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Data Center Profiler (DC Pro) Tool:

User's Manual

DC Pro Version 4

Manual Updated August 18, 2016

The User's Manual and the DC Pro tool were developed by Lawrence Berkeley National Laboratory (LBNL) for the U.S. Department of Energy (DOE)

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Table of Contents

Overview

This manual is a step-by-step guide for using DC Pro V4 (DC Pro) including how to get started, provide the required inputs, and view results. DC Pro is an "early stage" assessment tool designed for data center owners and operators to diagnose how energy use is distributed in their data center and determine ways to save energy and money. DC Pro estimates a data center's current and potential Power Usage Effectiveness (PUE)[1] and energy use distribution. It also provides a tailored list of recommended tasks for improvement. Results can be exported as stand-alone reports or for inclusion in other reporting material.

DC Pro and the simplified PUE Estimator as known collectively as the DC Pro Tools. Both tools are sponsored by the U.S. Department of Energy and hosted by the Lawrence Berkeley National Laboratory (LBNL, Berkeley Lab) on the Center of Expertise for Energy Efficiency in Data Centers website (CoE): datacenters.lbl.gov

Key Features

- Registration is required, but the tool is free to use;
- Web-based and confidential;
- Data are not available to other users;
- Designed for use at the beginning of an energy management plan to baseline energy use;
- Accuracy of the results depends on accuracy of the information entered;
- Basic guidance for entering the data correctly is built into the tool.

Figure 1: Center of Expertise Website

[1] PUE is the ratio of Total Facility Energy to IT Equipment Energy. It is the commonly used metric to describe data center infrastructure efficiency. More specifically, PUE = (IT Energy Use + Lighting Energy Use + Electric Distribution Loss + Fans Energy Use + Cooling & Humidity Control Energy Use + Standby Generation Loss + Misc. Losses) / (IT Energy Use).

Additional Tools

For a more detailed air management assessment, please see the Data Center Air Management Tool: https://datacenters.lbl.gov/tools/5-data-center-air-management-tool-featured

For guidance on calculating PUE with sub-metering, please see the Data Center Metering and Resource Guide: https://datacenters.lbl.gov/resources/data-center-metering-and-resource-guide

Getting Started

The DC Pro Tools page can be accessed from the Center of Expertise (CoE) homepage by clicking the "DC Pro Tools" listing as a Featured Resource or by clicking the Tools tab. It can be accessed directly by entering this address: datacenters.lbl.gov/dcpro

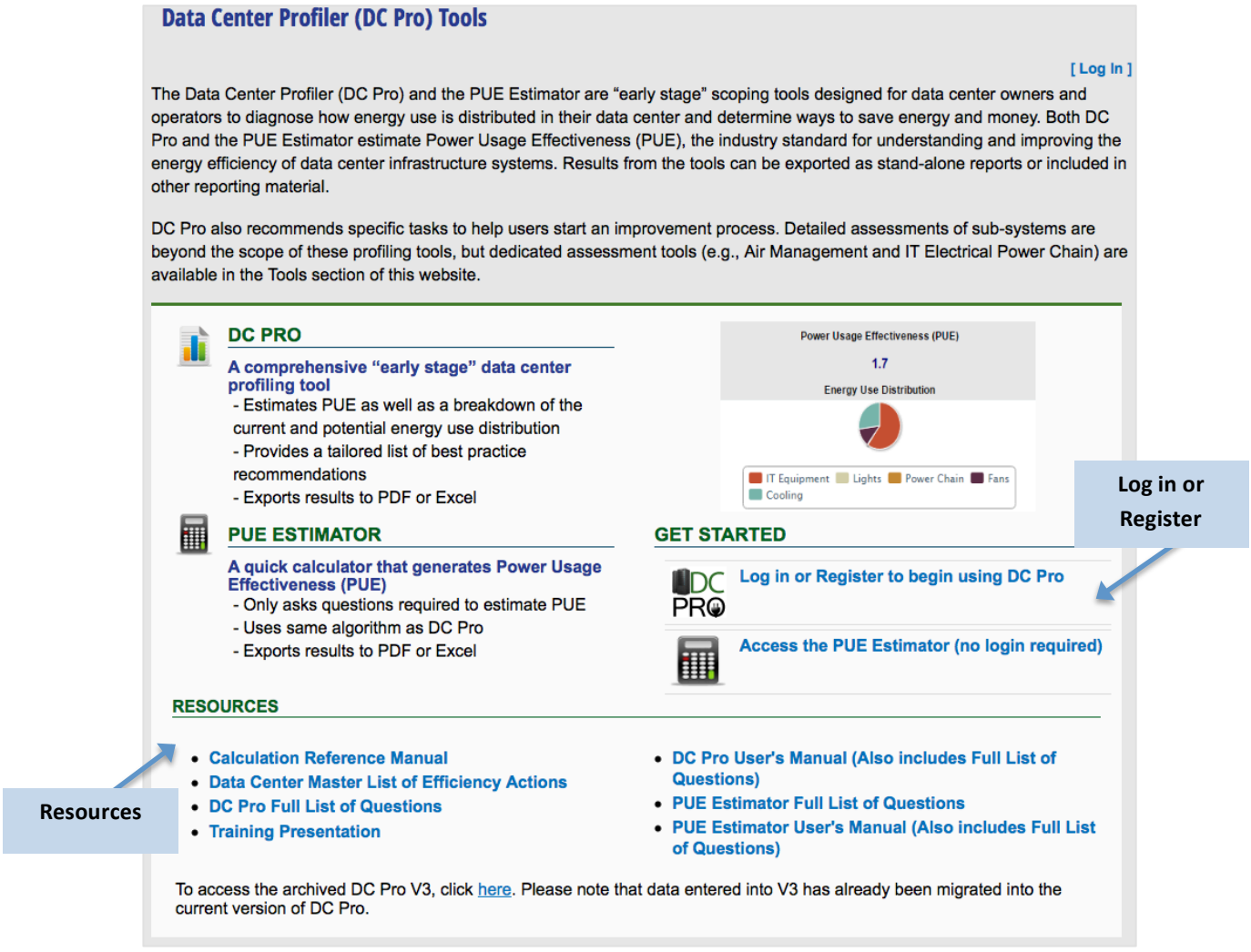

Figure 2: DC Pro Tools Page

The DC Pro Tools homepage hosts DC Pro, the PUE Estimator, and other resources that may be of interest, including:

- *Calculation Reference Manual*: In-depth look at the calculations taking place behind DC Pro;
- *Data Center Master List of Energy Efficiency Actions*: Complete list of best practices that are drawn upon for the tailored list of recommended tasks provided in DC Pro; and
- *DC Pro Full List of Questions*: Microsoft Word document to collect data offline.

Registering or Logging in

From the DC Pro Tools page click "Log in or Register to being using DC Pro." Log in credentials created in DC Pro V3 can be used for V4 and data previously entered into V3 will automatically be listed.

Figure 3: Log in or Registration

Once logged in, you are at the assessment home page, which includes the "How to use the tools on this page?" section. This section provides an overview of DC Pro's functionality and how to perform specific tasks, including:

- How to create a record for a new data center (Data Center for the Data Center Explorer);
- How to create a new assessment to estimate PUE, energy use distribution, and provide; tailored recommendations (DC Profile);
- How to add, edit, delete, and export DC Profiles.

The main steps for DC Pro are outlined below, but reading through the "How to use the tools" section is highly recommended. You can return to this page by clicking Assessment Home.

Creating a Data Center or Selecting Existing

If you already have a record for your data center, you will see it listed in the Data Center Explorer in the top left of the screen. If do not see your data center, or wish to enter a new one, click "add it here." A new data center does not need to be created each time you want to assess your data center; instead a new DC Profile should be created underneath the data center.

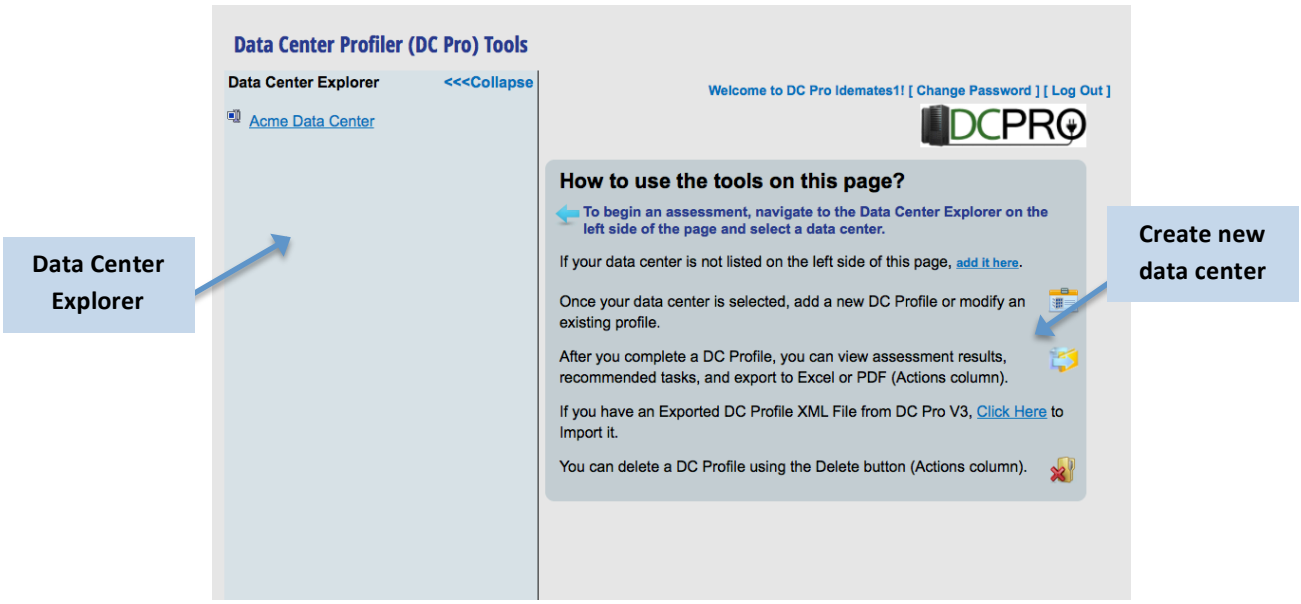

Figure 4: Assessment Home

Creating a New Assessment or Selecting Existing

From the Data Center Explorer click the data center you wish to assess. If you have previously assessed your data center, the profile(s) will be shown on the right under DC Profiles. Click Add DC Profile to start a new assessment. DC Profile and assessment may be used interchangeably.

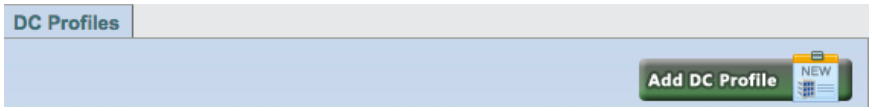

Figure 5: DC Profiles

Completing an Assessment (Sections 1 and 2)

There are three elements on the main screen – a list of sections on the left (white text on black), a performance summary on the right side bar, and a Print Profile button on the bottom.

Sections 1 and 2 are input sections and Sections 3 and 4 are populated from the data provided. The performance summary includes the PUE estimate (value) and energy use distribution across five standard end-use categories (pie chart). Both elements are updated automatically as questions are answered. Energy use distribution is also shown as a percentage if you hover the mouse over the pie chart. The Print profile button will be used when you have completed the assessment and wish to export inputs and outputs to PDF and/or Excel.

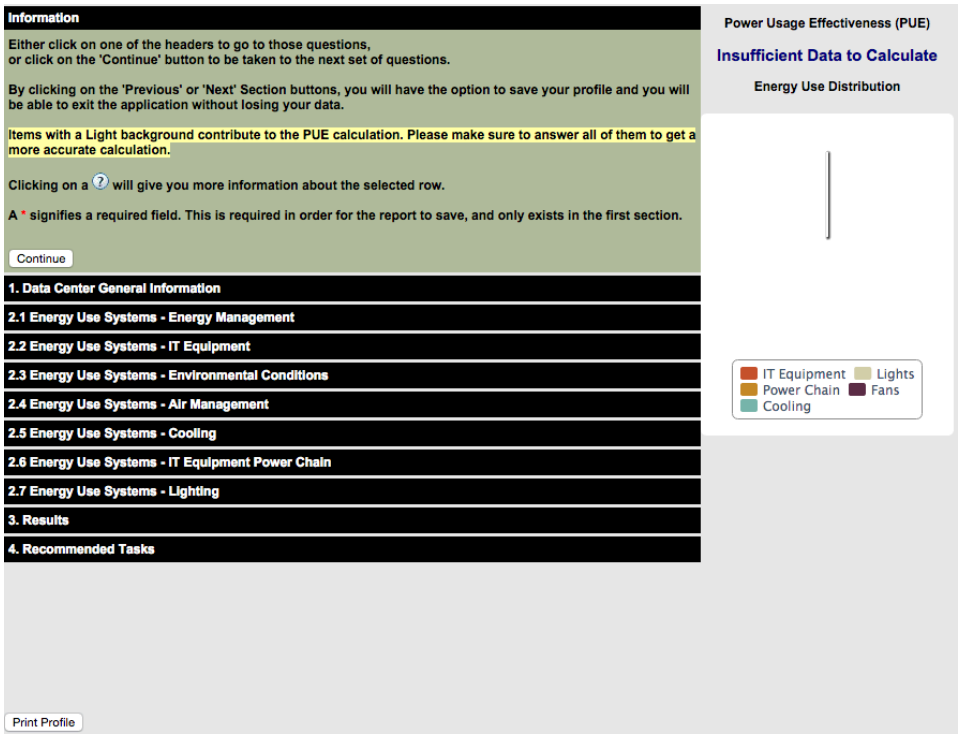

Figure 6: Assessment – All Steps

Please read the Information section before starting Section 1 as it provides guidance on how to complete the assessment and maximize the benefits of DC Pro. A few things to note:

- To move sections and save your data click Continue, Next Section, or in another section
- DC Pro will time out after several minutes of inactivity so save your data regularly
- Not all questions are required (*), but questions highlighted yellow are needed for PUE
- It is recommended to answer as many questions as possible to help DC Pro more accurately profile your facility and tailor recommended tasks for improvement
- Yes/No questions default to No for questions not answered
- Selecting some answers may open up additional questions or close open questions
- When clicked, the question icons (?) display a popup that explains in more depth what the question is asking

Section 1 - Data Center General Information

Section 1 captures basic, but important information about your data center. The Profile Name should be a descriptive name that you associate with the particular data center and reason you are profiling. The Organization refers to the company/institution that the data center is part of. Please choose the State/Region and County where your data center is located. Although the information is not technically required, it is needed to automatically assign a climate zone and estimate PUE.

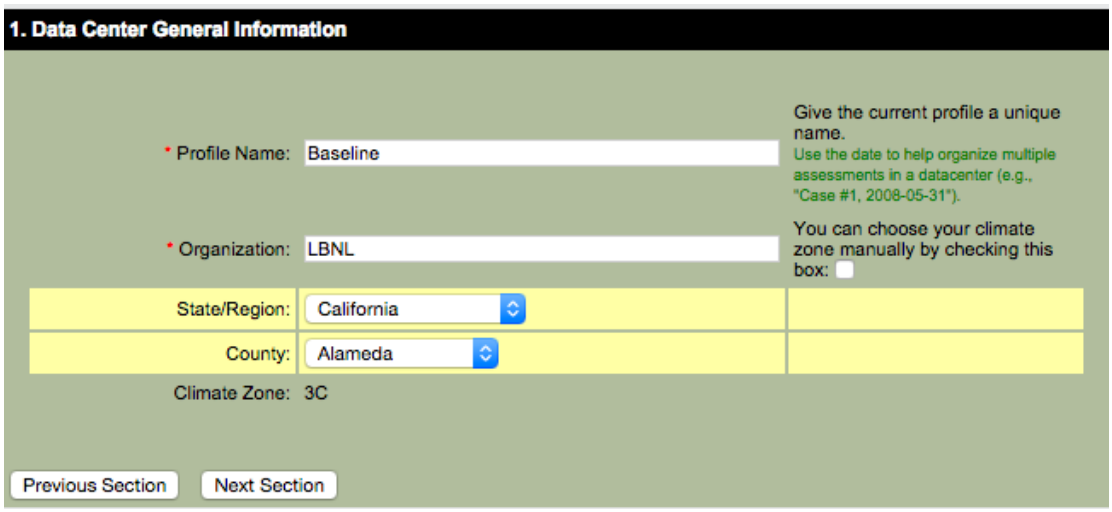

Figure 7: Data Center Information

The data center's climate zone will be calculated based on the State/Region and County inputs. DC Pro does not consider heating or cooling loads related to the building envelope or outside air since these loads are small compared to IT-related cooling load. The zone is considered for outside air treatment and the heat rejection side of cooling systems including economizer operation. For assistance in selecting the most applicable climate zone see Figure 8.

Temperature Climate Zone	Moisture: Moist (A) Dry (B) Marine (C)	Temperature	Moisture	Representative Location
1	A	Very Hot	Moist	FL Miami
2	A	Hot	Moist	TX Houston
2	B	Hot	Dry	AX Pheonix
3	A	Warm	Moist	GA Atlanta
3	B	Warm	Dry	CA LA
3	C	Warm	Marine	CA SF
4	A	Mixed	Moist	MD Baltimore
4	B	Mixed	Dry	NM Albuquerque
4	C	Mixed	Marine	WA Seattle
5	A	Cool	Moist	IL Chicago
5	B	Cool	Dry	CO Boulder
6	A	Cold	Moist	MN Minneapolis
6	B	Cold	Dry	MT Helena
7	_	Very Cold		MN Duluth
8	_	Subarctic		AK Fairbanks

Figure 8: Climate Zone Lookup Table

Section 2.1 - Energy Use Systems - Energy Management

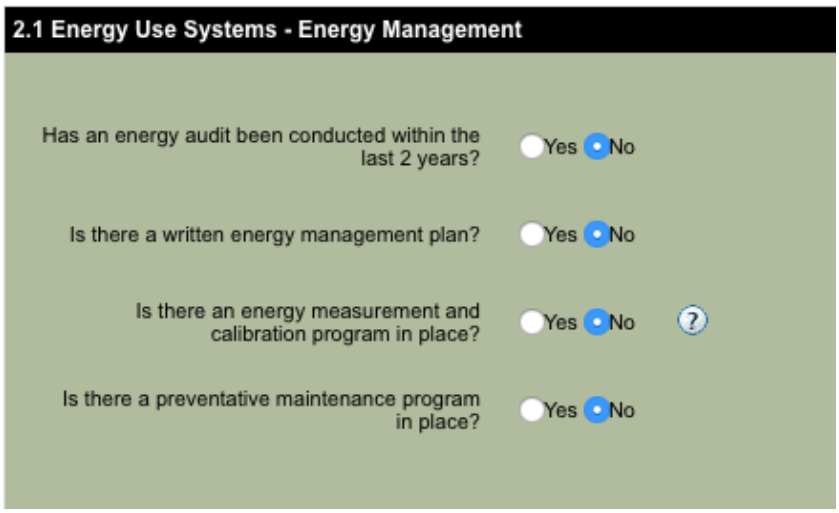

Figure 9: Section 2.1

Section 2.2 - Energy Use Systems - IT Equipment

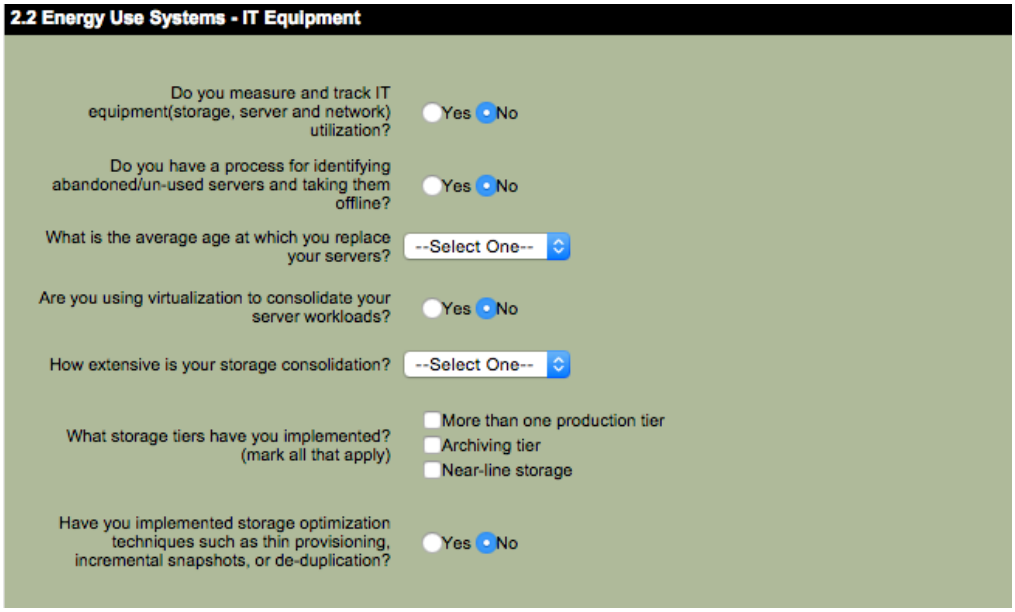

Figure 10: Section 2.2

Section 2.3 - Energy Use Systems - Environmental Conditions

Air Temperature Leaving the Cooling Coils

Air temperature leaving the cooling coils (supply air temperature - SAT) can be read from CRAC/CRAH/AHU display (if applicable). The next level of accuracy can be obtained by using a thermometer at the discharge of the fan (in raised floor if that is the case). For better accuracy beyond snapshot measurements, a temporary or permanent continuous measurement is recommended to collect data over a long period. This can be done using wired or wireless temperature sensors, local or central data collection and manipulation, and a dedicated or central dashboard. An average number should be used if multiple CRACs are operating. Make sure that the data from CRACs that are off are not included in the average.

Air Temperature Entering the Cooling Coils

Air temperature entering the cooling coils (return air temperature - RAT) can be read from CRAC/CRAH/AHU display (if applicable). The next level of accuracy can be obtained by using a thermometer at the unit air intake. For better accuracy beyond snapshot measurements, a temporary or permanent continuous measurement is recommended. This can be using wired or wireless sensors, local or central data collection and manipulation, and dedicated or central dashboard. An average number should be used if multiple CRACs are operating. Make sure that the data from CRACs that are off are not included in the average.

Active, Working Humidification

DC Pro requires a “yes” or “no” answer and will assign efficiency for cooling based upon the input. Check the unit to determine if the humidification system is enabled. A water or steam

connection is a sign that the unit may be equipped with an enabled humidification system; check to see if the water or steam supply valve is open and the unit display to see if humidification is enabled. DC Pro does not consider the potential for simultaneous humidification and dehumidification by the different CRAC/CRAH units.

Active, Working De-humidification

DC Pro requires a "yes" or "no" answer and will assign efficiency for cooling based upon the input. This function depends on set points for the temperature of the cooling medium, along with data center ambient temperature and relative humidity. For example, if 42°F chilled water is used, de-humidification naturally happens as long as data center relative humidity is above 30%. Checking the dew point temperature at the return and the supply a few times an hour will also help to detect if de-humidification is active, as well as checking the control panel for settings and status. Cooling units with full de-humidification capability will also be equipped with re-heat coils using refrigerant (hot gas), steam, hot water, or electricity, located downstream of the cooling coil. DC Pro does not consider the potential for simultaneous humidification and dehumidification by the different CRAC/CRAH units.

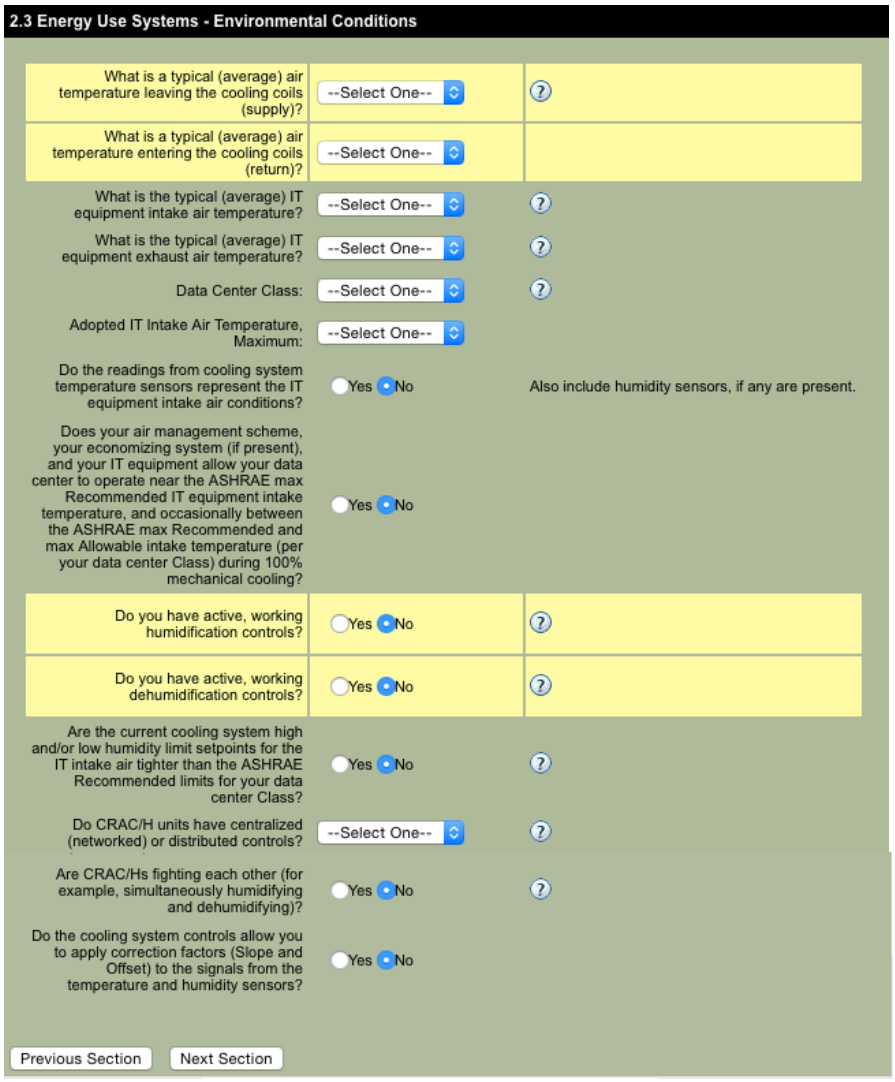

Figure 11: Section 2.3

Section 2.4 - Energy Use Systems - Air Management

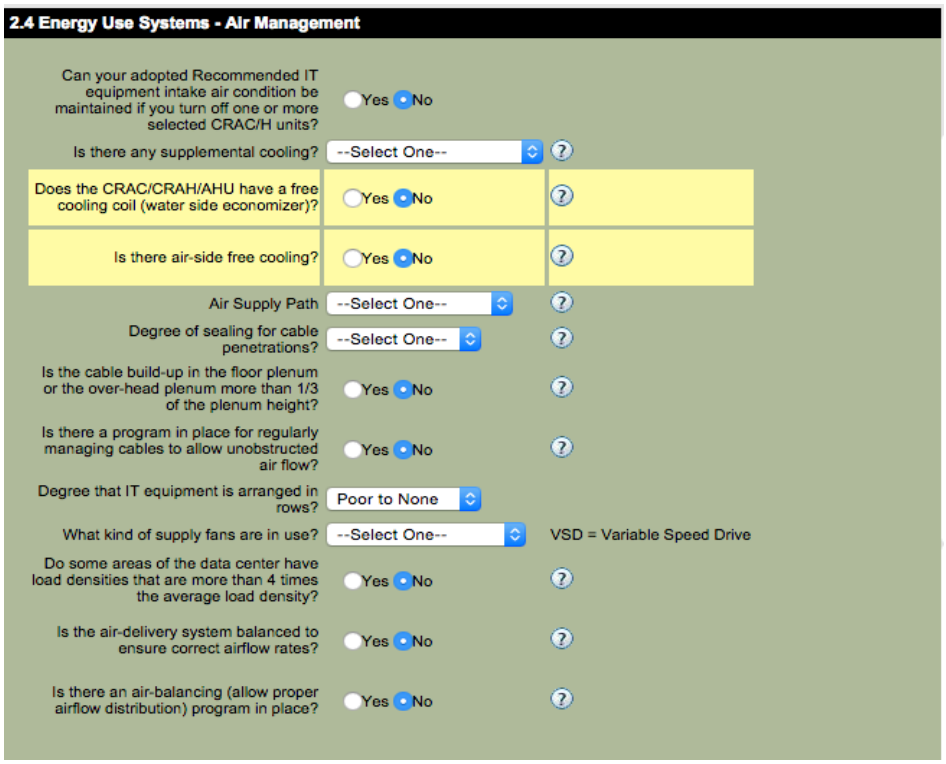

Figure 12: Section 2.4

CRAC/CRAH/AHU Free Cooling Coil (Water-Side Economizer)

DC Pro requires a "yes" or "no" answer and will assign efficiency for cooling based on the input. If you are not sure, you may check with the source of the chilled water. Typically, if the answer is yes, you may have a heat exchanger that provides cooling to the chilled water return using condenser (cooling tower) water. For CRAC units, the "free cooling" coil is the second coil in the unit which is located upstream of the DX coil. Another scenario is where an additional cooling coil, served by condenser water, is located in the unit.

Air-Side Free Cooling (Air-Side Economizer)

DC Pro requires a "yes" or "no" answer and will assign efficiency for cooling based on the input. Typically, if the answer is yes, the CRAC/CRAH/AHU units should have the means of getting the air directly from outside and the data center should be able to exhaust air directly to the outside. Ductwork or wall/raised floor, or ceiling plenums might facilitate the airflow.

Section 2.5 - Energy Use Systems - Cooling

Options are air-cooled DX, water-cooled DX, evaporative-cooled DX, and chilled water. If there is more than one type of cooling system serving the data center, select the dominant one (the one currently carrying the highest load). Based on input, additional questions appear. Except for "Chilled water", the answer to the secondary questions related to the cooling system types does not affect the calculations. Check the site and drawings to understand what type of cooling exists.

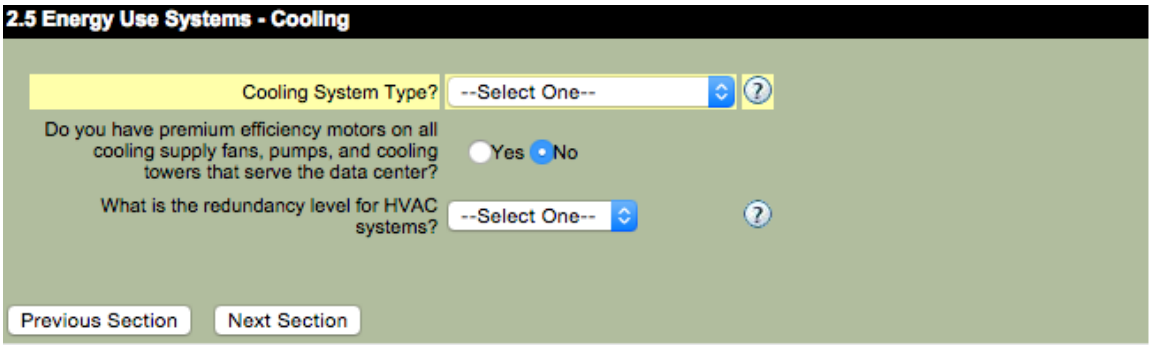

Figure 13: Section 2.5

Chiller type

If chilled water is selected as the cooling system type, then two more questions appear. The first is chiller type. If air-cooled is selected, no more questions will appear. Check the site and drawings to understand what type of chiller exists. If water-cooled chiller is selected then one additional question, water-side economizer, appears.

Chilled Water Supply Temperature

As was mentioned, when chilled water is selected for cooling system type, two more questions appear. The first is chiller type (discussed above). The second question addresses the chilled water supply temperature (CHWST). The display on the chiller is a source for the CHWST data. Another option is installing temperature sensors anywhere in the CHWS pipe. Again, an average taken over a period of time is strongly recommended in the absence of continuous monitoring. The higher the CHWST, the better the chiller efficiency.

Water-side Economizer

If water-cooled chiller is selected for chiller type, then another waterside economizer question appears. The options for answering this question are: none, integrated, or non-integrated. DC Pro will assign different efficiency for cooling based on this input. If unsure of this answer, examine the chilled water system. Generally, the system will have a heat exchanger that cools the chilled water return using condenser water. An integrated economizer is when the heat exchanger is installed in series with the chiller (on the chilled water side). It is always on line so it can operate to lower the compressor load as long as the condenser water is cooler than CHWR. A non-integrated system has the heat exchanger installed parallel to the chiller so there are only two states of operation (on or off). That means either the chiller(s) is providing cooling or the

heat exchanger but not both concurrently. Check the site and/or drawings to understand what type of economizer exists.

Section 2.6 - Energy Use Systems - IT Equipment Power Chain

To see if there is an Uninterruptible Power Supply (UPS), check the unit on site or review the drawings. DC Pro assigns no additional electrical recommendations based on "no" as answer to the UPS question. A "yes" answer will cause four more questions to appear (listed below).

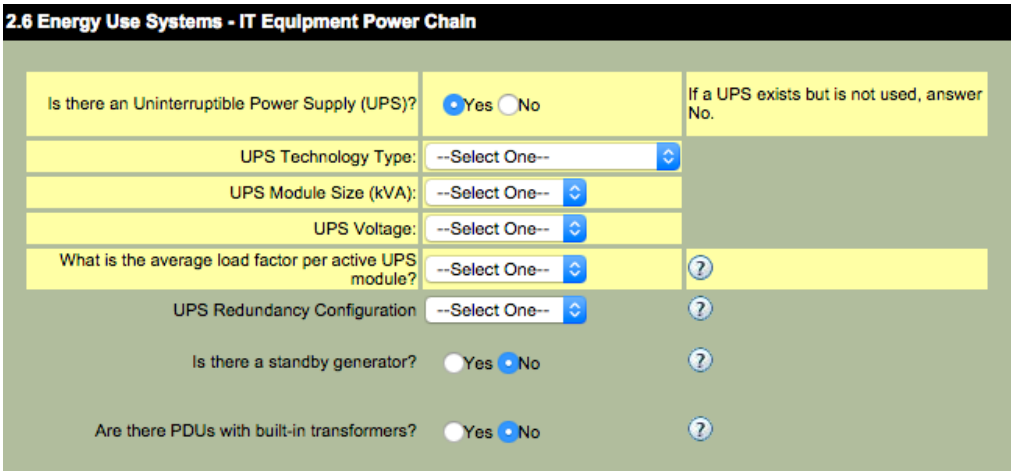

Figure 14: Section 2.6

- *UPS Type:* Observe on site or/and review equipment data sheets. There is little impact on PUE since efficiencies of these four types of UPS are considered close. The efficiency of a rotary UPS is considered a little higher.

- *UPS Module Size (kVA):* Read the size from the unit data sheet or the unit template. Different sizes of UPS generally exhibit different efficiencies.

- *UPS Voltage*: Read the voltage from the unit data sheet or the unit template. The efficiency of 480-volt systems is considered to be about 1% higher than 208-volt units.

- *Average load factor per active UPS module:* Load factor is the power output of the UPS divided by the capacity of the UPS. It has the most impact on the PUE within the electrical distribution parameter since efficiencies typically are lower at lower load factors. The actual output can often be read from the unit display and the load factor can be calculated once the unit's capacity is known. The other option is to install power meter(s) and obtain continuous measurement. In calculating the load factor, when there are UPSs with different capacity, a weighting factor should be considered. For example if, in the same data center, a 300KVA UPS is loaded at 40% and a 600KVA UPS is loaded at 20%, the average load factor is 26% and not 30%.

Section 2.7 - Energy Use Systems - Lighting

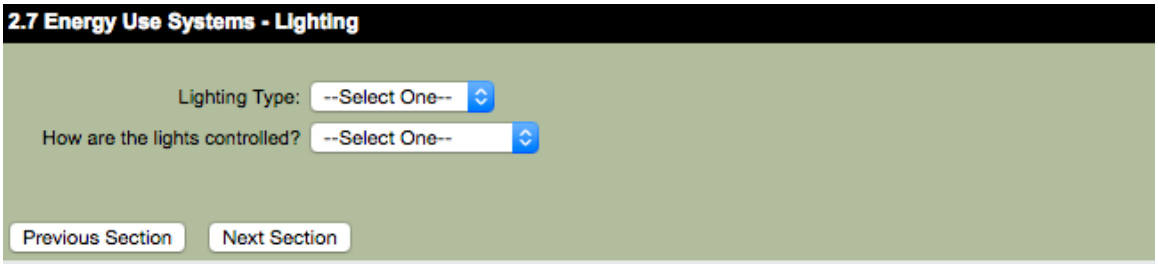

Figure 15: Section 2.7

Results and Recommended Tasks (Sections 3 and 4)

Based on how the questions were answered in Section 1 and Section 2, DC Pro populates Section 3 and Section 4. As mentioned previously, it is recommended to answer as many questions as possible to help DC Pro more accurately profile your facility and tailor recommended tasks for improvement. Yes/No questions also default to No for questions not answered.

Section 3 - Results

DC Pro estimates the data center's current PUE and energy use distribution. It also estimates the potential PUE and potential energy use distribution from implementing "all" the recommended energy efficiency tasks outlined in Section 4.

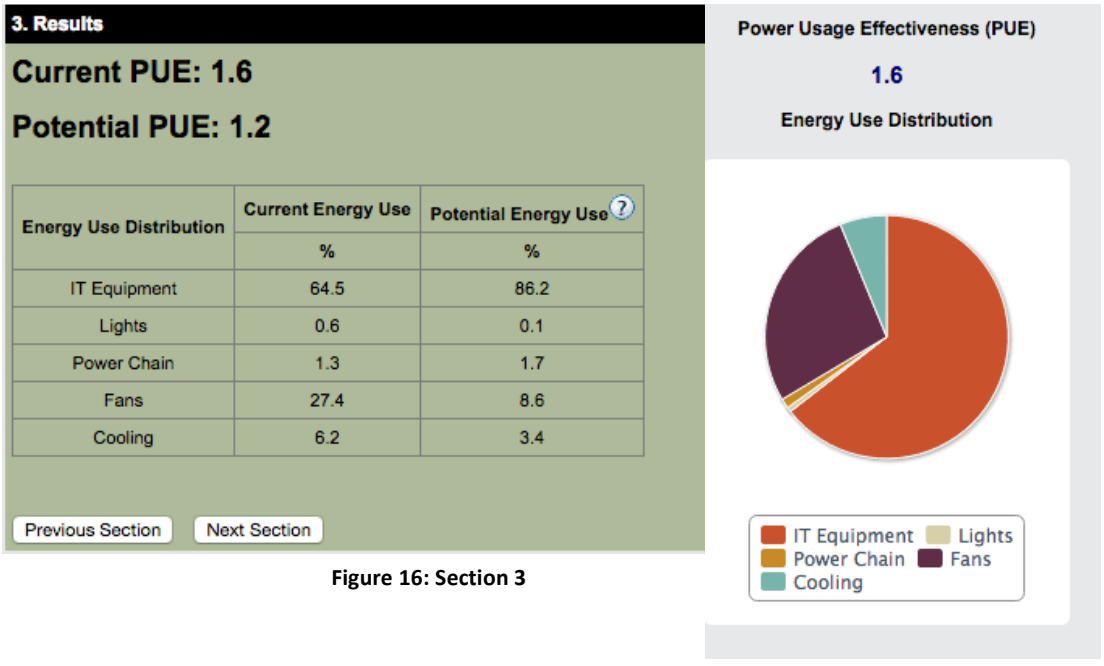

Figure 16: Section 3

Section 4 – Recommended Tasks

Tailored recommendations on how to increase energy efficiency in your data center are provided and are a great starting point for an improvement process. Recommendations cover the following end-uses categories:

- IT Equipment
- Environmental Conditions
- Air Management
- Cooling
- IT Equipment Power Chain
- Lighting
- Energy Management Measures
- Global Actions

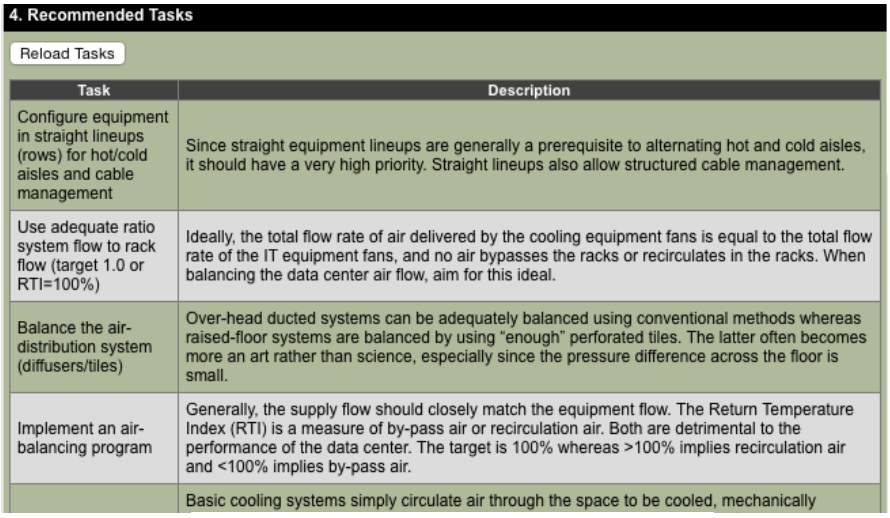

Figure 17: Section 4

The recommended tasks are based on the *Data Center Master List of Energy Efficiency Actions*, a document maintained by Lawrence Berkeley National Laboratory. The Master List can be accessed on the CoE website: datacenters.lbl.gov/resources/data-center-master-list-energy

Exporting/Printing an Assessment

By clicking Print Profile at the bottom left of the main screen you are taken to a summary page that combines the results, recommended tasks, and user input. The summary page can be exported to PDF by clicking Save to PDF or to Excel by clicking Export Results to Excel. Examples are provided on the next page, Figure 19.

To access this summary page and export after the initial assessment, click the data center from the Data Center Explorer then selecting the "arrow" icon for the DC Profile you are interested in.

Report generated through the DC Pro Tool (datacenters.lbl.gov/dcpro): 1/28/2016

Current PUE: 1.8

Potential PUE: 1.2

Energy Use Distribution	Current Energy Use	Potential Energy Use
	%	%
IT Equipment	56.3	83.5
Lights	0.6	0.1
Power Chain	10.3	1.7
Fans	13.8	6.4
Cooling	19.1	8.3

Task	Description
Configure equipment in straight lineups (rows) for hot/cold aisles and cable management	Since straight equipment lineups are generally a prerequisite to alternating hot and cold aisles, it should have a very high priority. Straight lineups also allow structured cable management.
Use appropriate overhead diffusers	The generally high pressure drops across the end devices (diffusers) and low pressure losses in the distribution system (ductwork) promote high air stability. Stability means that the system can be balanced successfully and that external disturbances have limited impact on that balance. In addition, the diffusers should have characteristics promoting penetration of the supply air into the cold aisles.

	A	B	C
1	**Current PUE: 1.8**		
2			
3	**Potential PUE: 1.2**		
4			
5	**Energy Use Distribution**	**Current Energy Use**	**Potential Energy Use**
6		**%**	**%**
7	IT Equipment	56.3	83.5
8	Lights	0.6	0.1
9	Power Chain	10.3	1.7
10	Fans	13.8	6.4
11	Cooling	19.1	8.3
12	**Task**	**Description**	
13	Configure equipment in straight lineups (rows) for hot/cold aisles and cable management	Since straight equipment lineups are generally a prerequisite to alternating hot and cold aisles, it should have a very high priority. Straight lineups also allow structured cable management.	
14	Use appropriate overhead diffusers	The generally high pressure drops across the end devices (diffusers) and low pressure losses in the distribution system (ductwork) promote high air stability. Stability means that the system can be balanced successfully and that external disturbances have limited impact on that balance. In addition, the diffusers should have characteristics promoting penetration of the supply air into the cold aisles.	
15	Use adequate ratio system flow to rack flow (target 1.0 or RTI=100%)	Ideally, the total flow rate of air delivered by the cooling equipment fans is equal to the total flow rate of the IT equipment fans, and no air bypasses the racks or recirculates in the racks. When balancing the data center air flow, aim for this ideal.	

Figure 19: PDF and Excel Examples

Full List of Questions

Below is a checklist of questions to be answered for DC Pro Steps 1 and 2. Questions that are mandatory to answer are indicated with a red asterisk (only for Section 1). Questions that impact the PUE calculation are identified by yellow highlights. Questions that require certain answers from a previous question are noted in blue.

Step 1

General Information	
Profile Name*	Enter name
Organization*	Enter name
Climate Zone (Asked only if you check the toggle switch on the right of Address)	Select from the List
State/Region	Select from the list of States
County	Select from the list of Counties for each State
Data Center Class*	Select from the list: A1, A2, A3, A4, B, C

Step 2

Energy Management	
Has an energy audit been conducted within the last 2 years?	Yes or No
Is there a written energy management plan?	Yes or No
Is there an energy manager directly responsible for the energy management plan? (Only asked if you have an energy management plan)	Yes or No
Has upper management accepted the energy management plan? (Only asked if you have an energy management plan)	Yes or No
Is there an energy measurement and calibration program in place?	Yes or No
Is there a preventative maintenance program in place?	Yes or No

IT Equipment	
Do you measure and track IT equipment (storage, server & network) utilization?	Yes or No
Do you have a process for identifying abandoned/un-used servers and taking them offline?	Yes or No
What is the average age at which you replace your servers	Select from the list: 0-2yrs, 3yrs, 4yrs, or 5+ years
Are you using virtualization to consolidate your server workloads?	Yes or No
How extensive is your storage consolidation?	Select from the list: 0%, 1% to 50%, 51% to 99%, or 100%
What storage tiers have you implemented? (mark all that apply)	Select from the list: More than one production tier, Archiving tier, Near-line storage
Have you implemented storage optimization techniques such as thin provisioning, incremental snapshots, or de-duplication?	Yes or No

Environmental Conditions	
What is the typical (average) air temperature leaving the cooling coils (supply)?	Select from the list: 55 F (13 C), 60 F (16 C), 65 F (18 C), 70 F (21 C), 75 F (24 C), 80 F (27 C), 85 F (29 C), 90 F (32 C), 95 F (35 C), 100 F (38 C), 105 F (41 C), 110 F (43 C), 115 F (48 C), or >115 F (>48 C)
What is the typical (average) air temperature entering the cooling coils (return)?	Select from the list: 55 F (13 C), 60 F (16 C), 65 F (18 C), 70 F (21 C), 75 F (24 C), 80 F (27 C), 85 F (29 C), 90 F (32 C), 95 F (35 C), 100 F (38 C), 105 F (41 C), 110 F (43 C), 115 F (48 C), 120 F (49 C), 125 F (52 C), 130 F (54 C), 135 F (57 C), 140 F (60 C), or >140 F (>60 C)
What is the typical (average) IT equipment intake air temperature?	Select from the list: 55 F (13 C), 60 F (16 C), 65 F (18 C), 70 F (21 C), 75 F (24 C), 80 F (27 C), 85 F (29 C), 90 F (32 C), 95 F (35 C), 100 F (38 C), 105 F (41 C), 110 F (43 C), 115 F (48 C), or >115 F (>48 C)
What is the typical (average) IT equipment exhaust air temperature?	Select from the list: 55 F (13 C), 60 F (16 C), 65 F (18 C), 70 F (21 C), 75 F (24 C), 80 F (27 C), 85 F (29 C), 90 F (32 C), 95 F (35 C), 100 F (38 C), 105 F (41 C),

	110 F (43 C), 115 F (48 C), 120 F (49 C), 125 F (52 C), 130 F (54 C), 135 F (57 C), 140 F (60 C), 145 F (63 C), 150 F (66 C), 155 F (68 C), 160 F (71 C), 165 F (74C), 170 F (77 C), 175 F, (79 C), 180 F (82 C), or >180 F (>82 C)
Adopted IT Intake Air Temperature Maximum	Select from the list: 65 F (18 C), 70 F (21 C), 75 F (24 C), 80 F (27 C), 85 F (29 C), 90 F (32 C), 95 F (35 C), 100 F (38 C), 105 F (41 C), 110 F (43 C), 115 F (48 C), or >115 F (>48 C)
Do the readings from cooling system temperature sensors represent the IT equipment intake air conditions?	Yes or No
Does your air management scheme, your economizing system (if present), and your IT equipment allow your data center to operate near the ASHRAE max Recommended IT equipment intake temperature, and occasionally between the ASHRAE max Recommended and max Allowable intake temperature (per your data center Class) during 100% mechanical cooling?	Yes or No
Do you have active, working humidification controls?	Yes or No
What type of humidifier do you have? (Only asked if you have active, working humidification controls)	Select from the list: Electric Resistance Heating/Infrared Lights, Steam from Boiler, Direct Evaporation, or Ultrasonic
Do you have active, working dehumidification controls?	Yes or No
Is there a continuous source of outside air admitted to the data center for ventilation? (Only asked if you either have active, working humidification or dehumidification controls)	Yes or No
Humidity control sensor location? (Only asked if you have a continuous source of outside air for ventilation)	Select from the list: Outside Air Stream Only, Recirculation Air Stream Only, or Outside Air Stream and Recirculation Air Stream
Are the current cooling system high and/or low humidity limit setpoints for the IT intake air tighter than the ASHRAE recommended limits for your data center Class?	Yes or No

Do CRAC/H units have centralized (networked) or distributed controls?	Select from the list: Centralized or Distributed
Are CRAC/Hs fighting each other (for example, simultaneously humidifying and dehumidifying)?	Yes or No
Do the cooling system controls allow you to apply correction factors (Slope and Offset) to the signals from the temperature and humidity sensors?	Yes or No

Air Management	
Can your adopted Recommended IT equipment intake air condition be maintained if you turn off one or more selected CRAC/H units?	Yes or No
Is there any supplemental cooling?	Select from the list: None, In-Row, Modular, Overhead, Rear-Door, or Liquid-Cooled Cabinet
Does the CRAC/CRAH/AHU have a free cooling coil (water side economizer)?	Yes or No
Is there air-side free cooling?	Yes or No
Air Supply Path	Select from the list: Overhead Ducts, Overhead Plenum, Underfloor Plenum, In-Row, Free
Is there a floor-tightness (sealing leaks) program in place? (Only asked if you employ an Underfloor Plenum as your Air Supply Path)	Yes or No
Degree of sealing for cable penetrations? (Only asked if you employ Overhead Plenum, Underfloor Plenum, In-Row, or Free as your Air Supply Path)	Select from the list: Poor to None, Fair, Good
Is the cable build-up in the floor plenum or the over-head plenum more than 1/3 of the plenum height? (Only asked if you employ an Overhead Plenum or Underfloor Plenum as your Air Supply Path)	Yes or No
Is there a program in place for regularly managing cables to allow unobstructed air flow? (Only asked if you employ an Overhead Plenum or Underfloor Plenum as your Air Supply Path)	Yes or No
Degree that IT equipment is arranged in rows?	Select from the list: Poor to None, Fair, Good
Is there a rack/lineup-tightness (using blanking	Yes or No

panels) program in place? (Only asked if your IT equipment row arrangement is Fair or Good)	
Degree of current implementation of alternating hot and cold aisles? (Only asked if your IT equipment row arrangement is Fair or Good)	Select from the list: Poor to None, Fair, Good
Degree that blanking panels are in place? (Only asked if your alternation of hot and cold aisles is Fair or Good)	Select from the list: Poor to None, Fair, Good
Where is the supply placed? (Only asked if your alternation of hot and cold aisles is Fair or Good)	Select from the list: Cold Aisles Only, Hot Aisles Only, Hot and Cold Aisles, Not Applicable
Is there a diffuser/tile-location (to conserve hot and cold aisles) program in place? (Only asked if your alternation of hot and cold aisles is Fair or Good)	Yes or No
Degree to which hot and cold aisles are currently fully enclosed? (Only asked if your alternation of hot and cold aisles is Fair or Good)	Select from the list: Poor to None, Fair, Good
What kind of supply fans are in use?	Select from the list: Constant Speed, Equipped with VSD
Do some areas of the data center have load densities that are more than 4 times the average load density?	Yes or No
Is the air-delivery system balanced to ensure correct airflow rates?	Yes or No
Is there an air-balancing (allow proper airflow distribution) program in place?	Yes or No

Cooling	
Cooling System Type?	Select from the list: Air-Cooled DX, Water-Cooled DX, Evaporatively-Cooled DX, or Chilled Water
Condenser cooling system (Only asked if your Cooling System is Water-Cooled DX)	Select from the list: Cooling Tower, Dry Cooler
Chiller Type (Only asked if your Cooling System is Chilled Water)	Select from the list: Air-Cooled, Water-Cooled
Chilled Water Supply Temperature (Only asked if your Cooling System is Chilled Water)	Select from the list: 45F (7C), 50F (10C), 55F (13C)
Water-side Economizer (Only asked if Water-Cooled is	Select from the list: None, Integrated, or Non-

your Chiller Type)	Integrated
Cooling tower fan control (Only asked if you answer Cooling Tower for your Condenser Cooling System or Water-Cooled for your Chiller Type)	Select from the list: Fixed Speed, Two-Speed Motor, Variable Speed Drive
Type of Valves (Only asked if your Cooling System is Chilled Water)	Select from the list: 2-Way, 3-Way
Do you have premium efficiency motors on all cooling supply fans, pumps, and cooling towers that serve the data center?	Yes or No
What is the redundancy level for the HVAC systems?	Select from the list: N, N+1, Exceeds N+1, 2N

IT Equipment Power Chain	
Is there an Uninterruptible Power Supply (UPS)?	Yes or No
UPS Technology Type (Only asked if you have a UPS)	Select from the list: Double Conversion, Double Conversion + Filter, Delta Conversion, Rotary
UPS Size (kVA) (Only asked if you have a UPS)	Select from the list: 50, 100, 150, 225, 300, 400, 500, 600, 750, 800, 900, 100
UPS Voltage (Only asked if you have a UPS)	Select from the list: 480, 208
What is the average load factor per active UPS module? (Only asked if you have a UPS)	Select from the list: 1% to 10%, 11% to 20%, 21% to 30%, 31% to 40%, 41% to 50%, 51% to 60%, 61% to 70%, 71% to 80%, 81% to 90%, 91% to 100%
UPS Redundancy Configuration (Only asked if you have a UPS)	Select from the list: N, N+1, 2N
Is there a standby generator?	Yes or No
Standby Generator Power Configuration (Only asked if you have a standby generator)	Select from the list: N, N+1, 2N
Is there a generator block heater? (Only asked if you have a standby generator)	Yes or No
Is there a thermostat on the generator block heater? (Only asked if you have a generator block heater)	Yes or No
Are there PDUs with built-in transformers?	Yes or No
What are the types of MV and LV transformers?	Select from the list: Temp rise 80C, Temp rise

(Only asked if you have PDUs with built-in transformers)	>80C, TP1, EPACT 2005
Average Load Factor per Active PDUs/Transformers? (Only asked if you have PDUs with built-in transformers)	Select from the list: 0% to 24%, 25% to 49%, 50% to 100%
What is the load imbalance between phases? (Only asked if you have PDUs with built-in transformers)	Select from the list: ≤ 20%, > 20%

Lighting	
Lighting Type	Select from the list: Fluorescent, LED, Other
What type of lamps are used? (Only asked if you have Fluorescent lights)	Select from the list: T-12, T-8, or T-5
What type of ballasts are used? (Only asked if you have Fluorescent lights)	Select from the list: Magnetic, Electronic
How are the lights controlled?	Select from the list: Hard-Wired, Manual Wall Switch, Occupancy Sensor, Timer

PUE Calculation Method

DC Pro takes user's inputs and refers to look-up tables to estimate data center energy distribution and PUE. The energy use breakouts are defined only in terms of percentages - there is no reference to energy type (electricity, fuel, other). The model assumes a completely homogenous data center. For example:

- Many real world data centers have more than one type of cooling system serving a single data center space. The model assumes there is only one type.
- Real world data centers are often a mix of row configurations, rack types, IT equipment types, air management schemes, high-density areas, and low-density areas. The model assumes the data center space is uniform in regards to these parameters.
- The model assumes that the temperature of the air leaving the cooling coils is the same at every coil, and the air temperature entering the cooling coils is the same at every coil.

The calculation method contains four lookup tables, described below and illustrated in Figure 20.

Constants: Electrical distribution loss (excluding UPS) is assumed to be 2% of total IT load. Lighting is assumed to be 1% of total IT load. It also assumes that IT load is the same 24/7. If your data center information is different, then corrections should be made to the results from the PUE Estimator.

Climate zone: Climate Zone can be entered directly or the PUE Estimator can choose based on location of the site. This is an input to the cooling system look-up table.

UPS loss: UPS loss has its own look-up table and the result is an input to the cooling system look-up table and normalizing calculation.

Cooling system energy: Based on cooling inputs, the table produces two inputs to the normalizing calculation: one is cooling energy and the other is fan energy, both expressed as a percentage of IT load. Energy use distribution is then calculated, and these are used in the PUE calculation.

For more information on how PUE is estimated, please see the Calculation Reference Manual: datacenters.lbl.gov/resources/dc-pro-tools-calculation-reference

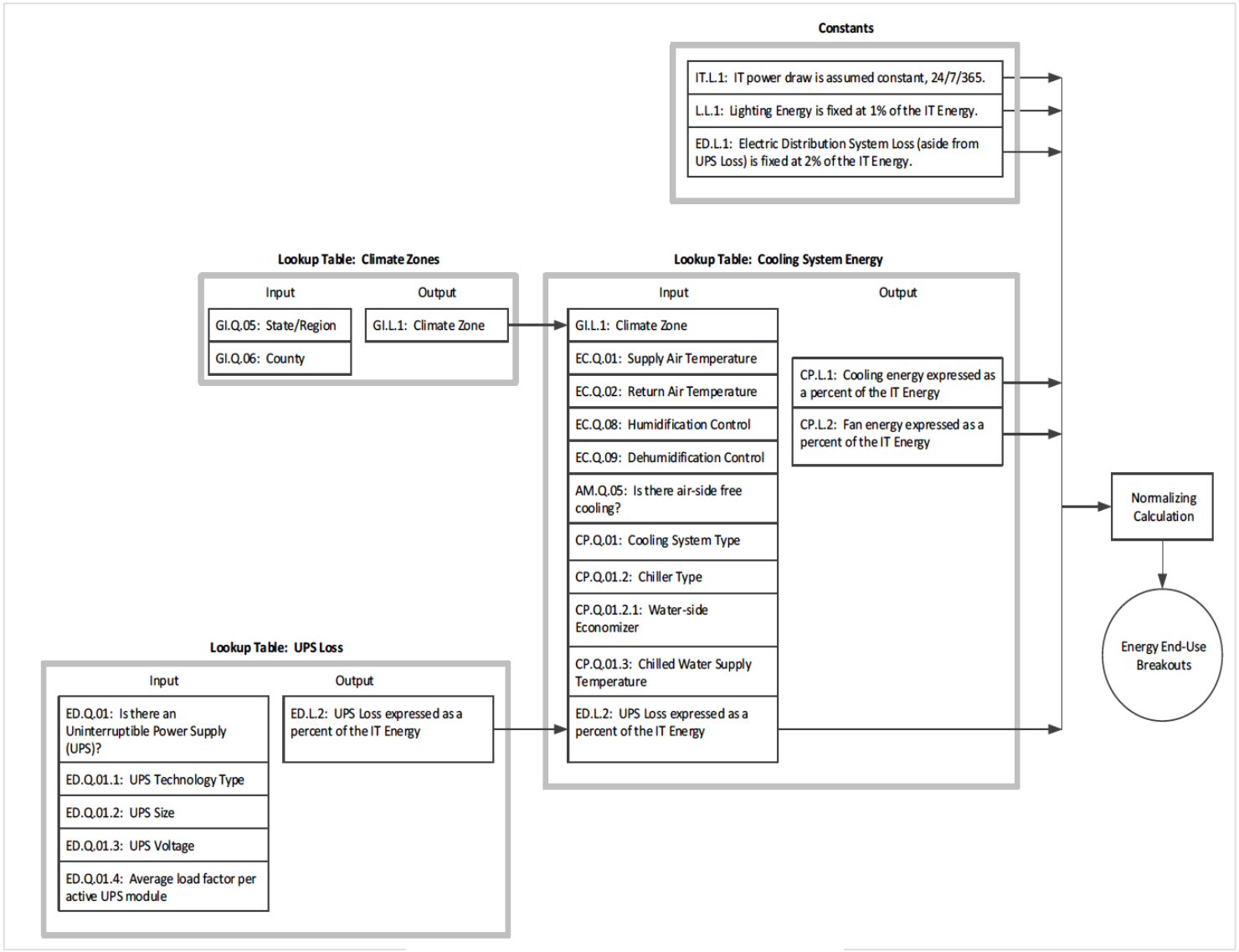

Figure 20: PUE Calculation Method Flow Chart