

# Data Center Toolkit Webinar Series: Part 4 – Introducing the New IT Equipment Energy Assessment Tool

January 21, 2020



# Webinar Logistics

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- This webinar is being recorded. The Q&A section will not be made publicly 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**  
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# Webinar Agenda

## Agenda

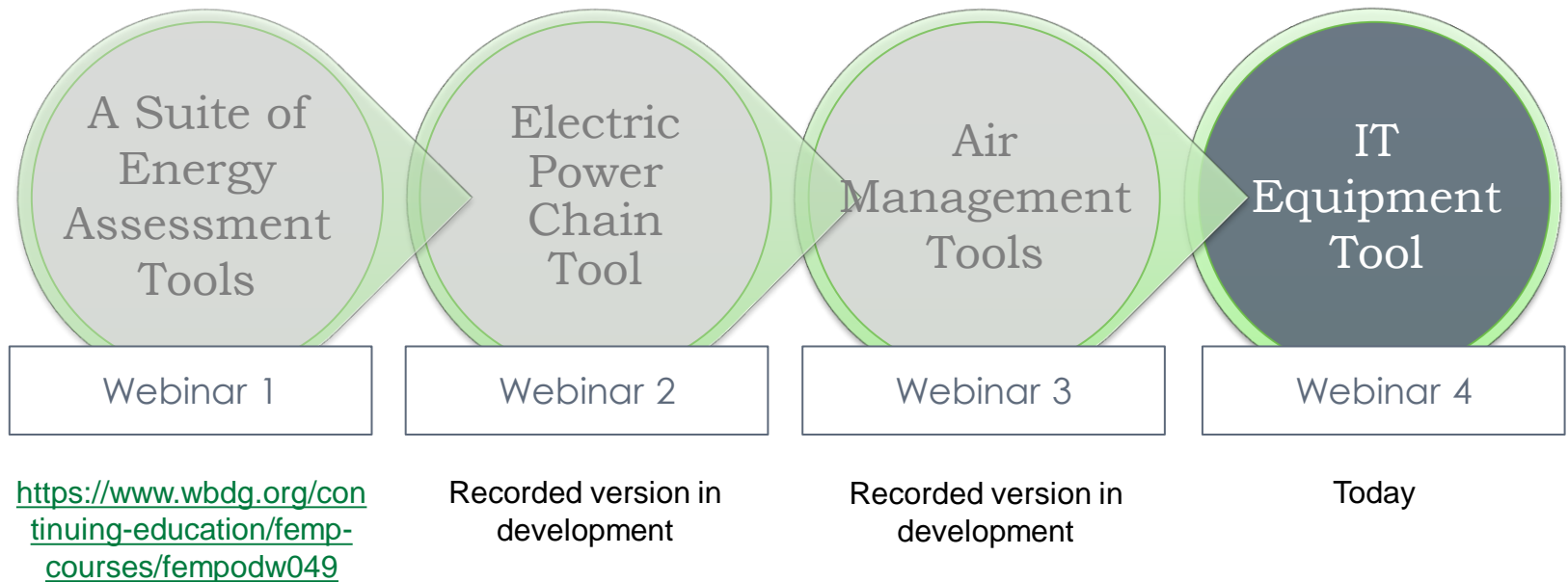
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|------|--|
| I.   | Introduction   |
| II.  | Context of IT Tool and Common Energy-Saving Measures |
| III. | Demonstration of IT Tool                             |
| IV.  | Resources and Q&A                                    |

## Learning Objectives

- Educate data center stakeholders on the **context** of IT equipment energy management in data centers and the **role** of the new IT Tool in the DOE/LBNL DC EE Toolkit.
- Educate stakeholders on identification of energy-saving **opportunities** at the IT level, including virtualization and consolidation, and the **use** of the IT Equipment Tool.
- Educate stakeholders in the DOE energy assessment **process** as it relates to IT equipment energy management.
- Educate stakeholders in ways in which the tool contributes to a concrete **plan of action** and budget and engender institutional support.

# Fourth in a Four-Webinar Series

This training series introduces a broad toolkit for identifying energy-saving opportunities in data centers.



# Data Center Energy Efficiency Toolkit





# DC EE Toolkit - Calculators

- Data Center Profiler (“DC Pro”), online
- PUE Estimator, online
- Air Management Tool, Excel
- Air Management Estimator, Excel
- Electrical Power Chain Tool, Excel
- **IT Equipment Tool, Excel.**

IT Equipment Tool is temporarily located at:

<https://datacenters.lbl.gov/tools/9-it-equipment-energy-assessment-tool>

It will be located permanently here (with the other tools) early 2021:

<http://datacenters.lbl.gov/tools>

# Context of the IT Equipment Energy Assessment Tool



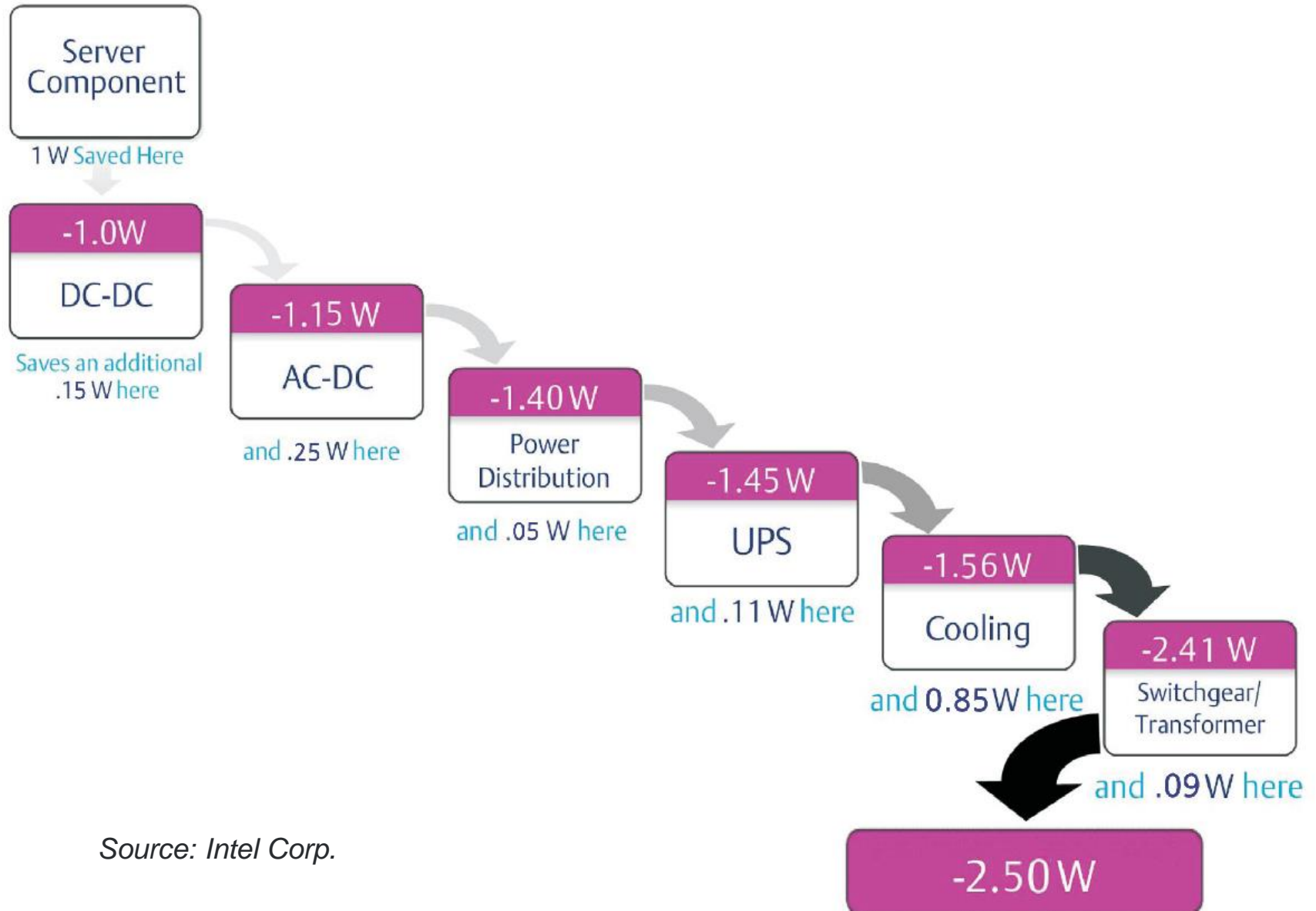


# Motivation for the IT Equipment Tool

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- A large part of data center energy is used by IT
- Significant opportunities for IT improvements
- IT no longer off-limits for energy efficiency efforts
- IT energy savings cascade through most support systems, multiplying savings
- High return on investment

# Total Savings for One Watt Saved At the IT Equipment



# IT Tool Helps Comply With Federal Requirements

The IT Equipment Tool will help agencies comply with several federal requirements:

- Energy Policy Act of 2005 (EPAcT)
- Energy Independence and Security Act of 2007 (EISA)
- Executive Order 13834 (2018)
- The Data Center Optimization Initiative/FITARA
- Energy Act of 2020

By identifying energy conservation measures, use of the IT Equipment Energy Assessment Tool and the data center assessment process furthers such FEMP initiatives as the ESPC/UESC program, the 50001 Ready program and the Energy Efficient Product Procurement Program.

# What does the IT Tool do?

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- Details various energy-saving measures
- Estimates energy and carbon savings in:
  - IT equipment
  - Support systems
- Provides tailored, hands-on recommendations

# Opportunities



# Key Energy-Saving Opportunities

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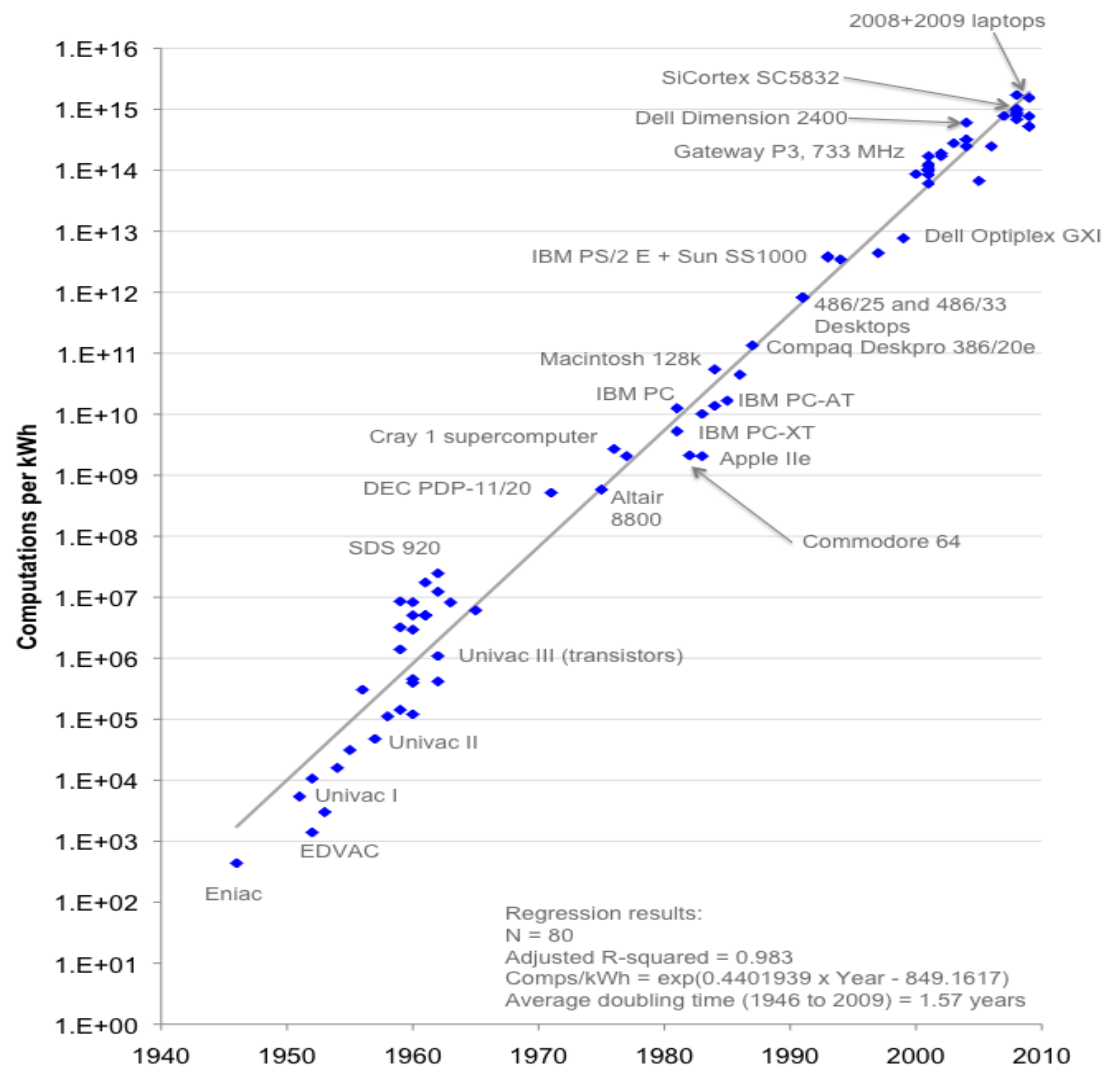
- **Removing** (decommissioning) long-term idling IT equipment.
- **Consolidating** applications from underutilized IT equipment onto fewer servers, leading to increased computational utilization
- **Replacing** (refreshing) IT equipment with new energy efficient gear.



# Removing Unused Servers

- Physically retire inefficient or unused equipment
- The Uptime Institute reported 15%–30% of servers are ON but not being used
- Decommissioning process includes:
  - Regularly inventory and monitor
  - Consolidate/retire poorly utilized hardware.

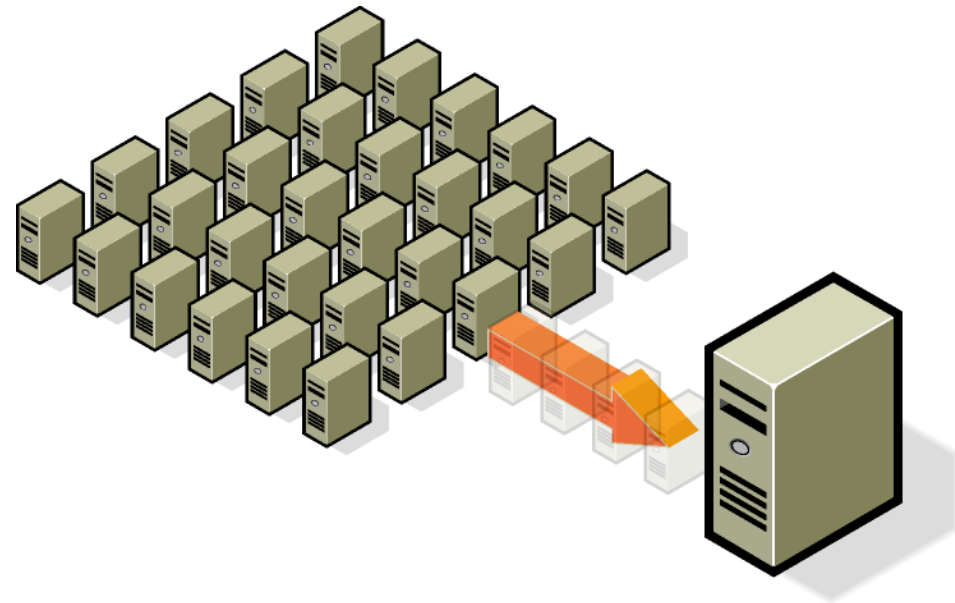
# Replacing: IT Efficiency Increases ~90x Every Decade



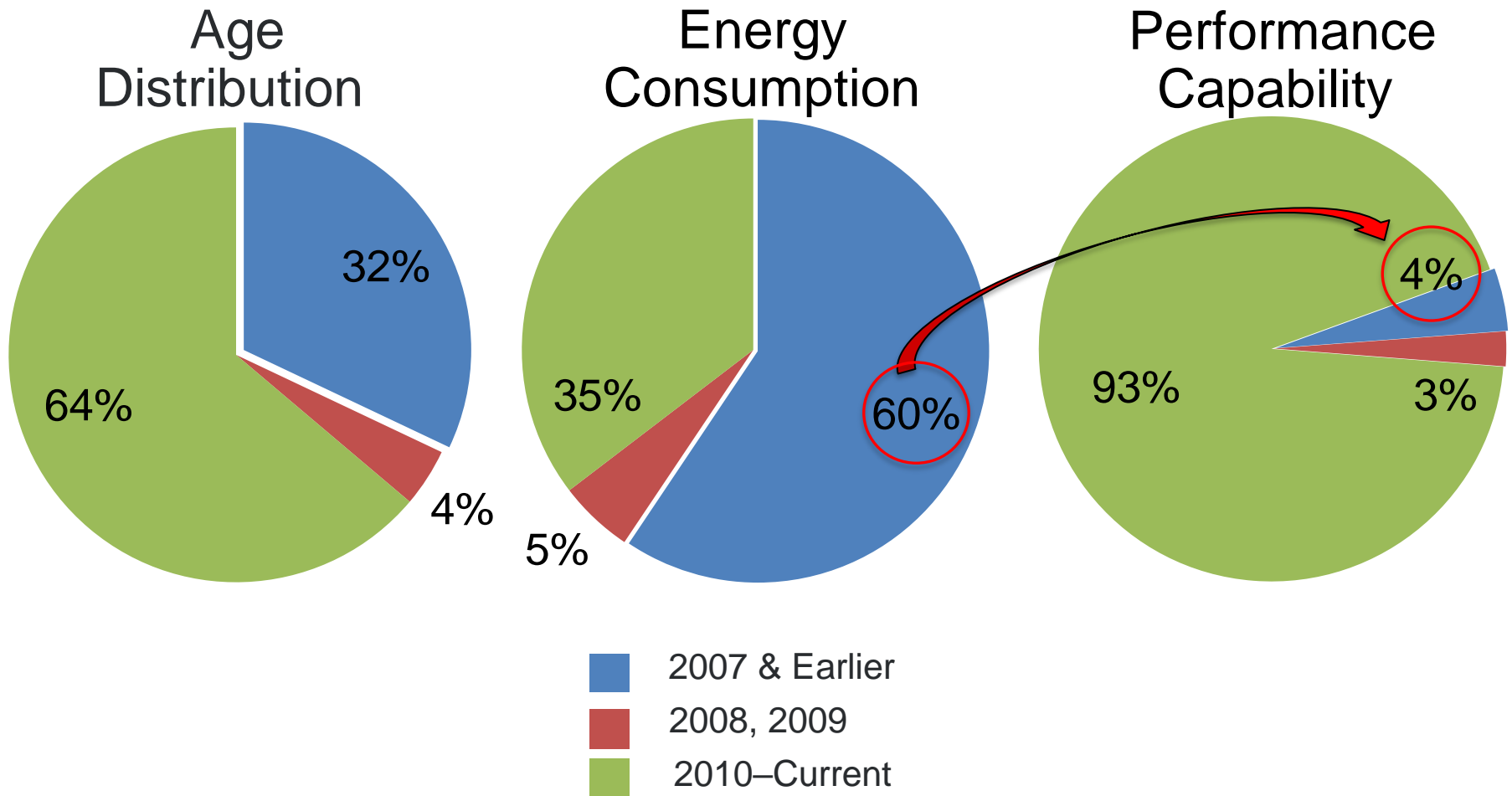
Source:  
Koomey et al. 2011

# Consolidating: Virtualize Servers & Storage

- Run many “virtual” machines on a single “physical” machine
- Consolidate underutilized physical machines, increasing utilization
- Energy is saved by shutting down underutilized machines



# Replacing: Old Servers Underperform



Data collected at a Fortune 100 company; courtesy of John Kuzma and William Carter, Intel

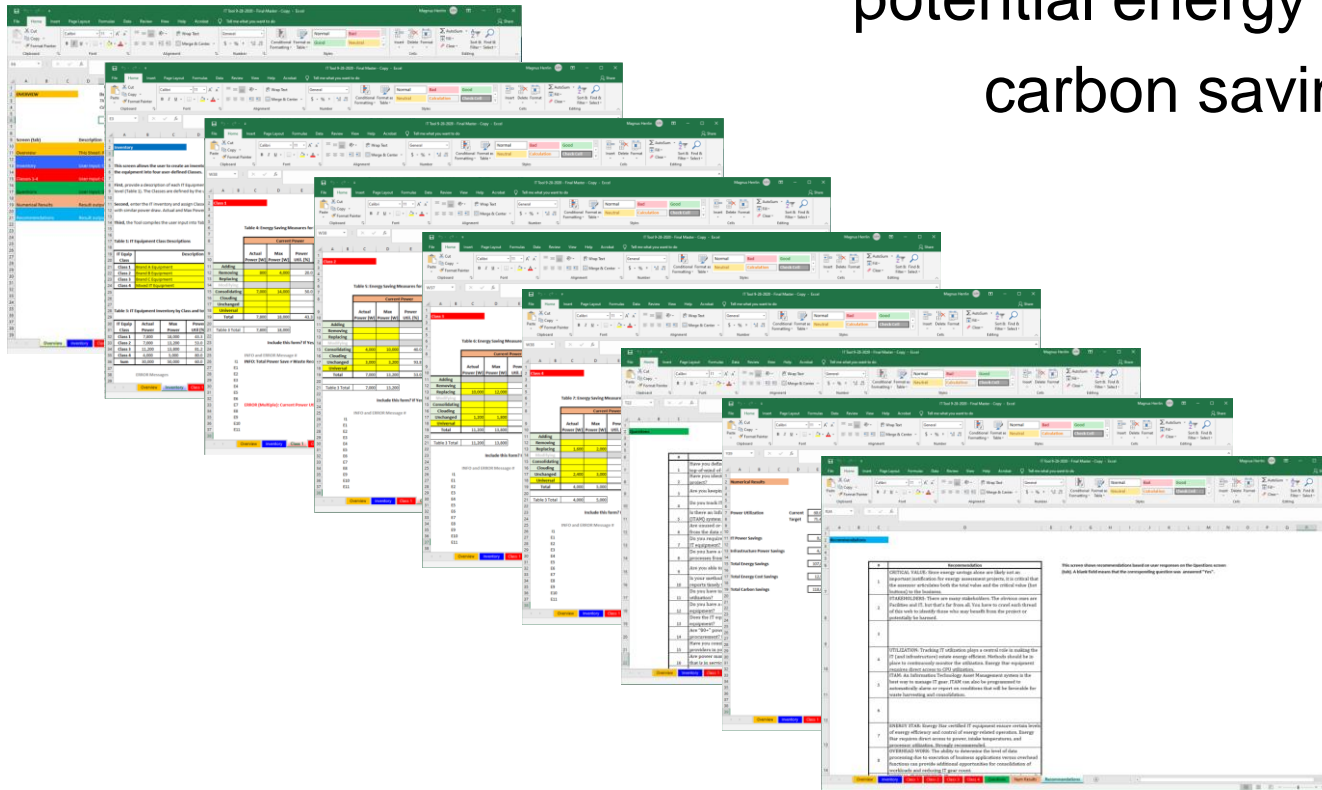
# Tour of the IT Tool

Note: This is an introduction to the IT Equipment Tool not a tutorial. The Data Center Energy Practitioner (DCEP) program provides an in-depth training on the tool, available at <http://datacenters.lbl.gov/DCEP>



# IT Equipment Tool

The IT Tool is a free Excel tool for assessing the IT energy status and providing recommendations and potential energy and carbon savings.



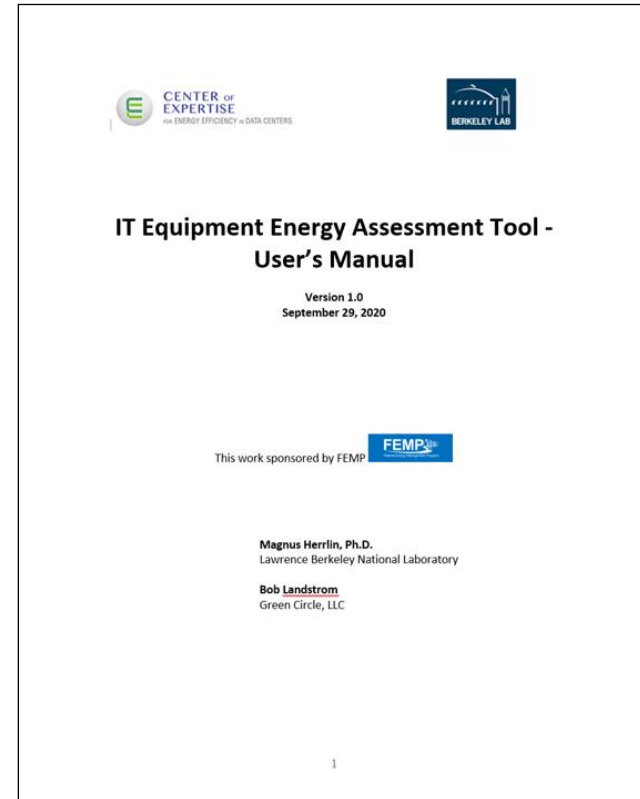
[datacenters.lbl.gov/Tools](https://datacenters.lbl.gov/Tools)



# User's Manual

Tool structure as well as user input forms and output data are described in this manual.

Appendices provide in-depth information on a number of useful topics.



This document is the official resource in using the  
DOE/LBNL IT Equipment Tool

# How is the Tool Used?

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First, the user fills in data and answers questions on up to six input screens. Each screen includes basic guidance for entering the data correctly.

Second, based on this user input, numerical results and recommended actions are given on two output screens.

Let's take a quick tour...

# Inventory: Structure for Organizing IT Data

The screenshot shows an Excel spreadsheet with the following components:

- Instructions (Rows 2-6):**
  - Row 2: "This screen allows the user to create an inventory of the IT equipment, and group the equipment into four user-defined Classes."
  - Row 3: "First, provide a description of each IT Equipment Class and its Power Performance level (Table 1). The Classes are defined by the user in the next step."
  - Row 4: "Second, enter the IT inventory and assign Classes (Table 2a). The IT Types are equipment with similar power draw. Actual and Max Power are per unit."
  - Row 5: "Third, the Tool compiles the user input into Tables 2b and 3."
- Table 1: IT Equipment Class Descriptions (Rows 19-24):**

IT Equip Class	Description	Power Performance
Class 1	Brand A Equipment	High
Class 2	Brand B Equipment	High
Class 3	Brand C Equipment	Mid
Class 4	Mixed IT Equipment	Mid
- Table 2a: IT Equipment Inventory (Rows 39-54):**

#	IT Equip Type	Number of Units	Actual Power [W]	Max Power [W]	IT Equip Class
1	A	20	350	700	1
2	B	4	400	500	4
3	C	5	800	2,000	2
4	D	1	1,200	1,800	3
5	E	8	100	500	1
6	F	10	300	320	2
7	G	6	400	500	4
8	H	20	500	600	3
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30					
- Table 2b: Utilization (Rows 55-64):**

Power Util. [%]	Comp Util. [%]	Potential Actions
50.0	48.5	High Consolidate
80.0	79.2	Mid Consolidate
40.0	33.8	High
66.7	61.8	Mid Remove
20.0		High
93.8	95.5	High
80.0	79.2	Mid
83.3	83.1	Mid
- Table 3: IT Equipment Inventory by Class and total (Rows 65-70):**

IT Equip Class	Actual Power	Max Power	Power Util [%]
Class 1	7,800	18,000	43.3
Class 2	7,000	13,200	53.0
Class 3	11,200	13,800	81.2
Class 4	4,000	5,000	80.0
Sum	30,000	50,000	60.0

Red arrows indicate the flow of data from the input tables (Table 1 and Table 2a) to the summary tables (Table 2b and Table 3).

## Nine (9) Tabs (sheets)

Yellow cells are input cells.

## Inventory - Tool Provides Potential Actions

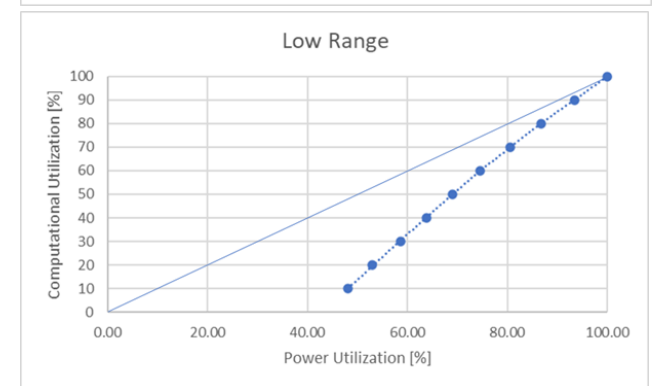
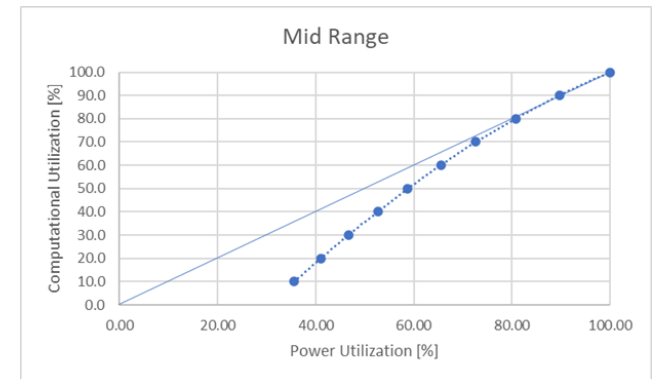
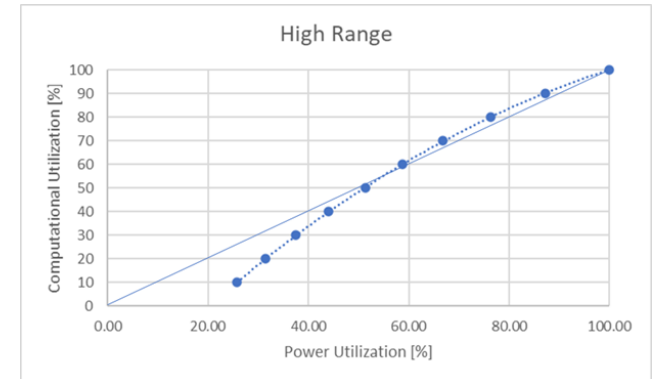
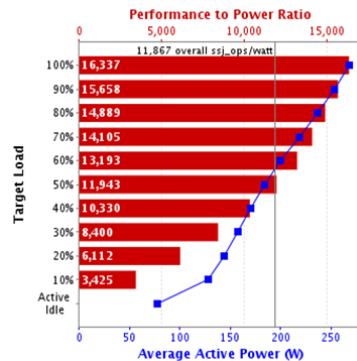
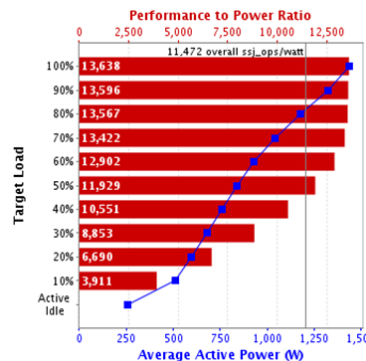
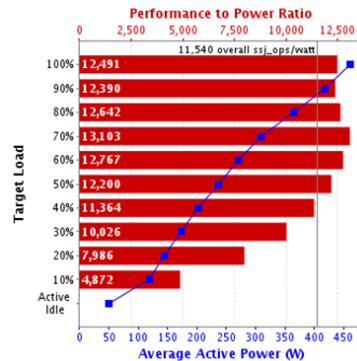
[illegible]

# Server Power Performance Curves

Power Performance is the ratio between Power Utilization and Computational Utilization. In turn, utilization is Actual Utilization to Max Utilization.

This slide shows three actual 2U servers representing three levels of Power Performance (blue curves in first set of three charts\*), and the generalized performance curves developed for the IT Tool (far right).

\* SpecPower



# Energy Saving Measures

Class 1

Energy-Saving Measures	Current Conditions				Target Conditions				Energy Savings	
	Current Power				Target Power				Power Reduction Factor	Power Save [W]
	Actual Power [W]	Max Power [W]	Power Util. [%]	Comp Util. [%]	Actual Power [W]	Max Power [W]	Power Util. [%]	Comp Util. [%]		
Adding					490	1,000	49.0	47.1		-490
Removing	800	4,000	20.0							800
Replacing									0.00	
Modifying										
Consolidating	7,000	14,000	50.0	48.5	5,000	8,000	62.5	64.6		2,000
Clouding										
Unchanged										
Universal										
Total	7,800	18,000	43.3	38.9	5,490	9,000	61.0	62.8		2,310

Table 3 Total	7,800	18,000
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Save Total	2,310
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Include this form? If Yes, IT Tool will check for Errors.

Yes

ERRORS Found

Error Check

Yellow cells are input cells.



# Numerical Results - Overview

Power Utilization

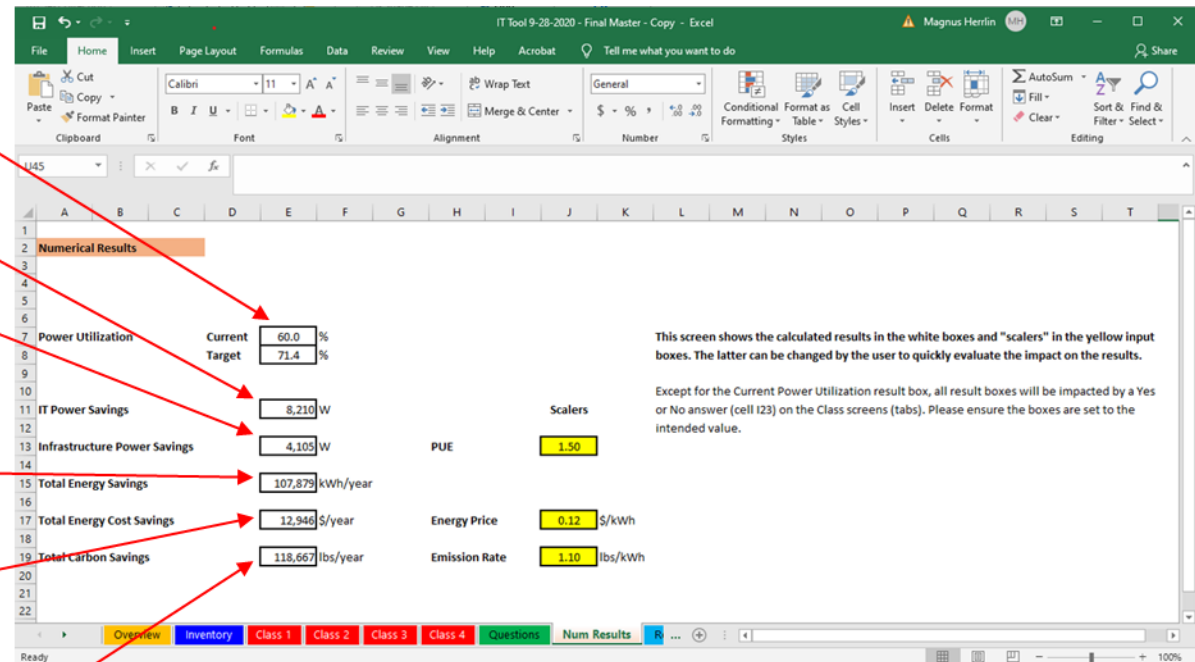
IT Power Savings

Infrastructure Power Savings

Total Energy Savings

Total Energy Cost Savings

Total Carbon Savings



Yellow cells are input cells.

# Numerical Results - Detail

## Numerical Results

Power Utilization	Current	60.0	%	<b>PUE =</b> Data Center Total Energy / IT Energy	
	Target	71.4	%		
IT Power Savings		8,210	W		Scalers
Infrastructure Power Savings		4,105	W	← PUE	1.50
Total Energy Savings		107,879	kWh/year		
Total Energy Cost Savings		12,946	\$/year	← Energy Price	0.12 \$/kWh
Total Carbon Savings		118,667	lbs/year	← Emission Rate	1.10 lbs/kWh

Yellow cells are input cells.

# Questions - Generates Best-Practice Recommendations

IT Tool 9-28-2020 - Final Master - Copy - Excel

Magnus Herrlin

File Home Insert Page Layout Formulas Data Review View Help Acrobat Tell me what you want to do

Clipboard Font Alignment Number Styles Cells Editing

Calibri 11

Normal Bad Good Neutral Calculation Check Cell

AutoSum Fill Clear Sort & Find & Filter Select

T56

Questions

#	Question	Yes/No
1	Have you defined "Critical Values" (hot-button issues that are top-of-mind of executives) for the IT project?	No
2	Have you identified the organizational stakeholders for the IT project?	No
3	Are you keeping an IT equipment inventory?	Yes
4	Do you track IT asset utilization?	No
5	Is there an Information Technology Asset Management (ITAM) system present to monitor IT utilization and status?	No
6	Are unused or obsolete IT equipment systematically removed from the data center space?	Yes
7	Do you require Energy Star certification on purchase of new IT equipment?	No
8	Do you have a way of discerning business-application processes from overhead processes?	No
9	Are you able to observe utilization of virtual assets?	No
10	Is your method of tracking IT utilization able to produce reports timely to enable Operations to manage inventory?	No
11	Do you have tools and processes for assessing IT asset utilization?	No
12	Do you have a clear decommissioning process for IT	

This screen allows the user to answer a number of IT equipment assessment questions. A "No" answer will result in a recommendation on the Recommendations screen (tab).

IF unsure, enter "No".

#	Question	Yes/No
1	Have you defined "Critical Values" (hot-button issues that are top-of-mind of executives) for the IT project?	No
2	Have you identified the organizational stakeholders for the IT project?	No

Yellow cells are input cells.

# Recommendations - Based on Question Responses

This screen shows recommendations based on user responses on the Questions screen (tab). A blank field means that the corresponding question was answered "Yes".

#	Recommendation
1	CRITICAL VALUE: Since energy savings alone are likely not an important justification for energy assessment projects, it is critical that the assessor articulates both the total value and the critical value (hot buttons) to the business.
2	STAKEHOLDERS: There are many stakeholders. The obvious ones are Facilities and IT, but that's far from all. You have to crawl each thread of this web to identify those who may benefit from the project or potentially be harmed.

# Input Examples: Key Energy-Saving Opportunities



# Removing (Decommissioning)

Class 1 has Three Energy-Saving Measures:

- Adding
- Removing
- Consolidating

	Current Power				Target Power				Power Reduction Factor	Power Save [W]
	Actual Power [W]	Max Power [W]	Power Util. [%]	Comp Util. [%]	Actual Power [W]	Max Power [W]	Power Util. [%]	Comp Util. [%]		
Adding					490	1,000	49.0	47.1		-490
Removing	800	4,000	20.0							800
Replacing									0.00	
Modifying										
Consolidating	7,000	14,000	50.0	48.5	5,000	8,000	62.5	64.6		2,000
Clouding										
Unchanged										
Universal										
Total	7,800	18,000	43.3	38.9	5,490	9,000	61.0	62.8		2,310

Table 3 Total	7,800	18,000
---------------	-------	--------

Save Total	2,310
------------	-------

Include this form? If Yes, IT Tool will check for Errors.

Yes

ERRORS Found

ERROR (Multiple): Current Power Utilization must not be <26.

- Removing Long-Term Idling IT Equipment (see Inventory)
- Enter Current Actual and Max Power (yellow cells)
- Tool calculates Power and Computational Utilization
- Tool calculates Power Save.

Note: ERROR message shown here intentionally to show the ERROR functionality



# Replacing (Refreshing)

Class 3 has Two Energy-Saving Measures:

- Replacing
- Unchanged

	Current Power				Target Power				Power Reduction Factor	Power Save [W]
	Actual Power [W]	Max Power [W]	Power Util. [%]	Comp Util. [%]	Actual Power [W]	Max Power [W]	Power Util. [%]	Comp Util. [%]		
Adding										
Removing										
Replacing	10,000	12,000	83.3	83.1	5,000	6,000	83.3	83.1	0.50	5,000
Modifying										
Consolidating										
Clouding										
Unchanged	1,200	1,800	66.7	61.8	1,200	1,800	66.7	61.8		0
Universal										
Total	11,200	13,800	81.2	80.6	6,200	7,800	79.5	78.6		5,000

Table 3 Total	11,200	13,800
---------------	--------	--------

Save Total	5,000
------------	-------

Include this form? If Yes, IT Tool will check for Errors.

Yes

No ERRORS Found

- Replace IT equipment with new energy-efficient gear
- Enter Current Actual and Max Power (yellow cells)
- Enter Target Power Reduction Factor (yellow cell)
- Tool calculates Target Actual and Max Power
- Tool calculates Power and Computational Utilization
- Tool calculates Power Save.

# Consolidation

Class 1 has Three Energy-Saving Measures:

- Adding
- Removing
- Consolidating

	Current Power				Target Power				Power Reduction Factor	Power Save [W]
	Actual Power [W]	Max Power [W]	Power Util. [%]	Comp Util. [%]	Actual Power [W]	Max Power [W]	Power Util. [%]	Comp Util. [%]		
Adding					490	1,000	49.0	47.1		-490
Removing	800	4,000	20.0							800
Replacing									0.00	
Modifying										
Consolidating	7,000	14,000	50.0	48.5	5,000	8,000	62.5	64.6		2,000
Clouding										
Unchanged										
Universal										
Total	7,800	18,000	43.3	38.9	5,490	9,000	61.0	62.8		2,310

Table 3 Total	7,800	18,000
---------------	-------	--------

Save Total	2,310
------------	-------

Include this form? If Yes, IT Tool will check for Errors.

Yes

ERRORS Found

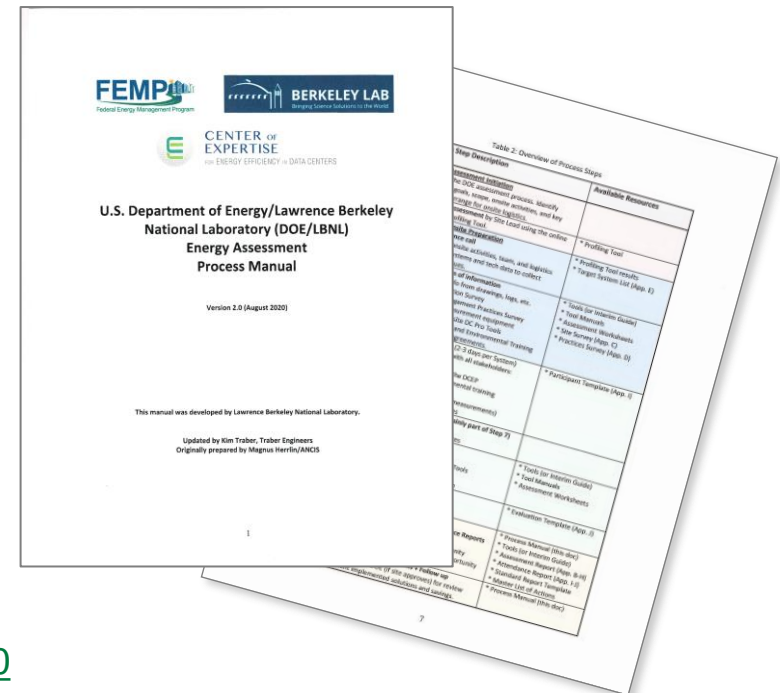
- Consolidate Sub-Utilized IT Equipment (see Inventory)
- Enter Current Actual and Max Power (yellow cells)
- Enter Target Actual and Max Power (yellow cells)
- This data may come from integrator and/or vendor
- Tool calculates Power and Computational Utilization
- Tool calculates Power Save.

# Energy Assessment Process



# Energy Assessment Process Manual

- The Process Manual provides administrative step-by-step instructions for conducting an energy assessment before, during, and after the onsite assessment
- Multiple appendices include useful templates for the assessments.
- Descriptions of all tools, guides and templates in the toolkit and their relationships to one another



[https://datacenters.lbl.gov/sites/default/files/Process%20Manual%20DOE%20v2\\_080320\\_0.pdf](https://datacenters.lbl.gov/sites/default/files/Process%20Manual%20DOE%20v2_080320_0.pdf)

# Plan of Action



# Holistic Approach - Takeaways

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An IT energy assessment should never be looked at in isolation. Data centers are complex environments with numerous interconnected energy consuming systems (IT, electrical, cooling, air management).

The data center should be viewed in a holistic way. This may often be difficult considering the disconnect between the facilities staff and the IT staff in many data centers.

The Tool Suite provides the Tools and the Process Manual helps in organizing the work.

# 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](#)
- [El. Power Chain Tool](#)
- [IT Equipment Tool](#)
- [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 \(DCEP\) Trainings](#)



# LBNL's Center of Expertise (CoE)

The image shows a screenshot of the LBNL Center of Expertise (CoE) website. The website has a green header with the LBNL logo and the text "CENTER OF EXPERTISE FOR ENERGY EFFICIENCY IN DATA CENTERS". Below the header is a navigation bar with links: HOME, ABOUT, TECHNOLOGIES, ACTIVITIES, TOOLS, ALL RESOURCES, TRAININGS, and CONTACT US. The main content area features a large banner for "Small Data Centers" with the text "Explore resources geared towards helping small data centers overcome the unique obstacles they face in reducing energy consumption and achieving monetary savings." To the right of the banner is a sidebar with social media links and a search bar. Callout boxes with dashed lines point to various features: "Use CoE's Energy Efficiency Toolkit" points to the "TOOLS" link; "Filter CoE's many resources by type and topic." points to the "ALL RESOURCES" link; "Choose from upcoming live webinars, pre-recorded trainings, and in-person Data Center Energy Practitioner (DCEP) trainings." points to the "TRAININGS" link; "Search resources by topics of interest." points to the search bar; "Explore the diverse activities that CoE is engaged in." points to the "ACTIVITIES" link; and "Follow us on Twitter @DataCenterCoE" points to the Twitter link.

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.

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CENTER OF EXPERTISE FOR ENERGY EFFICIENCY IN DATA CENTERS

U.S. DEPARTMENT OF ENERGY FEMP Federal Energy Management Program BERKELEY LAB

Follow us on Twitter @DataCenterCoE

Small Data Centers

Explore resources geared towards helping small data centers overcome the unique obstacles they face in reducing energy consumption and achieving monetary savings.

Center of Expertise @DataCenterCoE

Effective air management is critical for data center #EnergyEfficiency. CoE's Air Management Tools webinar will introduce free, easy-to-use tools to help you save #energy and money in your #DataCenter! Register here: [bit.ly/2wV6F5O](http://bit.ly/2wV6F5O).

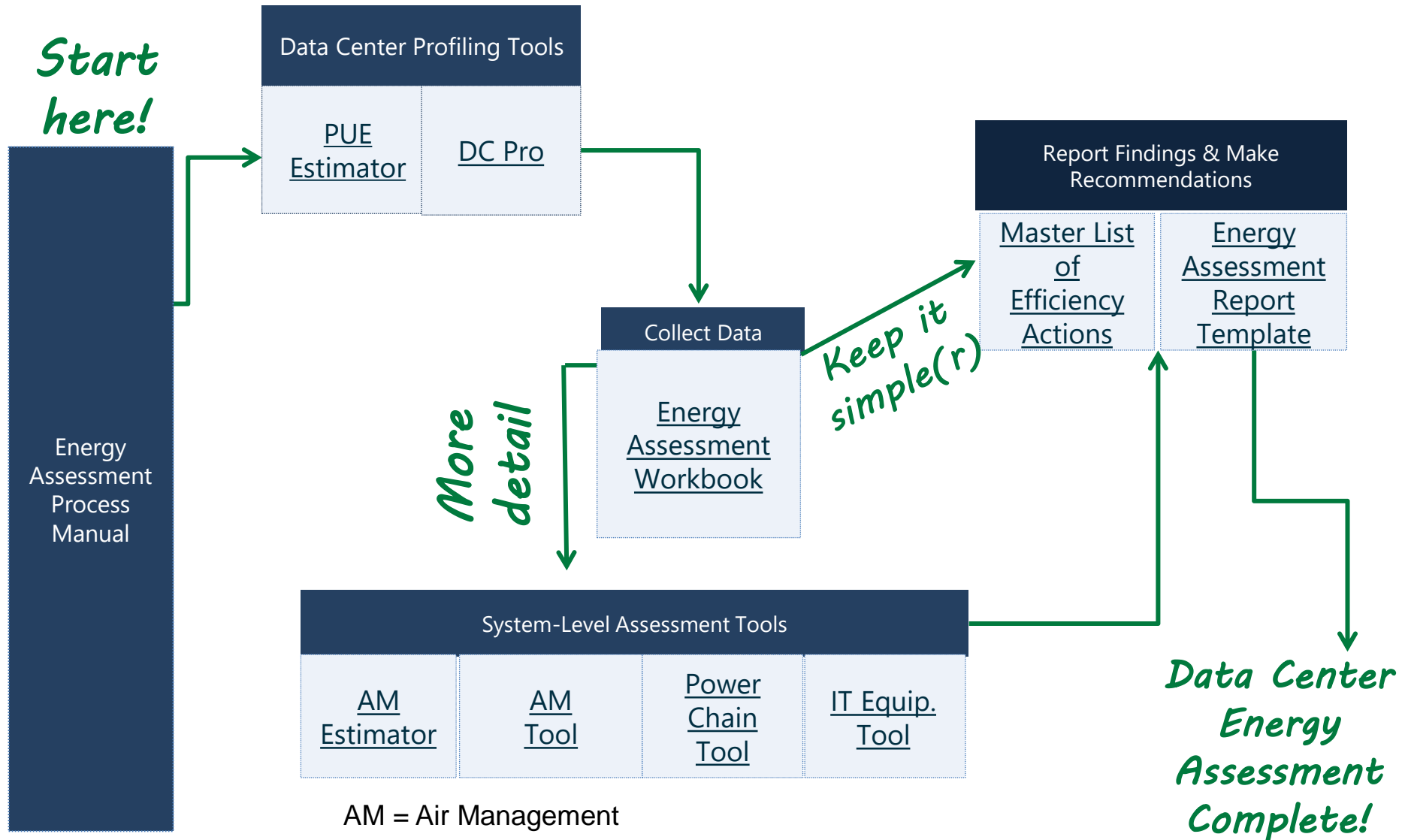
Sep 7, 2018

Center of Expertise @DataCenterCoE

There's still time to register for our Air Management webinar! Sign up here: [bit.ly/2xjhggq](http://bit.ly/2xjhggq)

Visit us at [datacenters.lbl.gov](http://datacenters.lbl.gov)

# CoE Data Center Energy Efficiency Toolkit



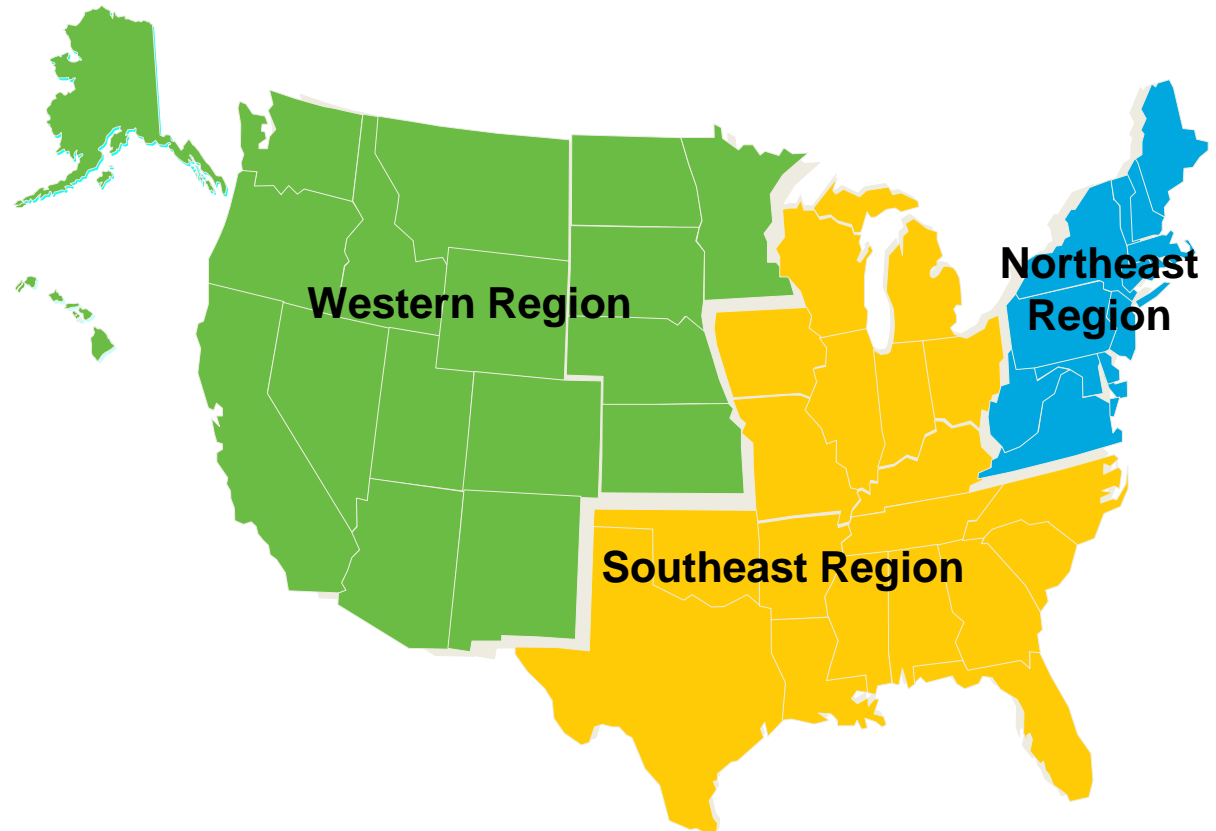
# Federal Project Executive

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# Today's Speakers



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# Questions?

# IACET Credit for Webinar



**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](http://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](mailto: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/femplw01212021b>

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.

# Backup Slides



# Data Center Profiling Tools (online)



## 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)

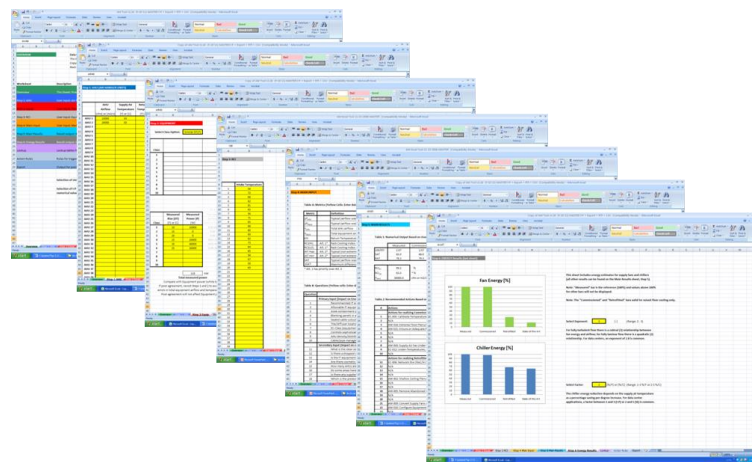
- Only asks questions required to estimate PUE
- Uses same algorithm as DC Pro
- Exports results to PDF or Excel

DC Pro and PUE Estimator can you found on the [CoE website](#).

# Air Management (AM) Tools (Excel)

The AM Tool was developed to fast-track energy savings in data centers. It provides:

- Reduction of supply airflow
- Increase in supply air temp
- Conformance with Thermal Guidelines
- Reduction in energy and energy-cost for fans and chillers
- Air management recommendations.

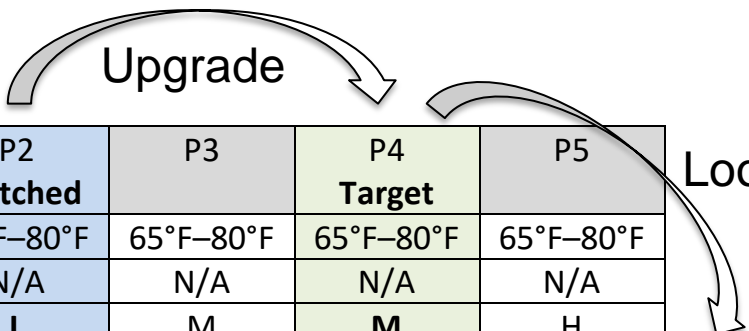


<http://datacenters.lbl.gov/Tools>

The Air Management Estimator =  
simplified Air Management Tool

# Air Management Lookup Tables

This resource presents energy savings for chillers and supply fans in a new tabular format for various upgrade scenarios.



AM Measure (AM Tool)	Reference	P1	P2 Matched	P3	P4 Target	P5
1: Recommended Range <sup>1</sup>	65°F–80°F	65°F–80°F	65°F–80°F	65°F–80°F	65°F–80°F	65°F–80°F
2: Allowable Range <sup>2</sup>	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			
5: Floor Leakage	L	M	M			
6: Tile Placement	L	M	H			
7: EC-Class	H	H	H			
8: CAV/VAV (CRAC)	L (CAV)	L (CAV)	H (VAV)			
9: CRAC Modularity	M (2) or H (3)	M (2) or H (3)	M (2) or H (3)			
10: Cable Management	L	L	L			

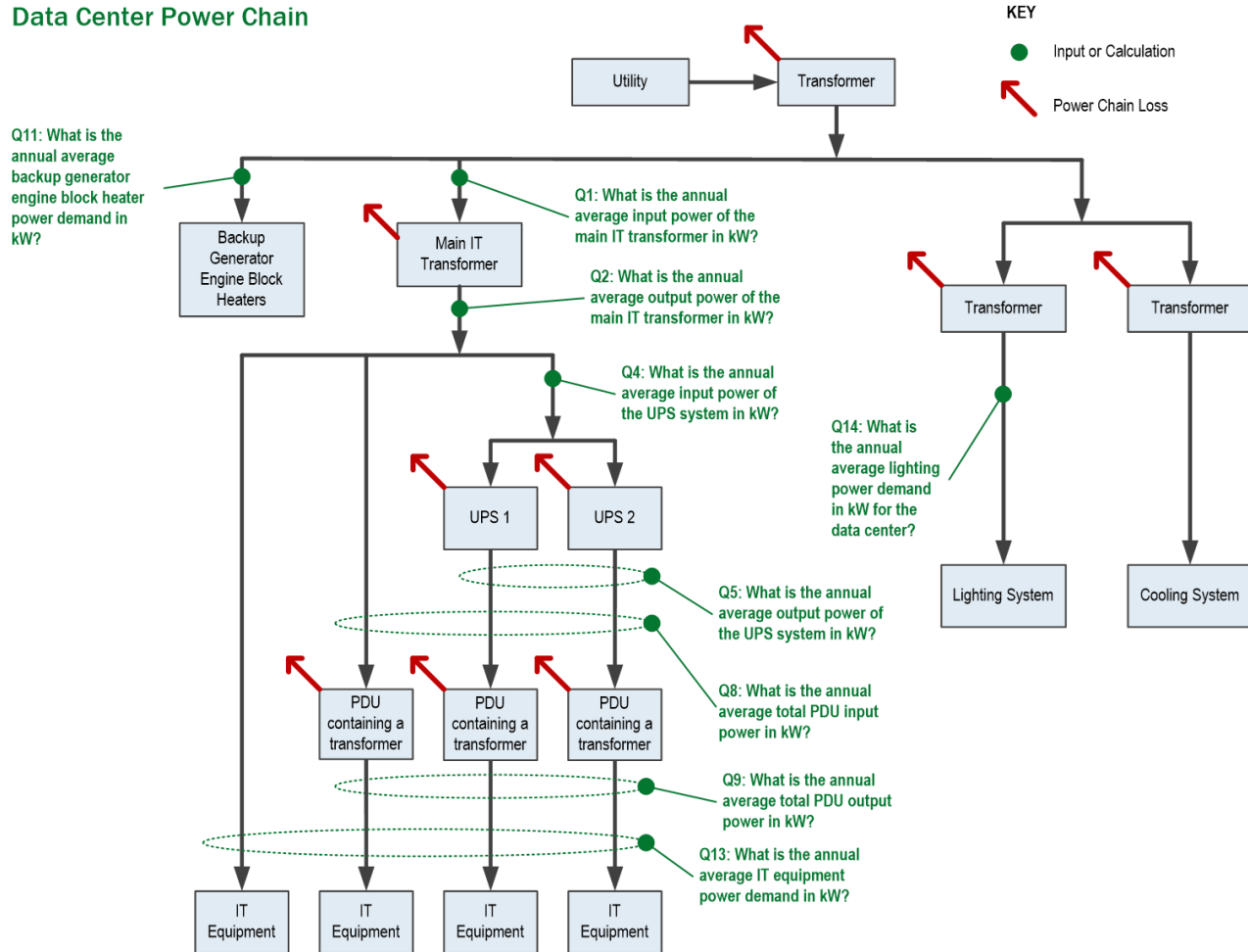
  

	Match	P1	P3	P2	P4	P5
Ref. 2.51 (typical)						
CAV		-33%	-33%	-76%	-80%	-90%
P1 - 1.67 CAV			0%	-26%	-39%	-69%
P3 - 1.67 CAV				-26%	-39%	-69%
P2 - 1.5 VAV					-18%	-58%
P4 - 1.4 VAV						-49%
CRAC/IT Airflow		1.67	1.67	1.5	1.4	1.1
		CAV	CAV	VAV	VAV	VAV

<http://datacenters.lbl.gov>

# Electrical Power Chain Tool (Excel)

## Data Center Power Chain



This tool helps identify energy opportunities in the electrical power chain.

It quantifies the energy and cost savings of the selected measures and calculates the payback periods.

This updated version (March 2020) offers a wider array of UPS load factors, control options, and updated efficiency curves.

<http://datacenters.lbl.gov/Tools>

# 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.**