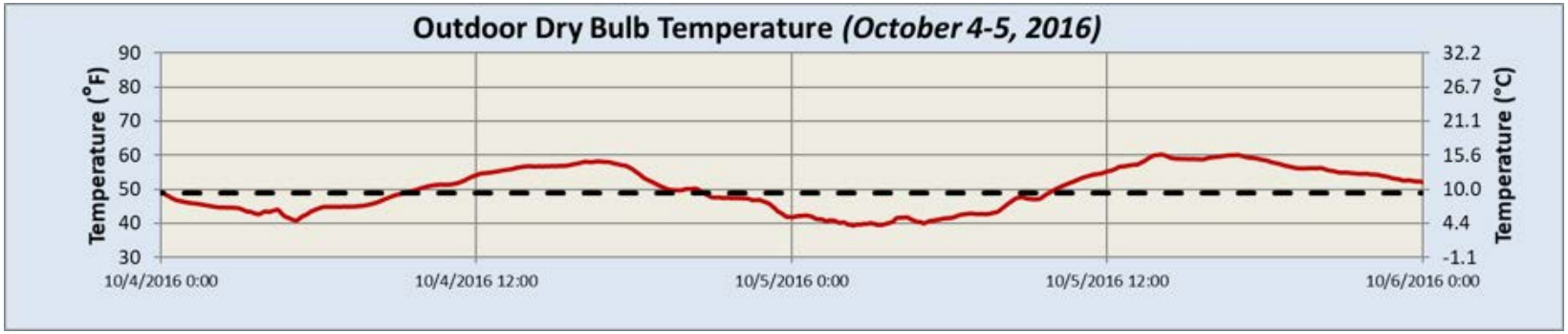




- Average entering water temperature to TSC 84°F (28.9°C)
- Operational Resiliency – avoided outage for cooling tower loop repair

Sample Data: Typical Loads and Heat Sinks





Data Center Metrics

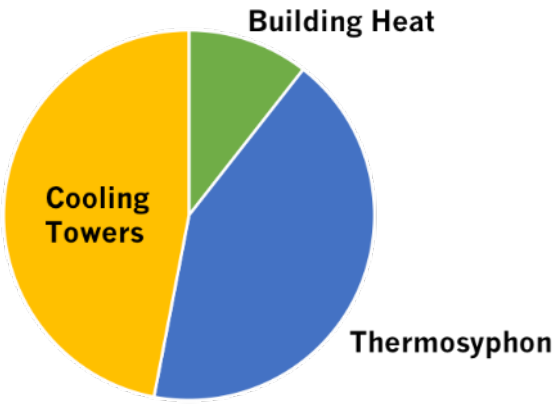
First year of TSC operation (9/1/2016–8/31/2017)

Hourly average IT Load = 888 kW

PUE = 1.034

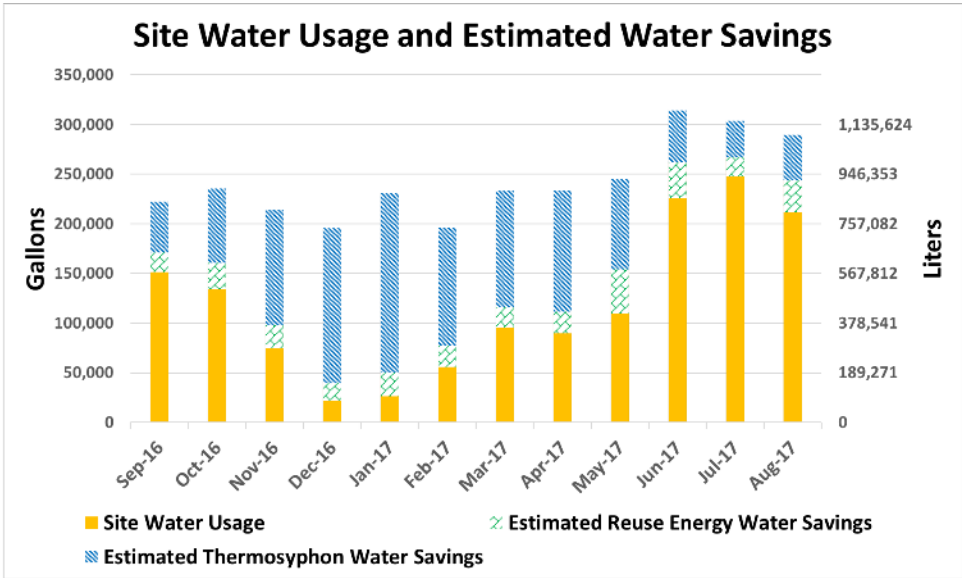
ERE = 0.929

Annual Heat Rejection



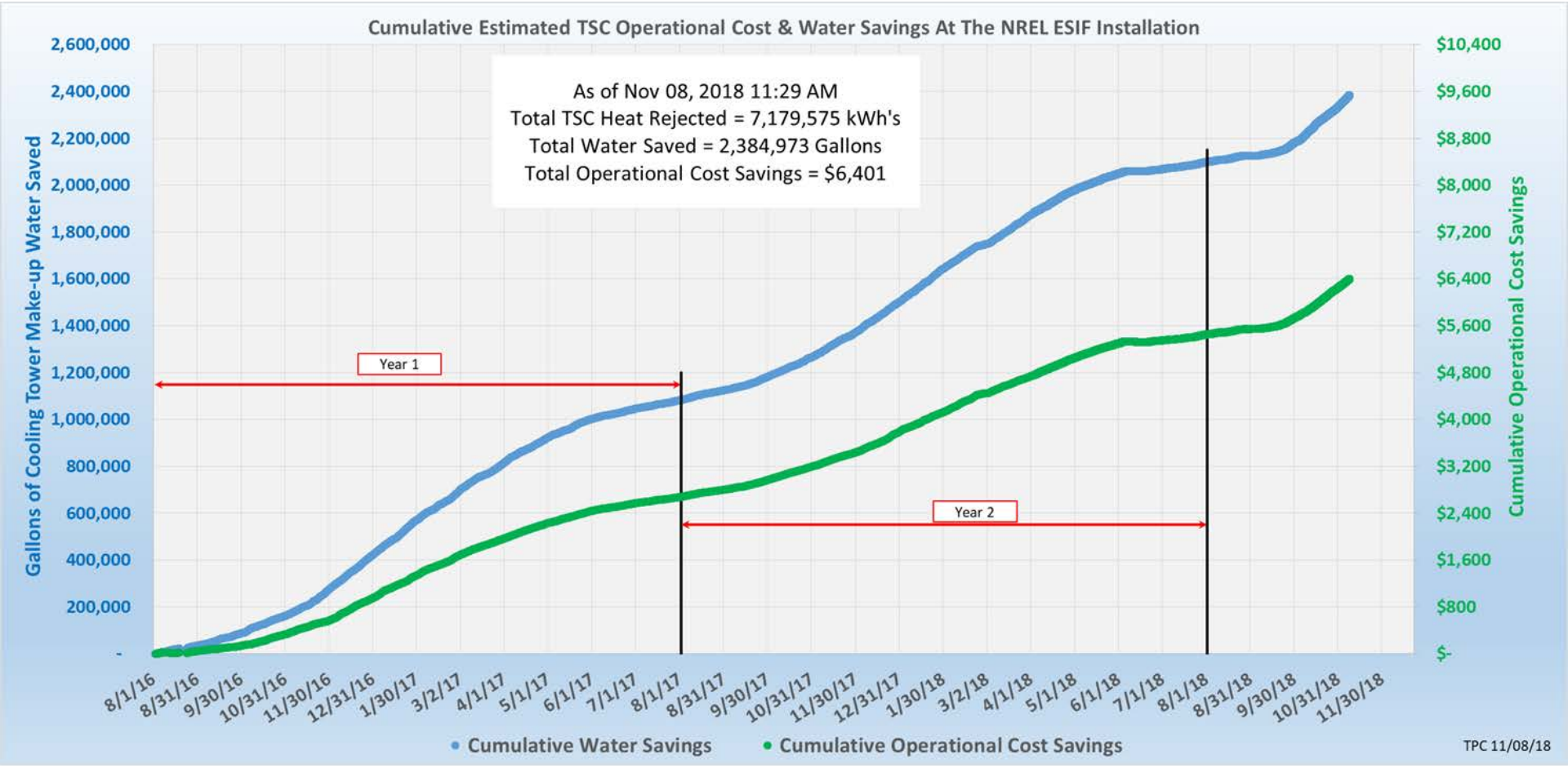
WUE = 0.7 liters/kWh

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



Cumulative Water and Cost Savings

Energy = $0.07/kWh
Water = $5.18/kgal



David Smith

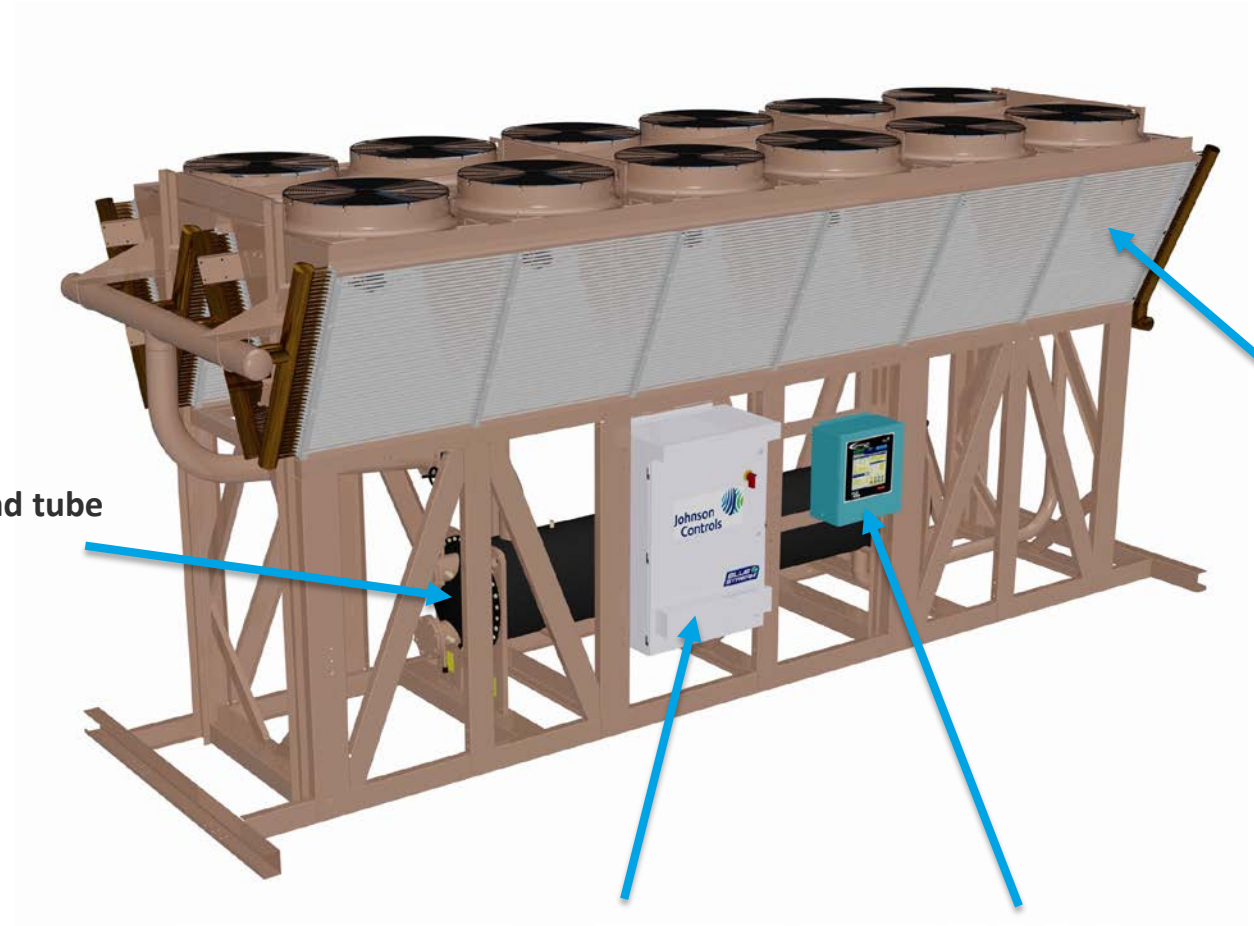
Sandia National Laboratories

Sandia – New Data Center Expansion

- Single TSC installed on new HPC data center
  - Data center designed to expand to 4 TSC units
- Data center designed for warm water cooling
  - 78-85 degrees Fahrenheit
- TSC to be running all day from October through April
  - Run during nights/mornings May through September
- Air handlers on separate water loop
  - Allows for higher processed water temperature for water-cooled systems

Sandia – New Data Center Expansion

Thermosyphon – Production Version



Condenser coil

Insulated shell and tube evaporator

VFD panel for fans

Control panel to optimize energy and water use

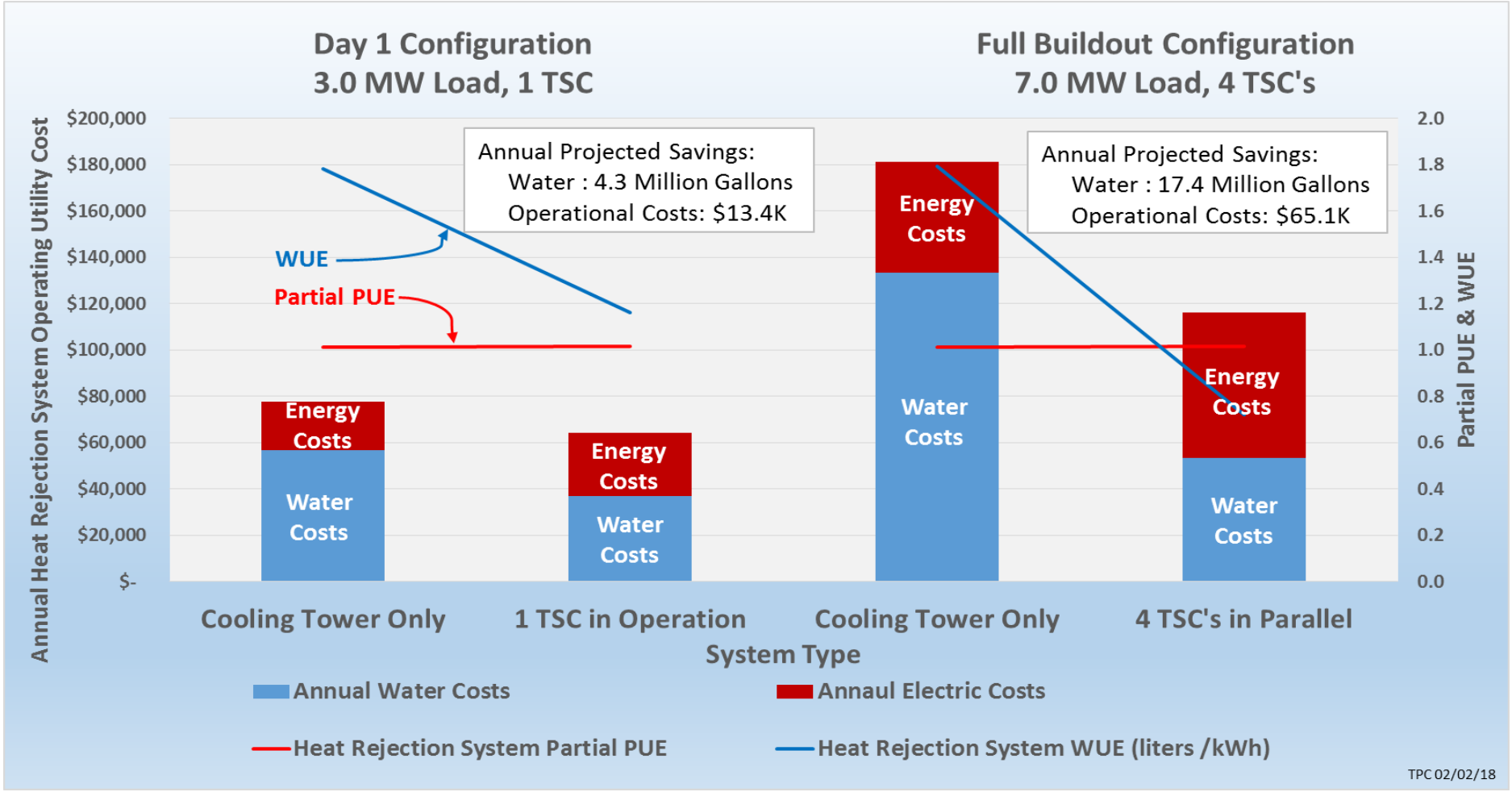
Benefits of TSC at Sandia

- Average annual precipitation in New Mexico: 9.4”
- Low cycles of concentration: 2.5
  - Much more blowdown
- Low maintenance
  - Easily cleanable, no water treatment
- Low operational costs
  - No make up water, no water treatment

Water Savings at Sandia

- Sandia estimated to save around 2x as much water as NREL
  - 2 million gallons of water saved per TSC per year at Sandia
  - Higher return water temperature allows for more water savings
  - Lower cycles of concentration causes larger water savings

TSC Modeling at Sandia

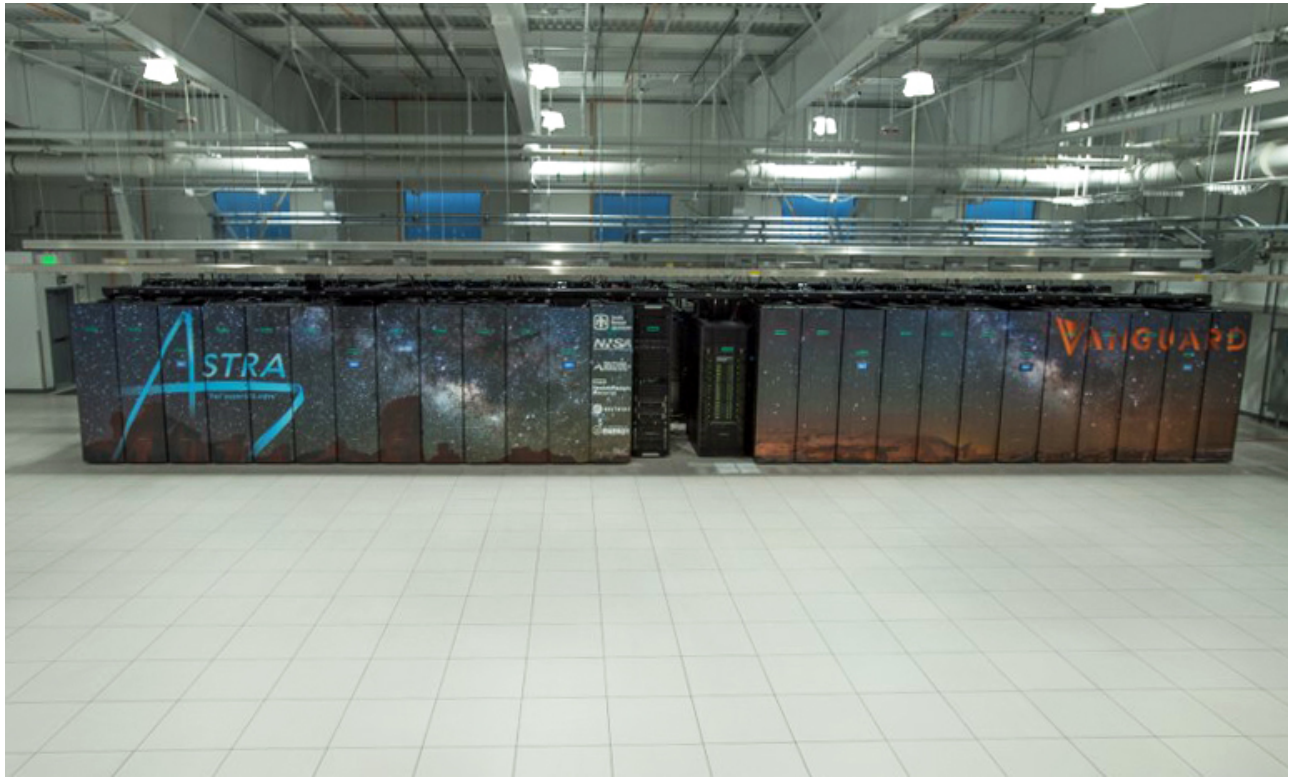


TSC Modeling at Sandia

- Johnson Controls modeled TSC for Sandia's application
- Required data for accurate model includes:
  - Dry bulb temperature throughout year
  - Desired water temperature
  - Power cost
  - Water cost
  - Cycles of concentration
  - Altitude
- TSC operational modes to save water or power

Sandia – New Data Center Expansion

- Current load: 1.4MW
- Entire cooling load on TSC at night



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

Conclusions

- NREL Installation
  - Modeling of a hybrid system showed that it was possible to save significant amounts of water while simultaneously reducing total operating costs
    - System modification was straightforward
    - System water and operational cost savings are in line with modeling
  - Hybrid system increased operational resiliency

- Paper, search ***NREL Publications 72196***

Conclusions

- Sandia Installation
  - Simple integration of TSC into new construction
    - Future TSC units can be added without an outage
  - Keep water-cooled and air-cooled systems on a separate loop
  - TSC is a supplemental cooling rather than a cooling tower replacement
    - Still need cooling towers during hot summer days unless climate and water temperature allows

Informal Discussions and Networking

- Today, after you get your lunch
  - Liquid Cooling; Dale Sartor and Dave Martinez
  - Software and Energy Efficiency; Sid Jana and Ryan Grant
  - Measuring, monitoring and managing; Torsten Wilde and Ghaleb Abdulla