

Data Center Energy Efficiency Assessment Toolkit

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Data centers are energy intensive and opportunities exist to reduce energy use, but significant knowledge and skills are required to perform energy assessments. The Federal Energy Management Program's (FEMP) Data Center Program assists federal agencies and other organizations with optimizing the design and operation of energy and water systems in data centers. It also funds the work at the Center of Expertise for Energy Efficiency in Data Centers (CoE) at Lawrence Berkeley National Laboratory. CoE develops and provides wide-ranging resources for managing data centers in an energy efficient manner.

The Center of Expertise's website (<http://datacenters.lbl.gov>) is a comprehensive resource for those involved in energy performance and decarbonization in data centers: simulation software, technologies, and training (live webinars, pre-recorded trainings, and live online Data Center Energy Practitioner (DCEP) trainings). You can filter the many resources by type and topic, as well as search resources by topic(s) of interest.

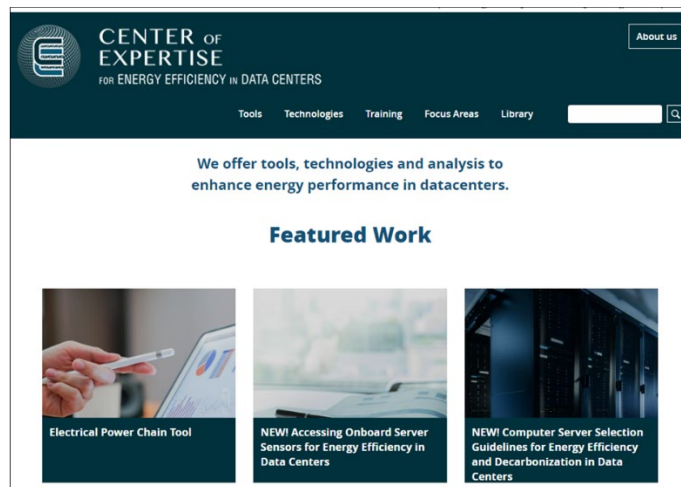


Figure 1. Center of Expertise Website

The main objective of this article is to provide an overview of the CoE's Data Center Energy Efficiency Toolkit (Toolkit) and its free resources, including energy assessment simulation software, manuals, worksheets, templates, and listings. The Toolkit provides guidance on using the Tools in order to achieve energy efficiency and decarbonization in data centers. In our context, a "tool" refers to any resource for facilitating energy assessments. With that in mind, you might want to think about this as a resource kit

rather than a toolkit. There is a FEMP on-demand webinar that provides additional information on the Toolkit: <https://wbdg.org/continuing-education/femp-courses/fempodw140>

A secondary objective is to increase the awareness of training courses offered by the Data Center Energy Practitioner (DCEP) program <http://datacenters.lbl.gov/dcep> which are partially funded by FEMP. These courses include training on most of the resources in the Toolkit.

Toolkit Flowchart

How can the Toolkit help the data center practitioner? It can assist in:

- organizing the energy assessment
- collecting the necessary data
- processing the data
- calculating actionable metrics
- suggesting hands-on actions (recommendations)

The arrows between the different Toolkit resources in Figure 2 suggest logical paths through an energy assessment. The online flowchart can be found at <http://datacenters.lbl.gov/Tools> By clicking on a resource in the Flowchart, it will take you directly to the resource itself. We will now step through the different resources and add some explanations.

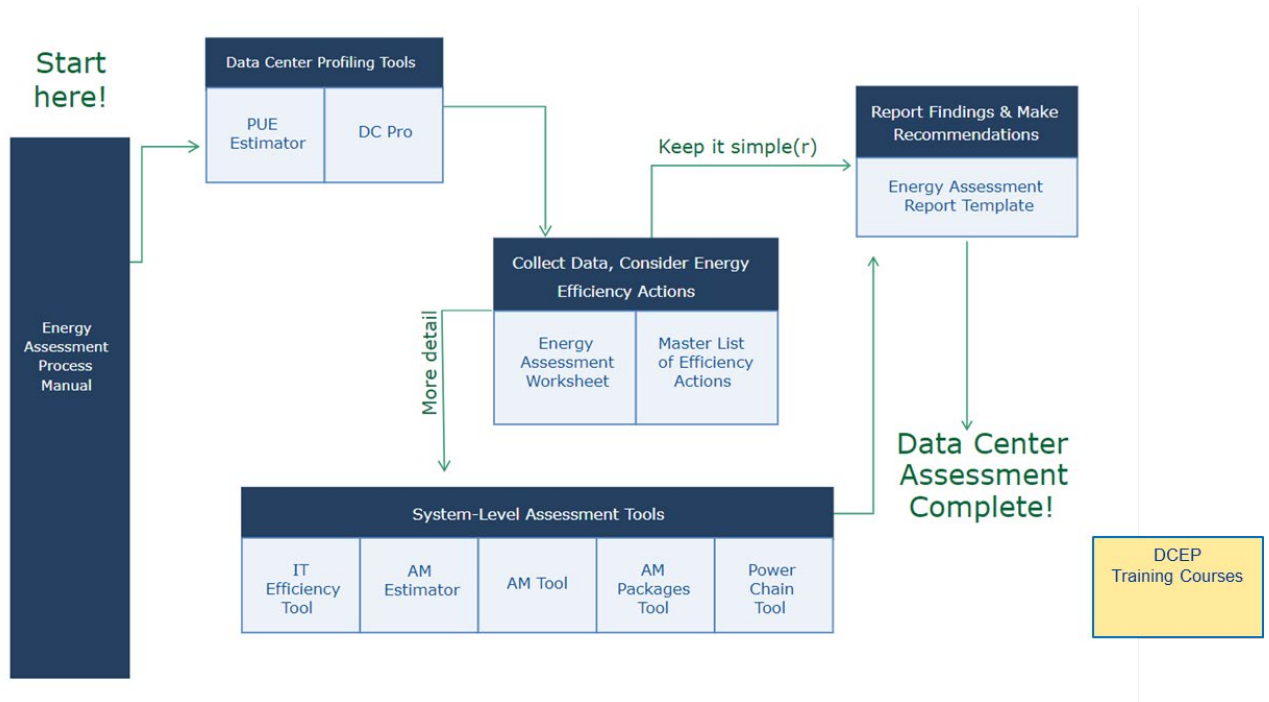


Figure 2. Toolkit Flowchart

Energy Assessment Process Manual

Let's start with the Energy Assessment Process Manual (the far left resource in Figure 2)

<https://datacenters.lbl.gov/resources/dcep-process-manual> The Process Manual is not a technical document but rather provides administrative step-by-step instructions for conducting an energy assessment before, during, and after the onsite assessment. The assessment process is broken down into four phases and is presented in easy-to-read tables, including process descriptions and available resources.

- Phase 1: Assessment Initiation
- Phase 2: Pre-Onsite Preparation
- Phase 3: Onsite Activities
- Phase 4: Post-Onsite Activities

At the end of the document, multiple appendices are listed, including useful templates for energy assessments.

Data Center Profiling Tools (DC Pro)

The top left resource in Figure 2 includes the online Data Center Profiling Tool (DC Pro)

<https://datacenters.lbl.gov/dcpro> DC Pro is an online, early-stage simulation tool designed for data center operators to diagnose how energy is used in their data centers and determine ways to save energy and money. DC Pro covers all major energy consuming systems in data centers, and it includes many energy-saving measures, allowing for various what-if scenarios. Specifically, it provides:

- Estimated Power Usage Effectiveness (PUE)
- Estimated energy use distribution (i.e., where the energy is used)
- Hands-on recommendations

The PUE Estimator (also in the top left resource in Figure 2) uses the same “engine” as DC Pro but with reduced input and output for improved clarity and speed. As the name suggests, the main output is an estimated PUE.

Master List of Efficiency Actions

The next step is at one of the resources towards the center of Figure 2, namely; Master List of Efficiency Actions <http://datacenters.lbl.gov/resources/data-center-master-list-energy> This is a living encyclopedia of data center energy efficiency measures. This is an essential desk reference with more than 250 energy-saving measures. For each measure, the Master List explains the principles involved and how energy savings are generated plus tips on implementation. Users can copy and paste relevant actions directly into an action plan or into an energy assessment report. This not only saves time but also ensures vetted expert recommendations.

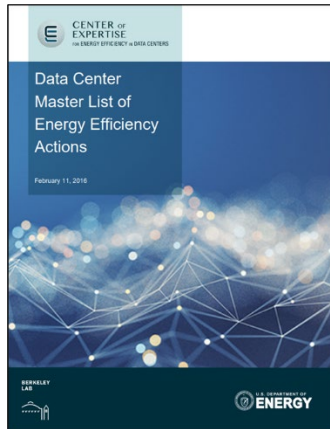


Figure 3. Master List of Energy Efficiency Actions

Energy Assessment Worksheet

In the same area of the Flowchart, we find the Energy Assessment Worksheet <http://datacenters.lbl.gov/resources/energy-assessment-worksheet> This is an Excel-based workbook to document metrics, actions, and measurements. It also allows different levels of analysis, including graphical representation of the results. The workbook can be used in parallel with any of the System-Level Assessment Tools and the Report Template (these resources are discussed below).

At this point, the user can choose one of two paths in the Flowchart (as indicated by the arrows). The first is a more detailed analysis using simulation tools. The second path takes us directly to the Energy Assessment Report Template.

System-Level Assessment Tools

We are now at the resources in the lower part of Figure 2 <http://datacenters.lbl.gov/tools> A “System-Level Tool” refers to downloadable Excel-based simulation software that deals with a single energy consuming system. There are three main System-Level Tools:

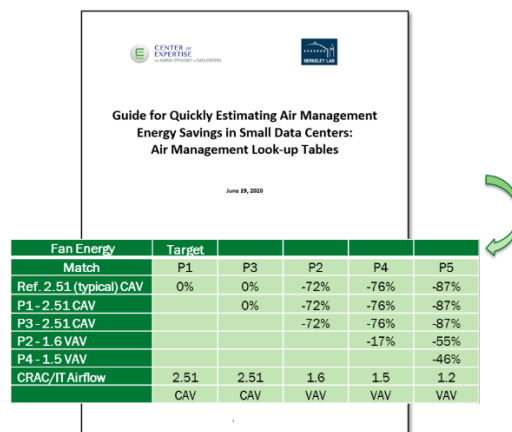
- The Air Management (AM) Tool helps optimize air management to improve energy efficiency and the thermal IT environment. It computes the Rack Cooling Index (RCI), which is an essential air management metric. The AM Estimator is a simplified version of the Air Management Tool.
- The IT Efficiency Tool helps estimate energy savings by improving the IT equipment design and operation. The IT power drives the demand for cooling and power chain energy.
- The Power Chain Tool estimates potential energy savings from efficiency actions in the electrical power chain (e.g., Uninterruptible Power Supplies (UPSs) and Power Distribution Units (PDUs)).

The System-Level Tools have the following features in common:

- What-if scenarios
- Hands-on recommendations
- Energy and cost savings
- CO2 reductions
- Water usage
- Simple payback for energy-saving measures
- Export/import data to/from the other System-Level Tools

AM Packages Tool

Want a quick and easy way to estimate air management savings without a simulation tool? Our research report “Air Management Look-up Tables” presents estimated energy savings in a tabular format for air management upgrade packages of measures. <https://datacenters.lbl.gov/resources/air-management-packages-tool> If these packages do not fit a particular data center, the Air Management Tool can be used to calculate a wide range of data centers and air management measures.



The image shows the cover of a report titled "Guide for Quickly Estimating Air Management Energy Savings in Small Data Centers: Air Management Look-up Tables" dated June 19, 2020. Below the cover is a table with the following data:

Fan Energy	Target	P1	P3	P2	P4	P5
Match						
Ref. 2.51 (typical) CAV	0%	0%	-72%	-76%	-87%	
P1-2.51 CAV		0%	-72%	-76%	-87%	
P3-2.51 CAV			-72%	-76%	-87%	
P2-1.6 VAV				-17%	-55%	
P4-1.5 VAV					-46%	
CRAC/IT Airflow	2.51	2.51	1.6	1.5	1.2	
	CAV	CAV	VAV	VAV	VAV	

Figure 4. Air Management Look-Up Tables

No matter which of the two paths (detail or simple) you select in the Flowchart, you will end up at the Report Template to the far right in Figure 2.

Energy Assessment Report Template

The Energy Assessment Report Template is an extensive (160 pages) Word template for crafting a data center energy efficiency assessment report that can be tailored to site-specific needs <http://datacenters.lbl.gov/resources/energy-efficiency-assessment-report> The template provides a

framework for reporting the results of an assessment, and it helps speed up the report writing and ensure that nothing is forgotten.

Complementary Resources

This completes our description of the Energy Efficiency Assessment Toolkit. However, Lawrence Berkeley National Laboratory has also developed a number of complementary resources addressing critical issues related to energy assessments in data centers. Examples of recent reports include:

- Computer Server Selection Guidelines for Energy Efficiency and Decarbonization in Data Centers
- Accessing Onboard Server Sensors for Energy Efficiency in Data Centers
- Thermal Guidelines and Temperature Measurements in Data Centers

These reports can be accessed by using the search field in Figure 1.

Data Center Energy Practitioner (DCEP) Training Courses

The comprehensive Data Center Energy Practitioner (DCEP) certificate training program is intended to help those managing data centers to reduce energy use and carbon footprint. These courses include training on most of the resources in the Toolkit. The official DCEP website <http://datacenters.lbl.gov/DCEP> includes program description, training calendar, sign-up links, and a listing of program developers, instructors, and DCEPs.

There are three DCEP courses:

- The one-day Generalist course provides a high-level view of IT and support systems + the DC Pro Tool and the electrical Power Chain Tool
- The two-day HVAC Specialist course is an in-depth review of HVAC/mechanical systems + the Air Management Tool
- The one-day IT Specialist course is an in-depth review of IT systems + the IT Efficiency Tool
- An Electrical Specialist course is planned to be completed by late 2024 or early 2025



Figure 5. Current Training Modules of the DCEP Program

Summary

The objective of this article is to provide a high-level description of the CoE's Data Center Energy Efficiency Assessment Toolkit. This free resource provides guidance on achieving energy efficiency and

decarbonization in data centers. Specifically, we review a number of manuals, worksheets, templates, listings, and simulation tools. Taken together, they provide a rich set of useful information. We finally addressed the DCEP training program since it includes training on most of the resources in the Toolkit.