DOE Data Center Air-Management (AM) Estimator:

User's Manual

Version 1 (June 30, 2017)

The User's Manual and the Air Management Estimator were developed jointly by Lawrence Berkeley National Laboratory (LBNL) and ANCIS Incorporated for the U.S. Department of Energy (DOE)

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OVERVIEW

What does the Air Management Estimator do?

Air management in data centers is essentially about keeping cold and hot air from mixing. Cold supply air from the air handler should enter the heat-generating IT equipment without mixing with ambient air and the hot exhaust air should return to the air handler without mixing. Managing the cold and hot air streams in data centers is important for cooling infrastructure energy/capacity management and IT equipment thermal management.

The DOE Data Center Air Management Estimator is a simplified version of the DOE Data Center Air Management Tool (DOE 2014a), which was developed to help accelerate energy savings in data centers without affecting the thermal IT equipment environment. The input options have been reduced in favor of increased clarity. Based on user input, the Estimator provides the potential for reducing the supply airflow rate and increasing the supply air temperature, both having an impact on energy use. The Estimator estimates the % energy reduction, kWh reduction, and the associated $ savings for supply fans and chillers. The Estimator is an Excel workbook with two input sheets and one output sheet.

Since the vast majority of data centers has raised-floor cooling with hot and cold equipment aisles, the Estimator is intended for such environments. Having some basic understanding of the physical data center environment makes the Estimator easier to understand and use.

How is the Air Management Estimator used?

First, the user fills in information on two input Excel sheets. Each sheet includes basic guidance for entering the information correctly. This User’s Manual provides more comprehensive information. In addition to this Manual, there are manuals available for the Air Management Tool (see the Reference section). Second, based on the user input, numerical output is given on an Energy Results Excel sheet.

DOE Software Tool Suite

The Air Management Estimator is part of the DOE Tool Suite which includes the Excel based Air Management Tool, an online Profiling Tool (DC Pro), and an online PUE Estimator. Please note that these tools are not a substitute for a detailed “investment grade” data center audit.

Air Management Estimator Download and Documentation

The Air Management Estimator and the User’s Guide (this document) can be downloaded from the Center of Expertise for Energy Efficiency in Data Centers’ website: http://datacenters.lbl.gov/tools

Questions, comments, and/or suggestions can be directed to mkherrlin@lbl.gov or mherrlin@ancis.us

Air Management Estimator Structure

The Air Management Estimator has six color-coded Steps (fully analogous to the Air Management Tool) for input and output (see Figure 1):

Estimator	Summary sheet
Step 1: AHU	Input: Air-handler unit (AHU) data for calculating the heat balance and RTI
Step 2: Equip	Input: IT equipment data for calculating the heat balance and RTI
Step 3: RCI	Input: IT equipment intake temperatures for calculating RCI
Step 4: Main Input	Input: Implementation levels of ten air management measures
Step 5: Main Results	Not used in the Estimator
Step 6: Energy Results	Output: Energy- and cost-savings estimates for supply fans and chillers.

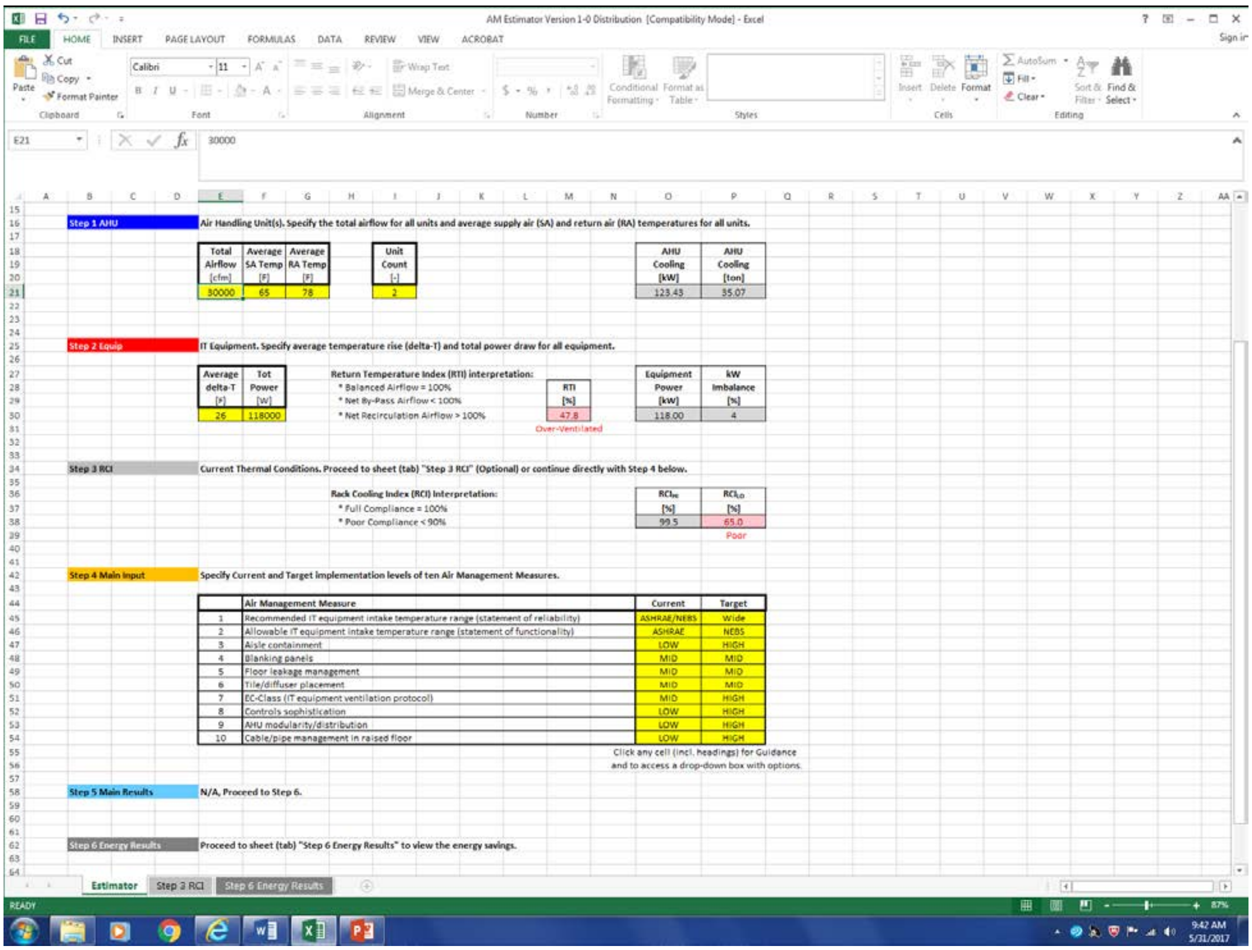

Figure 1: Estimator sheet (tab). Zoom in to see details.

INPUT/OUTPUT STEPS

This section describes the input and output steps in the order they appear on the Summary sheet (Figure 1). General Information applicable to all Steps includes:

- Yellow cells indicate cells where to input data. All other cells are locked
- Grey cells indicate calculated values (some turn red if data is out-of-bounds)
- Grayed out text/data are for internal use only
- All input cells have input-range checking to avoid data-entry errors
- Some input cells accept typed data whereas other cells have drop-down menus
- The Estimator comes preloaded with a simple case (as shown on the screen shots).

Step 1 AHU

This Step asks for information to determine the total heat extraction (cooling) from the data center. The principal purposes of the input on this Step and the next are to determine the heat balance in the data center and to calculate the Return Temperature Index (RTI).

<u>Input data (yellow cells) (Figure 2):</u>

- Total Airflow [cfm]: Total airflow from all air handler units
- Average SA Temperature [°F]: Average supply air temperature for all units
- Average RA Temperature [°F]: Average return air temperature for all units
- Unit Count [-]: Number of active air handler units.

For guidance on determining these input data, see the *Data Collection Guide* of the Air Management Tool.

<u>Calculated data (grey cells) (Figure 2):</u>

- AHU Cooling [kW]
- AHU Cooling [ton].

Resulting AHU cooling (heat extraction from the room by mechanical means) are calculated based on total AHU airflow and average AHU temperature drop. For calculation details, see the *Engineering Reference* of the Air Management Tool.

Step 1 AHU Air Handling Unit(s). Specify the total airflow for all units and average supply air (SA) and return air (RA) temperatures for all units.

Total Airflow [cfm]	Average SA Temp [F]	Average RA Temp [F]	Unit Count [-]	AHU Cooling [kW]	AHU Cooling [ton]
30000	65	78	2	123.43	35.07

Figure 2: Step 1 AHU input (detail of Estimator sheet).

Step 2 Equipment

This Step asks for information to determine the total heat addition (heating) to the data center. The principal purposes of the input on Steps 1 and 2 are to calculate the heat balance in the data center and to calculate the Return Temperature Index (RTI). This index plays an important role in understanding whether the data center is over-ventilated or under-ventilated.

Input data (yellow cells) (Figure 3):

- Average delta-T [°F]: Average temperature rise for all IT equipment
- Tot Power [W]: Total power draw by all IT equipment.

For guidance on determining these input data, see the *Data Collection Guide* of the Air Management Tool. If no delta-T data are available, Table 1 could serve as guidance.

Table 1: Typical Temperature Rise across IT Equipment.

Equipment Mix	ΔT [°F]
Traditional IT equipment	10 to 20
Modern IT equipment	20 to 30
Blade IT equipment	30 to 50

Calculated data (grey cells):

- Equipment Power [kW]
- kW Imbalance [kW]
- RTI [%].

AHU Cooling from Step 1 and Equipment Power (Step 2) must be reasonable close for a heat balance to exist in the data center. If there is poor agreement (>10%), the grey kW Imbalance cell will turn red. If this happens, revisit Steps 1 and 2 and look for potential errors. For calculation details, see the *Engineering Reference* of the Air Management Tool.

The RTI result cell shows the calculated RTI value. An RTI value of <100% indicate net by-pass airflow in the data center and an RTI value of >100% indicate net recirculation airflow. If the RTI is less than 90% (over-ventilated) or greater than 110% (under-ventilated), the grey cell will turn red to indicate less than ideal conditions. For more information on RTI, please see the *User's Manual* and the *Engineering Reference* of the Air Management Tool.

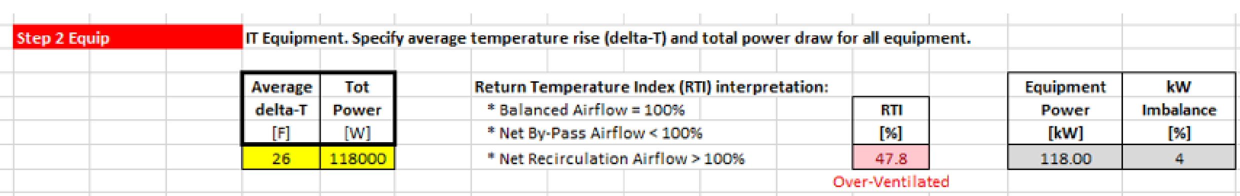

Figure 3: Step 2 Equipment Input (detail of Estimator sheet).

Step 3 RCI

This Step (tab) asks for information to determine the Rack Cooling Index (RCI). This metric is designed to gauge the compliance with the recommended and allowable temperature ranges of the thermal guidelines of ASHRAE and NEBS. RCI is often used to ensure that no degradation of the thermal environment occurs when air management is introduced for the purpose of saving energy.

If thermal management is not of interest, please proceed directly to Step 4 Main Input. However, if the thermal conditions are indeed of interest, please proceed to the Step 3 RCI sheet (tab) on the Excel interface. When completed the input, return to the Estimator sheet (tab). The calculated RCI values will now show in the two grey cells: RCI_{HI} [%] and RCI_{LO} [%].

The recommended and allowable ranges are user specified in Step 4 Main Input under the Current column for Air Management Measures 1 and 2. The selected ranges are echoed next to the Intake Temperature plot on the Step 3 RCI sheet (tab) in four grey cells.

RCI_{HI} is a measure of the absence of over-temperatures, and 100% mean no over-temperatures. Over-temperature conditions exist once one or more intake temperatures exceed the maximum recommended temperature. The lower the percentage, the greater risk that IT equipment experiences temperatures above the max allowable temperature. A value below 90% indicates poor compliance.

RCI_{LO} is an analogous index for temperature conditions at the low end of the temperature range. An RCI_{LO} of 100% mean no under-temperatures. Both RCI numbers at 100% mean that all intake temperatures are within the recommended temperature range.

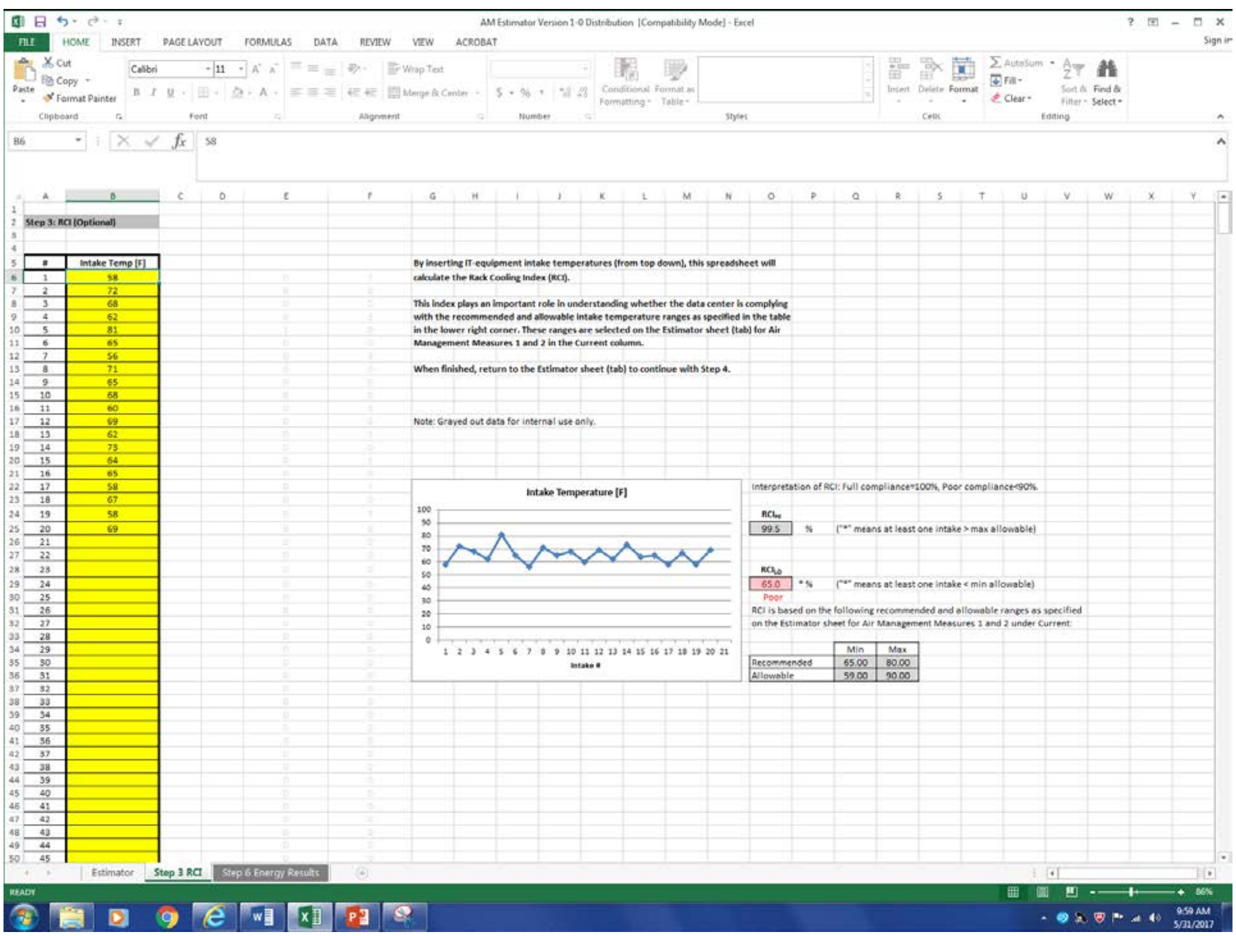

Figure 4: Step 3 RCI sheet (tab). Zoom in to see details.

For more on RCI, see the *User's Manual* and the *Engineering Reference* of the Air Management Tool. For guidance on determining the intake temperatures, see the *Data Collection Guide* of the Air Management Tool (see the Reference section).

<u>Input data (yellow cells) (Figure 4):</u>

- Intake Temperature [°F].

The data must be entered from the top down. If no data are available, leave all yellow cells blank.

<u>Calculated data exported to the Estimator sheet (tab):</u>

- RCI_{HI} [%] ("*" appended to the index means at least one intake > max allowable)
- RCI_{LO} [%] ("*" appended to the index means at least one intake < min allowable)

By inserting the IT equipment intake temperatures, the spreadsheet will calculate the Rack Cooling Index (RCI) and export RCI_{HI} and RCI_{LO} to the Estimator sheet (tab) (Figure 5).

<u>Other calculated data:</u>

- Intake Temperature Plot.

The plot dynamically updates and scales with changes made to the intake temperatures. The corresponding RCI values are shown immediately to the right of the plot in the two grey cells, which will turn red if either value is below 90% to indicate poor thermal conditions.

Step 3 RCI	**Current Thermal Conditions. Proceed to sheet (tab) "Step 3 RCI" (Optional) or continue directly with Step 4 below.**		
	Rack Cooling Index (RCI) Interpretation:	**RCI_{HI}**	**RCI_{LO}**
	* Full Compliance = 100%	**[%]**	**[%]**
	* Poor Compliance < 90%	99.5	65.0
			Poor

Figure 5: Step 3 RCI input (detail of Estimator sheet).

Step 4 Main Input

This Step asks for information to determine the current and target implementation levels of ten air management measures in the data center. The principal purpose of this input, together with the input from Steps 1 and 2, is to gather necessary information to calculate the energy savings due to air management.

<u>Input data (yellow cells) (Figure 6):</u>

- Table for Current and Target implementation levels.

Current refers to the existing implementation level of air management measures and Target refers to a target (future) implementation level of air management measures.

  - Measures 1 and 2: Recommended and allowable IT equipment intake air temperature ranges, respectively. The Current ranges will impact the RCI values calculated in Step 3 RCI. Input guidance and drop-down options are activated by selecting (clicking) a cell. You can temporarily drag the input guidance box to a different location on the worksheet to avoid interference with other input cells. All input guidance boxes on that worksheet will then appear in that location, until the workbook is closed and reopened.

- Measures 3-10 are key factors for air management. There are three options: LOW, MID, and HIGH level of implementation. Measure 8 has two options only: LOW and HIGH. Again, input guidance and drop-down options are activated by selecting a cell.

Step 4 Main Input — **Specify Current and Target implementation levels of ten Air Management Measures.**

	Air Management Measure	Current	Target
1	Recommended IT equipment intake temperature range (statement of reliability)	ASHRAE/NEBS	Wide
2	Allowable IT equipment intake temperature range (statement of functionality)	ASHRAE	NEBS
3	Aisle containment	LOW	HIGH
4	Blanking panels	MID	MID
5	Floor leakage management	MID	MID
6	Tile/diffuser placement	MID	MID
7	EC-Class (IT equipment ventilation protocol)	MID	HIGH
8	Controls sophistication	LOW	HIGH
9	AHU modularity/distribution	LOW	HIGH
10	Cable/pipe management in raised floor	LOW	HIGH

Click any cell (incl. headings) for Guidance and to access a drop-down box with options.

Figure 6: Step 4 Main Input (detail of Estimator sheet).

Step 6 Energy Results (there is no Step 5)

This final Step (tab) provides estimated energy and cost savings due to air management for both supply fans and chillers.

Calculated data (bars and grey cells) (Figure 7):

- % Energy Reduction
- kWh/year Energy Reduction
- $/year Savings.

The two bar charts show estimated percentage savings for four scenarios:

Measured:	With Current (Step 4) implementation level of air management
Commissioned:	Achievable with Current (Step 4) implementation of air management
Retrofitted:	Achievable with Target (Step 4) implementation of air management
State-of-the–Art:	State-of-the-art implementation of air management.

The Measured bars are the references (always 100%) and values above 100% for the other bars will not be displayed. This is a situation that should be avoided—the goal is to decrease the energy demand, not increase it. If this happens, please check that the data in Step 1 and Step 2 are realistic for the Current implementation level of air management specified in Step 4. Keep in mind that fan energy savings stem from decreasing the AHU airflow (over-ventilated space) and chiller energy savings stem from increasing the supply air temperature. Finally, since the Estimator is using look-up tables, the savings may not change when the input is changed marginally. For calculation details, see the *Engineering Reference* of the Air Management Tool.

Input data (yellow cells) (Figure 7):
Finally, five yellow input cells – not tied directly to air management – further adjust the savings.

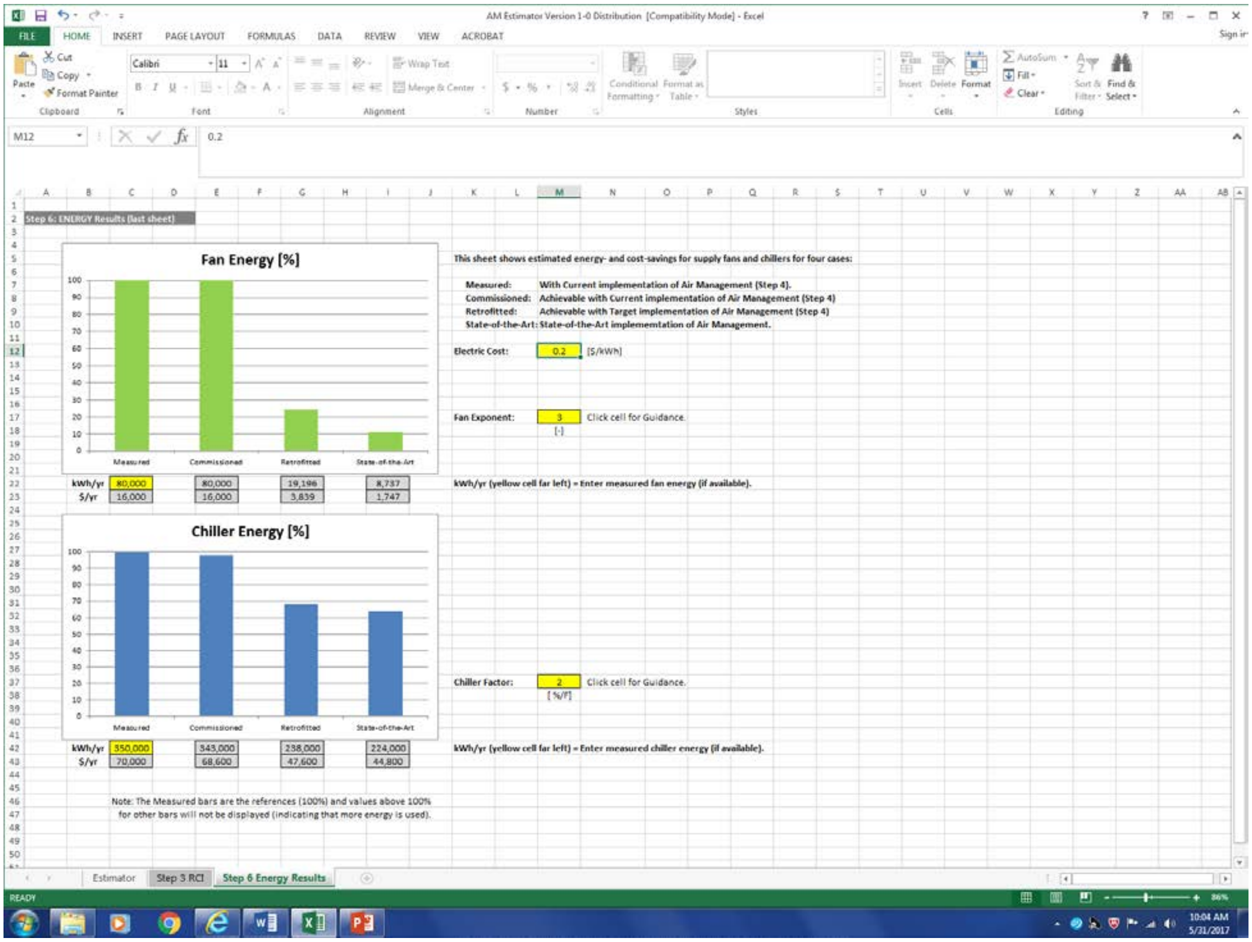

Figure 7: Step 6 Energy Results sheet (tab). Zoom in to see details.

- Fan Exponent [-].
  For fully turbulent airflow, there is a cubical relationship between fan energy and airflow. For data centers, however, an exponent of 2.8 is often used.

- Chiller Factor [%/°F].
  The reduction in chiller energy depends on the supply air temperature as a percentage saving per degree increase. For data center applications, a factor between 1 and 3 (I-P) is common.

- Annual Fan Energy [kWh/year].
  Enter the measured annual fan energy in kWh/year. This entry together with chart values will calculate the fan energy for each scenario (displayed under the chart).

- Annual Chiller Energy [kWh/year].
  Enter the measured annual chiller energy in kWh/year. This entry together with chart values will calculate the annual chiller energy for each scenario (displayed under the chart).

- Electric Cost [$/kWh].
  Enter the electric cost in $/kWh. This entry together with kWh/year will be used to calculate the associated annual costs for each scenario (displayed under the charts).

REFERENCES

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DOE. 2014b. Air Management Tool User's Manual (provides information on using the Tool)
https://datacenters.lbl.gov/tools/5-data-center-air-management-tool-featured

DOE. 2014c. Air Management Tool Engineering Reference (provides detailed information on the calculations, equations, metrics, and limitations)
https://datacenters.lbl.gov/tools/5-data-center-air-management-tool-featured

DOE. 2014d. Air Management Tool Data Collection Guide (provides information on collecting the necessary input data)
https://datacenters.lbl.gov/tools/5-data-center-air-management-tool-featured

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