NREL
Transforming ENERGY

Sandia National Laboratories' Holistic Data Center Design Integrates Energy- and Water-Efficiency, Flexibility, and Resilience

This success story highlights Sandia National Laboratories and their holistic data center approach, which provides resilient energy- and water-efficient cooling for high-performance computing (HPC) systems.

Figure 1. The 725E data center on Sandia's Albuquerque campus is optimized to first ensure that computing needs are met; a system of heat rejection ensures that the data center is running efficiently and effectively by minimizing energy and water use.

SANDIA'S HPC DATA CENTER ADDITION EARNS LEED GOLD

Sandia has four corporate data centers. The 725E data center houses state-of-the-art warm water direct liquid-cooled systems, which is the focus of this case study. This 14,000 square foot addition was completed in 2018 and is connected to the 725W data center (completed in 2005). The Sandia Infrastructure Computing Services team is responsible for all four data centers, enabling best practices to be tried out in one data center in order for them to be rolled out into the others as appropriate.

Sandia's 725E data center addition for HPC at the Labs' Albuquerque, New Mexico, campus (in a high desert climate zone) has earned the U.S. Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) v4 Gold Building Design and Construction (BD+C): Data Center Certification. This facility was designed to support 14 MW of information technology (IT) load at full buildout. A time-lapse[1] video shows the construction of this impressive 725E data center addition.

Innovation in HPC Liquid-Cooling Efficiency

From deploying some of the earliest liquid-cooled systems, to helping develop and engineer the first HPC system to reach 1 Teraflop (a measure of computer speed equal to one trillion floating-point operations per second), Sandia's rich history includes:

- Co-designing and installing the first instance of pumped liquid refrigerant rear-door heat exchangers (cooling doors) arranged in a laminar flow configuration
- Deploying HPC systems as a partnership with the vendor, where, in many instances, first-of-its-kind technology is installed.

[1] Sandia National Labs. "Time-Lapse Construction of Building 725-E, Sandia's new HPC Facility." Apr. 10, 2019. https://youtu.be/exhvwVf1AAQ.

The Green Grid has defined several key metrics to assess the cutting-edge performance of a data center. These metrics include:

- Power usage effectiveness (PUE)
- Energy reuse effectiveness (ERE)
- Water usage effectiveness (WUE)
- Carbon usage effectiveness (CUE).

DATA CENTER METRICS: THE PUE FAMILY

Energy

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

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

Sustainability

$$WUE = \frac{\text{"Annual site water usage"}}{\text{"IT energy"}} \quad \left(units \frac{L}{kWh}\right)$$

$$CUE = \frac{\text{"Total CO2 emissions"}}{\text{"IT energy"}} \quad \left(units \frac{kgCO2eq}{kWh}\right)$$

Sandia's optimized data center design and operation first ensures that computing needs are met, and Sandia's data center achieves this by focusing on a system of heat rejection to ensure that the data center is running both efficiently and effectively. This system functions by first on minimizing energy use (PUE), second on minimizing water usage (WUE), followed by reusing waste energy/heat (ERE) and then minimizing carbon usage (CUE) for the near future. The WUE goal is to minimize on-site water use without an increase in energy use. Sandia has also installed an on-site 250-kW PV system that is dedicated to 725E, thus further improving sustainability metrics on WUE and CUE.

MEETING DATA CENTER EFFICIENCY GOALS WITH A HYBRID COOLING SYSTEM

IT equipment, such as compute clusters and data storage systems, produces heat as a byproduct. When Sandia started constructing the 725E data center, its goal was to have 85% or more of the heat produced to be acquired via a liquid-cooling approach. The remaining heat produced (up to 15%) could then be rejected through the use of facility air handling units (AHUs). The 725E new expansion has achieved these goals by using a hybrid cooling system, consisting of the following:

- Air and water economizer (cooling towers)
- Evaporative cooling with face and bypass dampers
- Wet/dry fluid coolers (future upgrade)
- Thermosyphon dry coolers and chillers.

The 725E data center utilizes three different facility closed-loop systems that provide different supply temperatures for the cooling IT equipment. All of the heat energy from the 725E data center IT equipment is captured into these three loops:

- Process Water Loop (PW), 76°F supply as of August 2022
- Medium Temperature Water Loop (MTW), 60°F supply as of August 2022
- Chilled Water Loop (CW), 58°F supply as of August 2022, available through the Sandia district chilled water loop.

This design introduces flexibility as well as resilience in operations as it supports a variety of IT system combinations over time to:

- Optimize temperature for system type
- Maintain an operational data center, allowing for system installations and repairs without creating data center outages.

Figure 2 is a simple loop diagram of the 725E data center that shows the hierarchy of heat rejection options and heat inputs.

FEMP/NREL KEY APPROACH TO SUSTAINABLE DATA CENTERS

The Federal Energy Management Program (FEMP) and National Renewable Energy Laboratory (NREL) developed the following approach for optimizing data center sustainability, listed in order of importance:

1. PUE: Reduce energy use by making systems as efficient as possible.
   - **Maximize compute entering temperature to maximize energy efficiency.**
   - Use “free” cooling to reduce or eliminate compressor (chiller, direct expansion)-based cooling:
     - Install direct liquid-cooled computers that use warm water.
     - Capture as much heat as possible directly to the liquid-cooling system.
   - Optimize fan/pump speeds and uninterruptible power supply.
2. ERE: Reuse heat to achieve the lowest Energy Reuse Effectiveness possible.
   - **Maximize compute leaving temperature to maximize energy reuse.**
3. WUE: Reject as much remaining heat to dry coolers as possible.
   - **Maximize compute leaving temperature to maximize heat rejected dry to air.**
4. CUE: Maximize energy from renewable systems on-site or within grid region.
   - **Work toward the goal of 100% renewable energy 100% of the time.**

The five heat-rejection options for this IT load operate according to the following hierarchy:

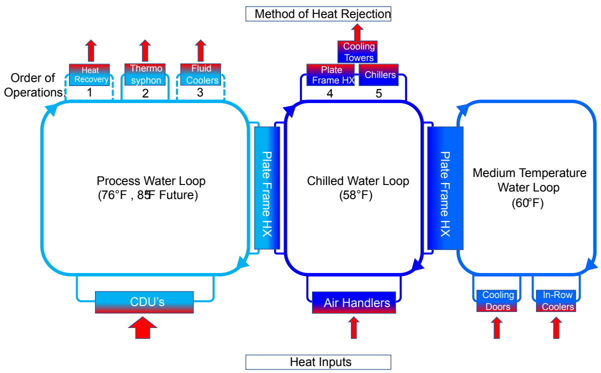
1. (FUTURE UPGRADE) When possible, heat energy from the PW is transferred through the energy recovery heat exchanger to the building/campus.
2. After reuse potential is exhausted, and when ambient temperatures permit it, heat is dissipated through the thermosyphon dry coolers.[2] When the PW return temperature is at least 4°F warmer than ambient outdoor dry bulb temperature, this is the primary method of heat rejection—minimizing water usage (WUE).
3. (FUTURE UPGRADE) Fluid coolers are closed loop heat rejection devices that consist of a coil inside an enclosure with a water spray section above the coil and a fan. Because fluid coolers are closed loop, the cooling water is never exposed to air and dirt like in a cooling tower, so a heat exchanger is not required between the cooling water and the fluid cooler. Fluid coolers have the additional advantage of being able to operate in dry mode when ambient temperature is cool, in hybrid dry/wet mode, or just wet mode. These multiple modes of operation can save a significant amount of water compared to cooling towers.
4. Cooling towers cool heated water by spraying the water over fill and drawing air across the fill. Cooling towers require a heat exchanger between the cooling water and the tower water to keep the water clean. Cooling towers are the most common heat rejection devices in data centers and offer the greatest capacity per area. Cooling towers do this at the lowest cost, making them an attractive option at many facilities, but they also use the most water.
5. Chillers lower the temperature of cooling water using a vapor compression mechanical refrigeration system. This heat is typically rejected into a cooling tower. Chillers have significant first costs and operating costs in both energy and water use from cooling towers. The warmer the cooling water, the less energy a chiller must use. The chillers that supply 725E are part of a district chilled water system that supplies chilled water to several other buildings in the area. Chilled water can be used to reduce the temperature (trim) of process water during the summer for systems that need cooler water.

[2] Sandia National Labs. "Cooling unit saves half-million gallons of water at Sandia supercomputing center." Sandia Labs News Release, Feb. 18, 2020. https://newsreleases.sandia.gov/supercomputing_water/.

Sandia has optimized the 725E data center design to minimize energy and water use. The multiple cooling loop design provides Sandia with the option to connect IT systems to the loop, meeting the system requirements while minimizing energy and water use. The preferred option for new IT is to house systems that reject as much of that heat as possible into the PW at the warmest possible temperature. The PW at Sandia is operated at the warmest possible temperature without compromising IT system performance, which is currently (August 2022) 76°F. Air-cooled IT systems are connected to the MTW, which is also operated at as warm of a temperature as possible without compromising IT system performance, currently (August 2022) 60°F. Cooling for the MTW is provided by the district chilled water system, which is also operated at the warmest possible temperature without compromising IT system performance, currently (August 2022) 58°F. As previously discussed, the source of the cooling depends on ambient dry bulb and web bulb temperature, which vary both daily and seasonally. This phased approach provides opportunities to transition to a non-mechanical cooled data center (no chillers), realizing a reduction in energy consumption and water usage (less evaporation, more gallons of water saved) and resulting in first cost and operational cost savings.

This multiple cooling loop design offers an added benefit of system resiliency, as being tied into a district chilled water system can enable planned maintenance on the various cooling systems. The different hydronic loops include larger pipes and isolation valves that enable HPC systems to be added or removed without interruption to data center facility operations.

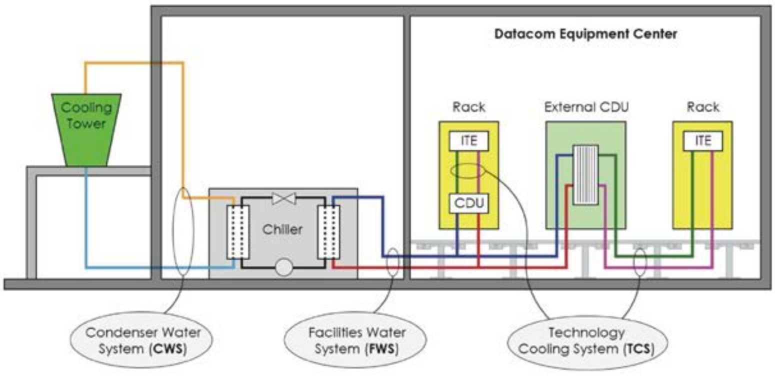
Figure 2. Sandia 725E cooling diagram



Liquid-Cooling Technologies

There are a variety of different liquid-cooling technologies that can be used within data centers. Transitioning from traditional air cooling to liquid cooling comes with energy efficiency gains by replacing fan energy with dramatically lower pump energy. This transition also enhances the opportunity to use waste heat from data centers to warm other buildings and facilities on the campus. These gains are achievable because the heat capacity of liquids is orders of magnitude larger than that of air, and with increasing chip (central processing unit [CPU], graphical processing unit [GPU], tensor processing unit [TPU]) power densities and higher heat fluxes, air cooling is rapidly approaching its limits (see ASHRAE sidebar, page 9). Liquid-cooling fluids on the IT loop side can range from treated water to glycol-based solutions to dielectric fluids (non-conductive). Several liquid-cooled solutions are considered hybrid solutions, in that the majority (but not all) of the heat load from IT equipment is captured and removed by the liquid—with the remaining heat load removed by traditional air cooling. However, some liquid-cooled solutions capture practically all the heat load without the use of any fans, which is the most energy-efficient. Most liquid-cooling approaches involve a cooling distribution unit (CDU), which interfaces with the facility cooling loop and provides cooling liquid at the appropriate temperature, pressure, and chemistry for the IT equipment.

Figure 3. CDU liquid-cooling system within a data center. Figure source: ASHRAE white paper[3]



[3] ASHRAE Technical Committee 9.9, Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment. 2019. Water-Cooled Servers: Common Designs, Components, and Processes. Atlanta, GA: ASHRAE. https://www.ashrae.org/File%20Library/Technical%20Resources/Bookstore/WhitePaper_TC099-WaterCooledServers.pdf.

NREL CLIMATE ANALYSIS FOR HEAT REJECTION SYSTEMS

The best heat rejection systems depend on climate, desired temperature, and the cost of energy and water. The leaving temperature of cooling towers and fluid coolers operating in wet mode is a function of wet bulb temperature. Cooling towers are rated by the Cooling Tower Institute (CTI) at a 7°F approach to the ambient web bulb temperature; however, a closer approach temperature is possible when towers are operated at part load. Indirect and direct evaporative coolers for air also operate based on wet bulb temperature, with similar approach temperatures.

Albuquerque is a warm but dry climate where evaporative cooling can supply most of the cooling. The web bulb temperature does not exceed 65°F, so a 5°F tower approach and a 2°F heat exchanger approach results in a 7°F approach—so 72°F cooling water can be supplied every hour of the year by cooling towers.

For additional information on climate analysis for data center cooling, see NREL's fact sheet, "A Method for Estimating Potential Energy and Cost Savings for Cooling Existing Data Centers" (**https://www.nrel.gov/docs/fy17osti/68218.pdf**).

LIQUID-COOLING TECHNOLOGY TYPES

The authors categorize liquid-cooling technologies into three technology classes:

- **Localized air-to-liquid heat exchanger:** Involves air-to-liquid heat exchanger (coil) placed at the back of a server-rack that captures server heat, resulting in energy efficiency gains by transferring heat to liquid closer to the server-rack source (versus computer room air handler units).
  - Variations include rear-door heat exchanger (RDHX) (also referred to in this document as cooling doors), enclosed cabinet, in-row coolers, and overhead cooling all utilizing some type of air-to-liquid heat exchanger close-coupled with the IT source.
- **Cold plates:** Standard fin-based heat sinks on chips are replaced with cold plates that have liquid flowing through channels to remove heat (this solution generally involves a cooling distribution unit).
  - Variety of technology solutions exist, and this approach can also be applied to memory and other heat-producing components.
- **Immersion:** Electronics submerged in a dielectric fluid (non-conductive), with two approaches:
  - Single-phase immersion cooling where heat load transferred to dielectric oil/fluid that is pumped around electronics by a cooling distribution unit
  - Two-phase immersion where an engineered dielectric fluid with a boiling point below IT components' maximum operating temperature removes heat load by undergoing a liquid-to-gas phase change, with that vapor transferring heat to a vapor-to-liquid heat exchanger, which then condenses back to a liquid in a passive cycle.

The cold plate and immersion classes are considered direct-liquid-cooling technologies. HPC data centers have been early adopters of direct liquid cooling due to rack power densities (the authors have experienced densities of 60 kW per compute rack in 2013, and recently surpassing 100+ kW per compute rack).

Figure 4. Sandia 725E data center

Sandia's 725E data center has three main types of heat inputs (see Figure 2):

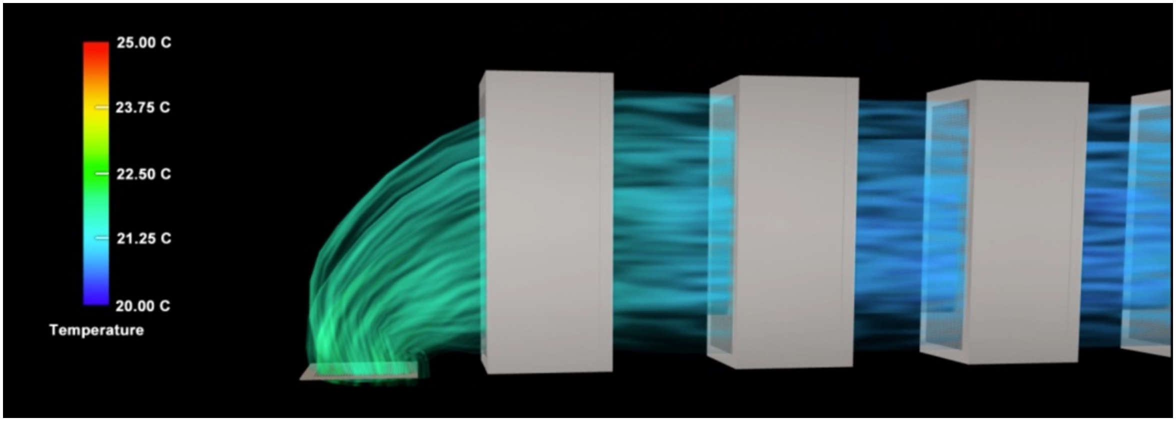
- CDUs tied into the PW that support HPC systems, utilizing cold plate liquid-cooling technologies:
    - Attaway[4] HPC system, typically operating around 600 kW (max 700 kW), uses a liquid system by Chilldyne that operates under vacuum pressure for resilient, energy-efficient data center cooling (full report and two-page fact sheet available).
    - Manzano HPC system, typically operating around 720 kW (max 960 kW), is a second system utilizing Chilldyne's vacuum-integrated liquid-cooling solution.
    - Yacumama[5] HPC system (relocated to Sandia's 725E data center in 2019) has a demonstration rack using the Aquarius fixed cold plate cooling technology from Aquila that eliminates the need for server auxiliary fans (full report available).
- In-row coolers on MTW:
    - Astra HPC system, typically operating around 1.2 MW, is the first flagship HPC system deployed in 725E.[6]
- Cooling doors (also known as RDHX) on MTW:
    - In this regard, Sandia has had great success in laminar flow arrangement.

[4] Center of Expertise for Energy Efficiency in Data Centers. 2022. "Cooling Performance Testing of Attaway's Negative Pressure CDU." Lawrence Berkeley National Laboratory. Accessed Sept. 6, 2022. https://datacenters.lbl.gov/resources/cooling-performance-testing-attaways.

[5] Sickinger, David, David Martinez, and Bob Bolz. 2019. *Energy Performance Evaluation of Aquila's Aquarius Fixed Cold Plate Cooling System at NREL's High Performance Computing Center*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-2C00-73356. https://www.nrel.gov/docs/fy19osti/73356.pdf.

[6] Sandia National Labs. "Astra and Sandia's 725E Data Center." April 24, 2020. https://youtu.be/6tneOq5M9m4.

Figure 5. Sandia air flow analysis (conducted for former Sandia Red Sky HPC system)

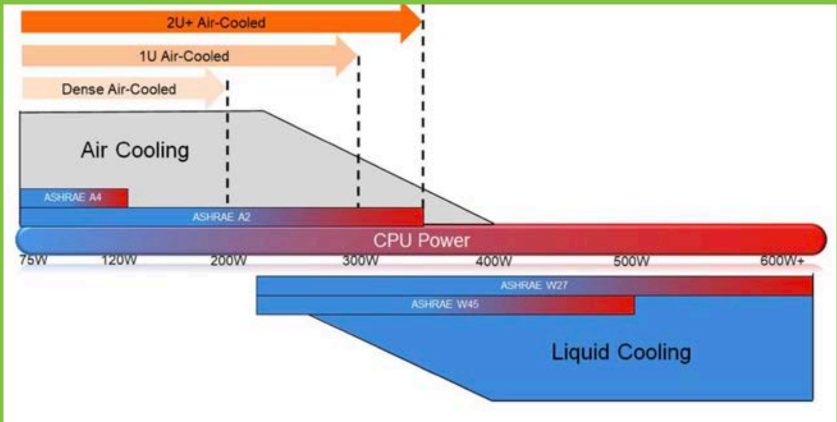


ASHRAE DATA CENTER RESOURCES

The ASHRAE Technical Committee (TC) 9.9 is a leader in data center environmental knowledge and industry best practices. There are 14 books in the ASHRAE Datacom Series, including one on *Liquid Cooling Guidelines for Datacom Equipment Centers*, along with white papers and technical bulletins.

An ASHRAE TC 9.9 white paper, *Emergence and Expansion of Liquid Cooling in Mainstream Data Centers*, indicates liquid cooling will become more mainstream due to increasing socket power (CPU/GPU/TPU) and included Figure 6 that shows when a transition from air to liquid cooling based on socket power is likely. Note that ASHRAE has also recently renamed the ASHRAE water classifications to clearly define the server supply temperature range. The upper temperature limits are now included in the W number (in degrees Celsius). The classes are newly named as follows: W17 (previously W1), W27 (W2), W32 (W3), W40 (new), W45 (W4), and W+ (W5). This change to ASHRAE W classes has been included in the fifth edition of *Thermal Guidelines for Data Processing Environments* (released in 2021) and will be included in the upcoming third edition of the *Liquid Cooling Guidelines for Datacom Equipment Centers*.

Figure 6. Air cooling versus liquid cooling, transition, and temperatures from ASHRAE TC9.9 white paper Figure 4.[7]



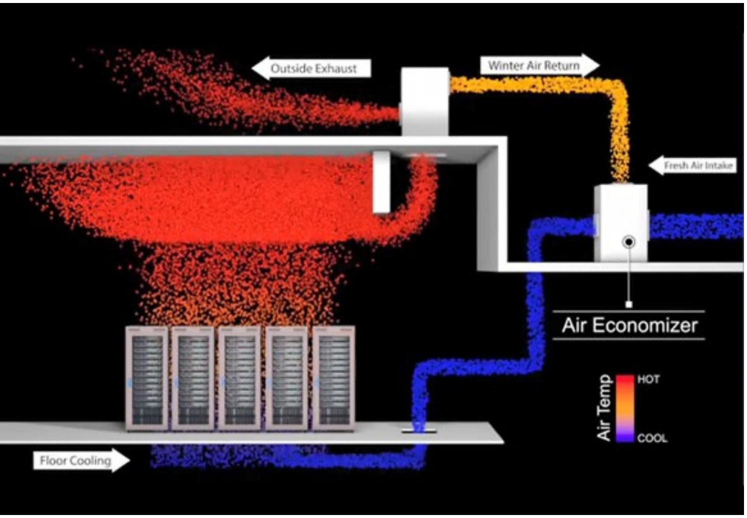
[7]ASHRAE Technical Committee 9.9, Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment. 2021. *Emergence and Expansion of Liquid Cooling in Mainstream Data Centers*. Peachtree Corners, GA: ASHRAE.
https://www.ashrae.org/file%20library/technical%20resources/bookstore/emergence-and-expansion-of-liquid-cooling-in-mainstream-data-centers_wp.pdf.

Air Handlers Manage Heat Based on Outdoor Air Temperature

Some of the computers housed within Sandia's data center do not use water cooling exclusively. To handle this, the building was designed with a very efficient air-cooling system in mind. "Since New Mexico is a dry climate, we can provide 90% of our outdoor air cooling without having to use chilled water," David J. Martinez, Sandia engineering program and project lead, explained to researchers. The air-cooling system consists of air handling units (AHUs, each with a 9-electronically-commutated-motor fan array, which provide greater efficiency and redundancy) located on the roof and operates in one of three modes:

1. The AHUs bring in outdoor air to provide "free" cooling (airside economizer) when the temperature is 78°F and cooler and the wet bulb temperature is 72°F and cooler.

Figure 7. Airside economizer



2. When the outdoor air temperature is above 78°F, the AHU uses direct evaporative cooling to cool the air by evaporating water into the air (Adiabatic cooling) with face and bypass dampers to allow for better temperature control and less pressure drop. Evaporative cooling provides 100% "free" cooling, so long as the air wet bulb temperature is below 65°F.

3. When the wet bulb temperature exceeds 65°F, mechanical cooling "trim" is provided by chilled water.

Heat generated by the computers rises to the top of the 25-foot ceiling (see Figure 7) and is removed from the space by large exhaust fans, allowing the facility to maintain an indoor temperature near 78°F to maintain 80°F at the face of the racks.

USING ANALYTICS TO OPTIMIZE IT EQUIPMENT AND BUILDING SYSTEM OPERATIONS

Sandia utilizes Nlyte software for data center monitoring, allowing for temperature monitoring, power monitoring, leak detection, and many more metrics. PUE is calculated utilizing the power metering data from the 725E data center, as well as the 726 chiller plant. The 726 chiller plant provides chilled water to the data center during warmer temperatures when the thermosyphons cannot provide adequate cooling. In addition to monitoring data center metrics within Nlyte (see Figure 8), SkySpark automated fault detection and diagnostics software is utilized by the Facilities team at Sandia in an ongoing commissioning effort.

SkySpark provides a platform for Facilities to compile data for analysis. Metrics such as water flow, tons of cooling, kW per ton, make-up water usage, and power usage allow for additional data center metrics which synchronize with those already gathered in Nlyte. Together, these metrics allow Sandia to reduce its usage of water and power by intelligently determining which cooling methods the system can use throughout the day.

Data Center Infrastructure Management

In addition to monitoring and metrics, Sandia uses Nlyte data center infrastructure management to log all IT equipment locations and operations (see Figure 9). IT equipment includes all compute systems and networking connections. Server information (such as support group and ownership) is automatically imported through a configuration management database integration.

Power usage is monitored in real time, and alarms are generated when readings exceed set thresholds. Nlyte also calculates data center-specific performance metrics, such as PUE.

Sandia monitors a variety of data points related to the data center's operational status. These data points include chilled water temperatures, process water temperatures, data center air temperatures, and power readings from switchboards to in-rack power distribution units. By monitoring these parameters and creating alarms, Sandia can immediately know when the infrastructure or sensors fail. The Nlyte data center infrastructure management also allows for simulated power outages, showing all affected devices downstream of an outage.

Figure 8. Sandia 725E data center performance metrics from Nlyte software

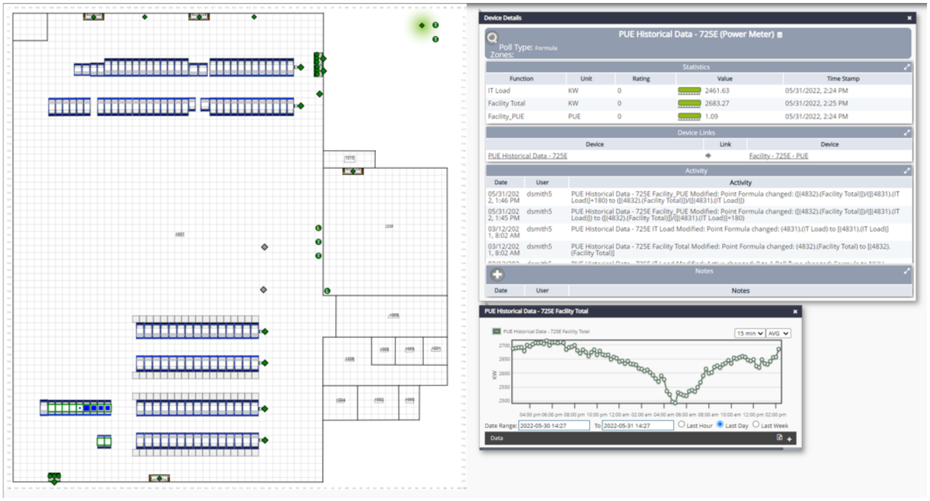


Figure 9. Sandia 725E data center floor plan and metrics from Nlyte software

Energy Management Information System

Sandia uses SkySpark software to help optimize building systems operations as part of their energy management information system (EMIS). Automated fault detection and diagnostics is an advanced EMIS capability that uses algorithms to detect equipment-level or system-level faults and diagnose their causes. The SkySpark system imports data such as temperatures and flow rates from the Siemens building automation system (BAS) and meter data. The SkySpark system also calculates and tracks key performance indicators, such as kW/ton for cooling systems and sends alerts when key performance indicators are outside of expected ranges.

In a collaboration between Sandia's Computing Service team and the Facilities team, optimization efforts are ongoing for the 725E data center. By monitoring the incoming data from the Siemens BAS, optimizations can be applied to the supporting infrastructure. A recent success story involves the enhanced operation of the four thermosyphons that are currently in use. A single thermosyphon was installed in 2018, with three more units added over time to support the increased load from the additional HPC systems. Each thermosyphon has its own dedicated onboard controller that automatically and continuously adjusts the speed of the condenser fans based on ambient conditions, loads, and utility costs. The Sandia team was able to optimize the combined operation of these units by programming the BAS to control all the thermosyphons, resulting in longer operation—thus saving more water and energy. By collecting and analyzing multiple data points, Sandia is also able to compare operational performance between thermosyphons and chillers that are part of the district loop (Figure 10), comparing efficiency in kW/Ton, and Figure 11, showing coefficient of performance.

Operational Data

To cool the data center, a sequence of operations is applied that reduces energy and water use whenever possible. When the PW returns a temperature that is at least 4°F warmer than ambient outdoor dry bulb temperature, thermosyphons will remove heat from the PW. When temperatures increase above this threshold, the process water will pass through a heat exchanger tied to building 726, the chilled water plant. When the wet bulb temperature allows, the chiller plant runs on cooling towers only through the use of a plate-frame heat exchanger. At higher wet bulb temperatures, the chiller is brought online and then used to chill the water. In the future, heat recovery systems and fluid coolers will be added to the sequence of operations.

When initially constructed, the 725E data center had a supply process water temperature of 67ºF, a low temperature necessary for cooling an indirectly liquid-cooling system. The installation of two CDUs, tied into the chilled water plant, allowed for this system to be decoupled from the main process water loop for building 725E. Currently (August 2022), the process supply water temperature is 78ºF, which allows the thermosyphons to run for a greater percentage of the year (as observed in Figure 10 and Figure 11 for all blue points warmer than 67°F). Sandia realizes an estimated 200,000 gallons of additional water savings per year from this change. In addition, Sandia sees around $63,000 in energy savings per year due to the reduction in chiller usage.

EMIS RESOURCES FOR FEDERAL FACILITIES

The Federal Energy Management Program offers a variety of research materials and resources to help agencies successfully implement an EMIS and meet federal facility energy efficiency requirements: **energy.gov/eere/femp/energy-management-information-systems-federal-facilities**.

FEMP's *Energy Management Information Systems Technical Resources Report* explores how an EMIS can integrate with data center information management systems to meet energy and water efficiency targets: **energy.gov/eere/femp/articles/energy-management-information-systems-technical-resources-report.**

Figure 10. Thermosyphon and chiller efficiency, outside air temperature vs. kW/ton

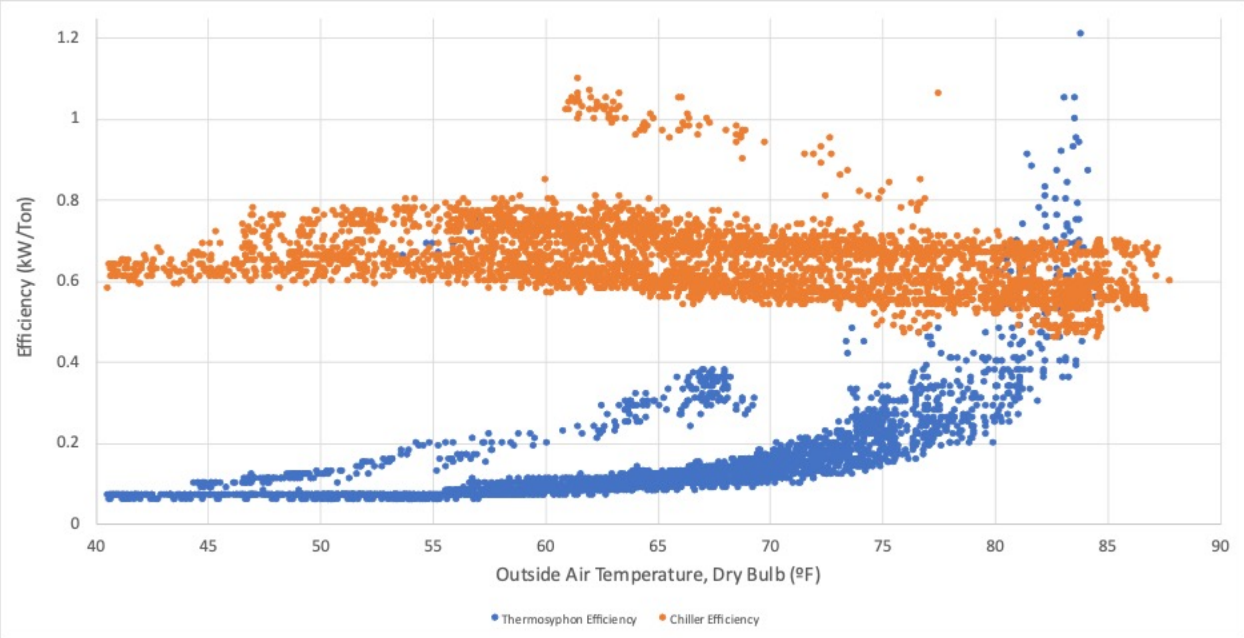
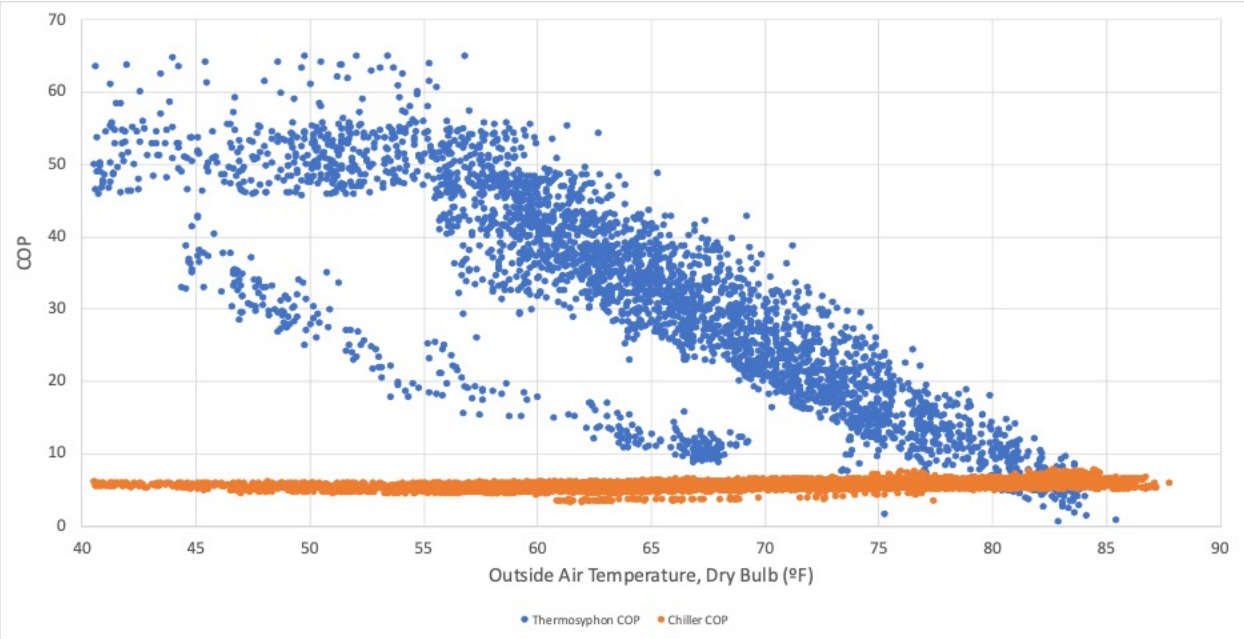


Figure 11. Thermosyphon and chiller coefficients of performance (COP)



A Sandia report planned for release in 2023 will detail additional metrics and lessons learned from ongoing commissioning efforts through the collaboration between Sandia's Computing Service team and the Facilities team.

DATA CENTER SUSTAINABILITY FEATURES COME TOGETHER

Sandia designed and operates a resilient energy- and water-efficient HPC data center. The data center utilizes three different facility cooling water loops that provide different supply temperatures for cooling IT equipment. This design introduces great efficiency as well as flexibility and resiliency into operation, supporting a variety of different IT system combinations over time to reduce energy use (PUE) by making systems as efficient as possible. The design achieves this by:

- Maximizing compute entering temperature to maximize energy efficiency.
- Utilizing "free" cooling to reduce compressor (chiller, DX) based cooling:
  - Install and operate direct liquid-cooled computers that use warm water
  - Capture as much heat as possible directly to the liquid-cooling system.
- Optimizing fan and pump speeds.

This design approach supports water efficiency (WUE) as well by rejecting as much remaining heat to dry coolers as possible by maximizing compute leaving temperature. And, the design allows for system installations and repairs without creating data center outages.

Each of the cooling water loops are operated at the warmest possible temperature while still meeting IT equipment requirements. Operating at the warmest temperature possible minimizes the system's energy and water use. The hierarchy of heat rejection that Sandia uses to save energy and water is first reuse the heat in other buildings (future), next reject the heat dry with thermosyphons and outside air free cooling, then reject the heat with evaporative cooling using cooling towers and fluid coolers (future). Chiller-based cooling is used as needed when ambient air is warm. Sandia uses an ongoing optimization method to minimize energy and water use, utilizing operational analytics. The analytics are then used to calculate, track, and optimize system performance overall.

The facility was given the LEED Gold certification[8] award and was selected to receive the Department of Energy's Sustainability Award,[9] given for the first time for efforts in high-performance computing and data centers. DOE's Sustainability Awards recognize outstanding contributions by individuals and teams for their work in sustainability.

LEARN MORE

With support from FEMP, NREL provides data center energy and water performance technical assistance to federal agencies. NREL and Sandia have a long history of partnering together on efficient data center design and operation.

For questions about Sandia's data center, contact Dave Martinez at **davmart@sandia.gov** and David Smith at **dsmith5@sandia.gov**.

For more details on the NREL sustainable data center approach and questions about data center technical assistance (including EMIS), contact Otto Van Geet at **Otto.VanGeet@nrel.gov** and David Sickinger at **David.Sickinger@nrel.gov**.

FEMP encourages federal agencies and organizations to improve **data center energy efficiency**, which can offer tremendous opportunities for energy and cost savings. For questions about FEMP's data center technical assistance, contact Rick Mears at **Rick.Mears@hq.doe.gov**.

[8] U.S. Green Building Council. 2022. "LEED Rating System." Accessed Sept. 6, 2022. https://www.usgbc.org/leed.

[9] Sandia National Labs. "High-performance computer facility at Sandia honored for sustainable building practices." Sandia Labs News Release, Sept. 16, 2020. https://newsreleases.sandia.gov/green_award/.

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