



# NREL Cooling Evaluation Capabilities

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Aaron Andersen

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Lab

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# Lab Testing

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# Optimization & Control Lab

Each “Building” station has:

- 480V, 3P, 400 A service (~330 kVA)
- 208V/3P also available in area

Fluid Conditioning Module

- Modulate flow and temperature
- Dump heat into ESIF research chilled water lines, ~100 tons (350 kW)

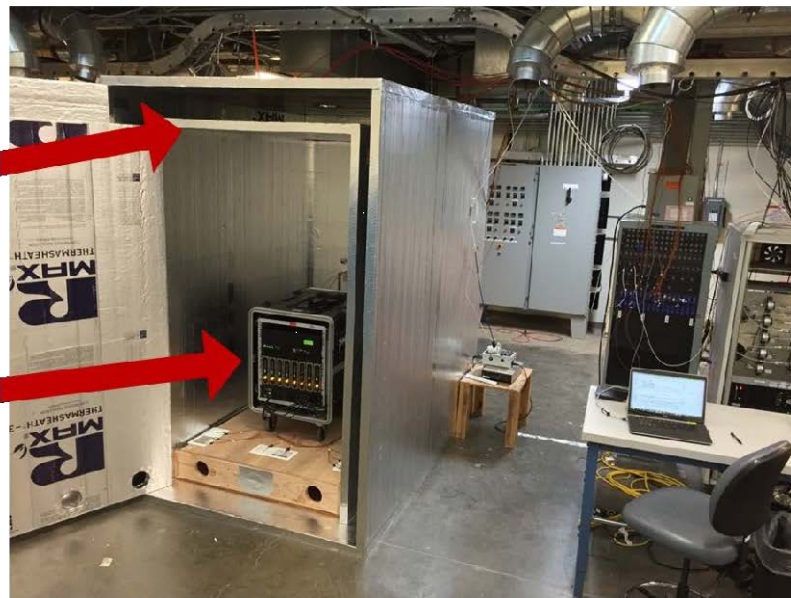


# HVAC Systems Lab

Thermally isolated calorimeter to measure energy flows:

- Electric power in
- Thermal heat out

Eight Liquid Cooled Servers in Explorer Rack



**Figure 6. Eight LSS servers in compact rack, sitting inside a guarded calorimeter at NREL's Advanced HVAC Systems Laboratory**

Photo by Eric Kozubal, NREL

# Schematic of an Experimental Setup

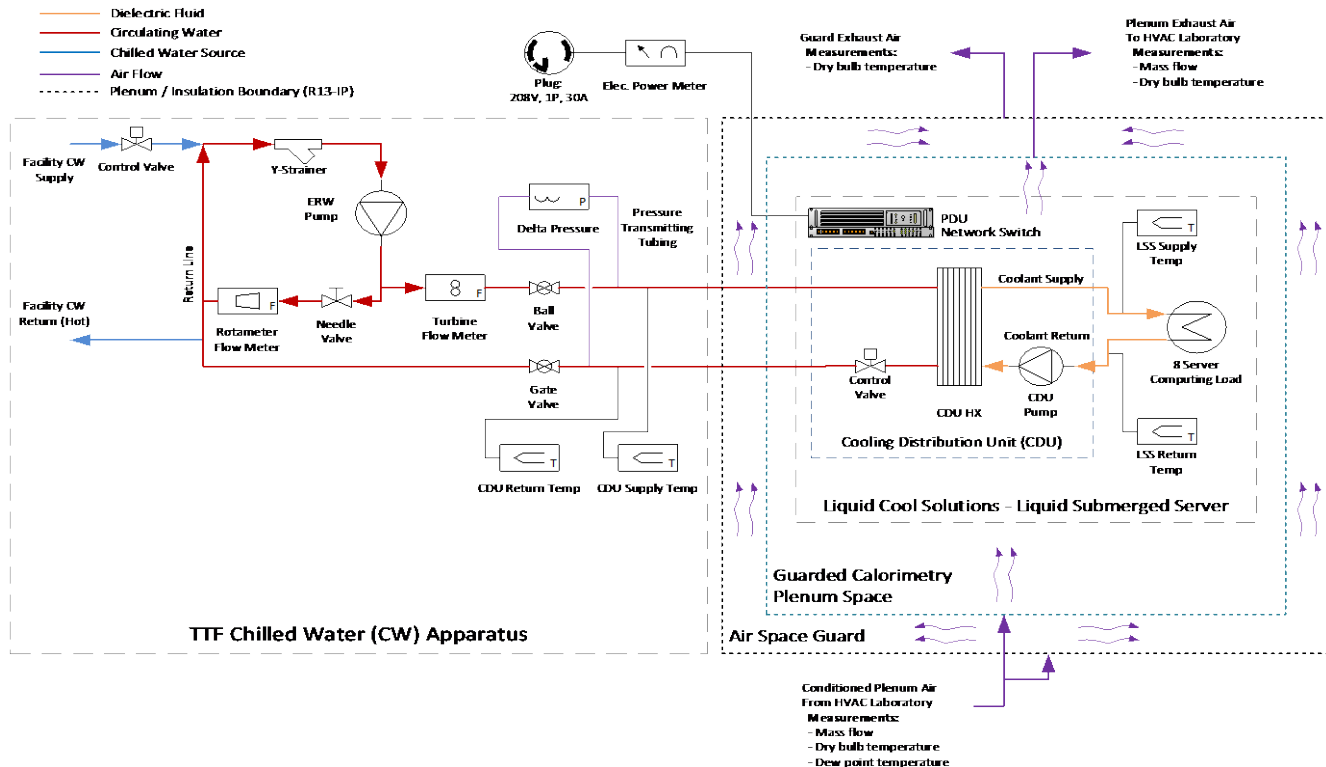


Figure 5. Process schematic showing fluid flows and sensors used to measure electrical and thermal power flows

# ESIF Data Center

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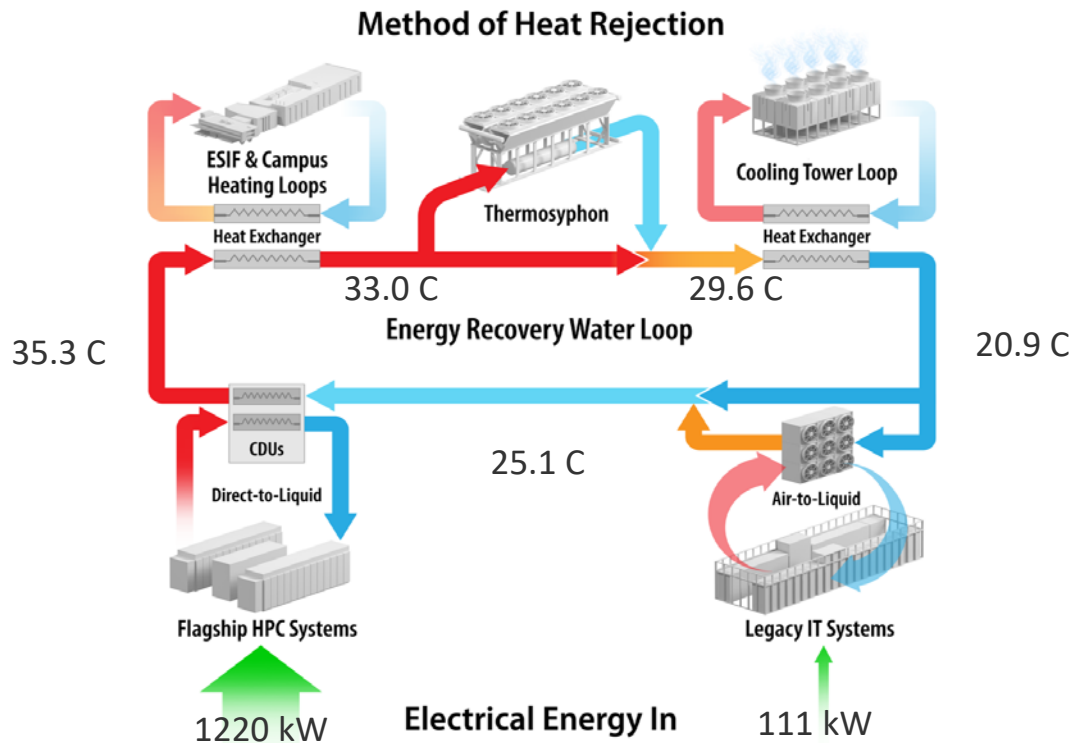




# ESIF Data Center Cooling Diagram

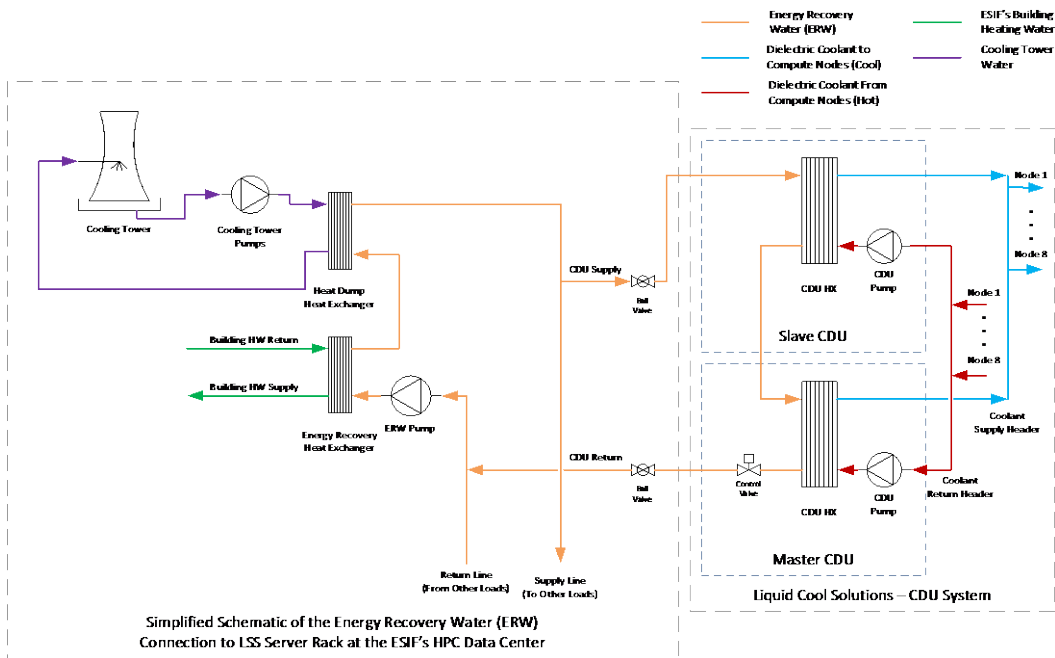
Temperature and Electrical data from November 2021

- Predominantly direct-to-liquid cooling
- Thermosyphon (dry-cooler) has demonstrated savings of 6.5 million gallons of water in a 5-year period
- Heavily instrumented with timeseries data capture
  - Mechanical
  - Electrical
  - Computing/Storage Equipment
- Regularly achieve PUE of < 1.04
- Energy Recovery ERE mixed seasonal results



Transforming ENERGY through computational excellence

# Example Data Center Evaluation



March 21, 2016 - Eric Kozubal, NREL, Harsh Patel and Daryl Lautenschlager, work on the LiquidCool Solution's "Liquid Submerged Server" at ESIF's HPC data center. (Photo by Dennis Schroeder / NREL)

Process schematic showing liquid flows of the LSS server rack installed at NREL's HPC data center at the ESIF. A more detailed schematic can be found in Appendix F: HPC Data Center Cooling Overview Schematic. In this diagram, the LSS system is located at "Other Liquid Systems."

# Resources

- Innovation Incubator: LiquidCool Solutions Technical Evaluation Laboratory Study and Demonstration Results of a Directed-Flow, Liquid Submerged Server for High-Efficiency Data Centers
  - [www.nrel.gov/docs/fy18osti/70459.pdf](http://www.nrel.gov/docs/fy18osti/70459.pdf)
- Thermosyphon Cooler Hybrid System for Water Savings in an Energy-Efficient HPC Data Center
  - Results from 24 Months and Impact on Water Usage Effectiveness:  
[www.nrel.gov/docs/fy18osti/72196.pdf](http://www.nrel.gov/docs/fy18osti/72196.pdf)
  - Modeling and Installation:  
[www.nrel.gov/docs/fy17osti/66690.pdf](http://www.nrel.gov/docs/fy17osti/66690.pdf)
- Energy Performance Evaluation of Aquila's Aquarius Fixed Cold Plate Cooling System at NREL's High Performance Computing Center
  - [www.nrel.gov/docs/fy19osti/73356.pdf](http://www.nrel.gov/docs/fy19osti/73356.pdf)
- Energy Performance Testing of Asetek's RackCDU System at NREL's High Performance Computing Data Center
  - [www.nrel.gov/docs/fy15osti/62905.pdf](http://www.nrel.gov/docs/fy15osti/62905.pdf)
- NREL Modeling and Analysis Capabilities
  - Techno-Economic Analysis (REopt)  
[reopt.nrel.gov/about/index.html](http://reopt.nrel.gov/about/index.html)
  - Modeling District Heat (URBANopt)  
[www.nrel.gov/manufacturing/district-energy-systems.html](http://www.nrel.gov/manufacturing/district-energy-systems.html)



# Questions?

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[www.nrel.gov](http://www.nrel.gov)

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