U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Federal Utility Partnership for Data Centers

Dale Sartor, P.E. and Magnus Herrlin, Ph.D.
Lawrence Berkeley National Laboratory

September 14, 2017

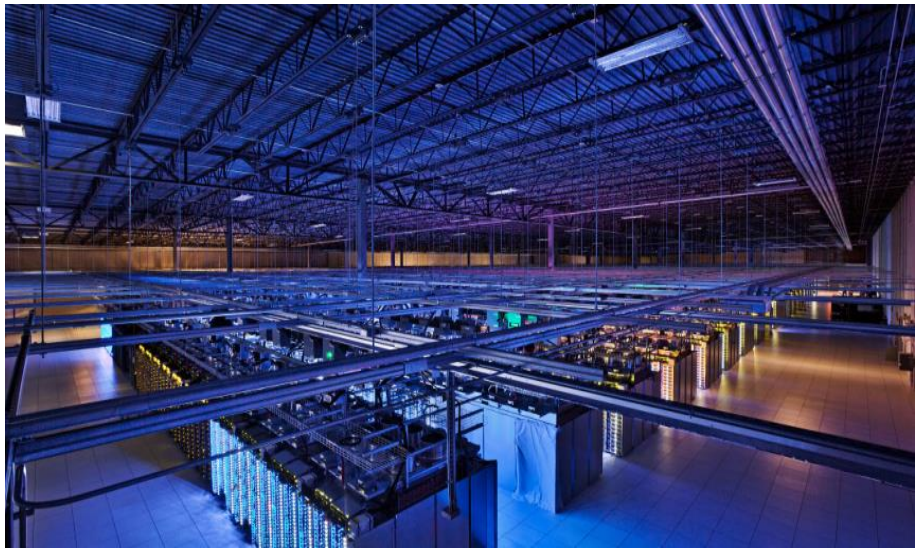
FEMP Federal Energy Management Program

Before We Begin

- Please do NOT put the call on hold.
- All lines have been muted, to be unmuted or to ask a question, please go to your meeting controls panel and raise your hand.
- To submit questions through the chat box, click the chat button and type in the dialogue box at the bottom right. Please, select if you want your comment to go to the entire group or to Elena Meehan to prompt a question to the presenter.
- Slides will be posted at datacenterworkshop.lbl.gov.
- Attendees can receive a certificate of completion by filling out an evaluation form; link provided at the end of the presentation.

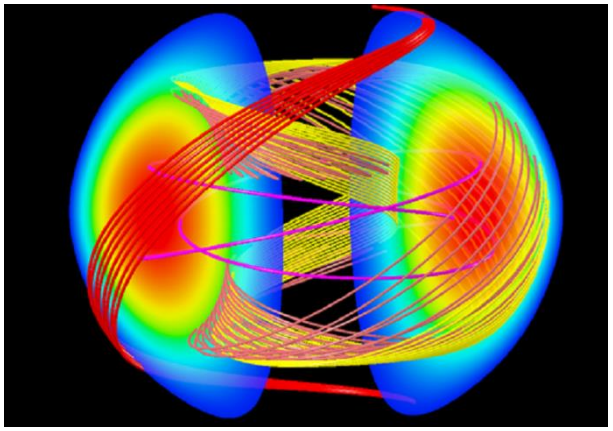
Agenda

- Data Center Energy Context, Federal Drivers, Performance metrics and Best Practices
- DOE and Utility Collaboration Strategy
- Example Collaboration - Current Demo Project
- CoE Resources to Help



Lawrence Berkeley National Laboratory (LBNL)

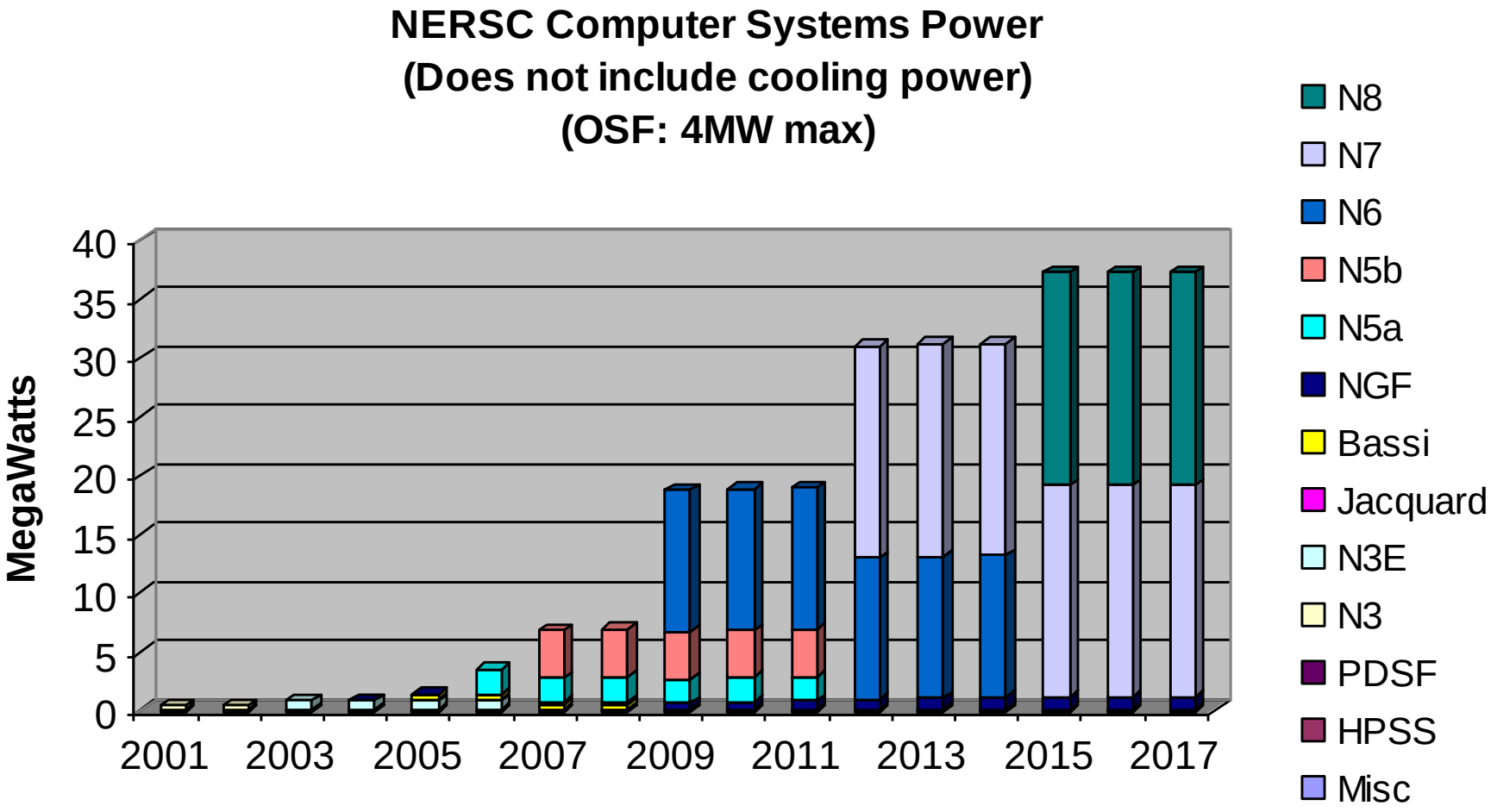
- Operates large systems along with legacy equipment



- We also research energy-efficiency opportunities and work on various deployment programs

LBNL Feels the Pain!

LBNL Super Computer Systems Power



Energy Use in Data Centers

Data centers are energy intensive facilities

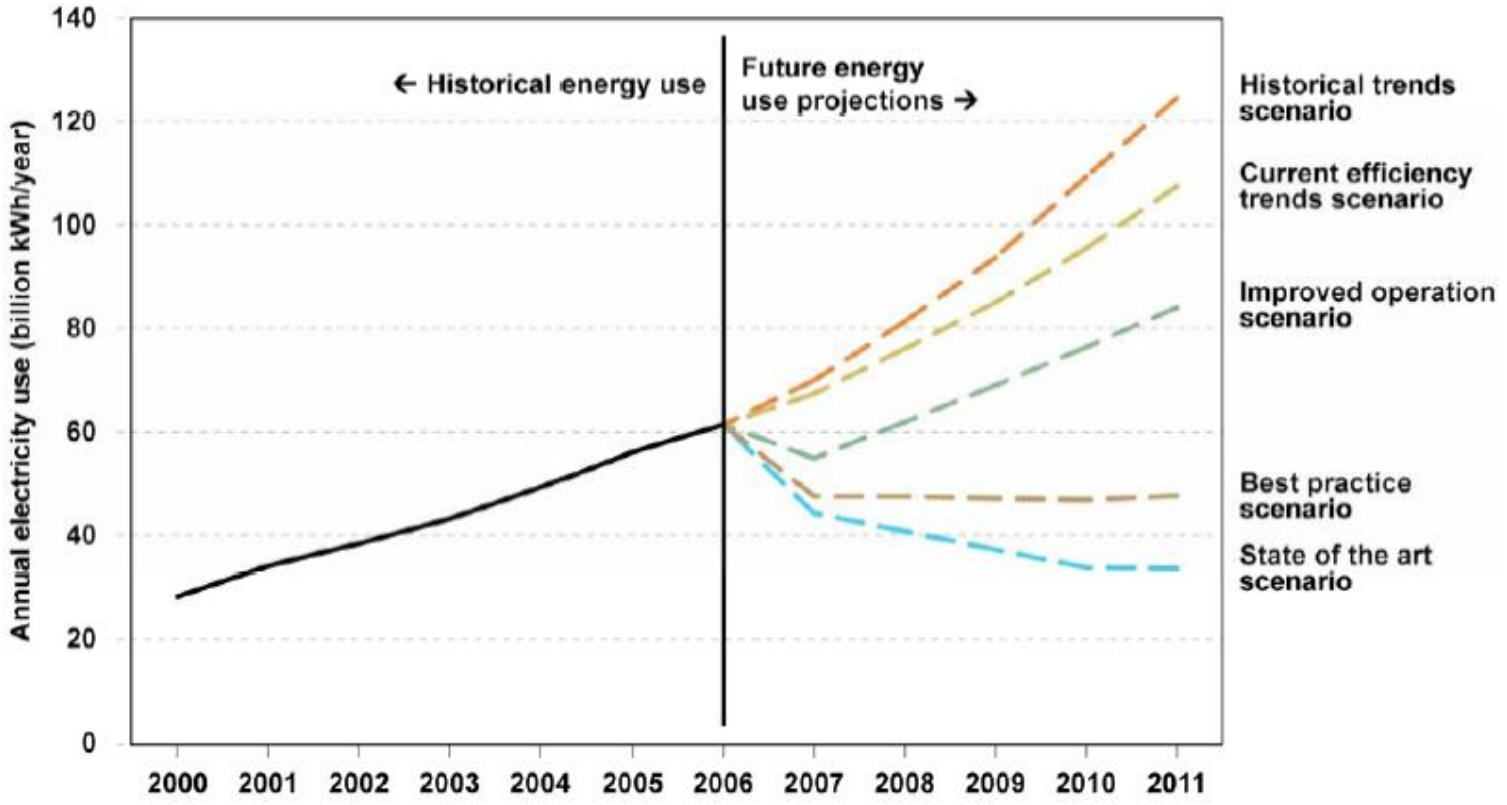
- 10 to 100+ times more energy intensive than an office
- Server racks now designed for more than 25+ kW
- Surging demand for data storage
- 2% of US electricity consumption
- Power and cooling constraints in existing facilities

Potential Benefits of Energy Efficiency

- 20-40% savings & high ROI typical
- Aggressive strategies can yield 50+% savings
- Extend life and capacity of infrastructures

Data Center Energy Projections in 2007

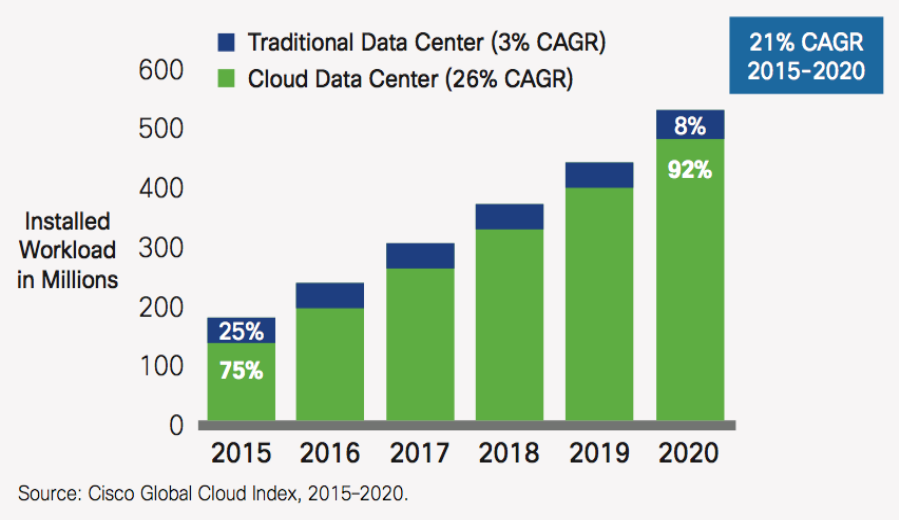
Report to Congress on Server and Data Center Energy Efficiency Public Law 109-431

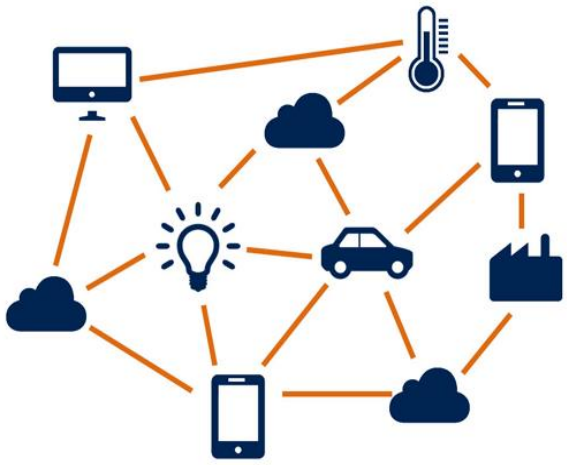


Brown et al., 2007, *Report to Congress on Server and Data Center Energy Efficiency Public Law 109-431*

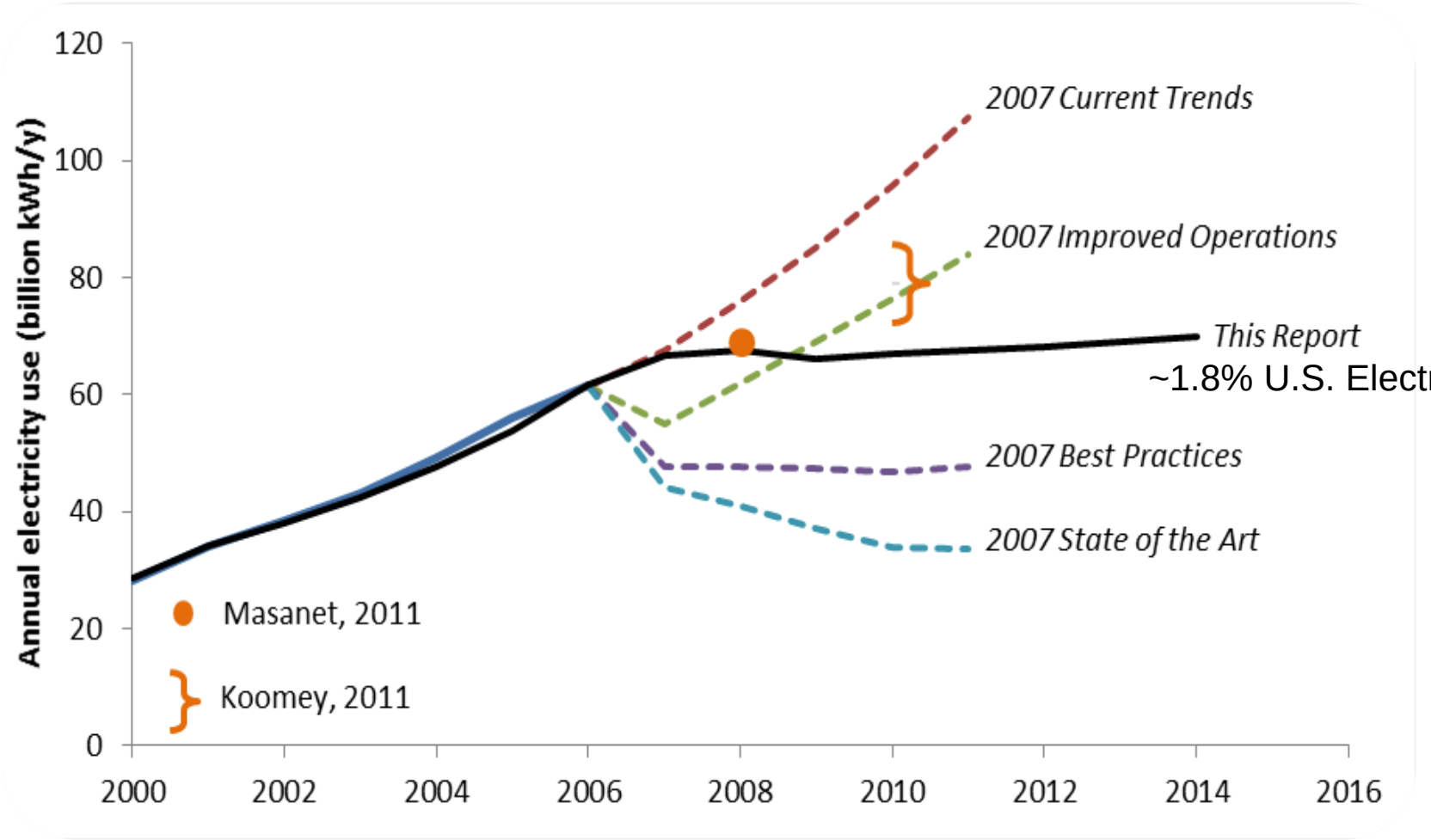
Data Center Landscape has Evolved Since 2007

- Emergence of cloud computing and social media
  - IP traffic increasing 20% annually
- "Hyperscale" data centers
- Growth in data storage
  - 20x increase since 2007
- "Internet of Things" capabilities
- New IT equipment
  - "Unbranded" ODM servers
  - Solid state hard drives
  - Faster network ports

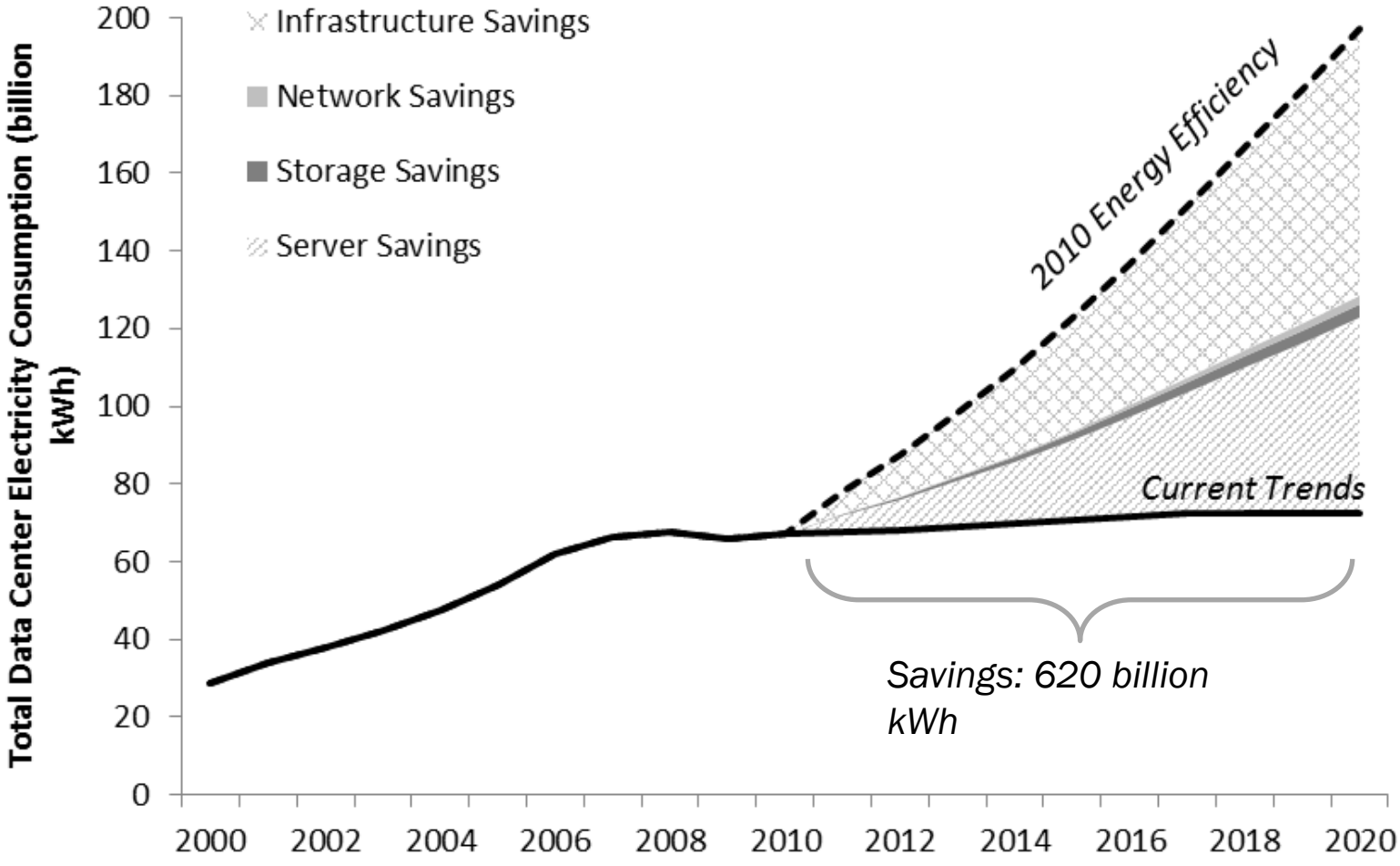




US Data Center Energy Usage Reports (2007 & 2016)

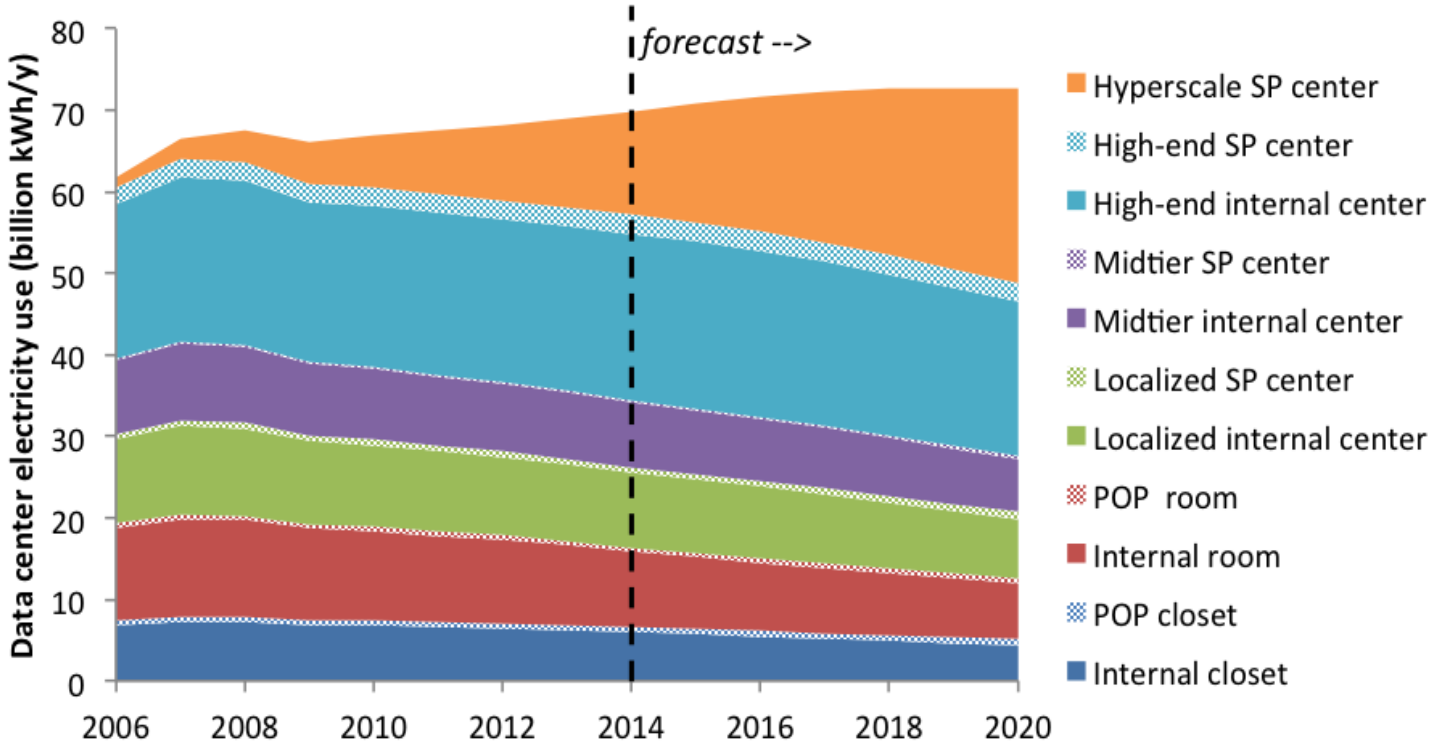


Results: Energy Use Projections and Counterfactual



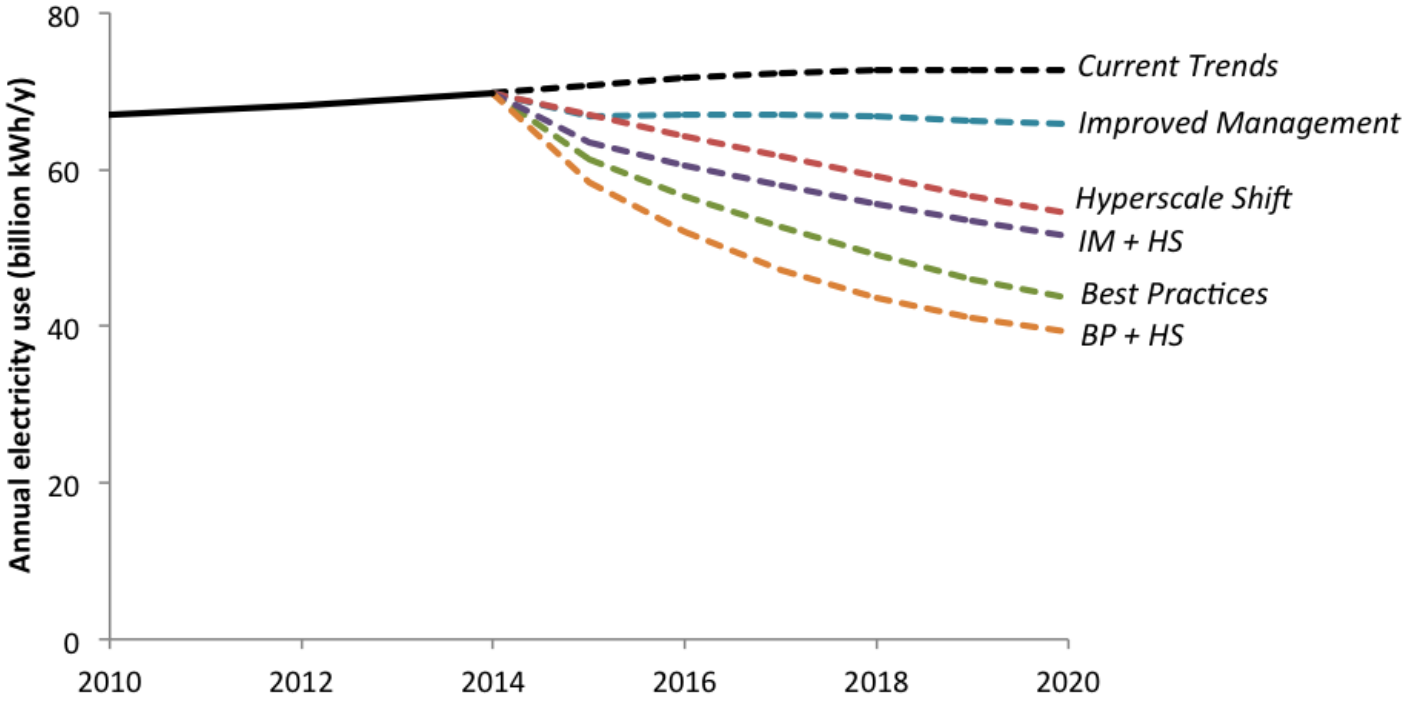
Energy Use Estimates by Data Center Type

- Hyperscale is a growing percentage of data center energy use

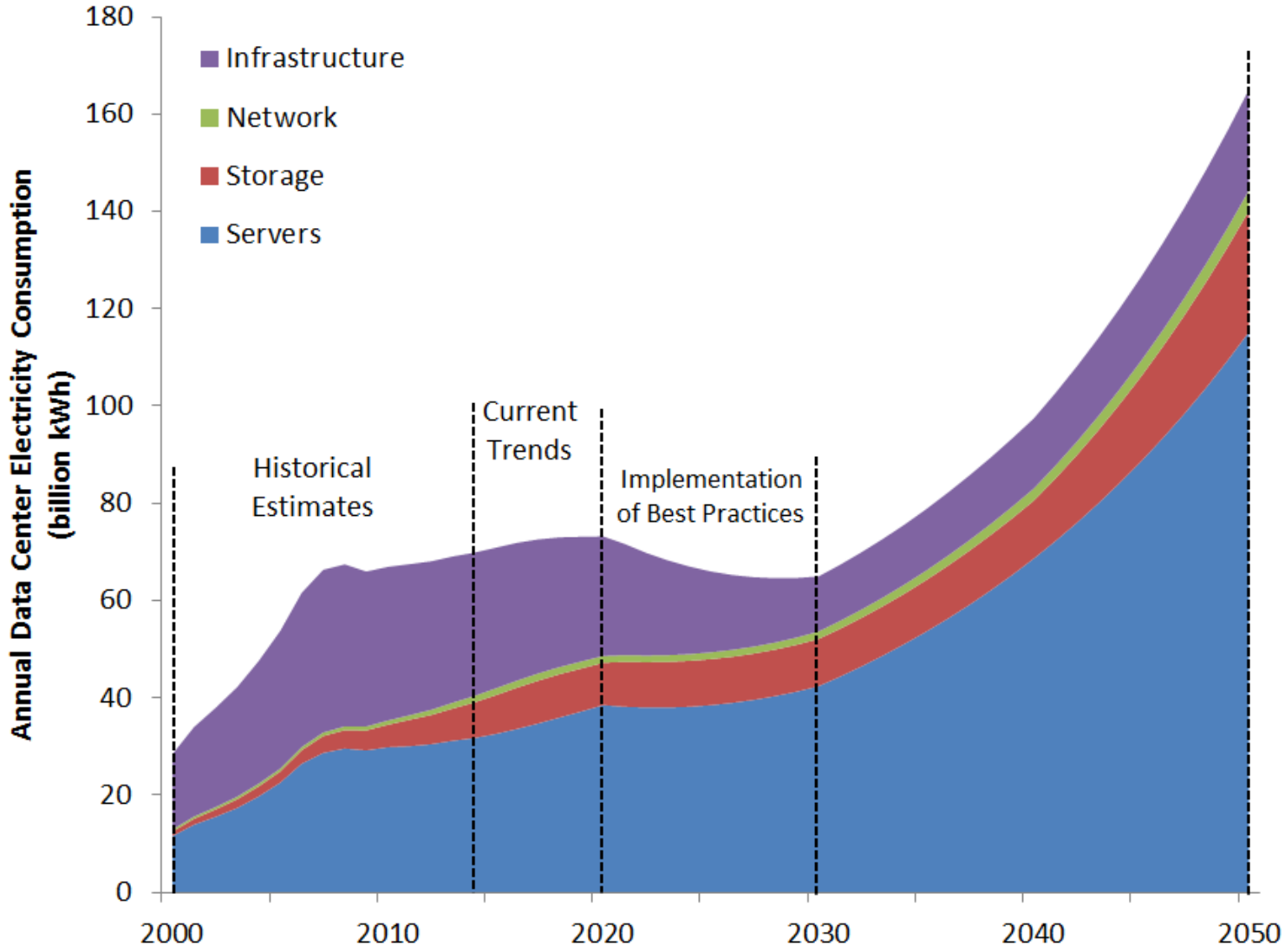


More Savings Available through Efficiency

- Annual saving in 2020 up to 33 billion kWh
- Represents a 45% reduction in electricity demand over current trends



2050 Projections



In Conclusion…

- **Data center energy use has approximately plateaued since 2008**
  - Expected to continue through 2020
- **Further efficiency improvements possible, but will eventually run out**
- **Next-generation computing technologies and innovative data center business models will be needed to keep energy consumption down over the next 20-30 years**

Fed Driver: Executive Order 13693

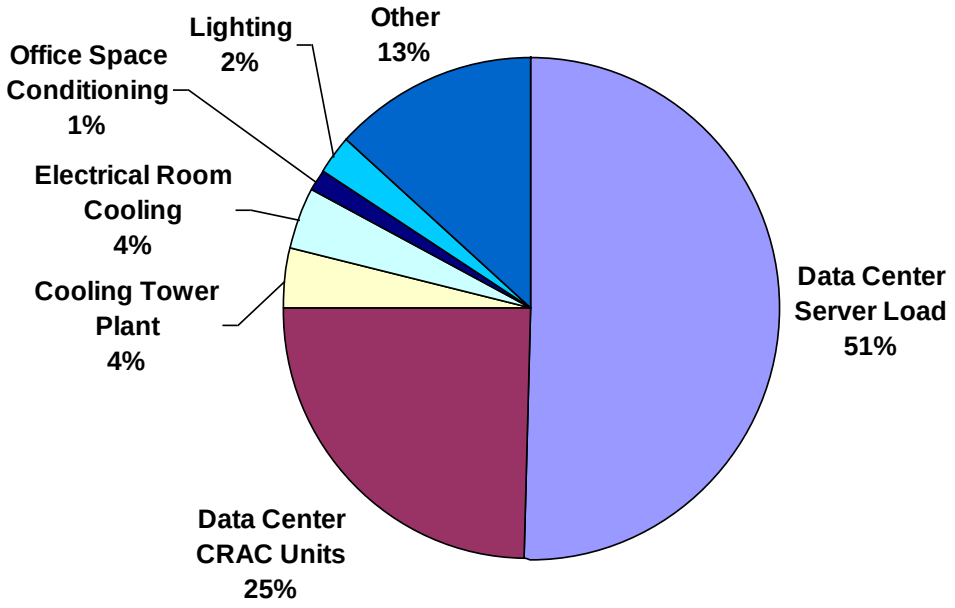
Specific goals for data centers

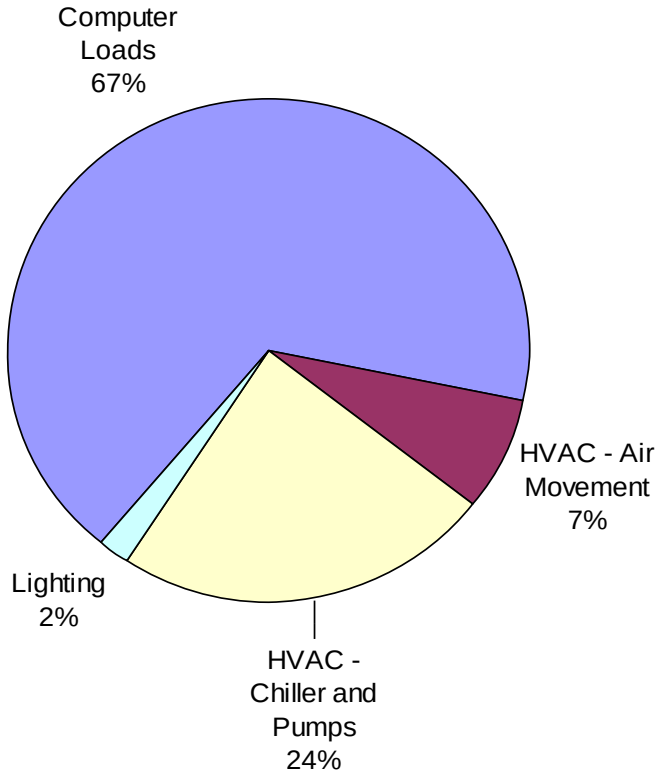
- Promote energy optimization, efficiency, and performance
- Install/monitor advanced energy meters in all data centers by FY2018
- Assign a Data Center Energy Practitioner (DCEP)
- Establish a Power Usage Effectiveness (PUE) target
  - between 1.2 and 1.4 for new data centers
  - less than 1.5 for existing data centers

Other related goals

- Reduce building energy 2.5% per year per sq. ft. thru 2025
- Increase clean and renewable energy – to 25% & 30% by 2020 & 2025
- Reduce water consumption 2% per year per sq. ft. thru 2025
- Make ENERGY STAR or FEMP designated acquisitions

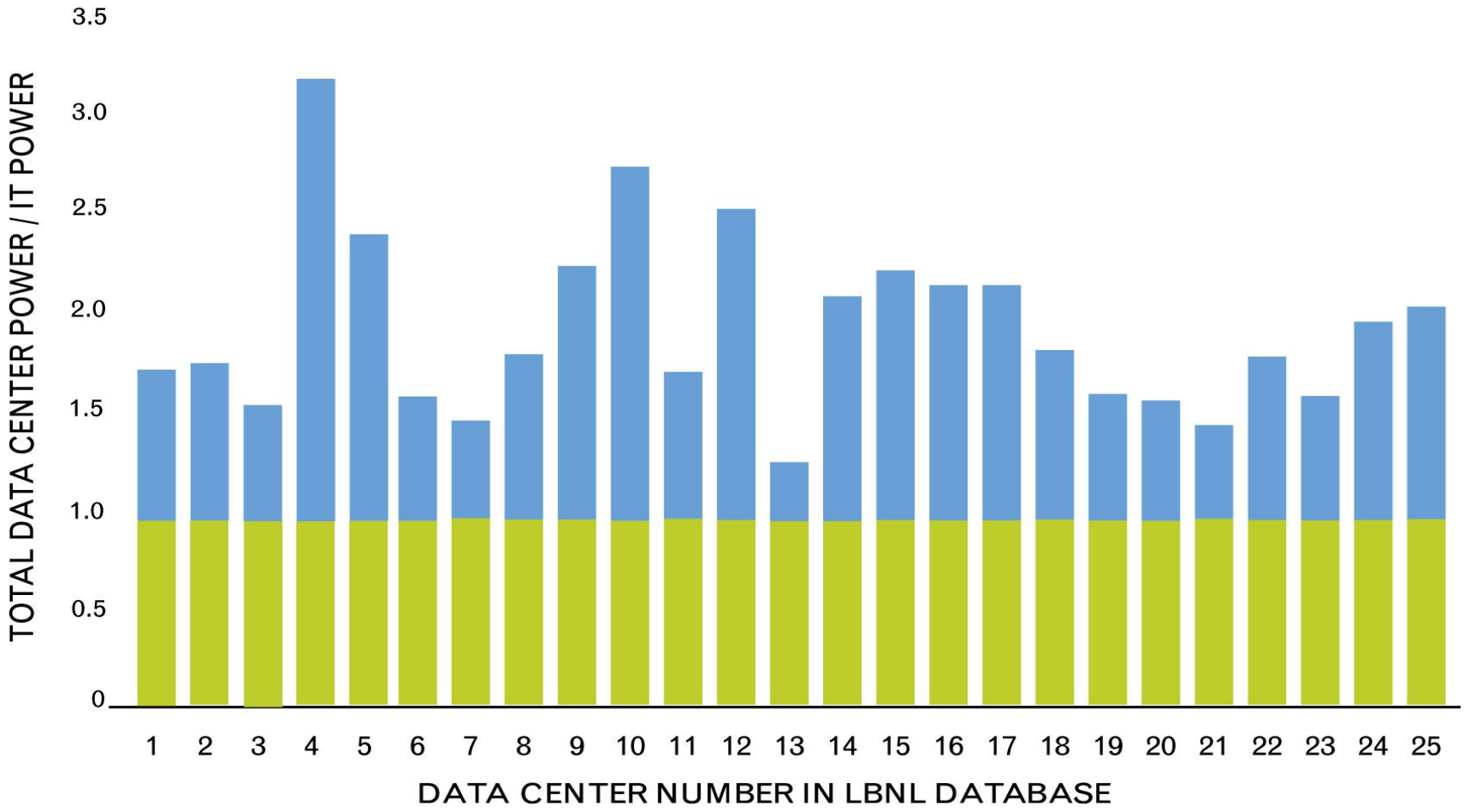
Benchmarking Energy Performance: So What is PUE?





High Level Metric: PUE

Power Utilization Effectiveness (PUE) = Total Power/IT Power



Sample PUEs

PUEs: Reported & Calculated	PUE
EPA ENERGY STAR Average	1.91
Intel Jones Farm, Hillsboro	1.41
T-Systems & Intel DC2020 Test Lab, Munich	1.24
Google	1.16
Leibniz Supercomputing Centre (LRZ)	1.15
National Center for Atmospheric Research (NCAR)	1.10
Yahoo, Lockport	1.08
Facebook, Prineville	1.07
National Renewable Energy Laboratory (NREL)	1.06

Source: Mike Patterson, Intel

Data Center Best Practices

1. Measure and Benchmark Energy Use
2. Identify IT Opportunities, and modify procurement processes to align with the procurement policy
3. Optimize Environmental Conditions
4. Manage Airflow (Air Management)
5. Evaluate Cooling Options
6. Improve Electrical Efficiency
7. Use IT to Control IT Energy

DOE and Utility Collaboration

- Federal efforts are resource constrained and cannot achieve significant market penetration on their own

  ➔ Key goal: leverage DOE and utility resources

- Initiated Strategic Plan in FY16
- FY17-18 activities:
  - Utility webinar on resources and partnering opportunities
  - Cost-sharing demonstration projects (targeting 2-3) for prescriptive air management “packages” for small data centers
  - White paper on demand response in data centers

Utilities

- Customer-facing efficiency programs
- A number of measures targeted through existing programs

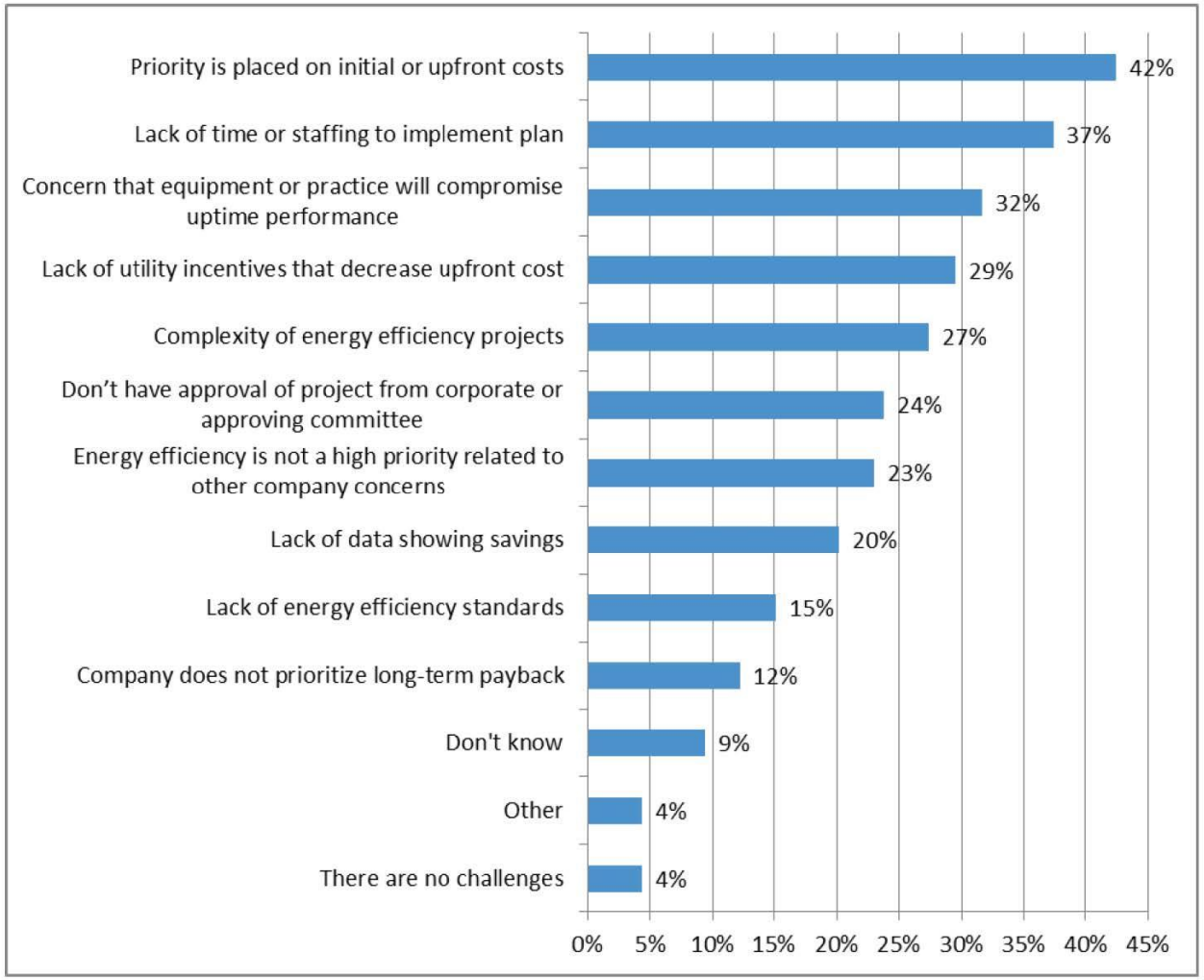
Virtualization	ENERGY STAR Server	Massive Array of Idle Disks	Uninterruptible Power Supply	Chillers/Cooling Towers	Thermal Energy Storage	Storage Consolidation	Airflow

Airflow	Variable Frequency Drive	Air-Side Economizer	Water-Side Economizer	Pumps/Motors	HVAC/CRAC	DC Power

Source: Environmental Protection Agency. 2012.

- Existing efforts often have low market penetration and savings- Federal data centers appear to be particularly under-served.
- Utility efforts are embedded in the marketplace but require technical resources and independent expertise.
- Utilities often find the existing technical information and literature complicated for their customers and “C-suite” audiences.

Barriers to Data Center Energy Efficiency Projects



Source: Cadmus, et al. 2015 for NYSERDA.

By working more closely, Department of Energy (DOE) and utilities can be more responsive to the barriers perceived by data center managers.

Strategy Overview

•DOE/LBNL and utilities can act as "honest brokers," providing credible third-party expertise. DOE efforts to-date have not focused on utility needs.

- **2016 report prepared by LBNL**
  - Interviews with representatives from 16 utilities
  - Literature review and applied knowledge from LBNL's related work
- **Seven strategies identified for DOE/LBNL and utilities to raise the energy efficiency of data centers. Goals:**
  - More accessible information and tools
  - Reach broader audience, including less-sophisticated users
  - Expand scope to include "softer" topics such as business-case analysis
  - Positive influence on regulatory process and decisionmaking (e.g. technologies allowable in programs).
- **Can formalize strategy through a collaborative framework**
  - Freestanding consortium or integrate efforts within an existing group

1. Expand audience of the Center of Expertise

Challenge: Strategic utility personnel often unaware of resources available from the Center of Expertise (CoE)

DOE/LBNL

- Tailor tools, best practices, and training for underserved groups such as small data center operators, utility customer representatives, senior managers, and others lacking deep background in data centers
- Reach broader audiences by publishing material in new places (e.g. business press)

Utilities

- Send staff to CoE trainings
- Incorporate pointers to CoE resources in customer-facing communications
- Provide view of market segmentation
- Customize CoE material to individual target audiences

2. Shift from emphasis on information "pull" to "push"

Challenge: Few people visit websites unprompted.

DOE/LBNL

- "Push" users to visit the CoE through email, social media, newsletters, and/or webinars
- Give more frequent and targeted presentations through:
  - Utilities
  - Consortium for Energy Efficiency (CEE)
  - Federal Utility Partnership Working Group (FUPWG)
  - Trade associations such as the Green Grid and ASHRAE

Utilities

- Engage customers in CoE's information streams

3. Support DOE deployment programs

Challenge: Limited utility awareness of DOE's programs.

DOE/LBNL

- Further promote DOE deployment programs (e.g. the Better Buildings Challenge and the Data Center Accelerator)
- Further promote the Federal Utility Partnership Working Group (FUPWG)

Utilities

- Engage the CoE to identify and approach promising data centers in service territory
- Provide support to partners/customers (measure identification, metering plans, reporting, etc.)

4. Help utilities make the case for robust market interventions

Challenge: Low market penetration of existing programs and under- or misinformed regulators.

DOE/LBNL

- Leverage recent national market assessment and tailor to local conditions
- Ensure proper treatment of retrofit as well as new-construction applications
- Act as an "honest broker" to increase regulators' level of competence including tailored trainings, state-level market assessments, and technical "White Papers" used to vet program proposals:
  - National regulatory entities such as National Association of Regulatory Utility Commissioners (NARUC)
  - FERC
  - NERC
  - ISOs
  - State/regional energy offices (individually and/or via NASEO)

Utilities

- Identify needs, helping DOE/LBNL establish priorities
- Share successes via CoE, FUPWG, and CEE
- Promote utility-branded versions of DOE resources
- Focus on new-construction in relevant markets (e.g., Northwest)
- Increase competency of non-datacenter account managers to address datacenters embedded in a diversity of "ordinary" buildings

5. Provide more comprehensive and relevant characterization of benefits

Challenge: Current efforts emphasize energy benefits while bigger drivers may be non-energy benefits.

DOE/LBNL

- Emphasize economics and non-energy benefits such as reliability (both within facilities and at the grid level) in CoE projects
- Address institutional barriers (e.g. IT staff vs. Facility staff needs)

Utilities

- Educate customers (end-users) with the goal of increasing perceived value of data center energy efficiency and program participation

6. Keep up with a changing technical landscape

Challenge: Emerging issues and opportunities such as demand response, smaller embedded data centers, liquid cooling, retro-commissioning, and waste-heat recovery need to be addressed.

DOE/LBNL

- Ensure core work on best practices, trainings, and tools keep pace, including updating already produced material
- Expand definition of best practices beyond technologies to management practices, standardized savings-calculation methods, downsized/partially-loaded datacenters, project quality assurance, finanical analysis, etc.

Utilities

- Identify gaps in the existing CoE offerings
- Help set priorities for the targeting of existing federal resources

7. Address practical aspects of implementation

Challenge: Utilities seek to go beyond defining idealized outcomes, i.e., to help customers in implementation in the context of practical constraints and challenges.

DOE/LBNL

- **Help utilities address challenges, such as:**
  - Harmonizing energy efficiency with fire codes
  - Coping with downsizing
  - Practical issues of metering and collecting data for computing PUEs
  - Helping customers perform cost-benefit analyses
  - Educating regulators.

Utilities

- **Promulgate new guidelines related to challenges**

Next Steps: Utilities

- **Encourage data center customers to participate in DOE & EPA programs**
- **Create forums for customers to share best practices and lessons learned**
- **Utilize CoE tools and resources with customers to improve efficiency**
  - Assist customers to benchmark energy performance of their data centers
- **Sponsor training opportunities**
  - Data Center Energy Practitioner (DCEP) training and certification
  - Awareness workshops
  - Webinars
- **Support demonstration/showcase projects**
  - Retrofit their own data centers – lead by example
- **Target federal data center customers with Utility Energy Service Contacts (UESCs)**
- **Fund efforts through a collaborative framework**

Next Steps: DOE/LBNL

- **Initiate 2-3 demonstrations of prescriptive retrofit packages for small data centers.**
  - Cost sharing with 1-3 utilities (and their customers).
  - Federal customers will be targeted, but there may be a mix
  - Builds on work underway with PG&E
- **Develop and host an annual webinar targeting utilities**
  - Describe overall opportunities and trends in the rapidly changing data center industry
  - Describe current projects and resources
- **Develop data center demand response white paper**

Example: Prescriptive Air Management "Packages" for Small Data Centers

- "Small" data centers (<5,000 ft^2) use ~50% of all energy used in data centers[1]
- Majority of energy saving potential, best opportunity
- … but a number of barriers:
  - Difficult to find (embedded)
  - Difficult to engage
  - Limited expertise
  - Limited resources
  - Limited savings for each individual data center.

•1) Shehabi, A. et al, 2016. U.S. Data Center Energy Usage Report.

Current Work at PG&E

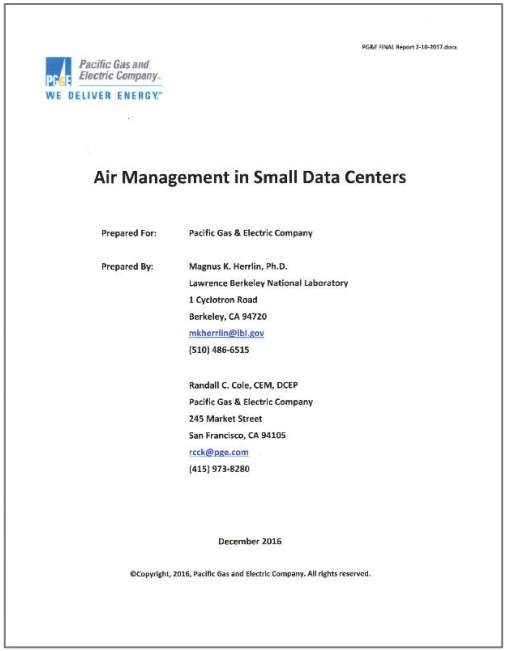
- Virtually all data center energy savings incentives currently offered to PG&E customers are using custom new construction or retrofit calculated programs
- Custom calculations are costly and not feasible to reach small imbedded data center market
- Focus on air management as a potential deemed opportunity for small data centers at reasonable program implementation cost.

Current Work at LBNL

- Focus on saving energy in small data centers
- Focus on air management
- Survey of portable air management monitoring tools
- Developing “packages” of air management measures.
- Center of Expertise for Energy Efficiency in Data Centers: http://datacenters.lbl.gov
- Reports, software, training,…

Potential Solution

- Develop prescriptive “packages” of air management measures through modeling.
- Methodology:
  - Select typical small data center
  - Select simulation tool
  - Select packages
  - Determine energy savings.



PG&E FINAL Report 2-16-2017.docx

Pacific Gas and Electric Company
WE DELIVER ENERGY

Air Management in Small Data Centers

Prepared For: Pacific Gas & Electric Company

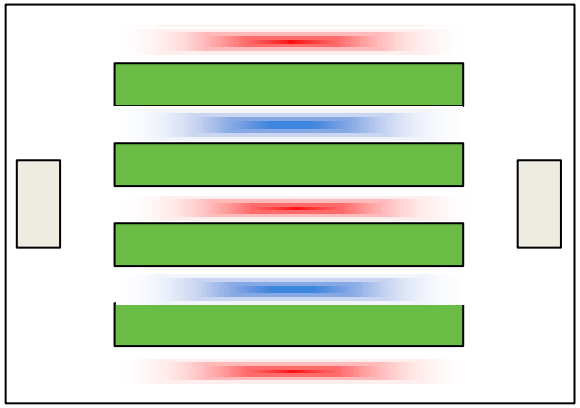
Prepared By:
Magnus K. Herrlin, Ph.D.
Lawrence Berkeley National Laboratory
1 Cyclotron Road
Berkeley, CA 94720
mkherrlin@lbl.gov
(510) 486-6515

Randall C. Cole, CEM, DCEP
Pacific Gas & Electric Company
245 Market Street
San Francisco, CA 94105
rcck@pge.com
(415) 973-8280

December 2016

Selection of "Typical" Small Data Center

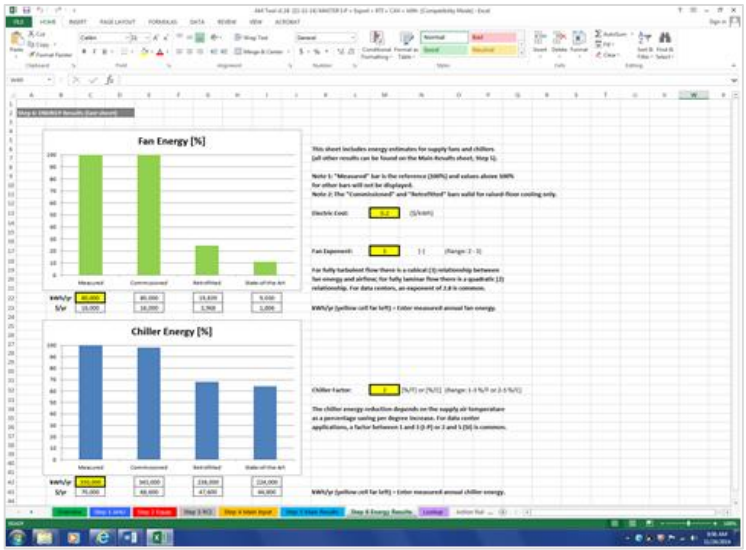
- 2000 ft^2
- **60 IT racks in 4 rows**
- **Raised floor, hot and cold aisles**
- Two 30-ton CRACs or three 20-ton CRACs
- CAV or VAV fans
- **82 kW IT equipment power**
- **25F temperature rise**
- **Embedded.**



Plan view of data center with four rows of IT racks

Selection of Simulation Tool

- Reviewed two tools: The DOE Air Management Tool and the Airflow Management Calculator.
- Both have pros and cons; quite complementary
- The DOE Air Management Tool allows manipulation of individual air management measures.



Selection of Packages

- Addressed most common individual measures
- Start with inexpensive, but effective measures

AM-Measure (AM Tool)	Reference	P1	P2	P3	P4	P5
#1: Recommended Range[1]	65-80°F	65-80°F	65-80°F	65-80°F	65-80°F	65-80°F
#2: Allowable Range[2]	N/A	N/A	N/A	N/A	N/A	N/A
#3: Aisle Containment	L	L	L	M	M	H
#4: Blanking Panels	L	M	M	M	H	H
#5: Floor Leakage	L	M	M	M	M	H
#6: Tile Placement	L	M	H	H	H	H
#7: EC-Class	H	H	H	H	H	H
#8: CAV/VAV (CRAC)	CAV	CAV	VAV	CAV	VAV	VAV
#9: CRAC Modularity	M (2) or H (3)	M (2) or H (3)	M (2) or H (3)	M (2) or H (3)	M (2) or H (3)	M (2) or H (3)
#10: Cable Management	L	L	L	L	M	M

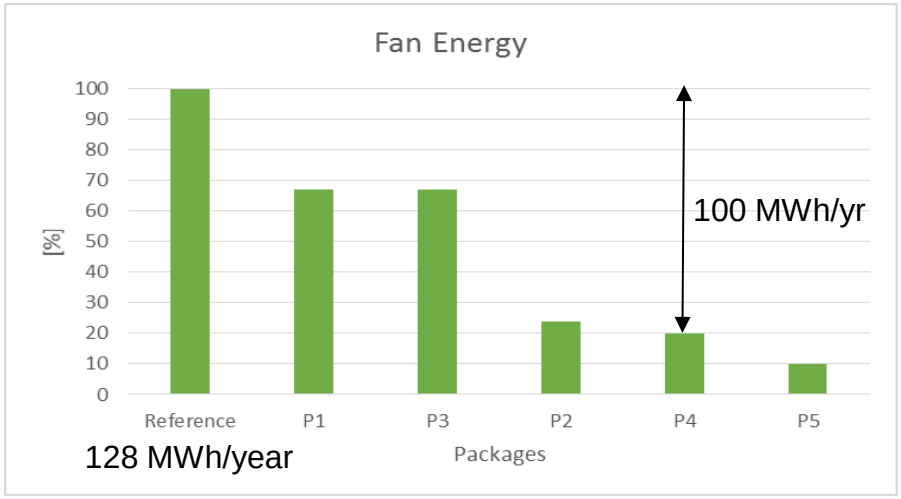
[1] The ASHRAE Recommended Range is used throughout.
[2] The ASHRAE Allowable Range does not enter the energy calculations.
Level of quality/implementation: L: Low, M: Mid, H: High.

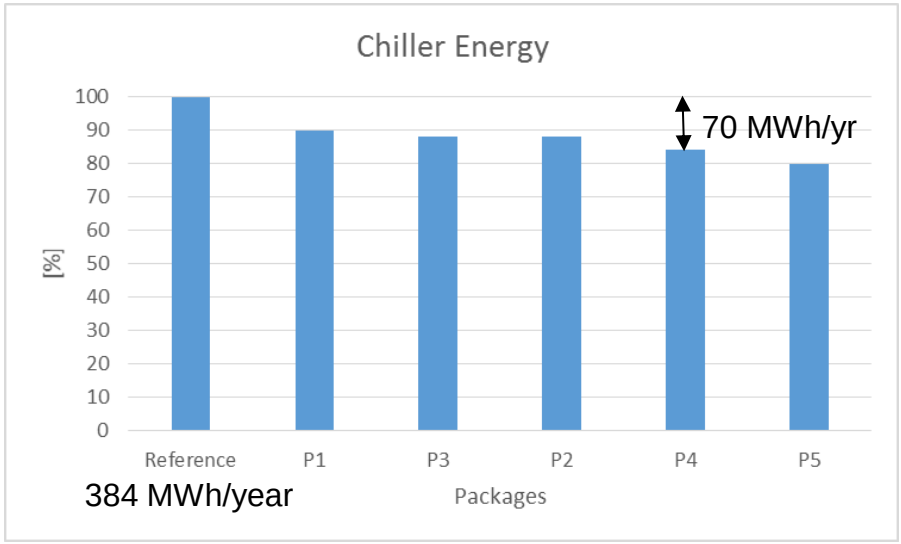
Determine Energy Savings

- Run each package through the simulation tool
  - Determine the increase in supply temperature
  - Determine the decrease in supply airflow
  - Determine chiller energy savings
  - Determine the supply fan savings.

Results

- Developed 6 packages
- Estimated savings
- Roadmap for selecting:
  - Matched data center
  - Target data center
  - Rebates.





Need for Simple, Inexpensive Air Management Monitoring Tools

- Access to simple, inexpensive tools for tracking air management is imperative. Many advanced monitoring systems are often too complex and expensive for small data centers.
- We looked at three portable tools that can be brought into the data center for checking the thermal conditions. We will demonstrate all three in a live data center in 2017 with funds from the Federal Energy Management Program (FEMP).

Selected Portable Air Management Monitoring Tools

Purkay Labs,
Audit-Buddy

Geist, Watchdog 15

PacketPower

Next Steps

- Demonstration project for the packages (2017/18)
- Demonstration project for the portable tools (2017)
- Methodology to find & engage the small data center
- Determine the generalized costs for the packages
- Develop deemed savings

DOE's Center of Expertise

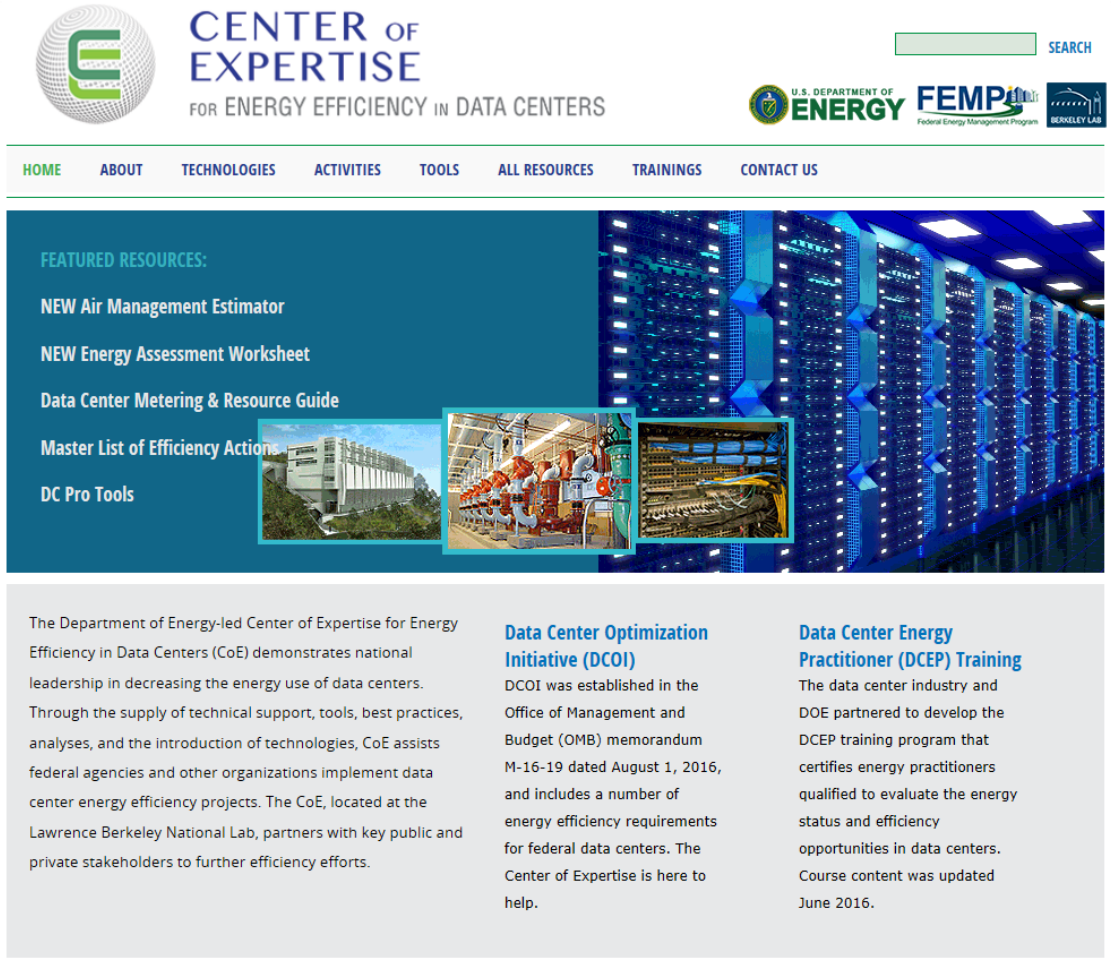
Datacenters.lbl.gov

Navigation

Search

Featured Resources

Featured Activities



Technologies

Cooling Air / Air Management

Technologies, example

Cooling Air / Air Management

In most cases, air distribution in data centers involves mixing of cooled air with air that has been heated by the IT equipment making it difficult to supply the cool air to where it is needed and resulting in inefficient heat transfer to the cooling system.

Poor air management leads to more air being circulated than required, which leads to air mixing and short circuiting. It also results in recirculated hot air, which is the cause of most host spots.

HIGH-LEVEL BEST PRACTICES

- Install the Racks in Rows
- Implement Hot and Cold Aisles
- Preserve Any Hot-Aisle/Cold-Aisle Arrangements
- Rearrange Perforated Floor Tiles, Locating Them Only in Cold Aisles and Matching the Tile Flow Rate with the IT Equipment Airflow Rate
- Cover Openings Within and Between Racks
- Evaluate the Air Path (Under the raised floor or in the ceiling space) and Rearrange the Cables, Wires, and Pipes to Address Possible Congestion in the Cooling Air Path
- Seal the Remainder of the Cable Penetrations
- Separate Cold Air and Hot Air
- Shut Off Extra CRAC/CRAH/AHU
- Reset Each CRAC/CRAH/AHU Chilled Water Valve Setpoint with the Highest Air Intake Temperature at the Racks in that Zone
- Convert the Data Center CRAC/CRAH/AHU Air Temperature Control to the Rack Inlet Air Temperature Control
- Use Modeling Tools such as CFD or Thermal Imaging Install Variable Frequency Drives (VFDs) on CRAC/CRAH/AHU Fans with Advanced Control

FEATURED RESOURCES

- Data Center Master List of Efficiency Actions provides more information on the high-level best practices outlined above as well as a more detailed list of best practices related to cooling air and air management.
- The excel-based Data Center Air Management Tool provides air management recommendations (actions) and the potential for reducing the supply airflow rate and increasing the supply air temperature without affecting the thermal equipment environment. The Tool also estimates % energy reduction, kWh reduction, and associated $ savings for fans and chillers. It is based on user input. An accompanying Data Collection Guide is also available.

Links:

Data Center Master List of Efficiency Actions
Data Center Air Management Tool
Datacenter Air Management Tool Data Collection Guide
All Air Cooling / Air Management Resources

Activities

HOME | ABOUT | TECHNOLOGIES | ACTIVITIES | TOOLS | NEWS & TRAINING | RESOURCES | CONTACT US

Data Center Energy Practitioner (DCEP) Training

All Activities
DCEP Training
DCOI
Tools
Small Data Centers
India
China
Better Buildings
High Performance Computing
Partnerships and Collaboration
Related FEMP Activities

Activities

CoE facilitates activities that range from training sessions and webinars, to the creation of tools, to specialized programs.

Data Center Energy Practitioner (DCEP) Training
The DCEP training program certifies energy practitioners qualified to evaluate the energy status and efficiency opportunities in data centers. A list of DCEP Program Developers, Instructors, and Practitioners is also maintained and available here.
[Edit]

Data Center Optimization Initiative (DCOI)
The Data Center Optimization Initiative (DCOI) requires federal agencies to develop and report on data center strategies to consolidate inefficient infrastructure, optimize existing facilities, improve security posture, achieve cost savings, and transition to more efficient infrastructure, such as cloud services and inter-agency shared services.
[Edit]

Training
List of upcoming and on-demand training events and news via our Twitter feed. Content is focused on information and opportunities to facilitate energy efficiency projects in data centers with special attention paid to resources for federal agencies.
[Edit]

Tools
Toolkits and calculators are available to support the implementation of best practices. Tools cover areas such "early stage" data center profiling to establish a baseline and efficiency potential, and more detailed sub-system assessments to identify opportunities.
[Edit]

Small Data Centers
Energy efficiency efforts and attention for data centers have historically focused on larger data centers. Despite their comparatively small size, small data centers (defined as server closets, rooms, and localized data centers under 5,000 square feet of computer floor) have significant energy savings potential.
[Edit]

India
The energy intensity of data centers, the growth of data center infrastructure in India, and the existing power deficit in the country calls for increased energy efficiency in Indian data centers. A public-private partnership is working to increase the energy efficiency of data centers in India.
[Edit]

China
Unprecedented demand and policies are driving rampant growth in data centers throughout China. Asia is experiencing 27% data center growth- which is expected to last through 2020. This is over two times the growth rate of other regions, and is dominated by China (Data Center Dynamics, Shanghai 2017). DOE and LBNL are working with China's Ministry of Industry and Information Technology (MIIT) and industry to promote open standards, test procedures, specifications, and evaluation metrics for U.S. and Chinese data centers.
[Edit]

Better Buildings Data Center Partners (Challenge or Accelerator)
DOE is working with public and private building owners to reduce energy use in data centers. There are over 34 partners committed to date through the Better Buildings Challenge and Data Center Accelerator programs.
[Edit]

High Performance Computing
Demand for High Performance Computing (HPC) is growing in both the public and private sectors. It is also highly energy-intensive. LBNL has organized a HPC Working Group to address the energy-efficiency issues related to these technologies and provides guidance and resources tailored to HPC.
[Edit]

Related FEMP Activities
A number of activities supported by the Federal Energy Management Program (FEMP) assist in making data centers more energy efficient. These activities and accompanying resources include the purchase of energy- and water-efficient products, project financing, and institutional change for sustainability.
[Edit]

Partnerships & Collaboration
Utilities and state energy offices are critical partners in disseminating energy efficiency information, opportunities, and incentives for the marketplace.
[Edit]

Partnerships & Collaboration Page with resources geared towards utilities

Activities, example: DCEP Program

http://datacenters.lbl.gov/dcep

Activities, example: Partnerships & Collaboration

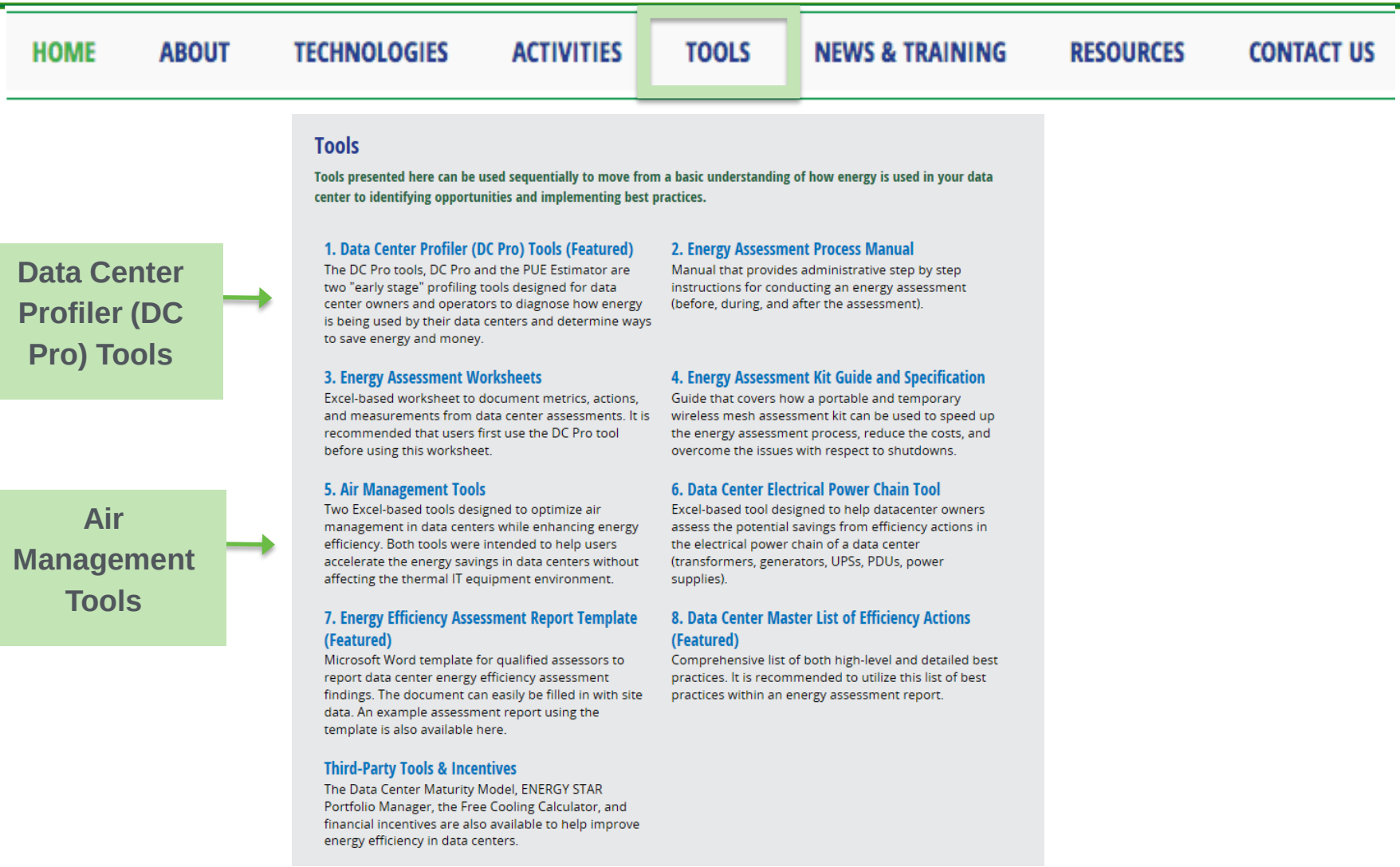
https://datacenters.lbl.gov/partnerships-collaboration

DCEP Federal Requirements

Memorandum M-16-19 (OMB and DCOI) states:

Implementing Instructions [for Executive Order 13693] advise that **“all existing and new data centers shall have at least one certified Data Center Energy Practitioner (DCEP) assigned to manage its performance.”**

Tools



Data Center Profiler (DC Pro) Tools

Air Management Tools

Tools, example 1: DC Pro Tool

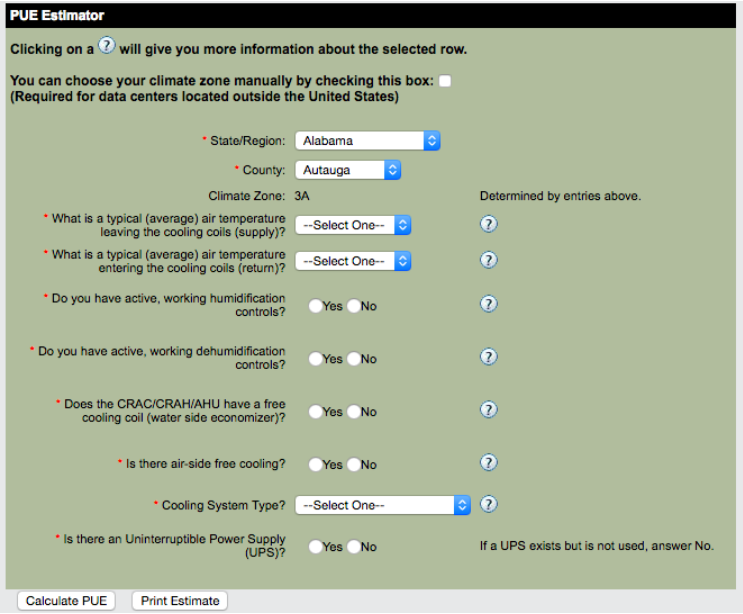
DC Pro Tools estimate PUE without sub-metering

DC Pro

DC Pro estimates current and potential PUE and energy use distribution. DC Pro also provides tailored recommended actions to start improvement process.

PUE Estimator, simplified DC Pro

PUE Estimator only asks questions that affect current PUE and does NOT provide potential PUE or recommended actions.



PUE Estimator tool input screen

http://datacenters.lbl.gov/dcpro

Tools, example 2: Air Management Tool

5. Air Management Tools

Data Center Air Management Tool: The Air Management Tool was developed to accelerate energy savings in data centers without affecting the thermal IT equipment environment by assessing the data center air-management status.

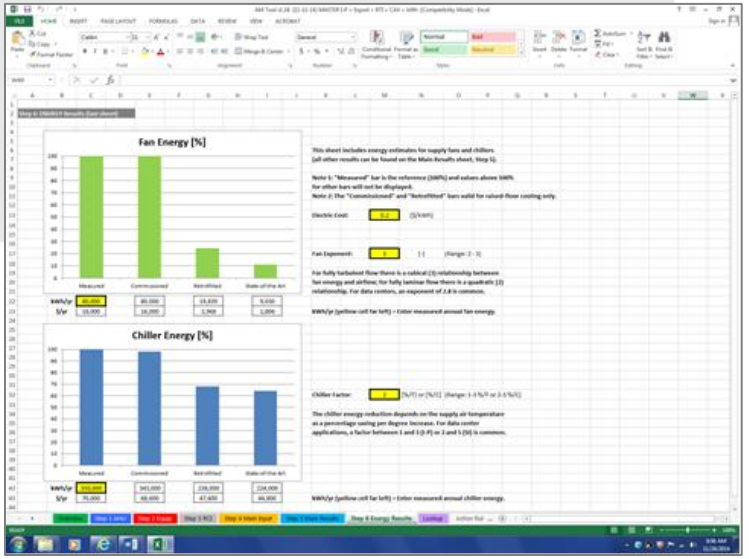
- Data Center Air Management Tool User Manual
- Data Center Air Management Tool Engineering Reference
- Data Center Air Management Tool Data Collection Guide

NEW Data Center Air Management Estimator: The Air Management Estimator is a simplified version of the Air Management Tool that uses the same engine. The input options in this tool have been reduced in favor of increased clarity.

- Data Center Air Management Estimator Tool User Guide

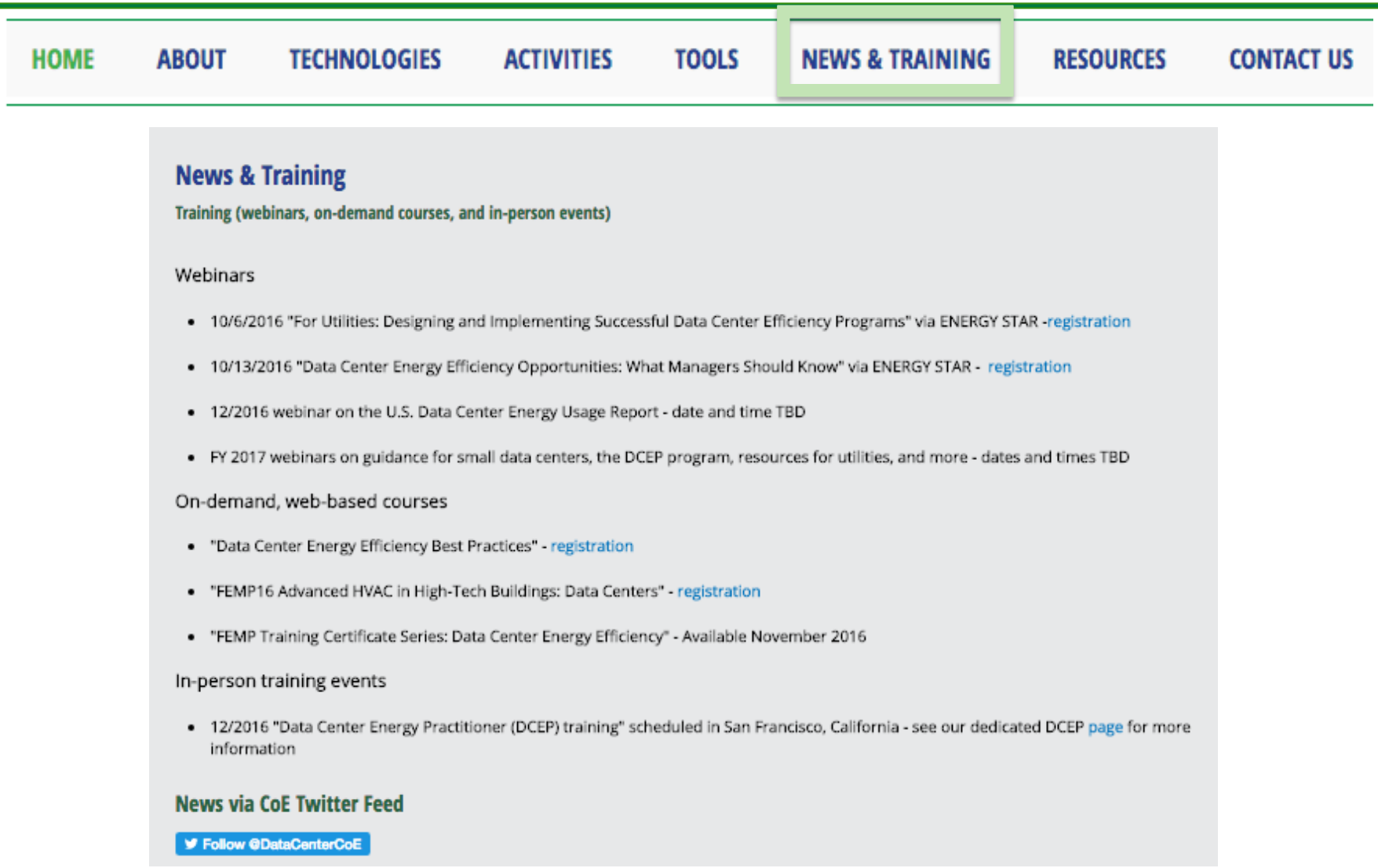
Files:

Air Management Tool v1.18.xls
AM Estimator Version 1-0.xls

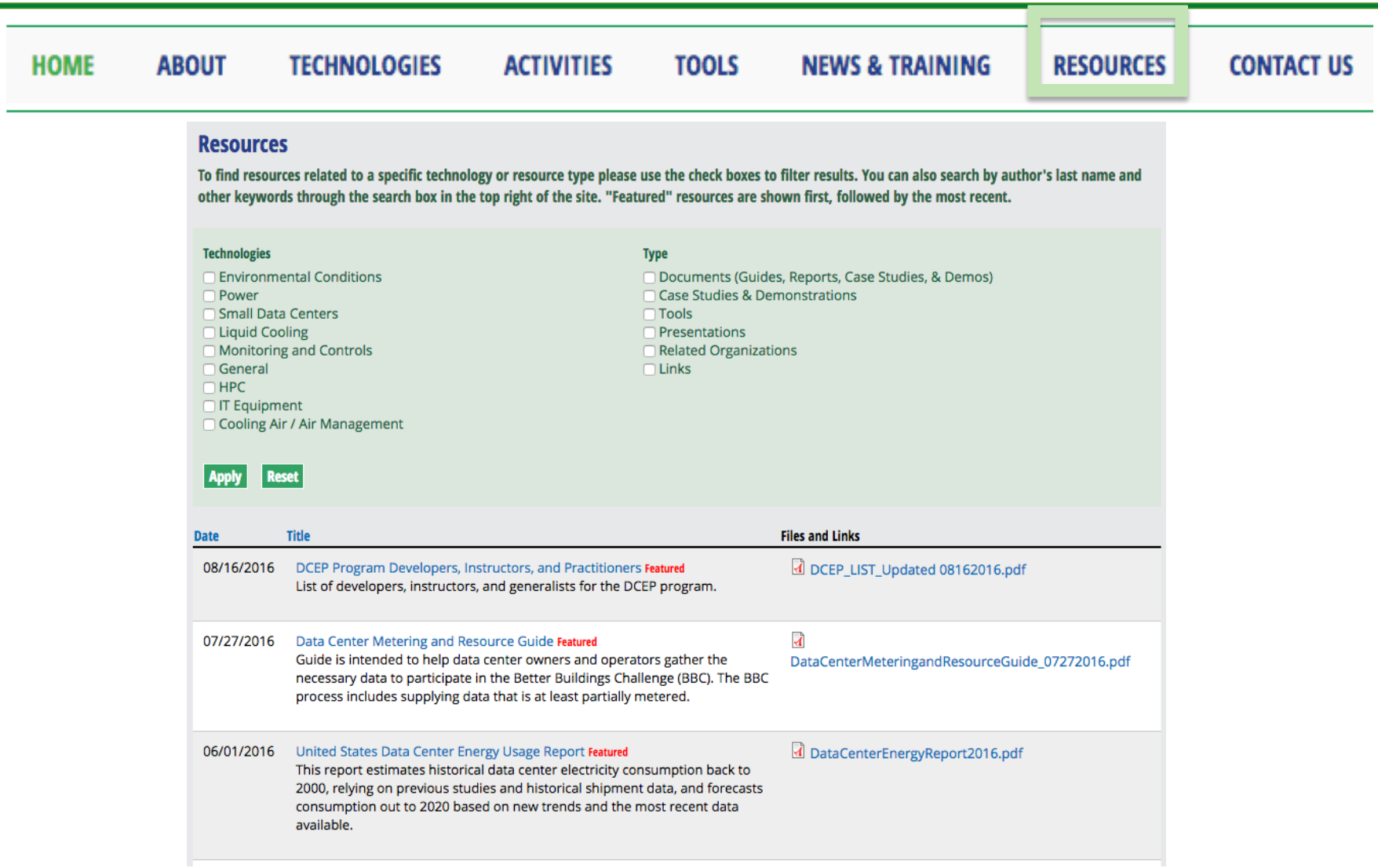


Tool output with fan and chiller energy savings

News and Training



Resources


HOME
ABOUT
TECHNOLOGIES
ACTIVITIES
TOOLS
NEWS & TRAINING
RESOURCES
CONTACT US
Resources
To find resources related to a specific technology or resource type please use the check boxes to filter results. You can also search by author's last name and other keywords through the search box in the top right of the site. "Featured" resources are shown first, followed by the most recent.
Technologies
Environmental Conditions
Power
Small Data Centers
Liquid Cooling
Monitoring and Controls
General
HPC
IT Equipment
Cooling Air / Air Management
Type
Documents (Guides, Reports, Case Studies, & Demos)
Case Studies & Demonstrations
Tools
Presentations
Related Organizations
Links
Apply
Reset
Date
Title
Files and Links
08/16/2016
DCEP Program Developers, Instructors, and Practitioners Featured
List of developers, instructors, and generalists for the DCEP program.
DCEP_LIST_Updated 08162016.pdf
07/27/2016
Data Center Metering and Resource Guide Featured
Guide is intended to help data center owners and operators gather the necessary data to participate in the Better Buildings Challenge (BBC). The BBC process includes supplying data that is at least partially metered.
DataCenterMeteringandResourceGuide_07272016.pdf
06/01/2016
United States Data Center Energy Usage Report Featured
This report estimates historical data center electricity consumption back to 2000, relying on previous studies and historical shipment data, and forecasts consumption out to 2020 based on new trends and the most recent data available.
DataCenterEnergyReport2016.pdf

Questions

Dale Sartor, P.E.
Lawrence Berkeley National Laboratory
MS 90-3111
University of California
Berkeley, CA 94720

DASartor@LBL.gov
(510) 486-5988
http://datacenters.lbl.gov/

Magnus Herrlin, Ph.D.
Lawrence Berkeley National Laboratory
MS 90-3111
University of California
Berkeley, CA 94720

MKHerrlin@LBL.gov
(510) 486-6515

Certificate of Completion

Attention Participants

In order to receive a certificate of completion, you **must** fill out the FEMP workshop evaluation form.

Access the FEMP workshop ***evaluation form*** and ***certificate of completion*** using this link:

https://fempcentral.energy.gov/Training/EventRegistration/EvaluationForm.aspx