From Challenge to Opportunity: Cost Effective Energy Efficiency Solutions in Data Centers

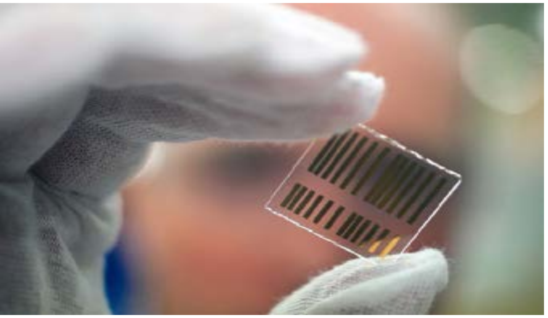
2016 Better Buildings Summit

Tuesday, May 10, 9:45-11:00AM

Speakers

- Moderator
  - Will Lintner – Department of Energy
- Presenter/Panelists
  - Steve Hammond – National Renewable Energy Laboratory
  - Monica Witt & Cindy Martin – Los Alamos National Laboratory
  - John Sasser – Sabey Data Centers

Sustainable Data Centers



Steve Hammond

May 2016

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

NREL's Dual Computing Mission

- Provide high performance computing and related systems and expertise to advance the lab mission, *and*
- Push the leading edge for data center sustainability.
- Leadership in liquid cooling, waste heat capture and re-use

  Holistic "chips to bricks" approaches to data center efficiency.
- ESIF - Showcase facility for visitors to see first hand best practices in use.
- Critical topics include
  - Liquid cooling and energy efficiency
  - Waste heat capture and re-use.
  - Carbon footprint, water usage

Where did we start?

- Started planning for new data center in 2006.
- Based on industry/technology trends, committed to direct liquid cooling.
- Holistic approach – integrate racks into the data center, data center into the facility, the facility into the NREL campus.
- High power density racks - 60KW+ per rack 100KW racks are not far off
- Liquid cooling at the rack, evap towers, no mechanical chillers
- Capture and use DC waste heat: office & lab space and export to campus
- Use chilled beam for office/lab space heating. Low grade waste heat use.
- Two critical temperatures:
  - IT cooling supply – could produce 75F on hottest day of the year.
  - IT return water - required 95F to heat the facility on the coldest day of the year.

Build the World's Most Energy Efficient Data Center

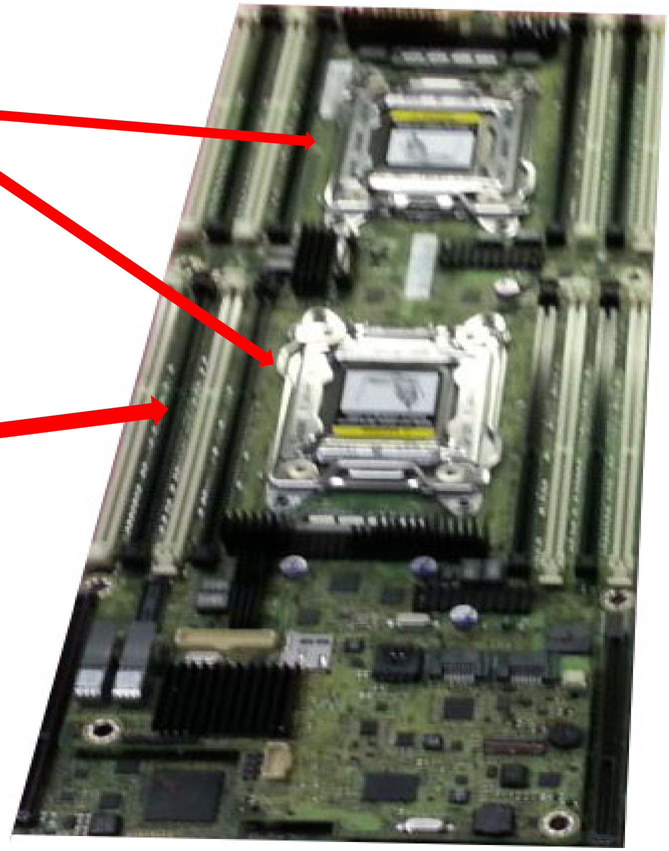
Energy Efficient Data Centers

- Choices regarding power, packaging, cooling, and energy recovery in data centers <u>drive TCO</u>.
- Why should we care?
  - Carbon footprint.
  - Water usage.
  - Limited utility power.
  - Mega$ per MW year.
  - Cost: OpEx ~ IT CapEx!
- **Space Premium**: Ten 100KW racks take much, much less space than the equivalent fifty 20KW air cooled racks.

Safe Temperature Limits

CPUs
~65C
(149F)

Memory
~85C
(185F)



GPUs
~75C
(167F)

CPU, GPU & Memory, represent ~75-90% of heat load …

Holistic View of Compute, Space, Power, Cooling

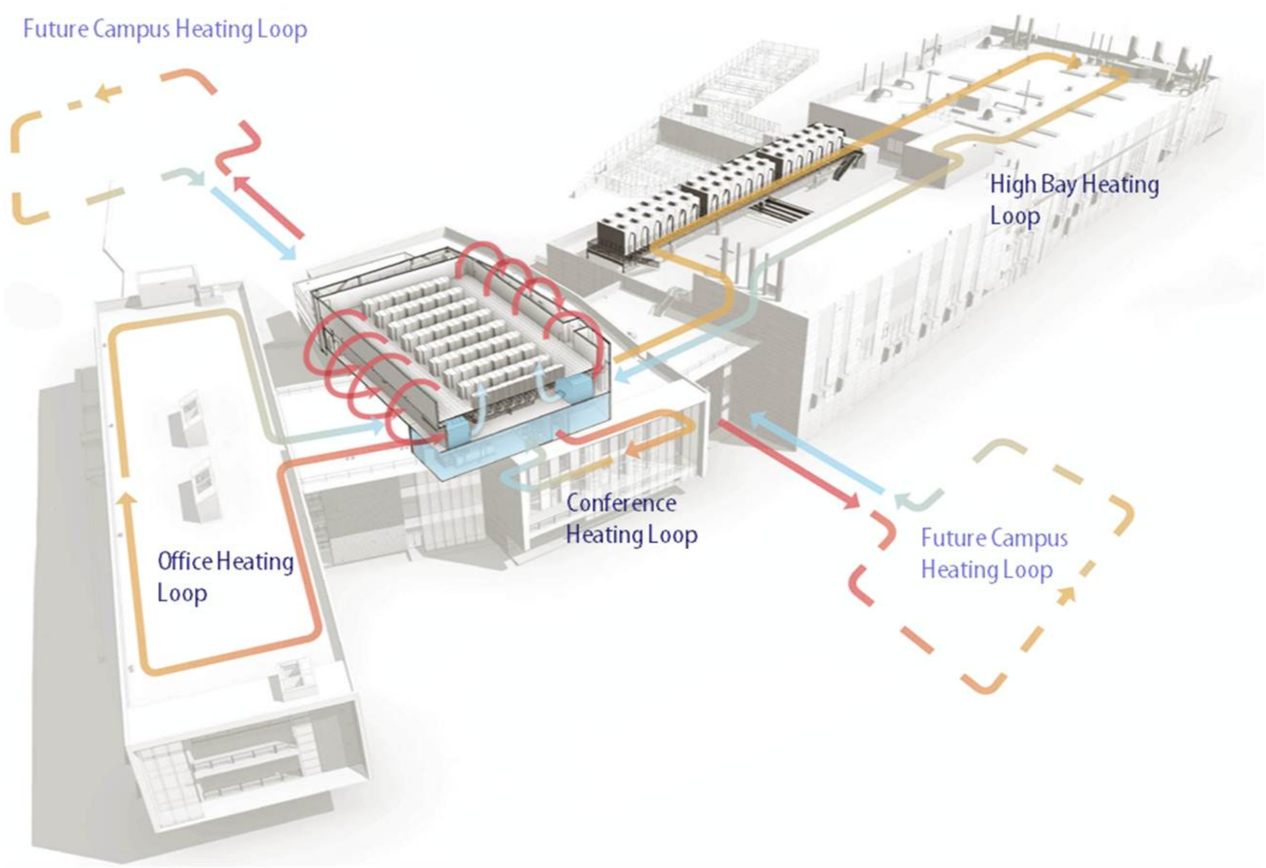
- **Electrical** distribution:
  - 208v or 480v?
- What is your "ambient" **Temperature**?
  - 13C, 18C, 24C, 30C, 35C, 40.5C …
  - (55F, 65F, 75F, 85F, 95F, 105F …)
- Approach to **Cooling**: Air vs Liquid and where?
  - Components, Liquid Doors or CRACs, …

- "Waste" **Heat**:
  - How hot? Liquid or Air? Throw it away or can you use it?

Cooling Efficiency

- Heat exchange: liquids are ~1000x more efficient than air.
- Transport energy: liquids require ~10x less energy. (14.36 Air to Water Horsepower ratio, see below).
- Liquid-to-liquid heat exchangers have closer approach temps than Liquid-to-air (coils), yielding increased economizer hours.

Heat Transfer		Resultant Energy Requirements			
Rate	ΔT	Heat Transfer Medium	Fluid Flow Rate	Conduit Size	Theoretical Horsepower
10 Tons	12°F	Forced Air	9217 cfm	34" Ø	3.63 Hp
		Water	20 gpm	2" Ø	.25 Hp



Future Campus Heating Loop
High Bay Heating Loop
Office Heating Loop
Conference Heating Loop
Future Campus Heating Loop

Biggest challenge is not technical

- Data Center best practices are well documented.
- However, the total cost of ownership (TCO) rests on three legs:
  - Facilities – “owns” the building and infrastructure.
  - IT – “owns” the compute systems.
  - CFO – “owns” the capital investments and utility costs.
- Why should “Facilities” invest in efficient infrastructure if the “CFO” pays the utility bills and reaps the benefit?
- Why should “IT” buy anything different if “CFO” benefits from reduced utility costs?
- *Efficiency ROI is real and all stakeholders must benefit for it to work.*
- Thus, organizational alignment is key.

What did we accomplish?

NREL Data Center

Showcase Facility

- ESIF 182,000 s.f. research facility
- Includes 10MW, 10,000 s.f. data center
- LEED Platinum Facility, PUE 1.06
- NO mechanical cooling (*eliminates expensive and inefficient chillers*).
- Use evaporative cooling only.

Utilize the bytes and the BTUs!

Data Center Features

- Direct, component-level liquid cooling (25C cooling water supply).
- 35-40C return water (waste heat), captured and used to heat offices and lab space.
- Pumps more efficient than fans.
- High voltage 480VAC power distribution directly to high power density 70-80KW compute racks.

Compared to a typical data center:

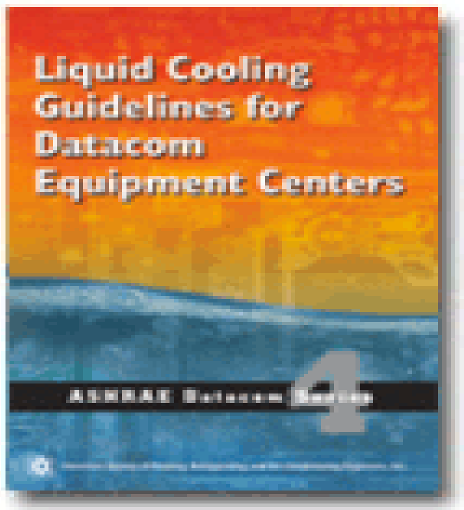
- *Lower CapEx – cost less to build*
- *Lower OpEx – efficiencies save ~$1M per year in operational expenses.*

Integrated "chips to bricks" approach.

Key NREL Data Center Specs

- Warm water cooling, 24C (75F)
  - ASHRAE "W2" category
  - Water much better working fluid than air - pumps trump fans.
  - Utilize high quality waste heat, +35C (95F).
  - +95% IT heat load to liquid.
- Racks of legacy equipment
  - Up to 10% IT heat load to air.
- High power distribution
  - 480VAC, Eliminate conversions.
- Think outside the box
  - Don't be satisfied with an energy efficient data center nestled on campus surrounded by inefficient laboratory and office buildings.
  - Innovate, integrate, optimize.

Liquid Cooling – New Considerations

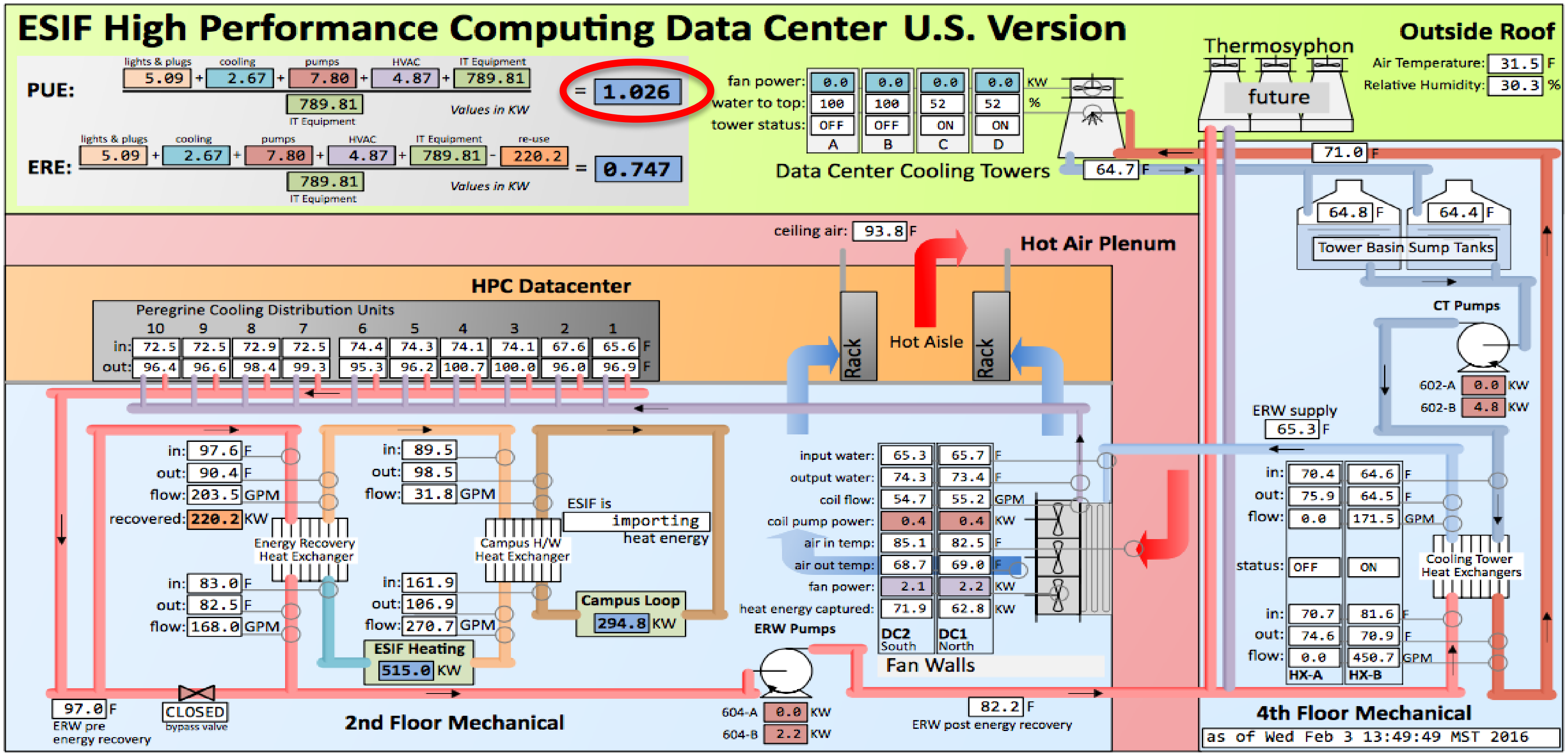


- Air Cooling:
  - Humidity, Condensation, Fan failures.
  - Cable blocks and grated floor tiles.
  - Mixing, hot spots, “top of rack” issues.
- Liquid Cooling:
  - pH & bacteria, dissolved solids.
  - Type of pipes (black pipe, copper, stainless)
  - Corrosion inhibitors, etc.
- When considering liquid cooled systems, insist that vendors adhere to the latest ASHRAE water quality spec or it could be costly.

Lessons Learned

- Liquid cooling essential at high power density.
- Compatible metals and water chemistry is crucial.
- Plan for a hierarchy of systems.
  - Cooling in series rather than parallel
  - Most “sensitive” systems gets “coolest” cooling
  - Highest quality waste heat, essential for waste heat re-use.
- Requires closer cooperation between facilities and IT staff.

View in NREL Data Center Ops



http://hpc.nrel.gov/COOL/index.html

Questions?

High Performance Computing and Sustainability at LANL

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LANL High Performance Computing Facilities Operations Manager

Monica Witt
LANL Sustainability Program Manager

LA-UR-16-22868

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HPC Supports LANL's Mission by Designing and Operating the Supercomputing Infrastructure

- LANL is well positioned to support current and future supercomputing platforms
- LANL is focused on enhancing efficiencies in all our High Performance Computing data centers
- HPC has developed key relationships with facilities peers within LANL and across the DOE Complex

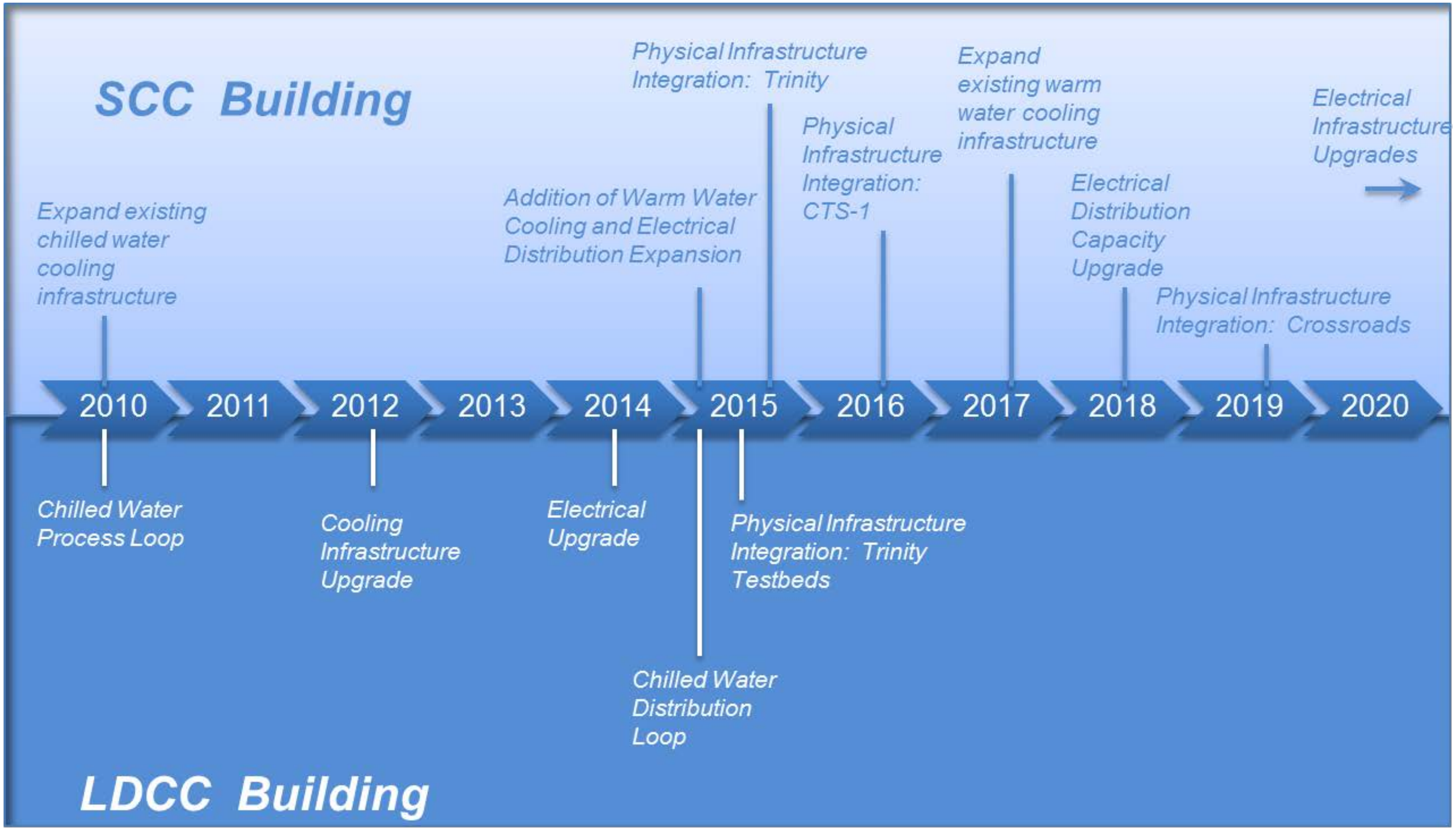
HPC Division Built and Maintains the Three Supercomputing Facilities at LANL

- Nicholas C. Metropolis Center for Modeling and Simulation
  - Strategic Computing Complex (SCC)
    - Built in 2002
    - Computing floor space: 44,000 square feet
    - Data center electrical capacity: 19,2 MW
    - Air Cooling Capacity: 21 MW
    - Water cooling capacity: 15 MW

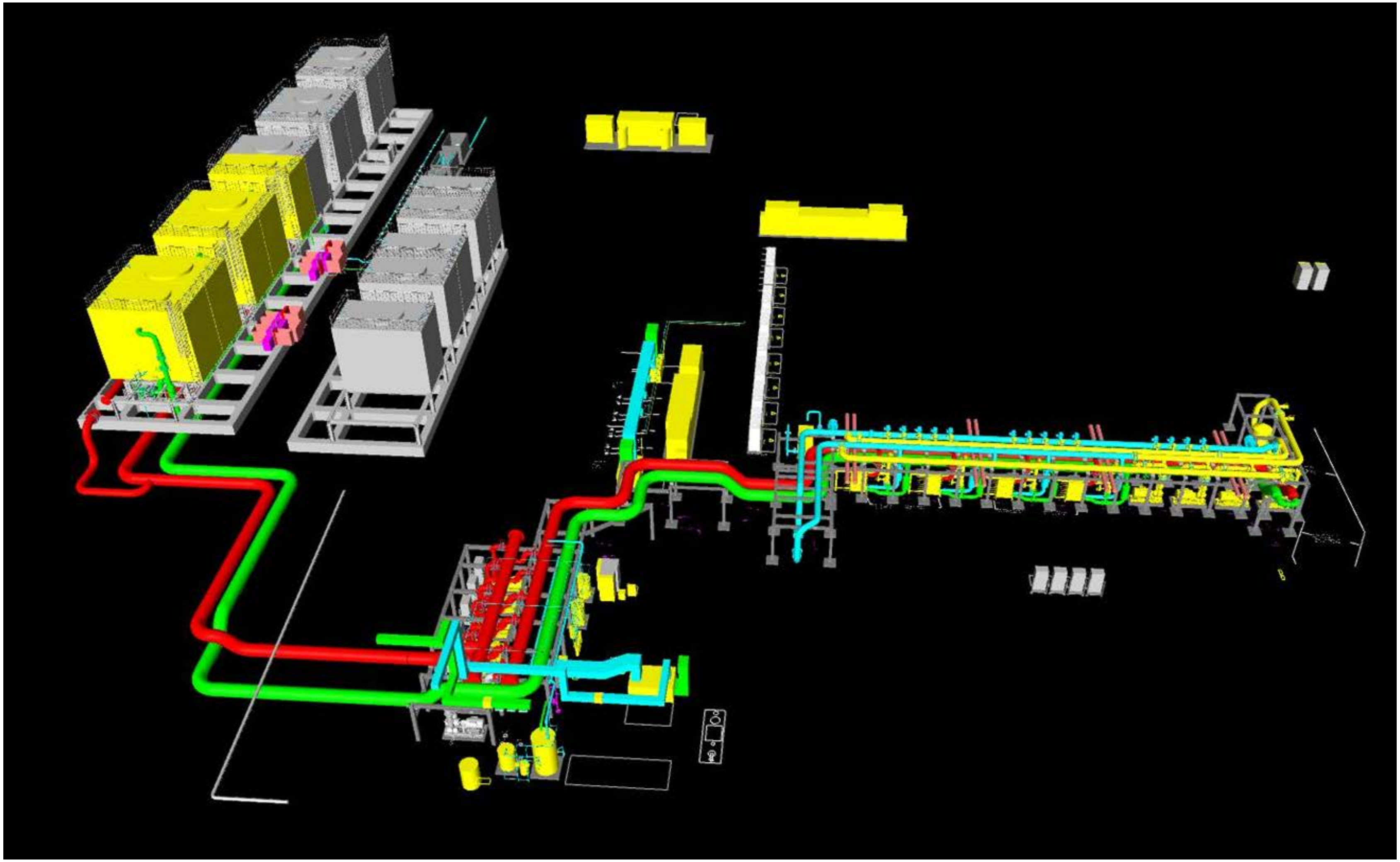
- Laboratory Data Communications Complex (LDCC)
  - Built in 1989
  - Computing floor space: 20,000 square feet
  - Data Center electrical capacity: 8 MW
  - Data Center air cooling capacity: 9 MW
  - Data Center water cooling capacity: 2 MW

- Central Computing Facility (CCF)
  - Built in 1961
  - Computing floor space: 22,000 square feet
  - Data Center electrical capacity: 1.5 MW
  - Data Center air cooling capacity: feed from LDCC
  - Data Center water cooling capacity: none

Facilities Infrastructure Upgrades are Ongoing



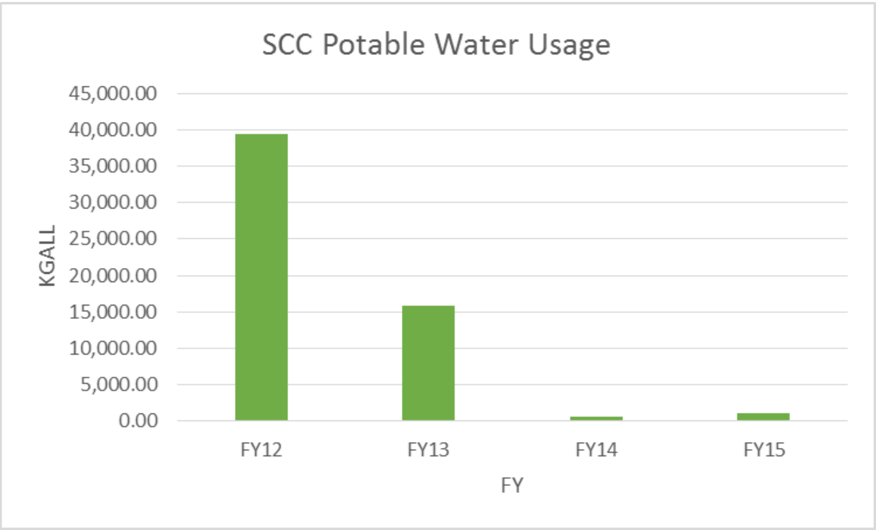
SCC Computer Cooling Equipment Project Overview



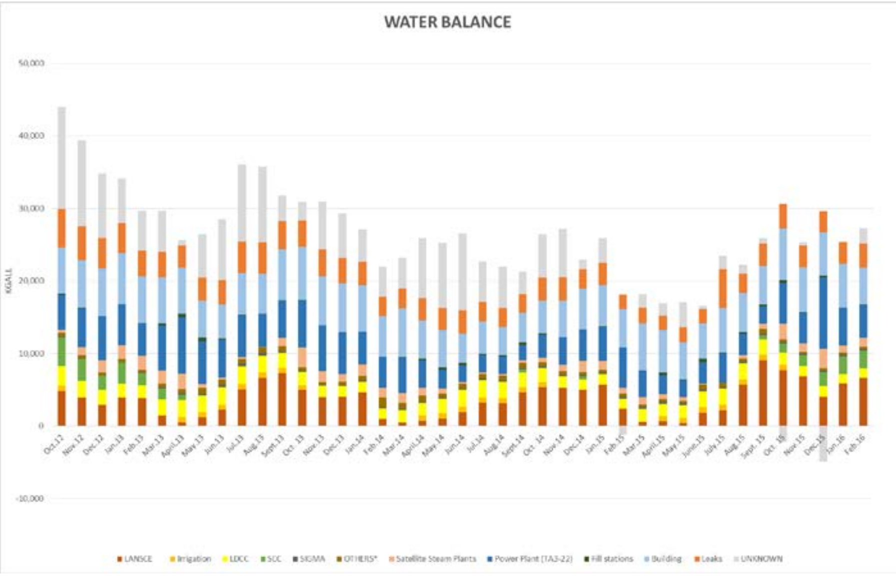
SERF-Sanitary Effluent Reclamation Facility

- The Sanitary Effluent Reclamation Facility treats effluent from the Sanitary wastewater treatment plan
- SERF supplies all water to the SCC Data Center

SCC and SERF



- LANL FY07 baseline year total consumption: 335 million gallons
- LANL FY15 total consumption: 262 million gallons



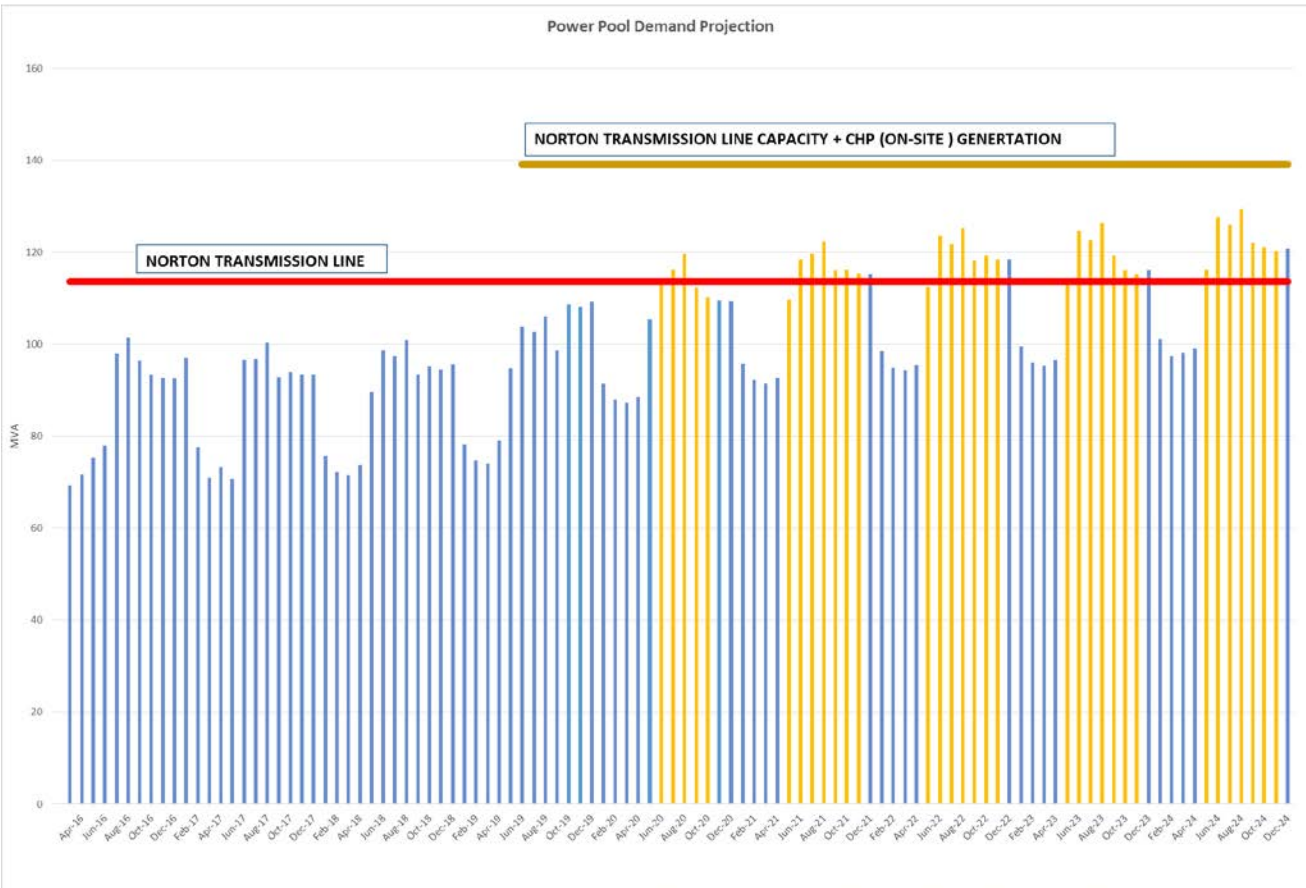
Energy Efficiency and Data Center: Power Utilization Effectiveness (PUE)

- PUE: metric used to determine the energy efficiency of a data center.
- Currently, LANL is defining the SCC, LDCC and CCF as CORE data centers

PUE and Power Consumption Projections

	2013			2014			2015			2016			2017		
Category	PUE	Computer Power (MW)	Power Fraction of Total	PUE	Computer Power (MW)	Power Fraction of Total	PUE	Computer Power (MW)	Power Fraction of Total	PUE	Computer Power (MW)	Power Fraction of Total	PUE	Computer Power (MW)	Power Fraction of Total
SCC	1.32	8	63.7%	1.56	11.47	61.0%	1.5	13.24	62.0%	1.5	23.01	74.4%	1.5	21.77	75.2%
LDCC	1.58	3.1	24.7%	1.57	5.27	28.0%	1.6	5.73	26.8%	1.6	5.55	18.0%	1.4	4.80	16.6%
CCF	1.5	1	8.0%	1.47	1.68	8.9%	1.8	2.03	9.5%	1.8	2.07	6.7%	1.8	2.12	7.3%
10 Data Centers	1.8	0.45	3.6%	1.8	0.4	2.1%	1.8	0.35	1.6%	1.65	0.3	1.0%	1.6	0.25	0.9%
Total		12.55			18.82			21.35			30.93			28.94	
Weighted Average	1.42			1.56			1.56			1.54			1.51		

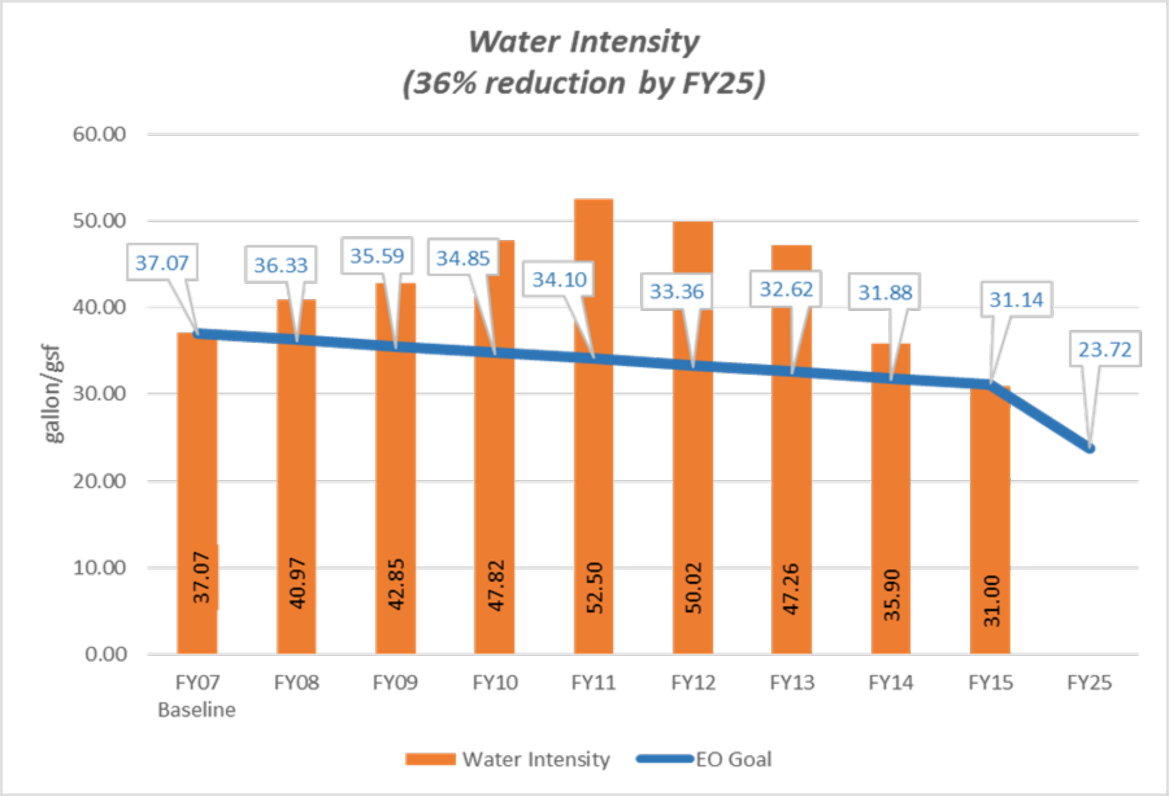
Electrical Projections-Utility Perspective



- Projections:
  - FY16: 113 MW
  - FY 19: 120 MW
  - FY 24: 130 MW
- Existing Norton Line Capacity: 116 MVA
- On-Site Generation starting in FY19: CHP plant (25MW-35MW)
  - 85% reliability
- PV (15 MW) + Battery Storage System to cover 15% time CHP plant will be off-line
- High Efficiency Lighting over 6.5 MGSF saving 1W/gsf

Overview-Water Intensity

- Overall, LANL reduced water use by 15% in FY15 compared to FY14. LANL reduced its water intensity by 16% compared to FY07



Better Building Challenge

The laboratory has become a supporting partner in DOE's Better Building Challenge. The projects that are featured in this challenge.

- Waterside Economizer
- Rotary UPS reconfiguration- Reduce number of RUPS used to support HPC infrastructure.
- Power Distribution Unit (PDU) reduction in both LDCC and SCC.

Thank you!

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Practical Data Center Efficiency Solutions

Better Buildings Summit 2016

Presentation by:
John Sasser
Vice President of Operations
Sabey Data Centers

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Sabey Data Centers

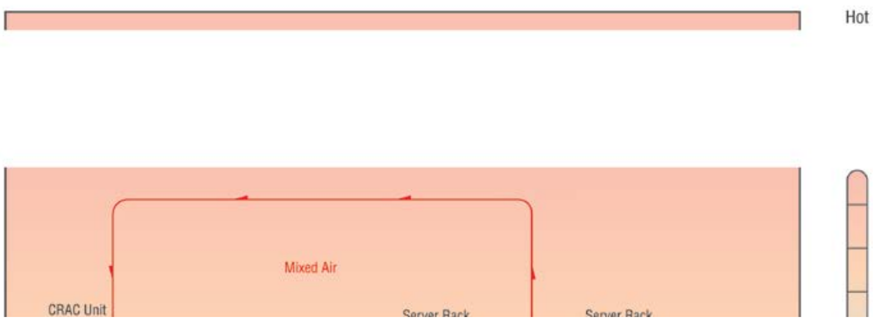
- Privately held data center provider
- Powered shell & wholesale colocation
- Newest campus in Ashburn, Virginia

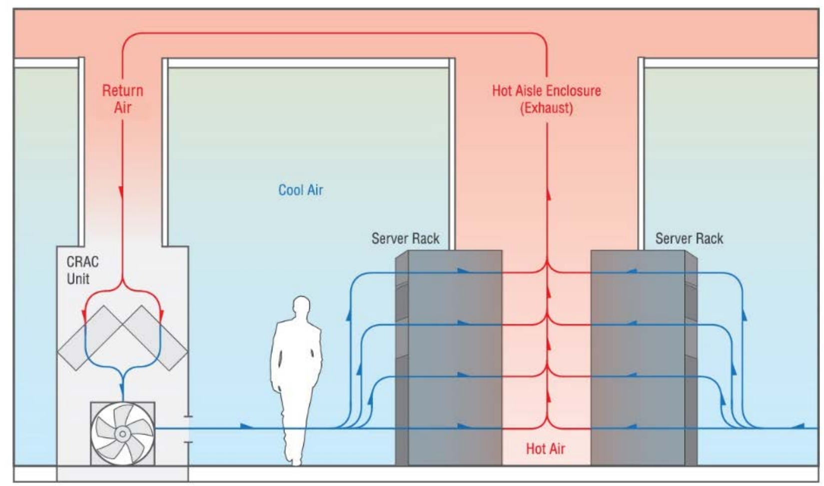
Practical Solutions

For wide scale adoption, practical data center solutions need to be:

- Cost effective
- Appealing to a wide spectrum of end users
- Not too scary. Data center users tend to be risk averse.

Traditional Cooling vs Hot Aisle Containment

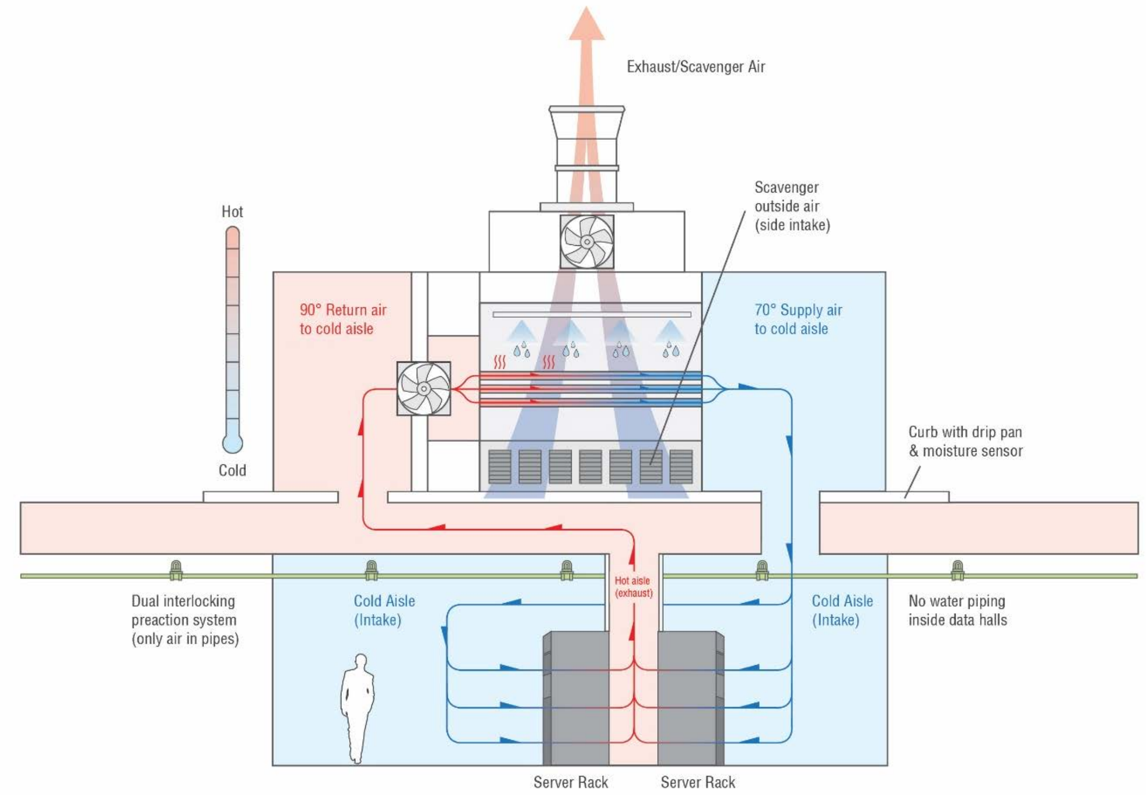




Enclosures

- Standard & customized solutions
- Flexibility & density

Indirect Evaporative Cooling



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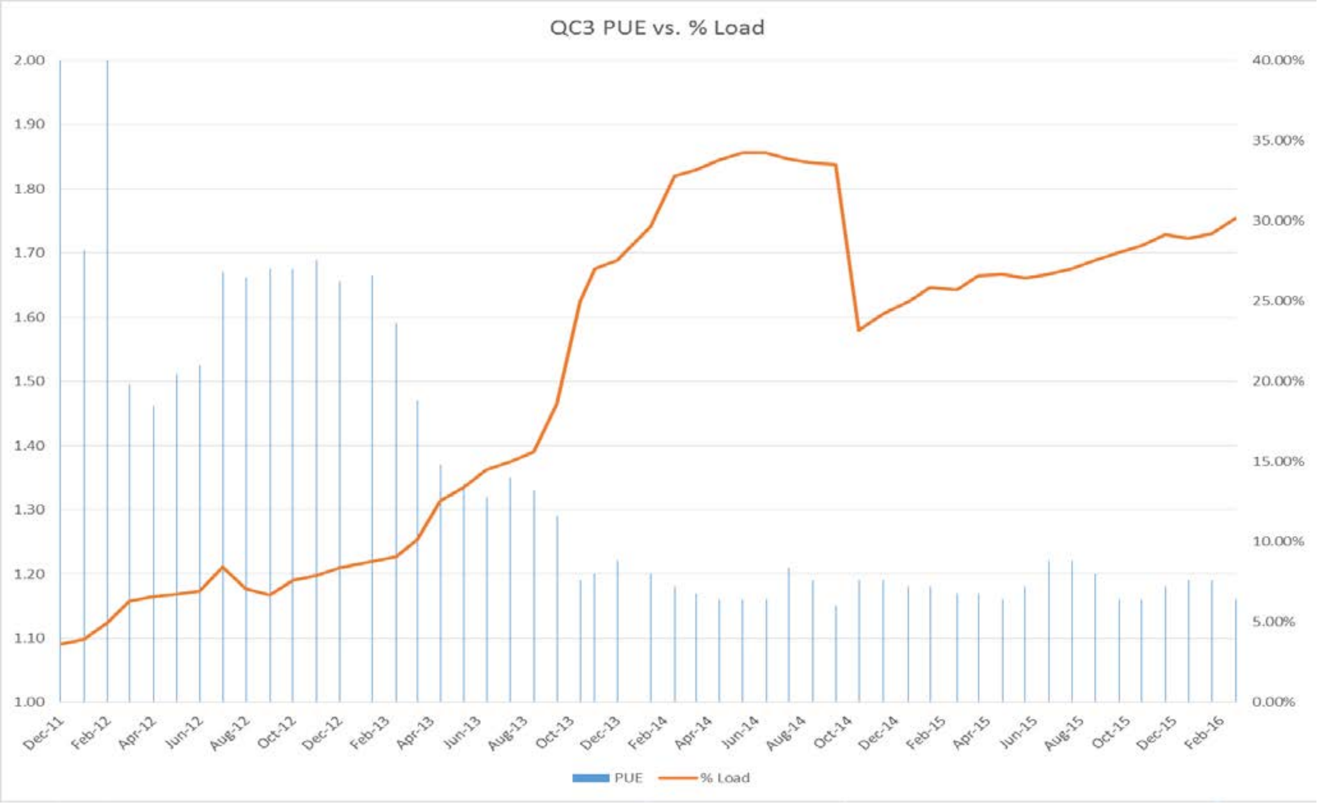
Mobile Commissioning Assistants

- Not too scary – prove that it works
- Newly patented

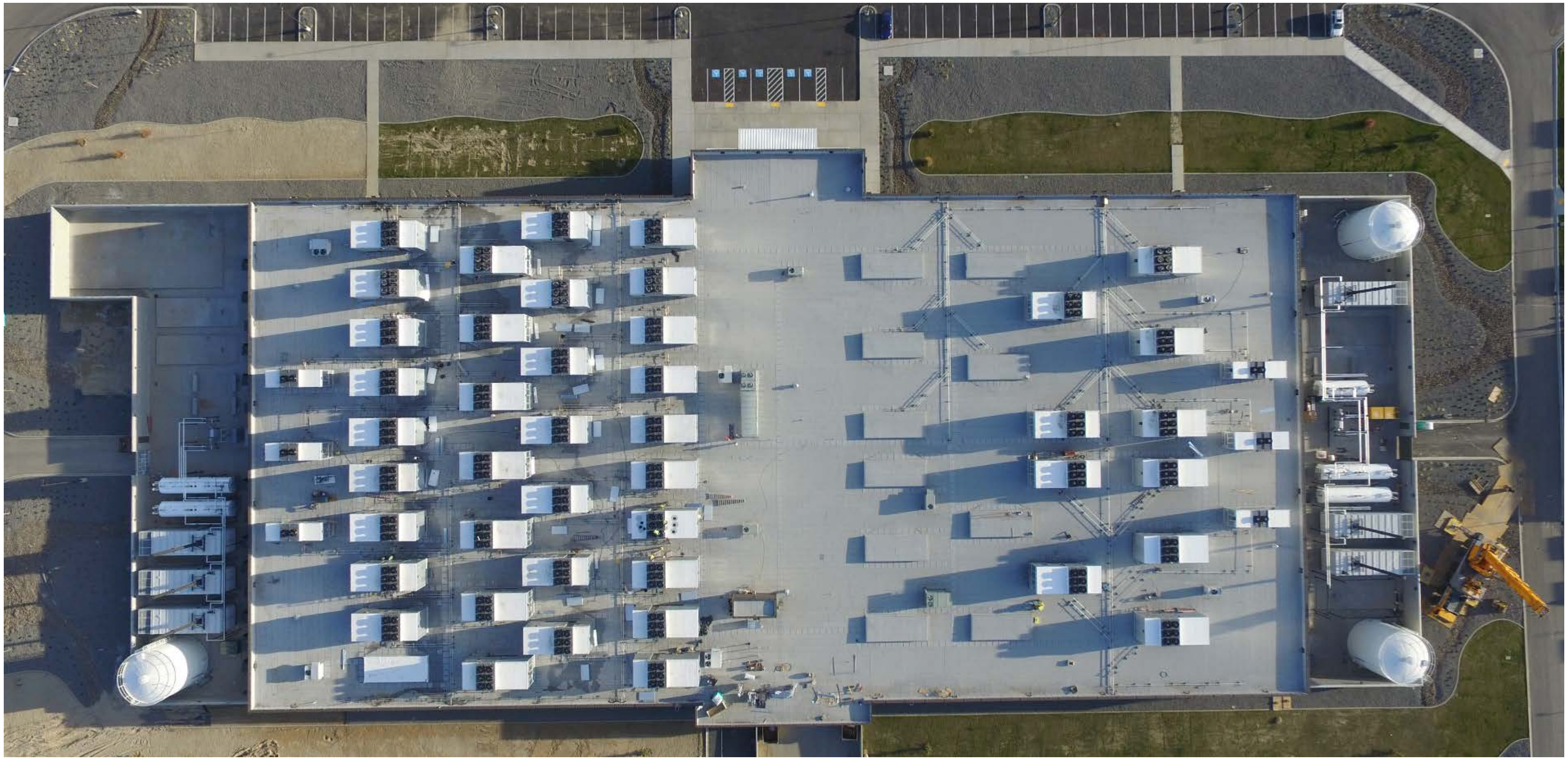
Intergate.Quincy

Energy Star Certified:

- 2015 & 2016
- 100 score, both years
- Energy Star PUE of 1.19 for 2016



Questions?



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Thank You!

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Presentation by:
John Sasser
Vice President of Operations
Sabey Data Centers

LANL Supplemental Slides

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Mechanical Infrastructure


- 5 open cell cooling towers
- Heat exchangers
- Tower and process pumps
- Strainers and tanks
- Air handling units
- 36” pipe for water loop



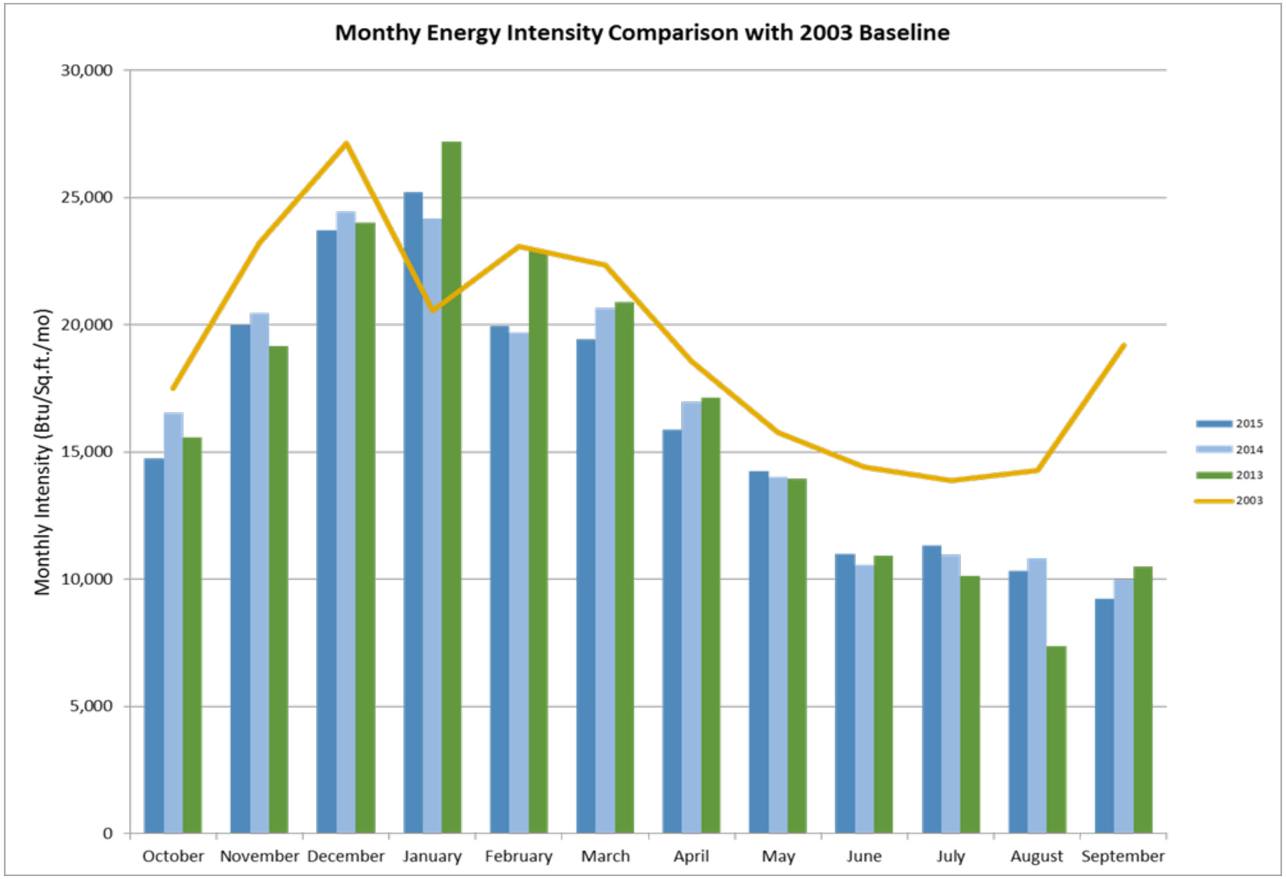
Electrical Infrastructure

- Interior substations I and J
- Exterior substations K
- Switchboards
- Cooling Tower Electrical Gear
- Miscellaneous Power Panels

Physical Infrastructure Integration for Trinity (PIIT) Effort

Overview-Energy Intensity

- Recommissioning and BAS upgrades have provided excellent results with energy savings over 40% in some facilities

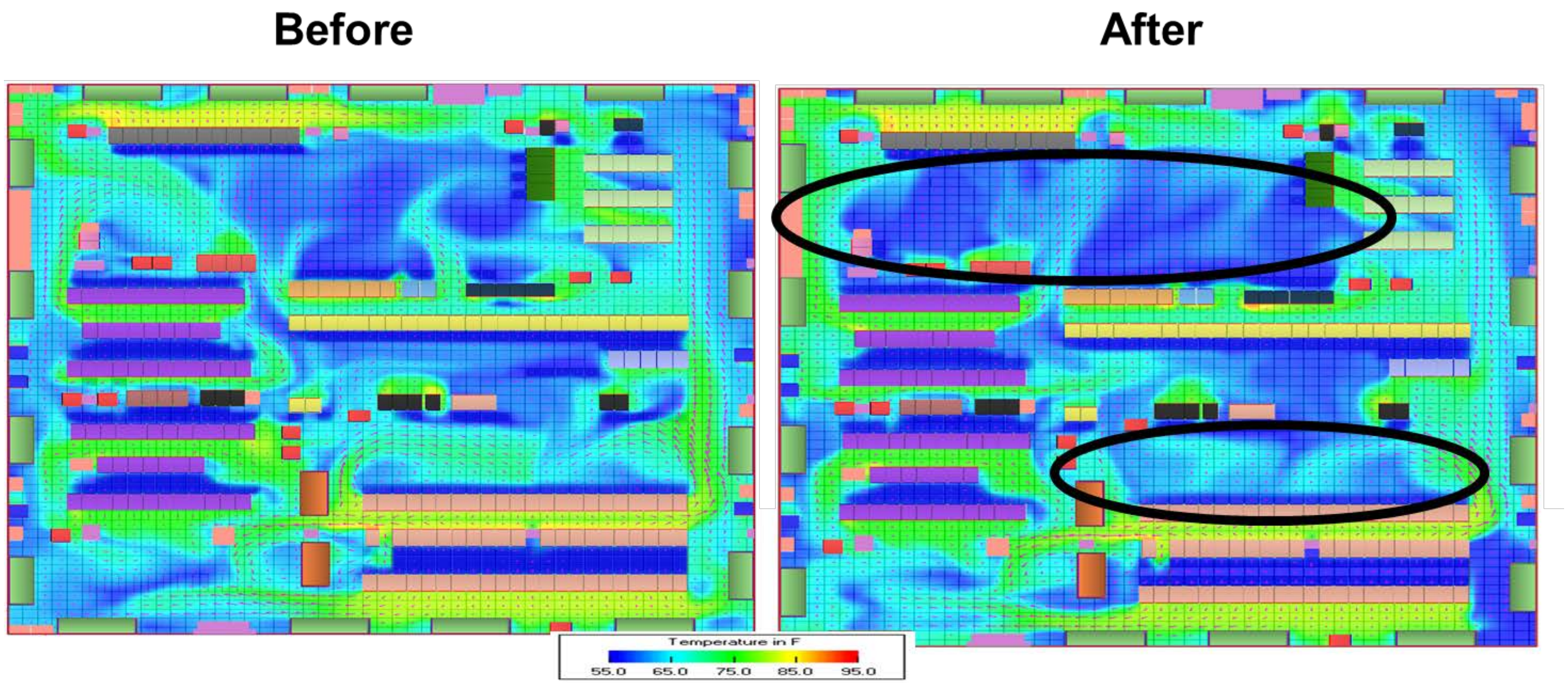


Better Building Challenge-Showcase Project. LDCC Water Side Economizer

- The existing central chiller water plant in LDCC serves the office spaces and three major mission-critical data centers.
- The goal of this project is to save cooling energy and water consumption:
  - Savings:
    - Energy: 3,420 MW-hr
    - Water: 2,500 kgall / year
- This upgrade will assist with the DOE Sustainability Goals and with the HPSB requirements
- This project will help to accomplish the institutional objective to achieve a PUE of 1.4 or less

Energy Efficiency and Data Center: Temperature Optimization Project

- Develop techniques in room and system modeling, data collection and testing with the end goal of more efficient temperature and airflow management in our data centers



Realized Efficiencies in the LDCC Data Center

- Return air temperature (RAT) to the Computer Room Air Conditioning (CRAC) units increased and average of 3.29 degrees; with some units increasing RAT by as much as 7.8 degrees
- With 4 CRAC units turned off we are capable of cooling ~1350 kW (over 1540 kW will all units previously), saving ~67 kW solely from turning off the units