U.S. Department of Energy/Lawrence Berkeley National Laboratory (DOE/LBNL) Energy Assessment Process Manual

Version 2.0 (August 2020)

This manual was developed by Lawrence Berkeley National Laboratory.

Updated by Kim Traber, Traber Engineers
Originally prepared by Magnus Herrlin/ANCIS

DISCLAIMER

CONTENTS

1 INTRODUCTION

1.1 Energy in Data Centers

Data centers are dynamic and energy-intensive facilities. However, the rapid rate of growth in data center electricity use that prevailed from 2000 to 2006 slowed significantly from 2006 to 2016, yielding total electricity use by data centers in 2016 of about 2% of all electricity used in the United States. Figure 1 below shows the historic and projected electric energy use in data centers.

The slower growth is attributable to energy efficiency improvements and a lower server installed base, arising in part from the Great Recession. The total energy savings potential

in data centers is still large, and energy assessments are an effective way to identify those potential savings.

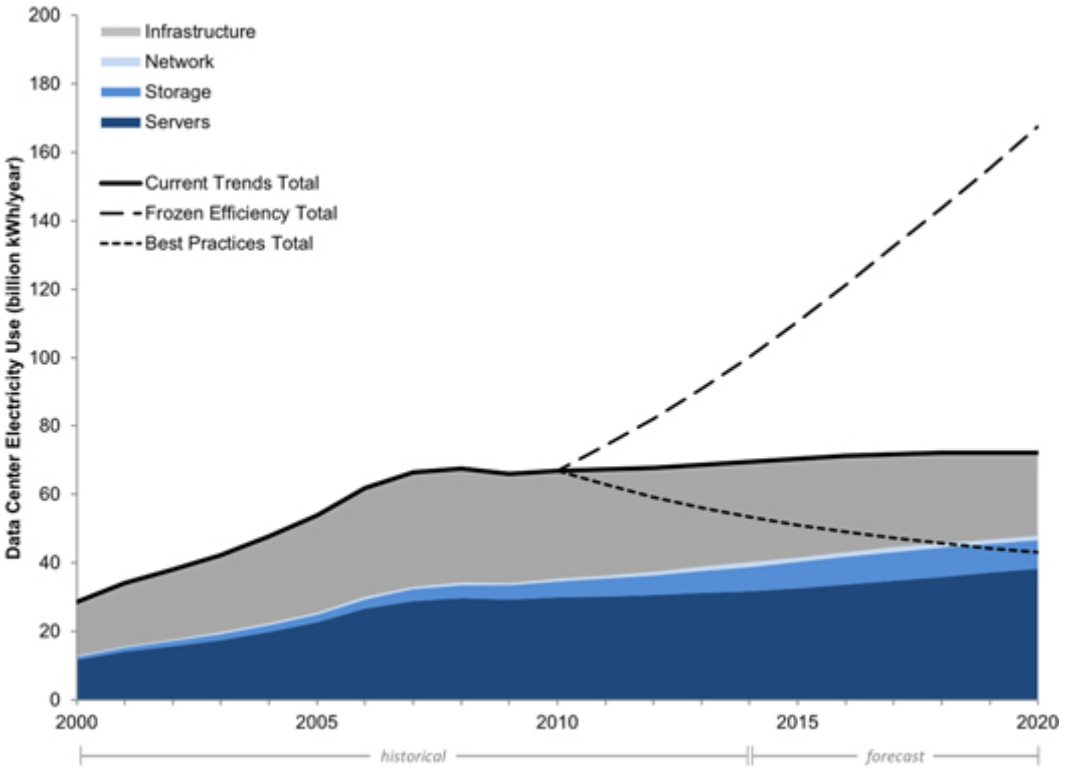

Figure 1. Historical and projected data center energy use (Shehabi et al., 2018)

1.2 Role of DOE/LBNL Energy Assessments In the Process to Implement Efficiency

Although a DOE/LBNL energy assessment is not meant to be a traditional investment-grade audit, the assessment is designed to provide the data center industry with tangible and sustainable savings in energy, cost and adverse environmental impacts. For best results, it is recommended that the individual conducting the energy assessment (the assessor) be a trained Data Center Energy Practitioner (DCEP).[1]

The DOE/LBNL assessment is aimed at developing an action plan for progress. This plan or roadmap has two main objectives:

- Enable energy savings by developing an energy profile with the internal data center team, reviewing select data center systems (HVAC, air management, electrical power chain, IT equipment), identifying potential energy-saving measures and documenting cost and energy savings from the measures.
- Multiply savings through replication by building internal awareness and expertise. Specifically, help the organization form an energy management program, cultivate internal champions to lead energy savings efforts and train the Site Lead in the

[1] For details, see datacenters.lbl.gov/dcep

DOE/LBNL Energy Assessment Process and the use of the Data Center Energy Efficiency Toolkit.

The role of the DOE/LBNL energy assessments in the overall energy-efficiency process and how private sector consultants fit in are depicted in Figure 2. The top two (blue) blocks represent the DOE/LBNL Energy Assessments (high-level profiling and in-depth system assessments). The next three (brown) blocks describe work by private sector consultants. Lastly, the last two (green) blocks represent savings validation and documentation by site personnel and engineering firms.

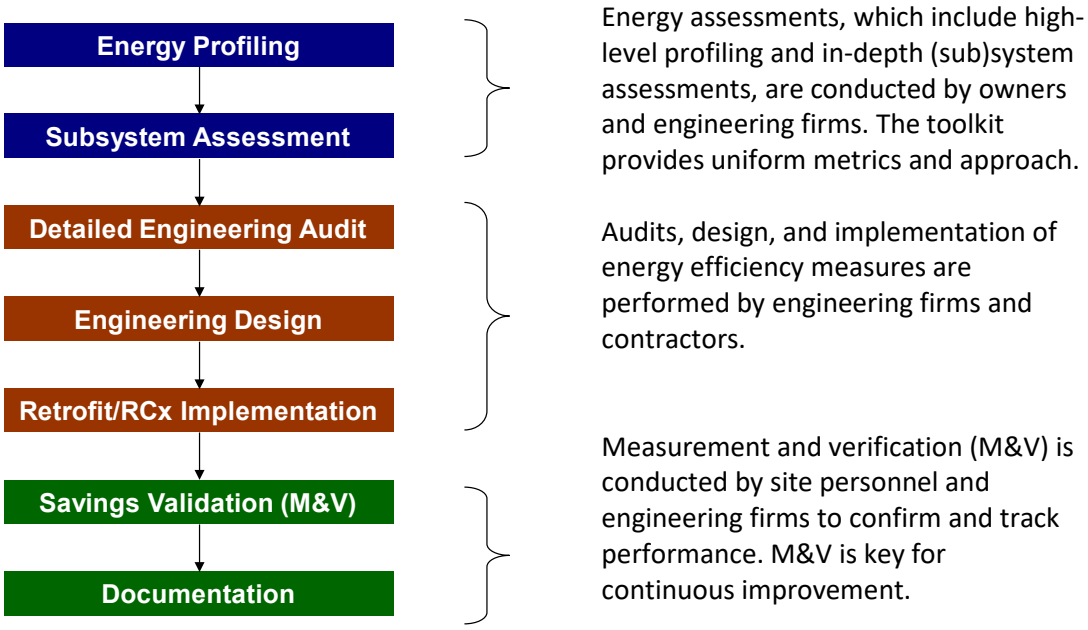

Figure 2: Overall Process for Saving Energy in Data Centers

1.3 Purpose of This Process Manual and Other Resources

This process manual provides step-by-step instructions for conducting a DOE/LBNL Energy Assessment before, during and after the onsite assessment. Multiple appendices include useful templates for the assessments. Assessment resources and their descriptions are listed in Table 1. In addition, Appendix A provides useful terminology.

Table 1: Data Center Energy Assessment Resources

Documents and Tools	Description
DOE/LBNL Energy Assessment Process Manual (this document)	Administrative step-by-step instructions for conducting an energy assessment before, during, and after the onsite assessment.
DCEP Training PDF Slides (if DCEP)	Program training curriculum.
Data Center Profiler (DC Pro) Tools • DC Pro and the PUE Estimator – Intuitive, question-based – User's Manual – Calculation Reference Guide – Training Presentation – Training included in DCEP https://datacenters.lbl.gov/dcpro	Two first-step or "early phase" scoping tools to estimate Power Usage Effectiveness (PUE) without sub-metering. The DC Pro Tools, which include DC Pro and the simplified PUE Estimator, are free and web-based. DC Pro provides potential PUE and tailored recommendations for improvement while the PUE Estimator only asks questions required to estimate PUE.
Data Center Master List of Energy Efficiency Actions https://datacenters.lbl.gov/resources/data-center-master-list-energy	Comprehensive list of recommended energy efficiency actions. The Master List also provides DC Pro with its tailored recommendations for improvement.
Assessment Workbook https://datacenters.lbl.gov/tools/3-energy-assessment-worksheets	Excel template that can be used to collect data as well as document measurements, metrics, and actions from the assessment. The workbook follows the same structure as the Master List and Assessment Report Template. Both the workbook and report template are designed for flexibility. Users can conduct, and report upon, a finely detailed energy assessment of large, complex facilities. They also can take simplified "whole-facility" paths that may feature more scrutiny of select (sub)systems.
Air Management Tools • Air Management Tool and Air Management Estimator - User's Manuals - Data Collection Guide - Engineering Reference - Training included in DCEP https://datacenters.lbl.gov/tools/5-air-management-tools https://datacenters.lbl.gov/resources/data-center-air-management-estimator	Excel-based tools that provides air management recommendations including reducing the supply airflow rate and increasing the supply air temperature without affecting the thermal environment. The Air Management Tool also estimates % energy reduction, kWh reduction and associated energy cost savings for fans and chillers.
Electrical Power Chain Tool • Intuitive, question-based • Diagrammed data center power chain w/measuring points	This Excel-based tool helps data center owners identify energy efficiency opportunities in the electrical power chain of a data center (transformers, generators,

• Updated UPS efficiency curve	UPSs, power distribution units). The tool quantifies the energy and cost savings of the selected measures and calculates the payback periods for each measure.
IT Equipment Efficiency Tool • User's Manual • Training included in DCEP	Forthcoming Excel-based tool that provides estimates of energy savings at the IT equipment level based on user input. It estimates power (W), energy (kWh), dollar and carbon savings.
Energy Efficiency Assessment Report Template and Example Report https://datacenters.lbl.gov/tools/7-energy-efficiency-assessment-report	Word template to report assessment findings as well as a real-word example. The report template is designed to be filled with actual site data, pasted directly from the Assessment Workbook.

In addition to the forthcoming IT Equipment Efficiency Tool, a number of other relevant resources are in development or under consideration. These include 1) a data center addendum to the Federal Energy Management Program's Measurement and Verification Guidelines for Energy Service Performance Contract Projects, and 2) an energy savings calculator for liquid cooling. The M&V guide addendum is not part of the assessment process, but it does contain valuable information on data center-specific measures and methodologies for assessing their savings.

2 PROCESS FOR DOE/LBNL ENERGY ASSESSMENTS

Table 2 provides an overview of the 10 assessment process steps outlined in this document as well as the available resources. The assessment process is broken down into four phases: Assessment Initiation (faint red), Pre-Onsite Preparation (faint blue), Onsite Activities (faint green), and Post-Onsite Activities (faint orange). The text sections following the table provide details on each of these process steps. Table 2 is written for a third-party assessor. For an in-house assessor, the difference between on-site and off-site becomes moot.

Table 2: Overview of Process Steps

#	Process Step Description	Available Resources
1	**Phase 1: Assessment Initiation** Introduce the DOE/LBNL assessment process. Identify preliminary goals, scope, onsite activities, and key personnel. Arrange for onsite logistics.	
2	**Preliminary assessment** by Site Lead using DC Pro or the PUE Estimator.	* DC Pro Tools/Manuals
3	**Phase 2: Pre-Onsite Preparation** **Kick-off conference call** - Review scope, onsite activities, team, and logistics - Identify target systems, tools, and data to collect	* DC Pro results * Target System List (App. E) * Selected System Tool(s)/Manuals

#	Process Step Description	Available Resources
	- Identify safety issues.	
4	**Off-site compilation of information** - Collect technical info from drawings, logs, etc. - Collect Site Description Survey - Collect Energy Management Practices Survey - Review required measurement equipment - Ensure functioning of the toolkit onsite - Review Safety, Health, and Environmental Training - Review confidentiality agreements.	* Assessment Worksheets * Site Survey (App. C) * Energy Management Practices Survey (App. D)
5	**Phase 3: Onsite Activities** (2-3 days per system) **Initiation onsite meeting** with all stakeholders: - Collect participant list - Overview presentation by the Assessor - Safety, health, and environmental training - Site tour of data center - Develop detailed work plan (measurements) - Assign roles and responsibilities	* Assessment Participants Template (App. I)
6	**Training to allow replication (mainly part of Step 7)** - Training on efficiency toolkit - Energy management best practices	* DC Pro Tools/Manuals * Air Management Tool * Air Management Estimator * Power Chain Tool
7	**Fundamental investigations** - Field measurements - System modeling with selected System Tools - Assessment Worksheets - Results compilation and presentation	* Selected System Tool(s)/Manuals * Assessment Workbook
8	**Preliminary Findings Meeting** - Directed to Site Management - Complete Assessment Evaluation	* Evaluation Template (App. J)
9	**Phase 4: Post-Onsite Activities** **Compilation of Assessment Report** - Observations and opportunities - Estimated energy savings for each opportunity - Estimated costs for implementing each opportunity	* Process Manual (this doc) * Assessment Report Template and Example Report * Assessment Workbook * DC Pro * Selected System Tool(s)/Manuals * Master List of EEMs * Any complete surveys and templates (App. B-J)
10	**Finalize reporting requirements + Follow up** - Draft to site for review, document savings	Same as above

2.1 Phase 1: Assessment Initiation (Process Steps 1-2)

The assessor contacts the initial site contact to identify preliminary scope, onsite activities, key personnel, and onsite logistics including approximate timing of the energy assessment. The initial site contact may or may not be the site lead, who is the onsite technical representative and primary person participating in the assessment.

Step 1: Establish Preliminary Scope and Onsite Activities

The preliminary scope of the energy assessment should be established in this initiation phase and be refined in the preparation phase (the next phase). Sharing this process manual with the site lead may not only help communicate the overall assessment process but also establish the scope and onsite activities. The ultimate goal of energy assessments is to provide the site with trained staff who can effectively apply the Data Center Energy Efficiency Toolkit and energy management principles to investigate systems in other data centers.

Identify the Site Lead

A primary point of the assessment initiation is to identify the site lead. This person must:

- understand the nature of the energy assessment
- be knowledgeable about the data center systems
- have contact with system operations and maintenance personnel
- facilitate the onsite activities, logistics, ensuring access to facilities, equipment and personnel
- Preferably be responsible for learning the Data Center Energy Efficiency Toolkit
- Preferably be able to replicate the identified system analyses.

Identify the Assessment Lead Team

The personnel who will be participating in the energy assessment need to be identified:

- Devoted Onsite Assessment Personnel (Assessment Lead Team)
  - Assessor
  - Site lead (the primary person participating in the assessment)
  - Other core personnel participating in the assessment (any other essential personnel beyond the Site Lead).
- As-Needed Personnel
  - System Operations/Maintenance Staff
  - Technical Support Staff
  - Management must participate in the Initiation Onsite Meeting (Step 5) and the Preliminary Findings Meeting (Step 8).

Arrange for Logistics

The onsite logistics tasks include the following:

- Solidify energy assessment timing; the total number of days on site depends on the number of system analyses (typically two to three days per primary system)
- Arrange gate-pass for the assessor
- Identify a conference room that can serve as an uninterrupted base
- Identify lodging issues
- Consider food services onsite to minimize lost time.

Step 2: Preliminary Assessment

The site lead should do a preliminary online assessment using one of the DC Pro Tools, based on available data. The assessor will be available (off site) to assist. Besides providing an energy profile of the data center, this preliminary assessment will help with the target systems identification in the next assessment phase (Step 3).

2.2 Phase 2: Pre-Onsite Preparation (Process Steps 3-4)

Step 3: Kick-off Conference Call

The kick off conference call ensures that scope, onsite activities, key personnel and onsite logistics have been identified. Other purposes are to identify the data center systems to be included in the energy assessment, technical information to be collected prior to the site visit (Step 4), and safety issues.

Target System Identification (see Appendix E)

- The activities are driven from the target system list, the data center systems that are the focus of the assessment. It is prudent not to allow one system to dominate the assessment. The preliminary offsite assessment with one of the DC Pro Tools (Step 2) should provide guidance. A primary goal is to use the DOE/LBNL in-depth system tools in the analyses of the target systems.
- The primary systems consist of the following three systems:
  - IT Equipment
  - HVAC Systems (Cooling and Air Management)
  - Electrical Systems.

Step 4: Off-Site Compilation of Information

Collect technical information and data from surveys, drawings, logs, etc. Enter the information into selected DOE/LBNL System Tool(s) or Assessment Workbook. The workbook can later be used to document measurements, calculations, metrics, and actions from the assessment (Step 7).

Site Description Survey (see Appendix C)

If one of the DC Pro Tools has not been used or more information is needed, request the site lead to complete the Site Description Survey to identify the *general* characteristics of the data center. See Appendix C.

- Principal data center description
  - Size
  - Type of data center (enterprise, co-location, telecom, etc.)
  - Geographic location
  - Fuel, fuel costs, and fuel unit cost.

- Primary System description
  - Type and number of equipment/systems
  - Redundancy
  - Control strategies
  - Power requirements and fuel types
  - Operating characteristics, normal operating conditions.

Energy Management Practices Survey (see Appendix D)

If one of the DC Pro Tools has not been used or more information is needed, also request the site lead to complete the Energy Management Practices Survey, see Appendix D. This survey provides high-level information on energy policies implemented at the data center.

Required Measurement Equipment

The assessor should review the collected data and determine the existence of any data gaps for which onsite measurements or other collection methods may be necessary. Identify the measurement equipment the assessor must bring to the site. Examples include equipment for measuring:

- Air temperature
- Air humidity
- Air flow rate
- Water temperature
- Water flow rate
- Electrical power.

Questions to ask the site lead include the following:

- Are there needs for special measurement equipment?
- Are there existing, accurate sensors?
- What can the control system report?

Functioning Onsite Data Center Energy Efficiency Toolkit

Ensure selected DOE/LBNL tools are working on a computer available to the site lead:

- the site lead should explore the toolkit as a preparatory exercise
- Download the Data Center Energy Efficiency Toolkit from https://datacenters.lbl.gov/tools
- The Air Management Tools (https://datacenters.lbl.gov/tools/5-air-management-tools) should be brought to the energy assessment by the assessor in a form that allows easy access by the team (e.g., memory stick).

Review Safety, Health, and Environmental Issues and Training

Identify site-specific safety, health, and environmental issues/training:

- Identify personal protective equipment the Assessor will be required to bring
- Identify personal protective equipment the Site Lead will provide
- Identify any special requirements
- Determine the safety, health, and environmental training requirements
- Establish a tentative schedule for safety, health, and environmental training
- Perform the training the first day of the onsite activities
- Training must be completed *and* documented before onsite activities.

Agreements

The site lead must provide the assessor with the appropriate confidentiality agreements:

- The parties must ensure the agreements are understood.
- The assessor must reviewed, signed, and return the agreements prior to entering the site.

2.3 Phase 3: Assessment Onsite Activities (Process Steps 5-8)

Typically, the onsite activities take about two to three days per primary system.

Step 5: Initiation Onsite Meeting

Begin the onsite activities with an initiation meeting with all stakeholders to review the assessment scope and onsite activities and to introduce the assessor to the lead team.

Collect Participant List (see Appendix I)

Document the following participant information:

- Name and title
- Company
- Address
- Phone number and email address.

Overview Presentation by the Assessor

The initial meeting is an energy *training*-assessment in that the assessment lead team should be an active participant in the assessment. Creating the ability for replication is a key goal of the energy assessment.

- The general framework of the energy assessment should be established.
  - Assessment scope
  - Onsite activities
  - Role of the assessor
  - Data Center Energy Efficiency Toolkit
  - Field measurement
  - Roadmap development
  - Preliminary findings meeting
  - Post-assessment activities

- The energy assessment is not a fault-finding activity but rather is designed to:
  - Share knowledge
  - Provide tools
  - Teach energy management best practices
  - Identify opportunities for improvement
  - Identify opportunities for replication

Safety, Health, and Environmental Training

Perform the safety, health, and environmental training identified in Step 4.

Site Tour

Conduct a brief site tour to familiarize the assessor with the data center facility. This is an excellent opportunity to ask and answer questions.

Develop Detailed Work Plan

Develop a detailed work plan by agreeing on potential energy efficiency opportunities to investigate, metrics to be analyzed, and measurement plan to be implemented. The off-site compilation of information (Step 4) should provide an excellent starting point for establishing required field measurements. The actual measurements are taking place during the fundamental investigations (Step 7).

Assign Roles and Responsibilities

With the site lead, assign roles and responsibilities among the members of the assessment team according to the Detailed Work Plan.

Step 6: Training of Lead Team to Allow Replication

Data Center Energy Efficiency Toolkit

While performing the onsite assessment (Step 7), the assessor should train the assessment lead team so that they sufficiently understand the toolkit, including the associated data collection of required input data. It is beneficial for the site lead to complete some of the analysis with the assessor. At the end of the onsite assessment, it is hoped that the site lead will be able to replicate the investigations.

Energy Management Best Practices

Identification of energy management best practices is an important part of a successful assessment. While performing the onsite assessment (Step 7), the assessor should highlight and transfer energy management best practice knowledge to the lead team. Understanding the overall energy assessment process as well as energy management best practices is an excellent replication vehicle.

Step 7: Fundamental Investigations

This step is where the rubber hits the road. First, the lead team collects the information based on the data gaps identified in Steps 4 and 5. Second, selected system tool modeling is performed to quantify potential energy opportunities. The Assessment Workbook can be useful even if a particular system tool is not available. Finally, the results are compiled into a presentation directed to the site management.

Some information (data) will be readily available, including data that can be collected from building management systems, equipment read-outs (e.g., UPS), operating information, and design data. Other data collection may require measurements and temporary metering. The assessment team could decide to use a design value in lieu of a measured value or decide to use estimates rather than actual data.

Field Measurements

Field measurements provide key input data to the Air Management Tool and other analyses. The detailed Measurement Plan developed in Step 5 should be applied. Ensure that all measurements required for determining critical data are performed while on site. Measurement Plan modifications are likely as the fundamental investigations proceed.

System Tool Modeling

When the measurements are completed and other data have been collected, the system modeling with selected system tool(s) should be performed to quantify potential energy opportunities. At this point, there should be no surprises regarding required tool input data if the process outlined above was followed.

Assessment Workbook

The Assessment Workbook is designed as a full-featured, unitary data collection tool. It is built to accompany the assessor and team leads into the field and guide collection at multiple levels of detail. The workbook can be used for collecting data (Step 4) but also for documenting measurements, metrics, calculations, and actions from the assessment. In 2020, the workbook was substantially expanded and revamped with several objectives:

1. Afford more robust subsystem investigations, including within large, complex multi-hall facilities
2. Also enable lighter, less resource-intensive data collection and analyses
3. Provide guidance on calculations where needed
4. Where possible, enable users to decide whether deeper data collection and analysis are warranted
5. Add new features, capabilities and better documentation and guidance

At the top of many tabs, below instructions, users will find Energy Efficiency Guidance. These text boxes will guide the user in interpreting some high-level observations, measurements or calculated metrics. In some cases, the workbook will indicate more analysis is needed and guide the user to the in-depth system tools, which offer more analytical insight and usually some recommendation of energy efficiency measures.

One indicator, for example, comes in the form of a simple pair of built-in diagnostics for air management (AM). The AM heat maps are a set of color-shaded tables that provide a framework for quickly, visually assessing air temperatures in the hot and cold aisles and inferring whether air management in the data center appears effective or probably would benefit from deeper scrutiny with the AM Tool. One heat map compares measured inlet temperatures to current ASHRAE guidelines for recommended and allowable temperatures for IT equipment by class. A second heat map reflects the temperature differential at the rack level between the hot and cold aisles and allows inferences of the effectiveness of air flow management and containment.

Data from the one of the DC Pro Tools (Step 2) can be used as a starting point for the more detailed assessment. But the Assessment Workbook also can provide some of the same functions. If sufficient data were available, the workbook will calculate and chart both a current Power Usage Effectiveness (PUE) and a prospective or post-treatment PUE, based on implementation of certain measures identified and described by the user.

Nearly all of the quantitative fields and tables in the Data Center Energy Assessment Report Template are mapped directly from the Assessment Workbook; fields between the tools are not linked and so will not autopopulate. But the workbook and report template are organized in the same fashion, subsystem by subsystem, and each table in the

template has a direct counterpart in the assessment workbook so that workbook tables can, in most cases, be pasted directly into the report template.

Results Compilation and Presentation

The assessment results are compiled into a brief slide presentation. Preparation for the preliminary findings meeting should also include discussions of presentation points with the assessment lead team.

- Preliminary findings must be accepted by the Site Lead before the Meeting
  - Opportunities
  - Best practices
  - Roadmap (action plan).
- Provide a presentation with no surprises
- This should not be a fault-finding presentation.

Step 8: Preliminary Findings Meeting

The Preliminary Findings Meeting is directed to site management, the personnel to whom the site lead wishes to communicate the findings. The meeting allows the assessment team to:

- Present real and tangible energy-efficiency opportunities
- Identify and promote energy management best practices (including discussing management process improvement opportunities,[2] if appropriate, in the spirit of DOE's 50001 Ready program or ISO 50001 certification)
- Present the Roadmap
- Modify recommendations based on information obtained during the meeting.

Assessment Evaluation Summary (see Appendix J)

The site lead and other participants should complete an assessment evaluation prior to the conclusion of the onsite activities.

2.4 Phase 4: Post-Onsite Activities (Process Steps 9-10)

The post-onsite activities are initiated by compiling the assessment report, the attendance report and assessment evaluation report. the assessment report is submitted to the site lead. the assessor revises the draft to the satisfaction of the site lead. the result is the final assessment report.

[2] For organizations that are mature in energy management and actively seeking additional opportunities, it may be appropriate to recommend enhancing their existing energy management system to be compliant with DOE-'s 50001 Ready program or the ISO 50001 standard. Both emphasize continuous improvement following a holistic and systematic approach with top management commitment. For organizations with less sophisticated energy management, it could be appropriate to recommend certain essential elements for near-term benefit. Guidance for implementing these elements are found in the 50001 Ready Navigator tool (https://navigator.lbl.gov/guidance/dashboard). Such opportunities may include, but not limited to, collecting energy data for analysis, developing clear energy performance indicators and baselines, establishing energy objectives and targets, monitoring performance improvement, and engaging senior management in energy management activates.

Step 9: Compilation of Assessment and Attendance Reports

Compilation of Assessment Report (see Assessment Report Template and Example Report).

The assessment report should be a brief narrative summary of the energy assessment. The report should contain the following elements.

Executive Summary

The executive summary should include key observations, opportunities, and estimated energy savings.

General information (see Appendix B)

General information includes the following:

- Data center owner
- Facility name
- Assessment dates
- DCEP name
- Data center contact with name, address, phone number, and email address.

Target Systems List (see Appendix E)

The data center systems targeted for the Assessment (Step 3). See Appendix E for a template.

Site Description Survey (see Appendix C)

The survey identifies the general characteristics of the data center (Step 4).

Energy Management Practices Survey (see Appendix D)

The survey provides a picture of the current energy management practices (Step 4).

Summary Energy Savings (see Appendix F)

A summary of the energy savings opportunities should be provided for each Primary System. See Appendix F for a template. For each Primary System, provide the following information:

- Estimate impact ($/year and kWh/year)
- Estimate cost for implementation
- Calculate simple payback (years).

Detailed Energy Savings (see Appendix G)

Detail the energy savings opportunities in the Detailed Energy Savings Table. See Appendix G for a template. Use one table for each primary system: IT Equipment, HVAC Systems, and Electrical Systems. For each opportunity, provide the following information:

- Brief description

- Estimate impact ($/year and kWh/year)
- Estimate cost for implementation
- Calculate simple payback (years)
- Identify the time horizon for completion:

    - Near-term (“N”) opportunities include improvements in operating practices, maintenance of equipment, relatively low-cost actions, or low-cost equipment purchases. Completion of the opportunity can be attained in less than one year.
    - Medium-term (”M”) opportunities would require purchase of additional equipment and/or changes in the system. It would be necessary to carry out further engineering and economic analysis. Completion of the opportunity could be attained in the one- to two-year timeframe.
    - Long-term (“L”) opportunities would require testing of a new technology and confirmation of performance of the technology with economic justification to meet corporate investment criteria. Completion of the opportunity could be attained in the two- to five-year timeframe.

Identified Actions (see Appendix H)

After the detailed energy savings, list actions required for implementing each efficiency opportunity. See Appendix H for a template. The LBNL Master List of Energy Efficiency Measures provides a comprehensive listing of actions that may be recommended as part of the assessment report and roadmap. See https://datacenters.lbl.gov/resources/data-center-master-list-energy

Roadmap

The roadmap (action plan) initially developed in Step 7 should be refined and discussed. As mentioned in the Introduction, this roadmap is a key outcome of the DOE/LBNL Energy Assessment.

Benchmarking

The purpose of this section is to summarize the metrics that were utilized as part of the assessment process and compare them to data from other facilities, where available. Useful metrics may include the following:

- PUE (-)
- DCiE (%)
- Cooling Efficiency (kW/ton) [kW/kW]
- UPS System Efficiency (%)
- Rack Cooling Index (RCI)® (%)
- Return Temperature Index (RTI)™ (%)

Potential Case Study

The assessment report may also discuss whether developing a case study from activities at the site is a possibility. Case studies are generally widely applicable, straightforward,

and generally focus on an aspect of areas such as fundamental systems, energy management best practices, innovative solutions, and comprehensive management activities.

Step 10: Finalize Reporting Requirements

- Submit the draft assessment report to the site lead 10 business days after completion of the onsite work
- The site lead provides review comments on the draft to the assessor
- The assessor revises the draft to the satisfaction of the site lead. The result is the final assessment report.

Follow Up

Follow up with the site to document implemented solutions and savings.

Appendix A: Terminology

Assessor

The energy expert assigned to complete the DOE/LBNL Assessment; the expert serves as the facilitator for all activities and often is a Data Center Energy Practitioner (DCEP).

DC Pro Tools

DC Pro Tools include the DC Pro and the PUE Estimator

DOE

U.S. Department of Energy

Data Center Energy Efficiency Toolkit

A suit of tools sponsored by the Center of Expertise for Energy Efficiency in Data Centers at Lawrence Berkeley National Laboratory and by DOE's Federal Energy Management Program. The toolkit includes this energy assessment process manual; DC Pro/PUE Estimator; the Air Management Tool/Air Management Estimator, the Power Chain Tool; the Master List of Energy Efficiency Measures for Data Centers; the Data Center Energy Assessment Workbook; and the Data Center Energy Assessment Report Template.

Initial Site Contact

Data center representative who serves as the initial contact

Lead Team

Core personnel participating in the assessment, including assessor and site lead

Preliminary Findings Meeting

This meeting is directed to site management.

Primary Systems

- IT Equipment
- HVAC Systems (Cooling and Air Management)
- Electrical Systems

Site Lead

Data center technical representative that will be the primary person participating in the assessment

Site Management

Data center personnel to whom the site lead wishes to communicate the findings

System Tools

The in-depth System Tools include the Air Management Tool, the Air Management Estimator, the Electrical Power Chain Tool, and the forthcoming IT Equipment Efficiency Tool.

Target Systems List

Listing of data center systems targeted for the assessment.

Appendix B: General Information

Data Center Owner		**Assessment Dates**	
Facility Name		**Assessment Type**	
Location		**Assessor Name**	
Data Center Contact Information			
Name			
Address			
City/State			
Phone			
Email			

Appendix C: Site Description Survey

Request the Site Lead to complete the Site Description Survey to identify the *general* characteristics of the data center.

Principal Data Center Description			
Total data center area			
Electrically active area			
Type (enterprise, collocation, telecom, etc.)			
Geographic location			
Annual fuel cost ($) and fuel unit cost ($/kWh)	Electricity		
	Gas		
	Oil		
Primary Systems Description			
General description of key IT-equipment ▪ Type and number of equipment ▪ Power requirements ▪ Operating characteristics ▪ Normal operating conditions			
General description of key HVAC systems ▪ Type and number of systems ▪ Redundancy ▪ Control strategies ▪ Power requirements and fuel types ▪ Operating characteristics ▪ Normal operating conditions			
General description of key electrical systems ▪ Type and number of systems ▪ Redundancy ▪ Control strategies ▪ Power requirements and fuel types ▪ Operating characteristics ▪ Normal operating conditions			

Appendix D: Energy Management Practices Survey

Request the Site Lead to complete the following Energy Management Practices Survey to identify energy policies implemented at the data center.

- Does your organization have a written CEO- or Board-approved policy that includes reducing energy consumption?
  □ No □ Yes □ Unknown or no answer

- Does your company/agency have a formal written energy management plan that is updated at least every two years?
  □ No □ Yes □ Unknown or no answer

- Does your company/agency have a corporate or facility energy manager position?
  □ No □ Yes

- Do the duties of manager include finding and implementing ways of reducing the energy consumption?
  □ No □ Yes

- In the last two years, have there been any corporate/agency or facility mandates to reduce energy consumption by a targeted percentage or amount?
  □ No □ Yes □ What was the percentage? _____%

- How many employees does the data center employ? _____

- Does the annual performance rating for the data center manager include a component with energy reduction goals that influence bonuses?
  □ No □ Yes □ Unknown

- In the last two years, have there been any projects in your data center to reduce energy consumption or projects that included a component aimed at reducing or managing energy?
  □ No □ Yes

- Were those projects a result of (check all that apply):
  □ New construction
  □ As a consequence of updating the data center
  □ A project focusing almost entirely on energy use
  On what systems were those projects focused?_____

- When you purchase new or replace equipment at the data center, does the life cycle cost, including energy use, affect what is purchased?
  - □ Always
  - □ Usually
  - □ Sometimes
  - □ Occasionally
  - □ Never
  - □ Unknown

- In managing operations and maintenance, do you analyze energy use trends to identify needed changes to operations or maintenance practices to reduce energy use?
  - □ No □ Yes

- Which financial methods does your firm typically use to evaluate energy efficiency improvements?
  - □ Initial Cost
  - □ Simple payback
  - □ Internal rate of return
  - □ Life cycle cost
  - □ Other (please explain) _____
  - □ Unknown

- What payback *(length of time)* do you normally require in order to consider an energy investment cost effective?
  - □_____ (Years*)*

- What rate of return do you normally require in order to consider an energy investment cost effective?
  - □ _____%

- What discount rate do you normally use in determining the life-cycle costs of various equipment options?
  - □ _____%

Appendix E: Target System List (Assessment Scope)

The three primary systems are IT Equipment, HVAC Systems, and Electrical Systems. Each primary system, in turn, consists of key sub-systems as shown below. Check the selected subsystems for the assessment.

Systems	**Target System(s)**
IT Equipment	
Servers	
Storage	
Networking	
HVAC Systems	
Air Management	
Cooling Systems	
Chilled-Water Plant	
Electrical Systems	
UPS	
PDU	
Lighting	
Onsite generation	

Appendix F: Summary Energy Savings

Energy Savings Opportunity Summary				
	Impact			
Primary System Opportunity	$/yr	kWh/yr	Cost	Payback yrs
IT Equipment				
HVAC Systems				
Electrical Systems				
Total				

Appendix G: Detailed Energy Savings

Energy Savings Opportunity for Primary System: _____ **(One table for each Primary System: IT Equipment, HVAC Systems, and Electrical Systems)**						
		Impact				
#	Opportunity	$/yr	kWh/yr	Cost	Payback yrs	N,M,L[1]
1						
2						
3						
4						
5						
:						
	Total					

Footnote 1:
N = Near-Term
M = Medium-Term
L = Long-Term

Appendix H: Identified Actions

Identified Actions for Primary System: _____ **(One table for each Primary System: IT Equipment, HVAC Systems, and Electrical Systems)**		
#	Opportunity	Action(s)
1		
2		
3		
4		
5		
:		

Appendix I: Assessment Participants (attendance)

Data Center Owner		**Location**	
Facility Name		**Assessment Date(s)**	
Name	**Address**	**Phone**	**email**

Appendix J: Assessment Evaluation

Data Center Owner		**Location**	
Facility Name		**Assessment Date(s)**	
Individual Evaluation Summary (5 highest/likely/good, 1 Lowest/unlikely/poor)			
The program increased my understanding of my data center systems. **Comments:**			
The program and information learned will be useful to me. **Comments:**			
Will you use the DOE/LBNL Tool Suite? **Comments:**			
The agenda was appropriate. **Comments:**			
The Assessor was knowledgeable and added value. **Comments:**			
Overall Comments and Suggestions:			

Resources

Assessment Report Template and Example Report: https://datacenters.lbl.gov/tools/7-energy-efficiency-assessment-report

Assessment Workbook: https://datacenters.lbl.gov/tools/3-energy-assessment-worksheets

Center of Expertise for Energy Efficiency in Data Centers: http://datacenters.lbl.gov

DC Pro Tools: https://datacenters.lbl.gov/dcpro

Data Center System Tools: http://datacenters.lbl.gov/tools

DCEP Training Program: http://datacenters.lbl.gov/dcep

Koomey, J, 2010, Growth in Data Center Electricity Use 2005 to 2010: http://www.missioncriticalmagazine.com/ext/resources/MC/Home/Files/PDFs/Koomey_Data_Center.pdf

Shehabi, Arman, Sarah J. Smith, Eric Masanet and Jonathan Koomey. 2018. "Data center growth in the United States: decoupling the demand for services from electricity use" Environmental Research Letters, Volume 13, Number 12. Dec. 18, 2018 https://iopscience.iop.org/article/10.1088/1748-9326/aaec9c/meta