U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

# Introducing the Data Center Energy Efficiency Kit

## A Suite of Tools for Diagnosing and Improving Energy Use

August 4, 2020


FEMP Federal Energy Management Program

# Webinar Logistics

- This webinar is being recorded. The Q&A section will not be made publically available.
- Your phone will be muted throughout the webinar.
- Enter any questions in the Question Box throughout the webinar.
- Instructions to take the quiz will be provided at the end of webinar.
- Slides will be sent out afterwards to those who attend the entire webinar.

# Today's Speakers

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CENTER OF EXPERTISE
FOR ENERGY EFFICIENCY IN DATA CENTERS

# Webinar Agenda

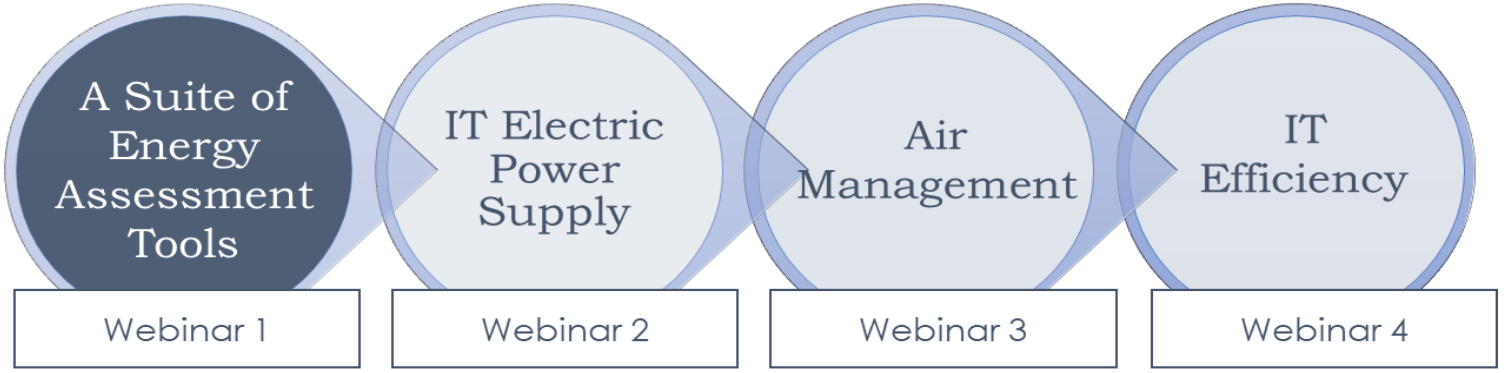
| Agenda | |
|---|---|
| I. | Introduction |
| II. | Need for a Data Center Energy Efficiency Kit |
| III. | What the DC EE Kit Is: Components, Functions, Use Cases |
| IV. | Resources and Q&A |

## Learning Objectives

- Educate data center stakeholders in the DOE energy assessment process and about assessment tools and their uses--as key instruments of an energy self assessment and for deeper dives into each data center subsystem (e.g., electric power, air management, cooling, servers, and other IT);
- Acquaint stakeholders with some energy conservation measure examples that frequently arise from an assessment and the outputs of some of the tools (e.g., energy and cost savings and payback periods);
- Illustrate synergies and trade offs between energy efficiency and redundancy--analyses that are helpful in deciding when and how to consolidate or move workloads to the cloud;
- Educate data center stakeholders about how the toolkit and energy assessment process can produce concrete plans of action and budgets and engender institutional support for retrofits and energy-efficient procurements

# First in a Four-Webinar Series

The next three webinars will take deeper dives into specific system-level tools and use cases.




**Webinar 2: Electric Power Supply**
Thursday, September 10 from 1:00 – 2:30 pm EDT
Register Here

**Webinar 3: Air Management**
Wednesday, October 7 from 2:30 – 4:00 pm EDT
Register Here

# Energy Exchange – August 10-14

Register Today!

- August 10-14
- More than 40 accredited training session
- Virtual trade show
- Technology pavilion
- Virtual building tours


| Recommended Live Sessions | |
|---|---|
| Tuesday, August 11 | Achieving Resilience in Financed Projects (Track F) |
| Wednesday, August 12 | Proven Methods to Overcome Key Challenges During Project Development (Track F) |
| Thursday, August 13 | Empowering Stakeholders Across the Nexus (Track B) |
| Friday, August 14 | Resilience Strategies to Action (Track B) |

# Need for a Data Center Energy Efficiency Kit

# Need for a Data Center Energy Efficiency Kit

- Federal agencies, building owners, and stakeholders need publicly available, open, and flexible tools for understanding their data centers in order to:
  - Quantify energy use
  - Identify potential energy saving measures
  - Develop energy management systems and action plans
  - Design new/expanded facilities for consolidation and future capacity
  - Comply with federal energy and optimization requirements (e.g., DCOI)
- Excel-based tools are unlocked – users can examine the underlying data and assumptions

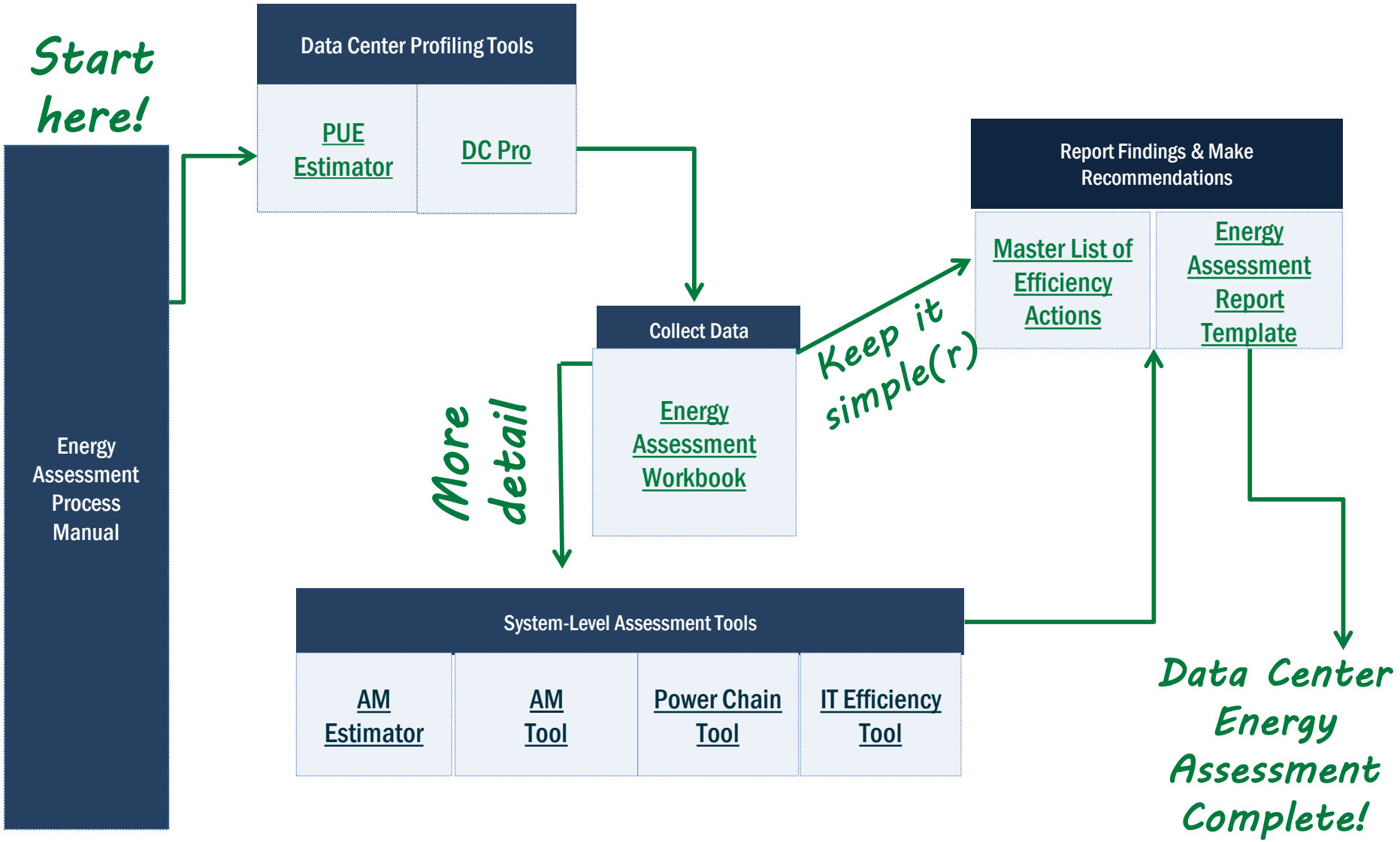
## CoE Data Center Energy Efficiency Toolkit

# What the DC EE Kit Is: Components and Functions

# What is the Data Center Energy Efficiency Toolkit?

- **A publicly available suite of tools for data center energy assessment:**
  - Data collection
  - Analysis and Benchmarking
  - Energy efficiency measure identification, description and recommendations
  - Estimated energy and cost savings and payback periods
  - Flexible, tailored reporting template
- **Multiple tool combinations and pathways available**
  - Á la carte analysis to full, all-systems data center energy assessment
  - Designed for multiple data center sizes, technologies and resources
- **First published tool in mid 2000s; several combined into a formalized energy assessment kit in mid 2010s**
- **Kit continues to evolve in capability and sophistication**
  - Major 2020 upgrades and updates with new technologies and capabilities

# CoE Data Center Energy Efficiency Toolkit



# Data Center Energy Assessment Process Manual

- **The Data Center Energy Assessment Process Manual is a launching point for an energy assessment and a step-by-step roadmap.**

- **Describes a formalized framework, roles and the process for a comprehensive energy assessment**
  - Identifies key actors: the assessor, a site lead, a site electrician, etc.
  - Exemplifies *best practices* in the conduct of an energy assessment and the relative roles of the assessor and site staff and management.
  - But the manual is still relevant to the user conducting an assessment of their own facility as a whole or just a primary system.

- **Descriptions of all tools, guides and templates and their relationships to one another**

# Data Center Profiling Tools

## DC PRO

**A comprehensive "early stage" data center profiling tool**

- Estimates PUE as well as a breakdown of the current and potential energy use distribution
- Provides a tailored list of best practice recommendations
- Exports results to PDF or Excel

## PUE ESTIMATOR

**A quick calculator that generates Power Usage Effectiveness (PUE)**

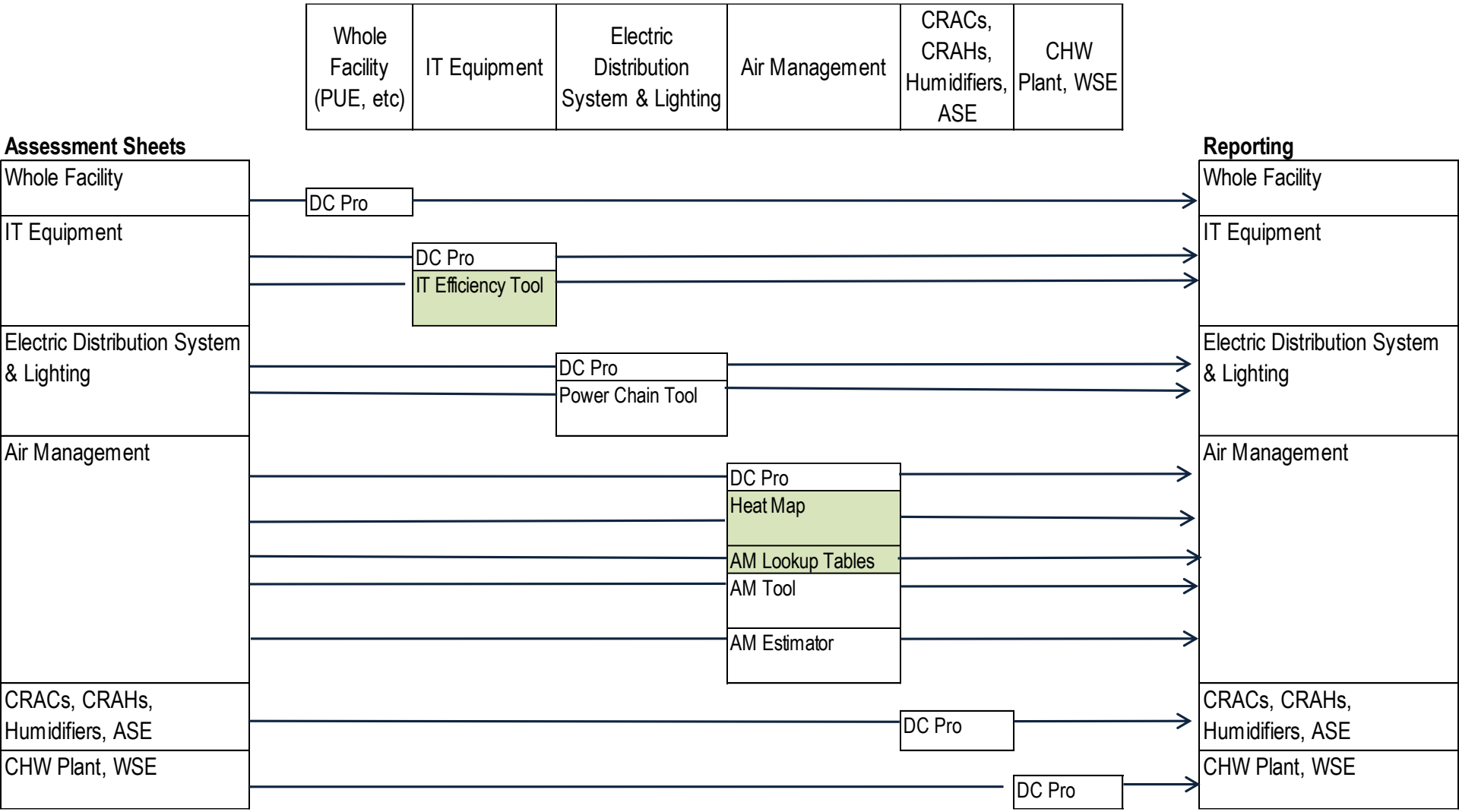
- Only asks questions required to estimate PUE
- Uses same algorithm as DC Pro
- Exports results to PDF or Excel

DC Pro and PUE Estimator can you found the CoE website.

# DC Energy Efficiency Assessment Workbook

- **System-by-system data repository**
- **Comprehensive numerical and graphical depiction of a data center's infrastructure and energy use**
- **Designed as unitary field collection tool**
  - Analytical inputs to all tools
  - Capable of standing alone
  - Supplies benchmark comparisons to other data centers
  - Most tables can be pasted directly into the Data Center Energy Efficiency Reporting Template
- **Major upgrade with Version 2**
  - Clarifies observations, measurements and calculations
  - Finer system-level resolution
  - Calculation methods and new embedded tools, e.g., AM Heat Maps

# Workbook: Data Collection, Analysis and Reporting by System

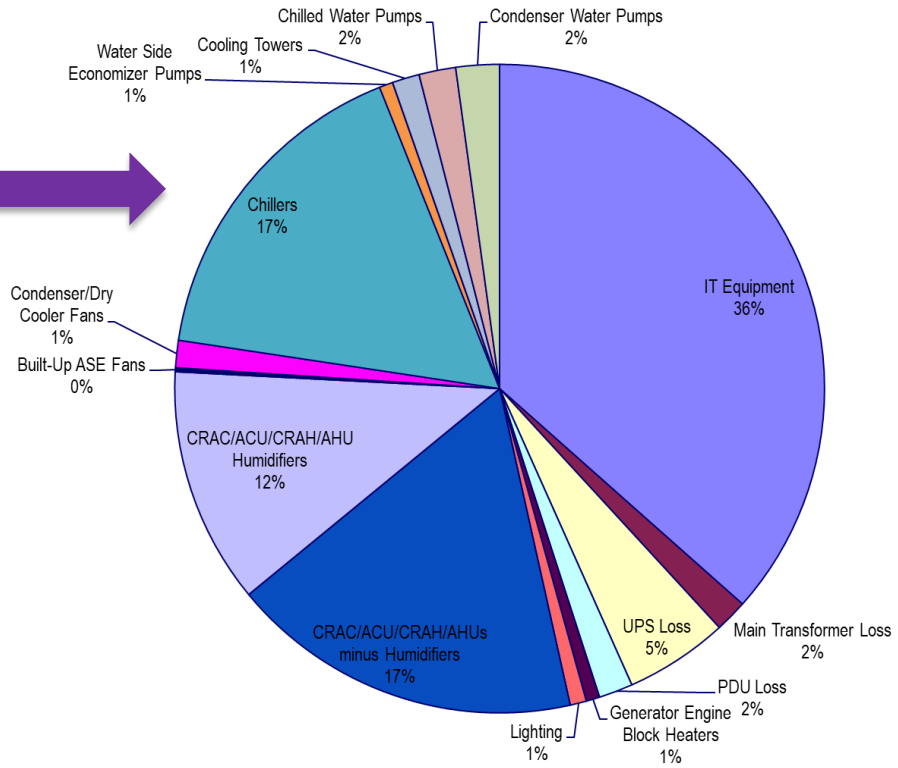


# DC Energy Efficiency Assessment Workbook

## Workbook Structure

- Instructions, Keys, Abbreviations, Sample Analysis Formats
- Whole-Facility Level
- Purchased Energy, PUE, Current Energy Use Breakouts
- Electric Distribution System
- IT Equipment
- Lighting
- Data Center Air Management
- Data Center Air Side Cooling System
- Cooling Plant
- Energy Efficiency Measures to Pursue, Projected Energy Use Breakouts

## Power Usage Effectiveness and Energy Use Breakdown

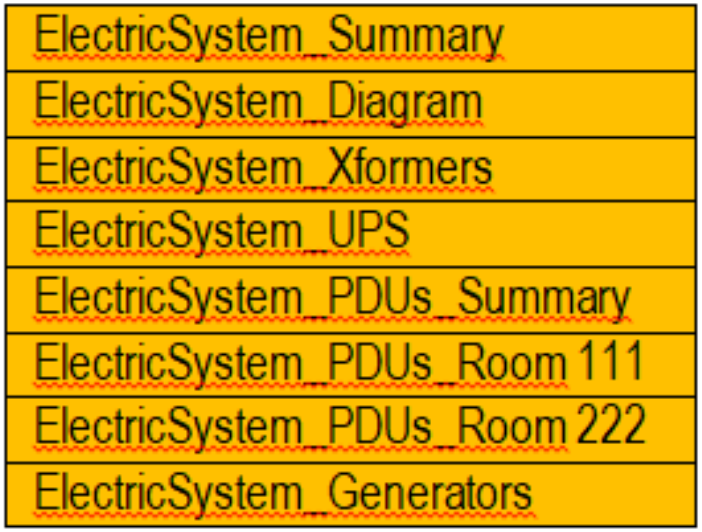


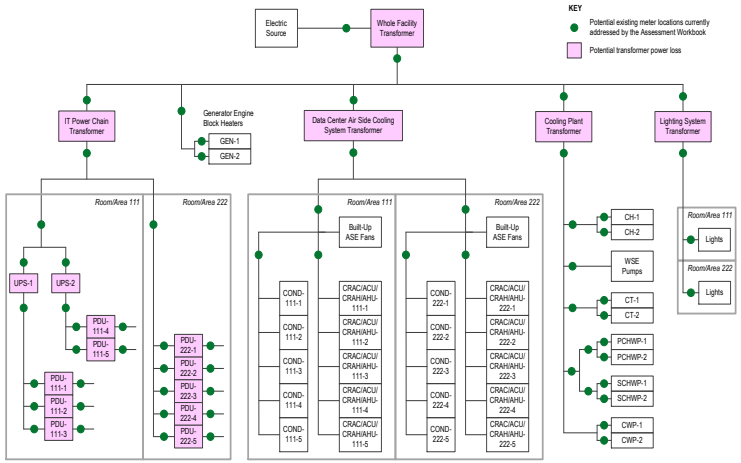

Hosted at Data Center Energy Efficiency Assessment Workbook

# DC Energy Efficiency Assessment Workbook

## Tabs by System

- Summary Tab - Total energy use and performance metrics for the given system
- Diagram Tab - Simple diagram of the system
- System Component Tabs - For example, in the Electric Distribution System section, there are separate tabs for the transformers, the UPSs and the PDUs.



# DC Energy Efficiency Assessment Workbook

## Top of Each Tab

- Instructions
- Energy Efficiency Guidance - **How to interpret your results and point to potential measures or further analysis or status quo**
  - Example: Are rack inlet temps consistent with ASHRAE 9.9 Guidelines for recommended/allowable IT equipment temperatures? Are there spots with low Delta T?

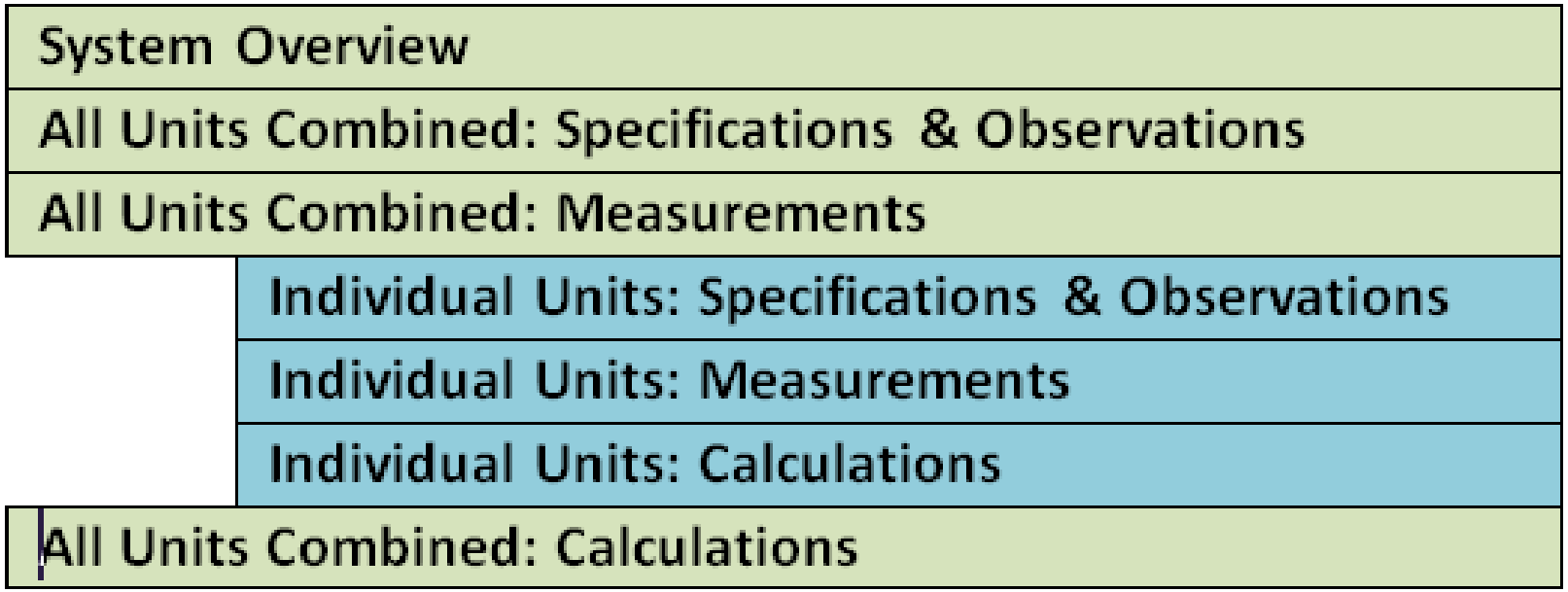
**Rack Temperature Rise (deg F)**

| Position in Row | Rack Level | Row 1 | Row 2 | Row 3 | Row 4 | Row 5 | Row 6 | Row 7 | Row 8 | Row 9 | Row 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Beginning | High | 12 | 21 | 22 | -2 | 11 | 15 | 14 | 6 | 12 | 10 |
| | Middle | 19 | 20 | 26 | -1 | 20 | 12 | 16 | 16 | 15 | 10 |
| | Low | 18 | 20 | 22 | 4 | 17 | 11 | 21 | 19 | 22 | 15 |
| Middle | High | | 20 | 16 | 11 | 13 | 4 | 25 | 23 | 26 | 15 |
| | Middle | | 21 | 21 | 15 | 5 | 3 | 26 | 20 | 23 | 19 |
| | Low | | 20 | 18 | 15 | 4 | 1 | 23 | 19 | 23 | 16 |
| End | High | | 21 | 19 | 21 | 7 | 0 | 15 | 19 | 20 | 12 |
| | Middle | | 18 | 6 | 4 | 8 | 1 | 8 | 14 | 14 | 3 |
| | Low | | 23 | 1 | 0 | 17 | 3 | 4 | 14 | 13 | 1 |

- Resources for EEMs - **Pointers to other DCEE tools that offer tailored EEM recommendations.**

# DC Energy Efficiency Assessment Workbook

## Body of Each Tab




- Workbook supports multiple server halls and multi-unit systems (multiple UPS modules, air handlers, pumps, chillers, etc.).

# DC Energy Efficiency Assessment Workbook Cont.

- **Calculations are based on one full year of operation**
  - Tabs for binned data and weather time series are provided for extrapolations.
  - Detailed directions on each calculation
- **Spot Measurements vs. Annual Profiles**
- New features include AM Heat Maps
  - Simple, color-coded diagnostic: Is air management a problem and worth a system-level analysis?

**Rack Intake and Exhaust Temperature Measurements**

| | | Row 1 | | Row 2 | | Row 3 | | Row 4 | | Row 5 | | Row 6 | | Row 7 | | Row 8 | | Row 9 | | Row 10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Position in Row | Rack Level | Hot Aisle Temp | | Cold Aisle Temp | | Hot Aisle Temp | | Cold Aisle Temp | | Hot Aisle Temp | | Cold Aisle Temp | | Hot Aisle Temp | | Cold Aisle Temp | | Hot Aisle Temp | | Cold Aisle Temp | | Hot Aisle Temp |
| | | deg F | | deg F | | deg F | | deg F | | deg F | | deg F | | deg F | | deg F | | deg F | | deg F | | deg F |
| Beginning | High | 87 | | 75 | 76 | 97 | 99 | 77 | 90 | 88 | 90 | 79 | 90 | 105 | 84 | 70 | 74 | 80 | 79 | 67 | 65 | 75 |
| | Middle | 90 | | 71 | 78 | 98 | 100 | 74 | 95 | 94 | 100 | 80 | 98 | 110 | 84 | 68 | 65 | 81 | 80 | 65 | 62 | 72 |
| | Low | 92 | | 74 | 80 | 100 | 103 | 81 | 97 | 101 | 102 | 85 | 102 | 113 | 87 | 66 | 60 | 79 | 77 | 55 | 53 | 68 |
| Middle | High | | | 79 | 80 | 100 | 105 | 89 | 93 | 104 | 108 | 95 | 113 | 117 | 88 | 63 | 55 | 78 | 75 | 49 | 48 | 63 |
| | Middle | | | 78 | 81 | 102 | 109 | 88 | 90 | 105 | 110 | 105 | 115 | 118 | 90 | 64 | 56 | 76 | 71 | 48 | 40 | 59 |
| | Low | | | 73 | 79 | 99 | 102 | 84 | 87 | 102 | 107 | 103 | 114 | 115 | 87 | 64 | 57 | 76 | 72 | 49 | 45 | 61 |
| End | High | | | | 75 | 96 | 100 | 81 | 78 | 99 | 103 | 96 | 108 | 108 | 85 | 70 | 58 | 77 | 76 | 56 | 50 | 62 |
| | Middle | | | | 77 | 95 | 99 | 93 | 92 | 96 | 100 | 92 | 103 | 104 | 82 | 74 | 68 | 82 | 80 | 66 | 61 | 64 |
| | Low | | | | 70 | 93 | 96 | 95 | 92 | 92 | 97 | 80 | 90 | 93 | 80 | 76 | 71 | 85 | 81 | 68 | 66 | 67 |

- Tables can be copied and pasted directly into the Data Center Energy Efficiency Report Template.
- Electric Meters

# Master List of DC Energy Efficiency Measures

- **Living encyclopedia of all data center EEMs**
  - Recognized as an essential desk reference for data center energy efficiency – top download for CoE
  - >250 energy-saving changes in components, operations or other actions
- **Several tools recommend common EEMs:**
  - DC Pro, Air Management Tool, Electric Power Chain Tool
- **The Master List contains all common EEMs, plus many others that do not appear elsewhere in the toolkit.**
- **For each EEM, the list explains the principles involved and how energy cost savings are generated, plus tips on implementation and more in-depth references.**

# Master List of DC Energy Efficiency Measures

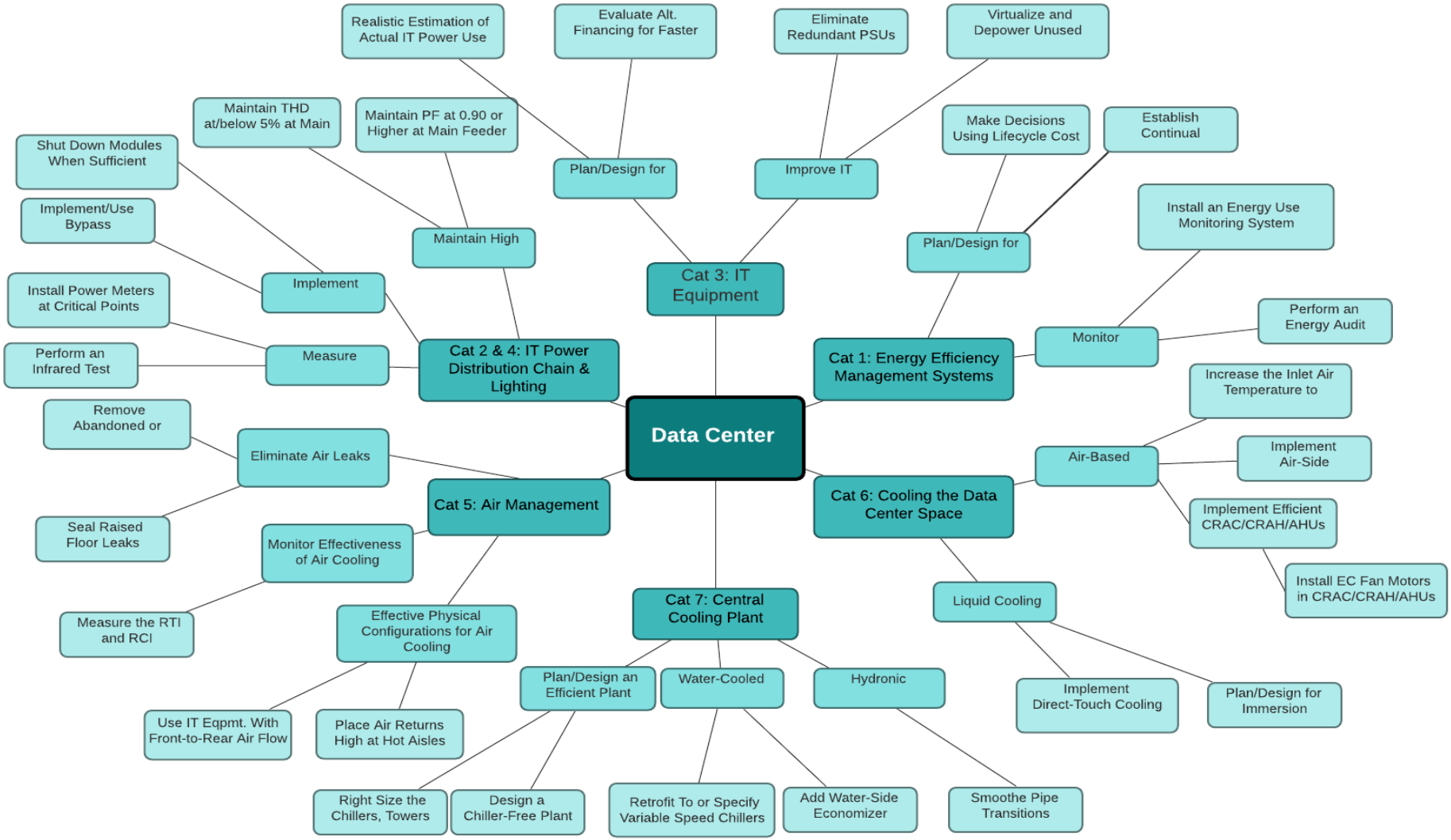
Seven major categories or families of measures:

| Master List Categories |
| --- |
| Category 1: Data Center Energy Efficiency Management |
| Category 2: IT Power Distribution Chain |
| Category 3: IT Equipment |
| Category 4: Lighting |
| Category 5: Air Management |
| Category 6: Cooling the Data Center Space |
| Category 7: Central Cooling Plant |

Some have sub-categories:

| Sub-Categories for Category 7: Central Cooling Plant |
| --- |
| Category 7.1: Entire Cooling Plant, Any Type |
| Category 7.2: Chilled Water Plant |
| Category 7.3: Cooling Tower Plant |
| Category 7.4: Pumps and Hydronic Distribution |

# Master List Measures: Design, Installations, Operational Changes*




* *Illustration only. Full taxonomy covers more than 250 EEMs.*

# DC Energy Efficiency Assessment Report Template

**A framework for presenting the results of your assessment**

- Word document is designed to present as much – or as little – as you need

**Instructions**

- Instructions are in ***blue italics***.
- Instructions and entire report subsections can be hidden, revealed or deleted as desired through keyboard shortcuts provided on the first page.

**Captions and Cross-References**

The template uses Word's Captions and Cross-Referencing features, so tables and figures can be renumbered easily after deletions, additions or re-sequencing.

# DC Energy Efficiency Assessment Report Template

## Copy and Paste from Tools

- Template is designed to receive information from the Energy Assessment Workbook and other tools in the DCEE Kit. The source of the information is identified in every case.
  Example:

Table 1 - Potential Total Savings

***Source:***
*Data Center Energy Efficiency Assessment Workbook v2.0*
*Tab: EEM Summary*
*Table: Potential Total Savings*

| | Current | Projected | Savings |
|---|---|---|---|
| Annual Energy Cost | $xxx,xxx | $xxx,xxx | Xx% |
| PUE | x.xx | x.xx | Xx% |

# DC Energy Efficiency Assessment Report Template

## Placeholders

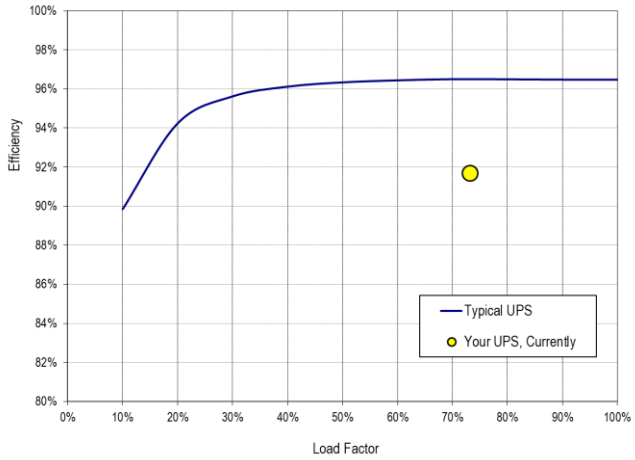
Text in blue highlight are placeholders, ready to accept your actual results. Example:

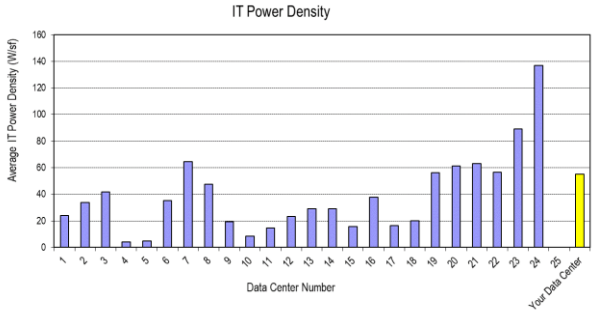
Based on an estimated energy cost of $xxx/kWh, energy cost savings of approximately $xx,xxx per year are possible through the EEMs recommended in **Table 2** with an average payback period of xx years. These recommendations represent approximately xx% energy savings in overall data center energy consumption (relative to the xxxx baseline). If all of the recommended EEMs are implemented, the overall power usage effectiveness (PUE) could be improved from the current estimated value of x.x to x.x.

# In-Depth, System-Level Tools

# Electric Power Chain Tool

- **This Excel-based tool identifies energy-savings opportunities in:**
  - Transformers, generators, UPSs, and power distribution units
- **Users answer 26 questions, and the tool:**
  - Benchmarks IT power density and UPS efficiency against other data centers
  - Recommends EEMs and quantifies their energy and cost savings and payback periods



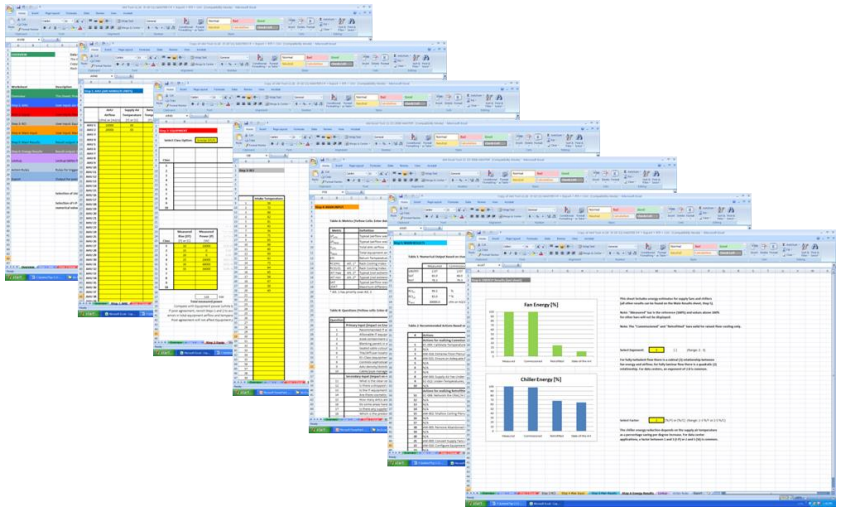

Note: Savings estimates are driven by user inputs and based on typical practice. The tool does not account for interactive effects. Actual savings will vary based on site-specific conditions and operations.

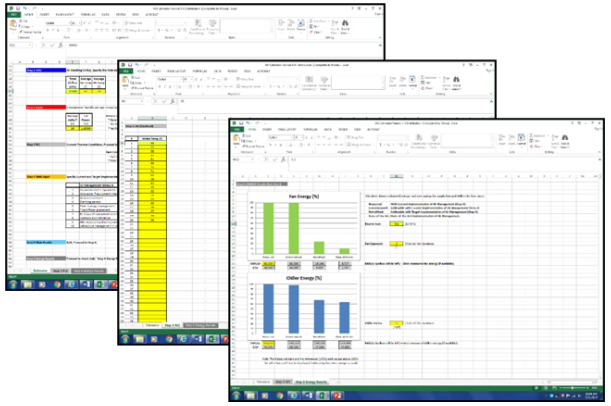
# Air Management (AM) Tools

- Air management is about keeping cold and hot air from mixing – key to cooling and IT thermal management

- The Excel-based AM Tool was developed to fast-track energy savings in data centers. It provides:
  - Potential for reducing supply airflow
  - Potential for increasing supply air temp
  - Measure conformance with ASHRAE Thermal Guidelines
  - Estimates of energy and energy cost reduction for fans/chillers
  - Air management recommendations

- The AM Estimator is a simplified version of the AM Tool, using the same engine. The input has been reduced for ease of use.





# IT Equipment Efficiency Tool *(In Development)*

- IT is at the core of DC energy use. Saving IT energy impacts nearly all DC consumption.
- The Excel-based IT tool energy energy savings by identifying changes in IT equipment and management.
- Organizes energy and equipment inputs and provides:
  - Energy savings
  - Energy cost savings
  - Carbon savings
  - Best practices

| | Current | | | Target | | | |
|---|---|---|---|---|---|---|---|
| | Actual Power [W] | Max Power [W] | Power Util. [%] | Actual Power [W] | Max Power [W] | Power Util. [%] | Power Save [W] |
| Adding | | | | | | | 0 |
| Removing | | | | | | | 0 |
| Replacing | 5000 | 7000 | 0.71 | 3500 | 4000 | 0.88 | 1500 |
| Modifying | | | | | | | 0 |
| Consolidating | 4200 | 7000 | 0.60 | 3000 | 5000 | 0.60 | 1200 |
| Clouding | | | | | | | 0 |
| Unchanged | | | | 0 | 0 | | 0 |
| Total | 9200 | 14000 | 0.66 | 6500 | 9000 | 0.72 | 2700 |

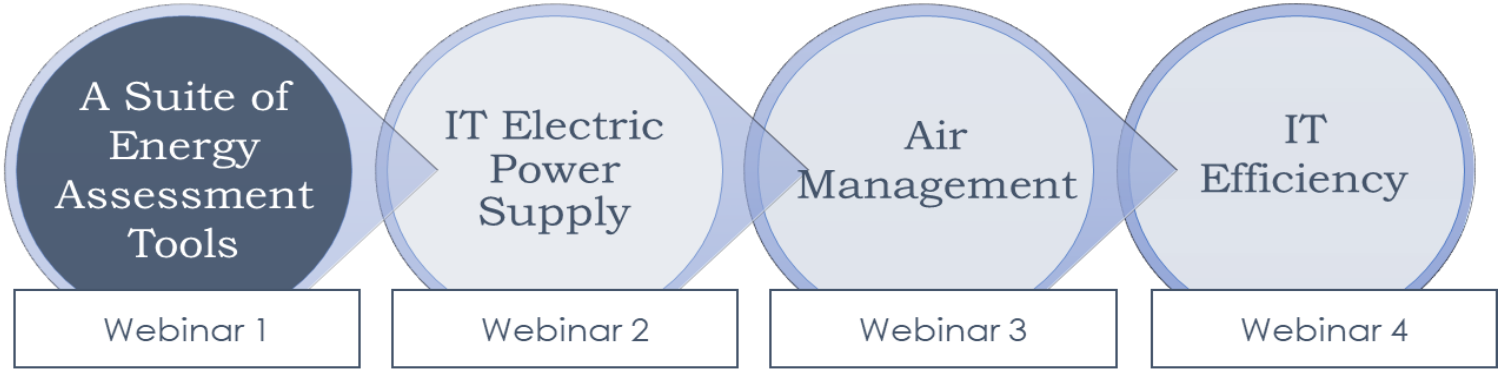
| | | | | | |
|---|---|---|---|---|---|
| Power Utilization | Current | 70.0 | % | | |
| | Target | 76.9 | % | | |
| IT Power Savings | | 6,700 | W | | Scalers |
| Infrastructure Power Savings | | 6,700 | W | PUE | 2.00 |
| Total Energy Savings | | 117,384 | kWh/year | | |
| Total Energy Cost Savings | | 11,738 | $/year | Energy Price | 0.10 $/kWh |
| Total Carbon Savings | | 117,384 | lbs/year | Emission Rate | 1.00 lbs/kWh |

# Use Cases for the DC EE Toolkit

- **Á La Carte**
  - From a simple estimation (e.g., Power Usage Effectiveness) to a comprehensive diagnosis (e.g., air management)
- **Simplified Whole-Facility Pathway**
  - An energy assessment covering all major systems but with a simplified whole-systems approach and modest data collection and analysis
- **Full Data Center Energy Assessment**
  - Component-by-component scrutiny of the full data center with detailed characterization of energy use and energy-saving measures
- **Hybrid**
  - Simplified approach with deeper dives into systems or subsystems where needed

# Four-Webinar Series

The next three webinars will take deeper dives into specific system-level tools and use cases.

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# Resources and Q&A

# FEMP's Data Center Program

FEMP's Data Center program assists federal agencies and other organizations with optimizing the design and operation of data centers. 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
- The Energy Assessment Process Manual

## Key Resources

- Better Buildings Data Center Challenge and Accelerator
- Small Data Centers, Big Energy Savings: An Introduction for Owners and Operators
- Data Center Master List of Energy Efficiency Actions

## Training

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

# LBNL's Center of Expertise (CoE)

Use CoE's Energy Efficiency Toolkit

Filter CoE's many resources by type and topic.

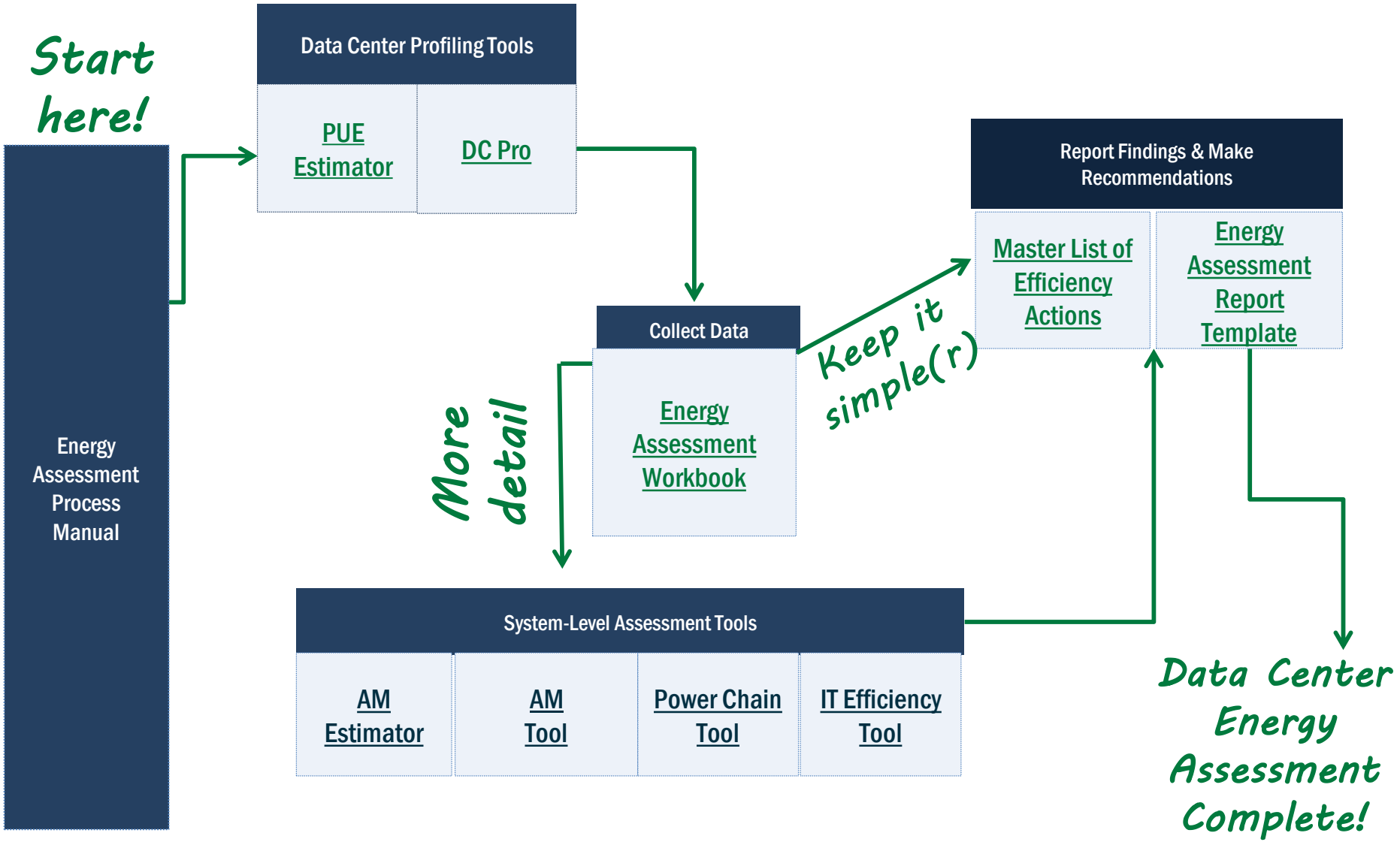
Choose from upcoming live webinars, pre-recorded trainings, and in-person Data Center Energy Practitioner (DCEP) trainings.

Search resources by topics of interest.

Explore the diverse activities that CoE is engaged in.


**Visit us** at datacenters.lbl.gov

# CoE Data Center Energy Efficiency Kit



# New Tools In Development

- **Air Management Lookup Tables**
  - Prescriptive packages of air management EEMs based on desired efficiency outcomes
  - Designed to cater to small data centers

- **Liquid Cooling Energy Savings Estimator**

# Federal Project Executive

## Federal Project Executives (FPEs)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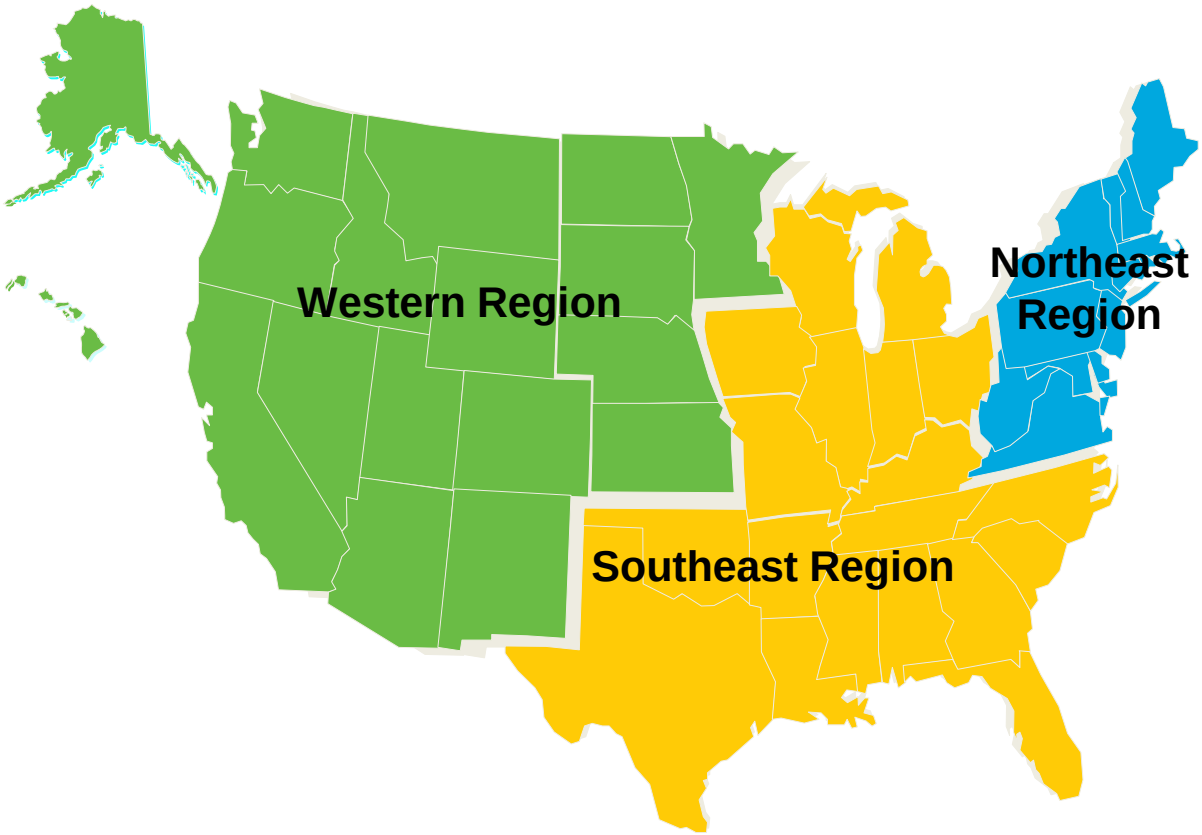

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CENTER OF EXPERTISE
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# Questions?

# IACET Credit for Webinar

WBDG WHOLE BUILDING DESIGN GUIDE a program of the National Institute of Building Sciences

ACCREDITED IACET PROVIDER

**The National Institute of Building Sciences' (NIBS) Whole Building Design Guide (WBDG) hosts the FEMP training program's learning management system (LMS).**

**The WBDG LMS:**

- Allows for taking multiple trainings from multiple organizations through one platform.
- Houses the assessments and evaluations for all accredited courses.
- Allows you to:
  - Track all of your trainings in one place.
  - Download your training certificates of completion.
- Eases the CEU-achievement process.

**Visit the WBDG at www.wbdg.org to view courses and create an account**

# IACET Credit for Webinar

**To receive IACET-Certified CEUs, attendees must:**

- Attend the training in full (no exceptions).
  - If you are sharing a web connection during the training, you must send an e-mail to Elena Meehan (elena.meehan@ee.doe.gov) and indicate who was on the connection and who showed as connected (will reflect in the WebEx roster).
- Complete an assessment demonstrating knowledge of course learning objectives and an evaluation **within six weeks of the training**. A minimum of 80% correct answers are required for the assessment.

**To access the webinar assessment and evaluation, visit:**

https://www.wbdg.org/continuing-education/femp-courses/femplw08042020

If you have a WBDG account and enrolled previously, simply log in and click the *Continuing Education* tab on the user account page. Click *Proceed to Course* next to the course title.