Cloud & Infrastructure Community of Practice

Chartered by the CIO Council

May 26, 2020

FEMP's Data Center Program

FEMP's Data Center program assists federal agencies and other organizations with optimizing the design and operation of energy and water systems in data centers to enhance agency's mission.

Assistance

- Project and technical assistance from the Center of Expertise including identifying and evaluating ECMs, M&V plan review, and project design review.
- Support agencies in meeting OMB's Data Center Optimization Initiative requirements

Tools

- Data Center Profiler (DC Pro) Tools, including PUE Estimator
- Air Management Tools
- Energy Assessment Worksheets

Key Resources

- The Energy Assessment Process Manual
- Data Center Master List of Energy Efficiency Actions
- Small Data Centers, Big Energy Savings: An Introduction for Owners and Operators

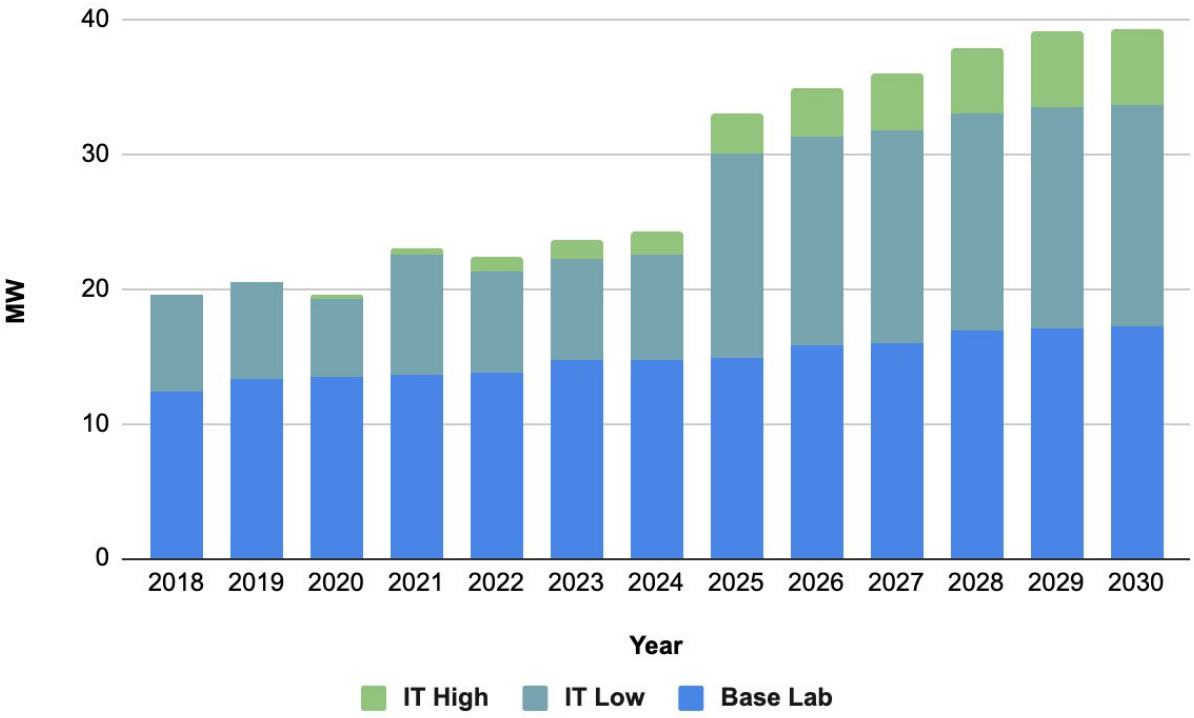
Training

- Better Buildings webinar series
- Nine on-demand FEMP data center trainings
- Center of Expertise Webinars
- Data Center Energy Practitioner Trainings

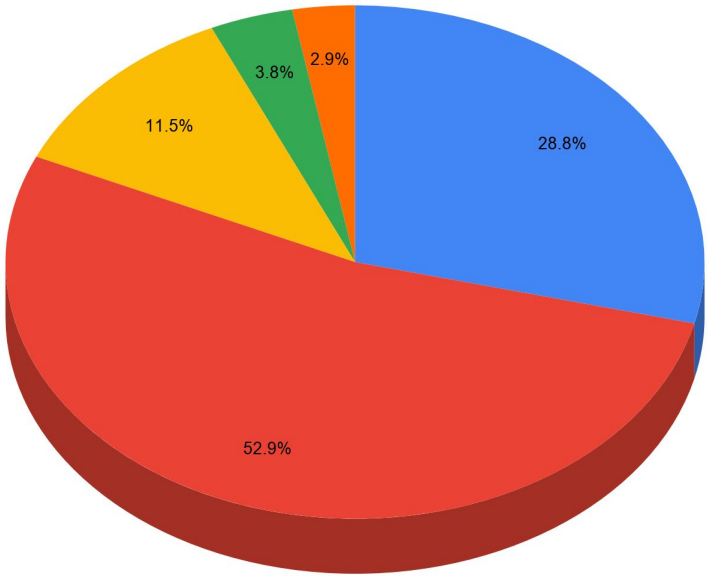
Working Together for Energy Efficient Computing

Jeff Broughton
NERSC Deputy for Operations
Lawrence Berkeley National Laboratory
May 22, 2020

Computing is an Increasing Fraction of LBNL Energy Consumption



Relative Cost of Energy



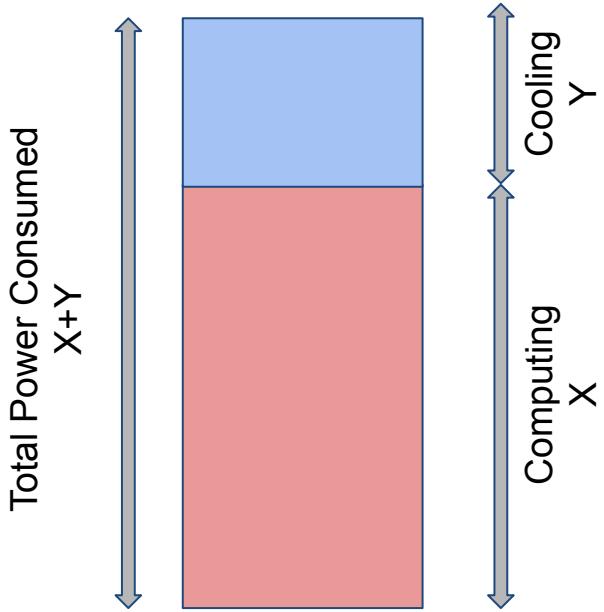
- Computing Systems
- People
- Construction
- Facilities
- Power

Power cost, also

NERSC Budget Breakdown

How do we measure computing energy efficiency?

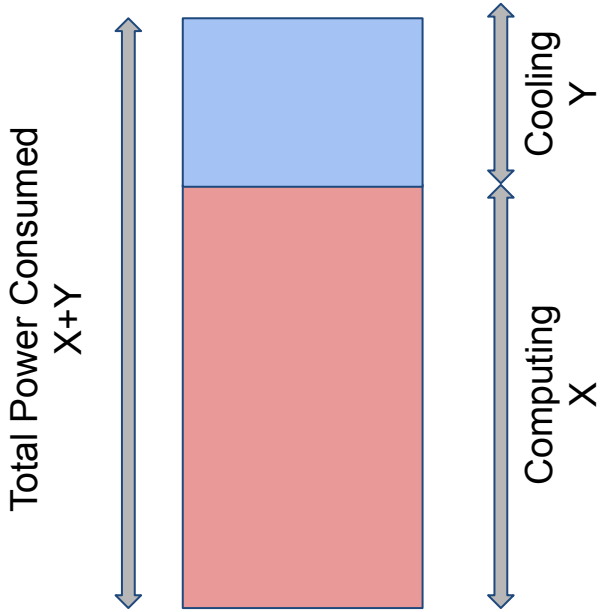
Power Usage Effectiveness (PUE)
= (X + Y) / X



PUE	Examples
Bad: > 2	“Closet” computing
Poor: ~1.7	Poorly-optimized data center
Good: ~1.3	Well-optimized data center with conventional cooling
Best: PUE < 1.1	Data center with economizers, liquid-cooled systems, etc.

How do we measure computing energy efficiency?

Power Usage Effectiveness (PUE)
= (X + Y) / X



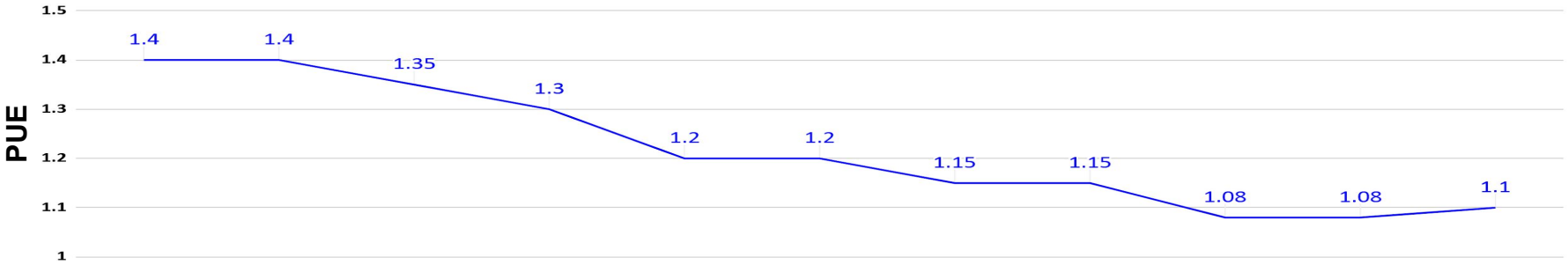
Drivers

- Physical plant design
- System cooling technology
- Matching cooling capacity to load

- Application capacity needs
- System architecture
- Software efficiency

- Environmental impact
- “Green” power
- Water usage

Energy Efficiency is a Long Term Effort



Franklin

Air-cooled

Cray XT4
0.27 PF
2007

Hopper

Hybrid w/ chillers

Cray XE6
1.05 PF
2010

Edison

Hybrid w/ full-time economizers

Cray XC30
1.26 PF
2013

Cori

Hybrid w/ full-time economizers

Cray XC40
14.0 PF
2015

Energy Efficiency Optimization Project

2017 - ongoing

Edison Retirement

May 2019

Oakland → Berkeley

Complex Options Demand a Multi-disciplinary Approach

Warm Water Cooling

~50F → 90-120F
ASHRAE Standards

More Efficient Component Cooling

Air Cooling → Direct liquid cooling
Hybrid/Indirect liquid cooling

Elimination of Chillers

Compressors → Full-time Economizers
Part-time Economizers

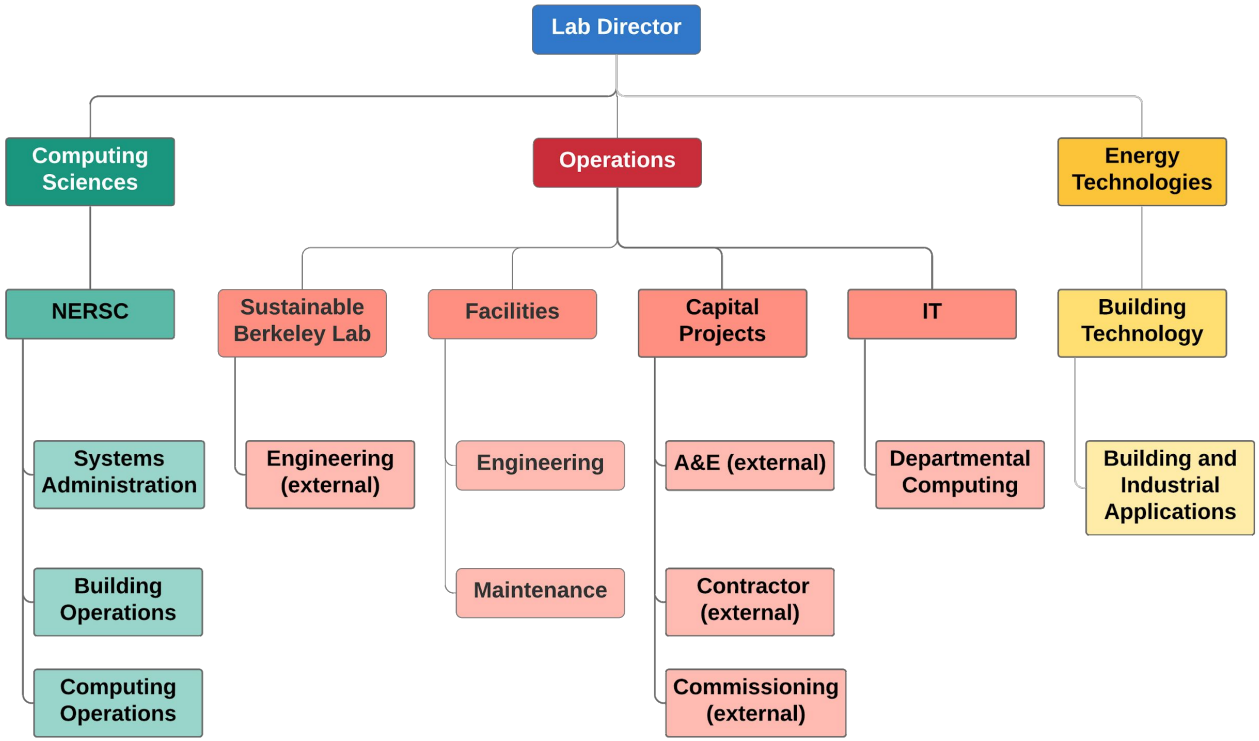
Control Sophistication

Thermostat → Data Analytics
System/Plant Coordination
Machine Learning

Denser Packaging

<1KW/sf
<200 lb/sf → 10KW/sf
350 lb/sf

Computing and Support at LBNL



Data Collection is Prerequisite to Progress

OMNI Data Collection System

Current Data Sources

- Substations, panels, PDUs, UPS
- Cray XC internal SEDC data
- Onewire Temp & RH sensors
- BMS through BACNET
- Indoor/Outdoor Particle counters
- Weather station

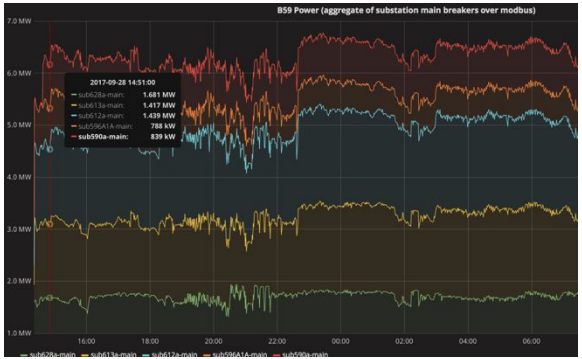
System Data Sources (WIP)

- Syslog
- Job Data
- Lustre + GFPS statistics
- LDMS

Rabbit MQ, Elastic, Linux

- Collects ~20K data items per second
- Over 100TB data online
- 45 days of SEDC (versus 3 hours on SMW)
- 180 days of BMS data (6X more than BMS)
- > 2 years of power data

Kibana, Grafana, Skyspark

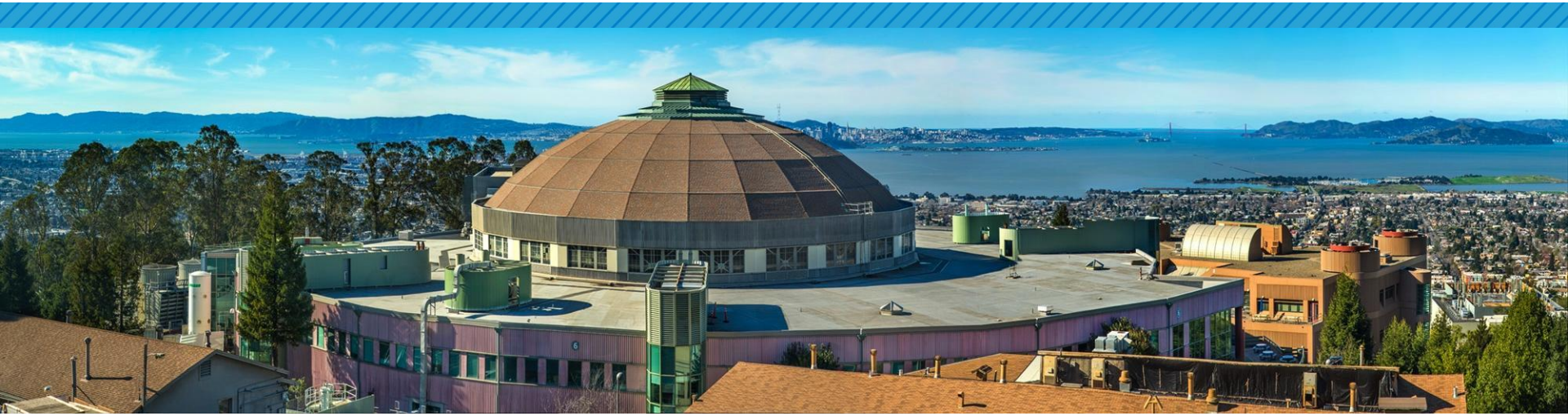


Lessons Learned

- Align goals of different divisions
- Connect expertise across the organization,
- Include outside experts
- Computing needs in house skills
- Focused effort is essential
- Investment in time and funding is necessary

Driving Continual Improvement in Energy Performance through Teamwork

At Berkeley Lab's National Energy Research Scientific Computing Center (NERSC)



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John Elliott | Chief Sustainability Officer
DCOI | 26 May 2020

NERSC Efficiency Optimization Team

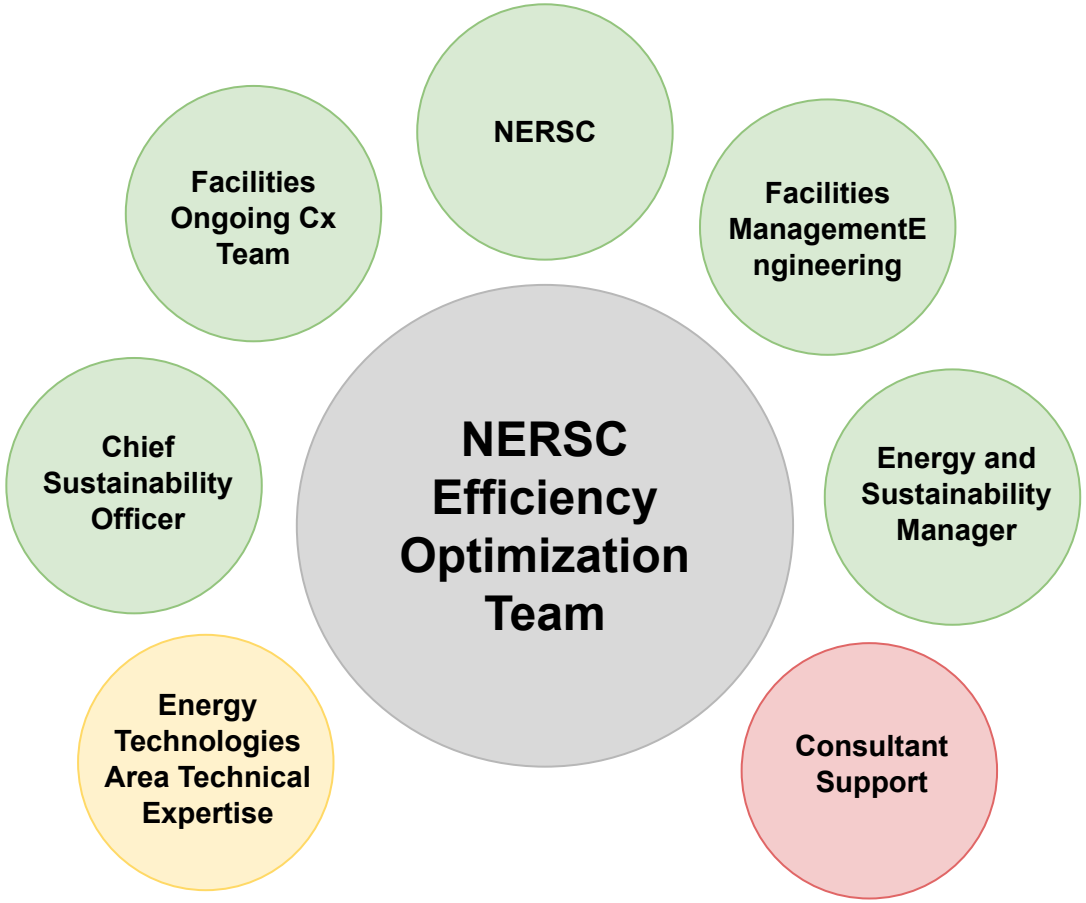
1. Active since the fall of 2016
2. Focus on continual improvement in energy and water performance at NERSC
3. Meet regularly
4. An initial two-year effort to:
   - Target (and achieve) savings equivalent to 37% of the non-compute load
   - Improve monitoring capabilities for efficiency
5. Currently focus on:
   - Maintaining performance
   - Capturing additional savings
   - Preparing for center growth

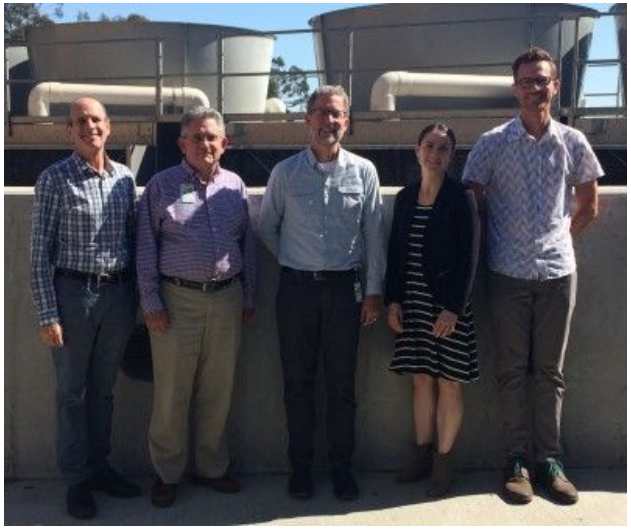
Key Elements of Ongoing Commissioning

Oriented around continual improvement

1. Cross-functional, dedicated team
2. Repeated cycle to select opportunities, complete and verify savings
3. Regular team check-ins
4. Periodic feedback for continual improvement
5. Tools and process to maintain savings

Include All Key Stakeholders and Needed Competencies





Members of the NERSC Efficiency Optimization Project team (left to right): Norm Bourassa and Jeff Broughton of NERSC; John Elliott and Deirdre Carter of Sustainable Berkeley Lab; and Walker Johnson of kW Engineering. Not pictured: Brent Draney, Jeff Grounds, and Ernest Jew of NERSC; Mark Friedrich of Berkeley Lab Facilities, Steve Greenberg and Jingjing Liu of Energy Technologies Area.

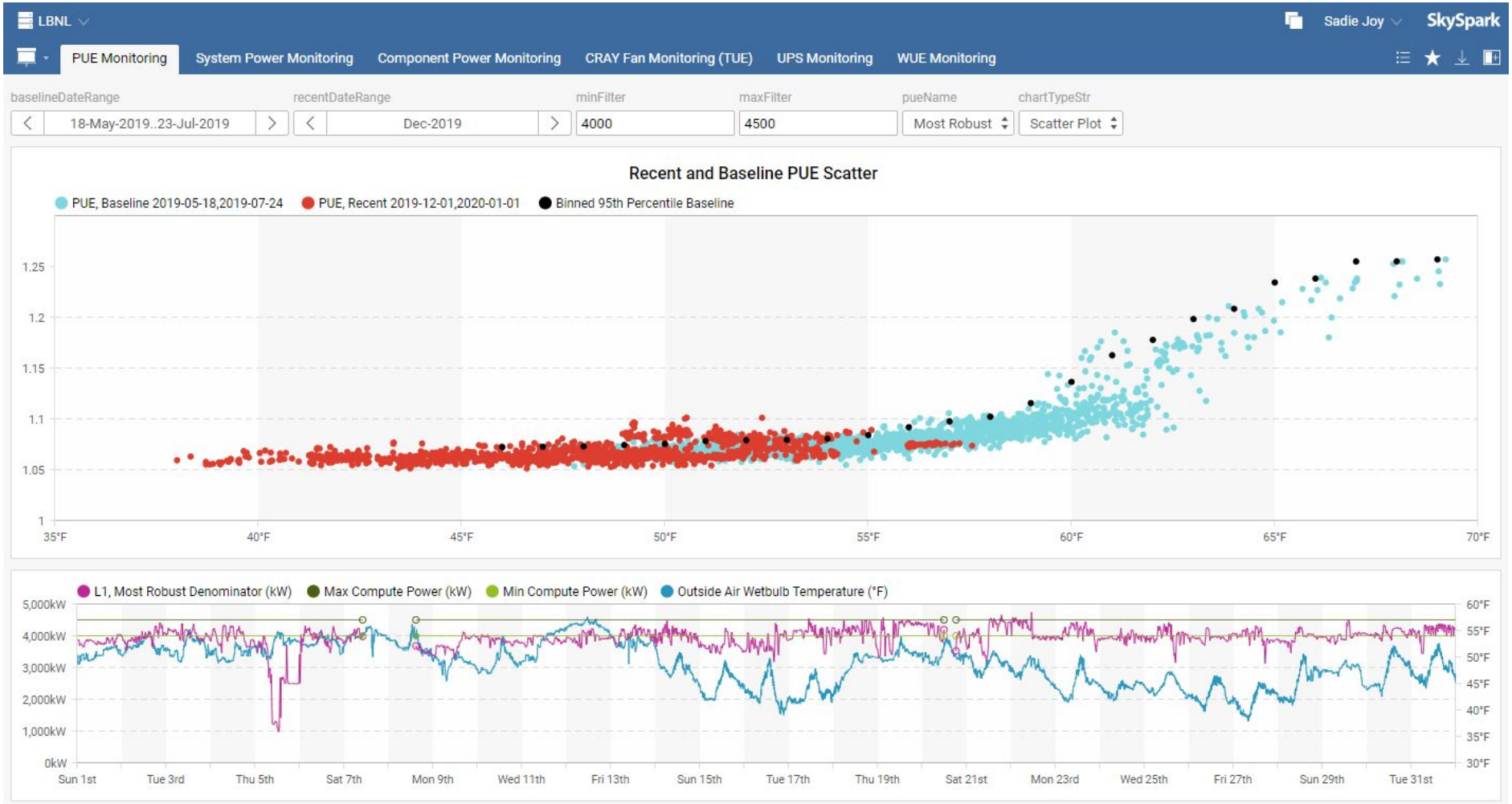
At NERSC - Identified Opportunities to Complete Over 1-2 Years

	Measure Title	Energy Savings (kWh/year)	Water Savings (gal/year)	Cost Savings ($/year)
1	Install Firmware to Enable ESS Mode for UPSs	350,000	140,000	$20,300
2	Implement Tower Water Supply Temperature Reset and Reduced Tower Water Pump Speed	380,000	N/A	$22,040
3	Reset Cooling Water Temperature Setpoint and Enable Cray Dynamic Fan Control	275,000	110,000	$15,950
4	Install New Heat Exchanger	760,000	300,000	$44,080
5	Install Bypass Valves	35,000	10,000	$2,030
	Total	**1,800,000**	**560,000**	**$104,400**

Total Non-IT Energy (kWh)	**4,866,000**
Savings as a % of Non-IT Energy	**37%**

Skypark - Software Tool for Monitoring

Continuous tracking of plant efficiency



Consistent process to evaluate performance

Script to perform a monthly review of energy and water performance

Metric	Skyspark View	Baseline Period	Post Period	Determination of Deviation	Follow-up action if there is a Significant Deviation	Related EEMs
1	PUE vs wb	May 18, 2019 - July 23, 2019 This period covers after Edison was taken offline and before one of the four CT fans went offline.	Most recent complete month	A cluster of "Recent" data points that are 0.1 or more above the "Binned 95 Percentile Baseline".	Switch Chart Type from Scatter Plot to Time series	All
2	System Power Monitoring - Baseline and Recent	Same as above	Most recent complete month	A cluster of data points above the "Binned 95 Percentile Baseline"	Switch Chart Type from Scatter Plot to Time Series	2,3,4,5
3	Component Power Monitoring - Baseline and Recent - Tower Water Pump	Same as above	Most recent complete month	A cluster of "Recent" data points more than 50% above the "Baseline"	Switch Chart Type from Scatter Plot to Time Series	2,3,4,5
4	Component Power Monitoring - Baseline and Recent - Cooling Water Pump	Same as above	Most recent complete month	A cluster of "Recent" data points more than 50% above the "Baseline"	Switch Chart Type from Scatter Plot to Time Series	2,3,4,5
5	Component Power Monitoring - Baseline and Recent - Cooling Tower Fan	Same as above	Most recent complete month	A cluster of "Recent" data points more than 50% above the "Baseline"	Switch Chart Type from Scatter Plot to Time Series	2,3,4,5
6	UPS Monitoring	Trend view of most recent complete quarter of data		Efficiency < 95% means ESS mode has been disabled.	Look at PDU Monitoring app in SkySpark to see if any PDUs have gone offline.	1
7	Cray dynamic fan - Baseline and Recent - TUE	Same as above	Most recent complete month	A cluster of "Recent" data points more than 50% above the "Baseline"	Use Metrics 1-5 to determine a change in plant operation.	3
8	Recent and Baseline WUE	Same as above	Most recent complete month	Still under consideration.	Switch Chart Type from Scatter Plot to Time Series	

Rigorous Institutional Process

- ISO 50001, an international energy management standard promoted by DOE and co-developed by Berkeley Lab
- An continual-improvement framework to ensure that Berkeley Lab's energy and water management activities are strategic, effective, and persistent
- An Energy and Water Management System Manual that defines, documents, and guides all energy and water savings activities
- Special attention to significant energy uses (such as NERSC)
- Berkeley Lab is going up for certification in late FY 2020

Contact

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510-486-7188

Links for more information:

NERSC Efficiency Optimization - 2 page overview

Less is More: LBNL Breaks New Ground in Data Center Optimization - NERSC News Center Story

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ENERGY EFFICIENCY &
RENEWABLE ENERGY

FEMP's Center of Expertise for Energy Efficiency in Data Centers

5/26/20

FEMP
Federal Energy Management Program

What is the Center of Expertise?

The CoE serves as a an information and resource hub for data center owners, operators, and other stakeholders interested in achieving energy reductions and cost savings.

Receive energy efficiency recommendations from CoE's Energy Efficiency Toolkit

Filter CoE's many resources by type and topic.

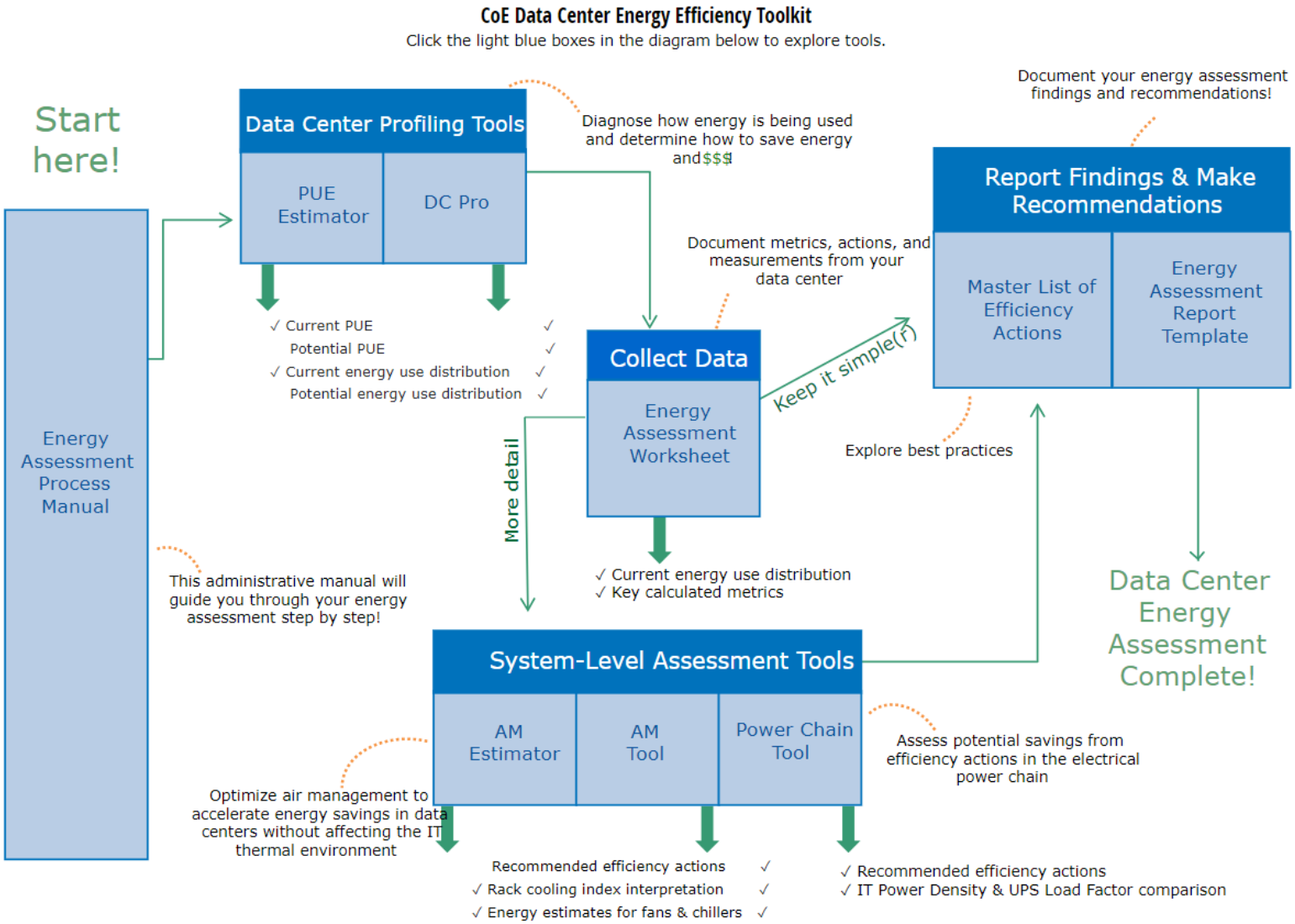
Choose from upcoming live webinars, pre-recorded trainings, and in-person Data Center Energy Practitioner (DCEP) trainings.

Search resources by topics of interest.

Explore the range of activities that CoE is engaged in.

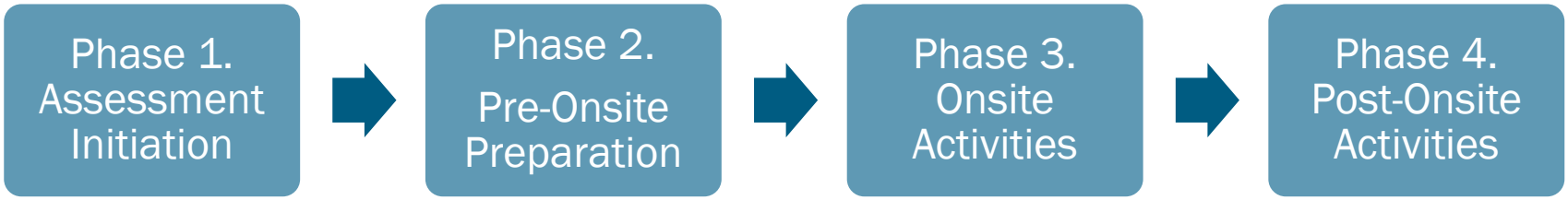
Follow us on Twitter @DataCenterCoE

Center of Expertise Toolkit



Resources for Stakeholder Engagement in DCs

- CoE's process manual is a step-by-step guide for conducting an energy assessment in your data center.
- Stakeholder engagement is integrated throughout the process.



- FEMP's 50001 Ready Navigator is an online system that provides step-by-step guidance for implementing and maintaining an energy management system.
- Visit Navigator.lbl.gov for Resources & Guidance on:
  - Obtaining management commitment on a project
  - Forming & managing an effective energy management team

Building the Business Case for Energy Efficiency in *Your* Data Center

- Interactive resource enables users to identify stakeholders across organization who are critical to a project's success and assess relevant drivers and barriers.
- Explore resources that can help overcome barriers and win over stakeholders- including successful case studies, CoE tools, training opportunities, and more!

FEMP's Center of Expertise is here to help!

- **CoE provides assistance including:**
  - Project Technical Assistance
  - Selection of energy efficiency measures
  - Review of Metering and Monitoring Plans
  - Support to agencies in meeting DCOI requirements
  - Facilitate design "Charrette" with key stakeholders

Contact us at via email at CoE@lbl.gov with your inquiries or questions!

Thank You

Visit us at datacenters.lbl.gov