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Room-Level Energy and Thermal Management in Data Centers: The DOE Air Management Tool

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Advanced Indoor Environmental and Energy Solutions for Mission-Critical Facilities

Outline

- The Thermal Interface
- Air Management
- Environmental Requirements
- Show Compliance
- DOE Air Management Tool
- Typical Energy Savings.

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Different Responsibilities

Equipment Vendor

Box vs. Rack vs. Room

End User

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A Typical Day in a Data Center…

- Always a smile
- Nice hair-do
- Fashionable high heels
- Those were the good old times!

But wait…
stilettos + perforated floor tiles = @!!&

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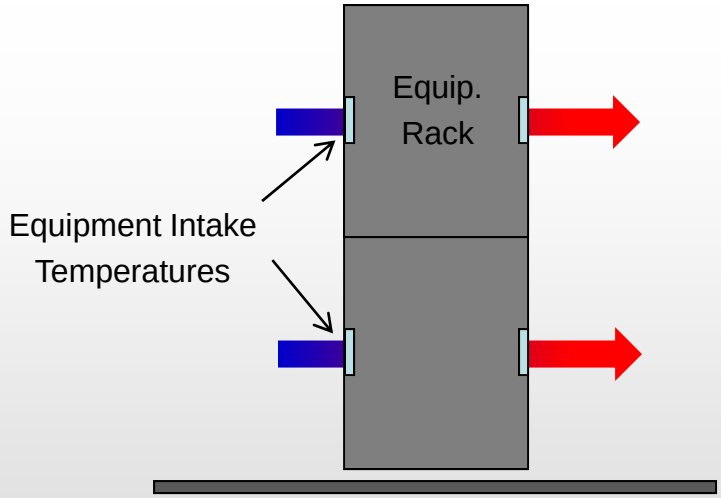
The Thermal Interface

Air-cooled servers depend exclusively on the *intake* air temperature for effective cooling. Today, most (but not all) environmental specs refer to the intake conditions.



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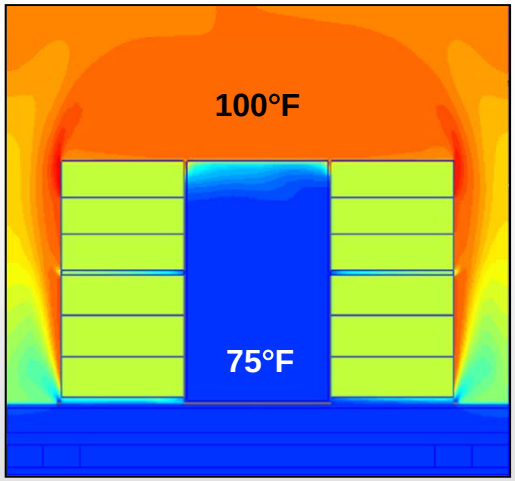
Air Management

The goal of Air Management is to minimize mixing of hot and cold air by minimizing air *recirculation* of hot air and minimizing *by-pass* of cold air. Both measures result in energy savings and better thermal conditions.

Next-to-perfect Air Management with enclosed cold aisle



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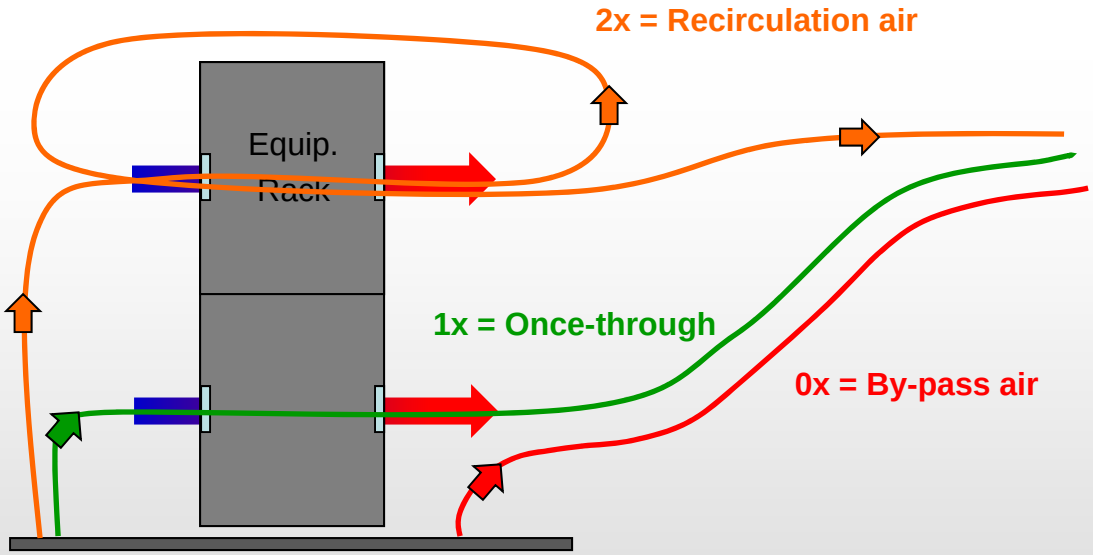
Once-Through Cooling

"Once-through cooling" is key to air management. It means that each cold air "cluster" passes through the server equipment exactly one time.



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Air Management Measures

- Place cold-air supplies in front aisles to conserve hot and cold aisles

- Install blanking panels in empty server positions in the equipment racks

- Install containment systems by introducing physical barriers around the aisles

- Seal raised floor systems by plugging unintentional openings (leaks).

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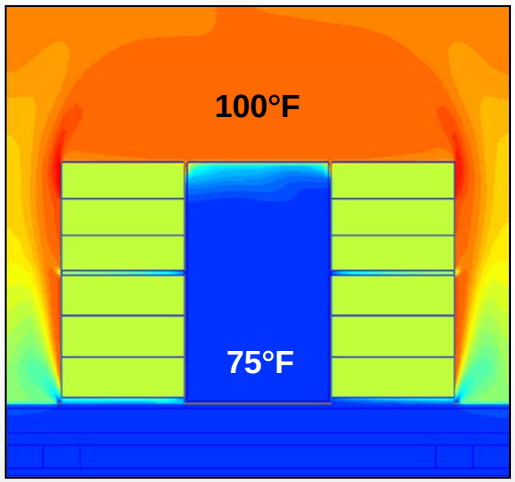
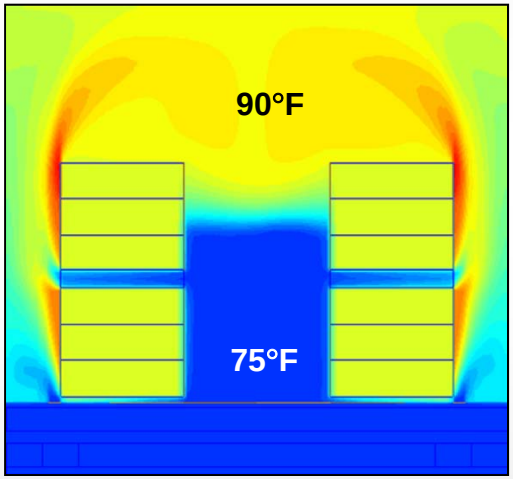
Thermal Impact of Air Management

Next-to-perfect air management



Business-as-usual air management



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Importance of Air Management

- Thermal Management. Adequate thermal conditions (server intake temperatures) are important for the reliability and longevity of electronic equipment.
- Energy Management. Air Management helps reduce operating costs by enhancing economizer utilization, improving chiller efficiency, and reducing fan energy.
- Capital Management. Improved energy efficiency also results in reduced capital investments for cooling equipment, air-moving equipment, and real estate.

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Temperature Specifications

(@ Equipment Intake)	Min and Max Recommended	Min and Max Allowable (Long-Term)
Temperature (°C)		
Data Centers ASHRAE	18° – 27°C	15° – 32°C
Telecom NEBS	18.33° – 26.67°C	5° – 40°C
Temperature (°F)		
Data Centers ASHRAE	64.40° – 80.60°F	59° – 89.60°F
Telecom NEBS	65° – 80°F	41° – 104°F

ASHRAE (2009) Special Publication, *Thermal Guidelines for Data Processing Environments*; Telcordia (2001) *Generic Requirements NEBS GR-3028-CORE*; Telcordia (2006) *Generic Requirements NEBS GR-63-CORE*.

www.ashrae.org www.telcordia.com

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Determining Compliance

The **Rack Cooling Index (RCI)**® is a performance metric designed to gauge compliance with the thermal guidelines of ASHRAE/NEBS.

- RCI_{HI} (100% mean no temperatures above max recommended)
- RCI_{LO} (100% mean no temperatures below min recommended)

Both at 100% mean that all temps are within the recommended range, i.e., absolute compliance. The lower the numbers, the greater probability intake temperatures are outside the allowable range.

ASHRAE (2008) Special Publication, *Thermal Guidelines for Data Processing Environments*.
www.ashrae.org

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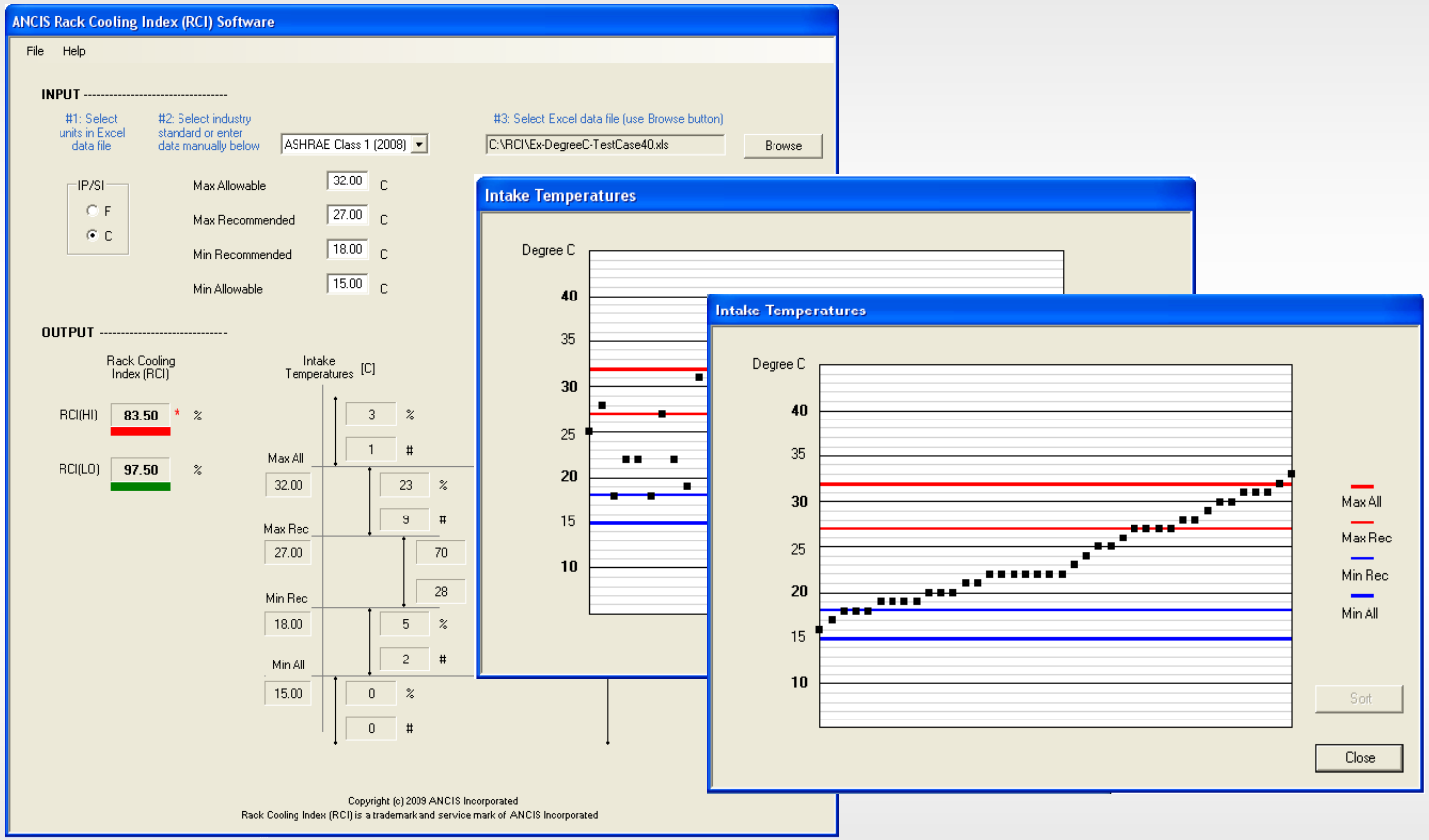
Rack Cooling Index (RCI)® Software



RCI Software: http://www.ancis.us/rci.html

Rack Cooling Index (RCI) is a Registered Trademark of ANCIS Incorporated

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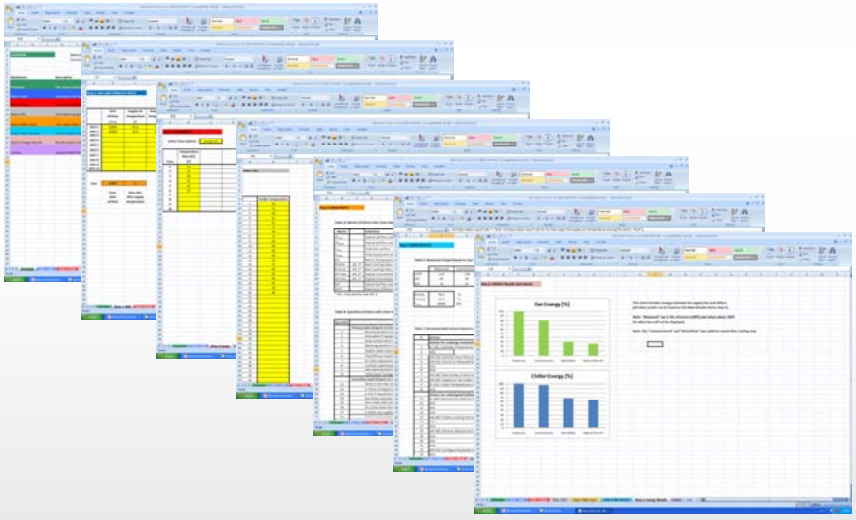
DOE Air Management Tool

The DOE Air Management Tool is a free Excel tool for assessing the data center air-management status and providing recommendations and energy savings.



Tool: http://www1.eere.energy.gov/industry/datacenters/software.html

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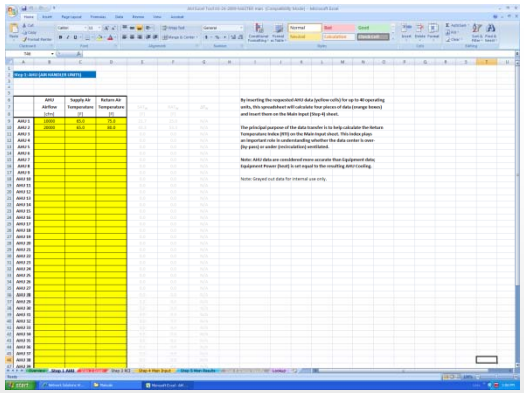
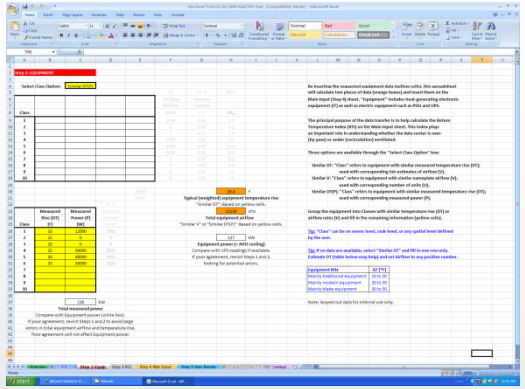
Input

First, the user fills in data and answers questions on four input Excel sheets. Each sheet includes basic guidance for entering the data correctly.

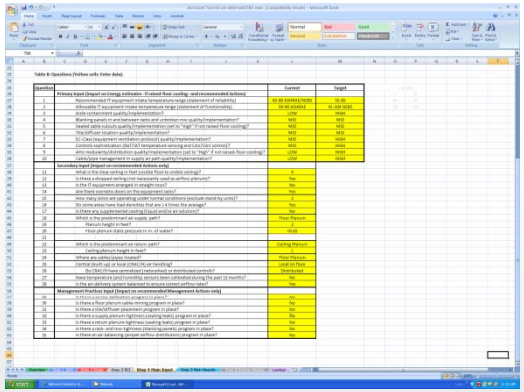
Air Handlers



IT-Equipment



Room Layout



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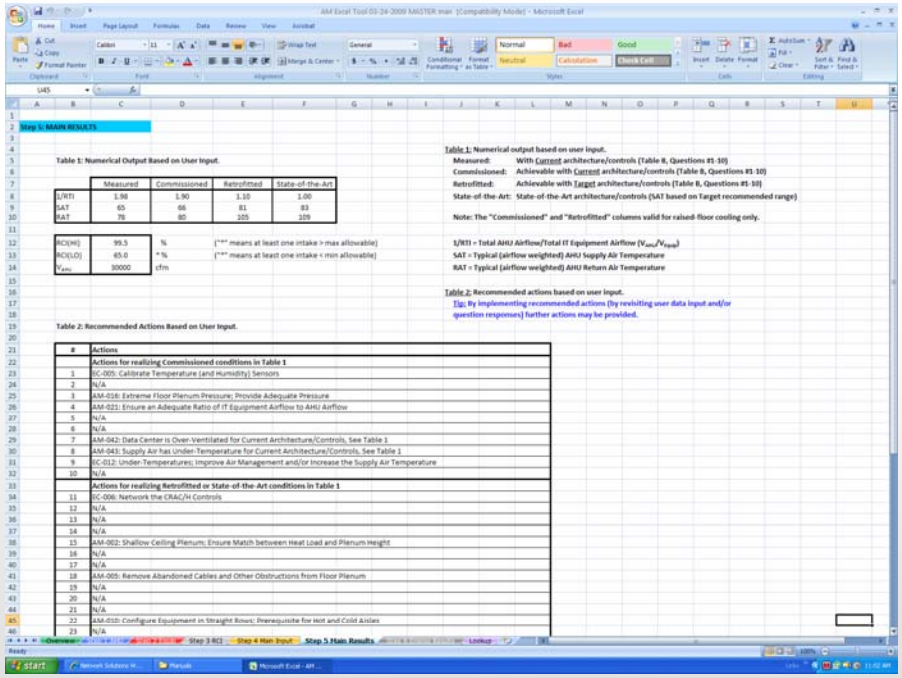
Output

Second, based on the user input, numerical output and recommended air management actions are given on an output Excel sheet.



Step 5: MAIN RESULTS

Table 1: Numerical Output Based on User Input.

	Measured	Commissioned	Retrofitted	State-of-the-Art
1/RTI	1.98	1.90	1.10	1.00
SAT	65	66	81	83
RAT	78	80	105	109

RCI(HI)	99.5	%
RCI(LO)	65.0	%
V_{AHU}	30000	cfm

("*" means at least one intake > max allowable)

("*" means at least one intake < min allowable)

Table 1: Numerical output based on user input.
Measured: With Current architecture/controls (Table B, Questions #1-10)
Commissioned: Achievable with Current architecture/controls (Table B, Questions #1-10)
Retrofitted: Achievable with Target architecture/controls (Table B, Questions #1-10)
State-of-the-Art: State-of-the-Art architecture/controls (SAT based on Target recommended range)

Note: The "Commissioned" and "Retrofitted" columns valid for raised-floor cooling only.

1/RTI = Total AHU Airflow/Total IT Equipment Airflow (V_{AHU}/V_{ITE})
SAT = Typical (airflow weighted) AHU Supply Air Temperature
RAT = Typical (airflow weighted) AHU Return Air Temperature

Table 2: Recommended actions based on user input.
Tip: By implementing recommended actions (by revisiting user data input and/or question responses) further actions may be provided.

Table 2: Recommended Actions Based on User Input.

#	Actions
	Actions for realizing Commissioned conditions in Table 1
1	EC-005: Calibrate Temperature (and Humidity) Sensors
2	N/A
3	AM-016: Extreme Floor Plenum Pressure; Provide Adequate Pressure
4	AM-021: Ensure an Adequate Ratio of IT Equipment Airflow to AHU Airflow
5	N/A
6	N/A
7	AM-042: Data Center is Over-Ventilated for Current Architecture/Controls, See Table 1
8	AM-043: Supply Air has Under-Temperature for Current Architecture/Controls, See Table 1
9	EC-012: Under-Temperatures; Improve Air Management and/or Increase the Supply Air Temperature
10	N/A
	Actions for realizing Retrofitted or State-of-the-Art conditions in Table 1
11	EC-006: Network the CRAC/H Controls
12	N/A
13	N/A
14	N/A
15	AM-002: Shallow Ceiling Plenum; Ensure Match between Heat Load and Plenum Height
16	N/A
17	N/A
18	AM-005: Remove Abandoned Cables and Other Obstructions from Floor Plenum
19	N/A
20	N/A
21	N/A
22	AM-010: Configure Equipment in Straight Rows; Prerequisite for Hot and Cold Aisles
23	N/A

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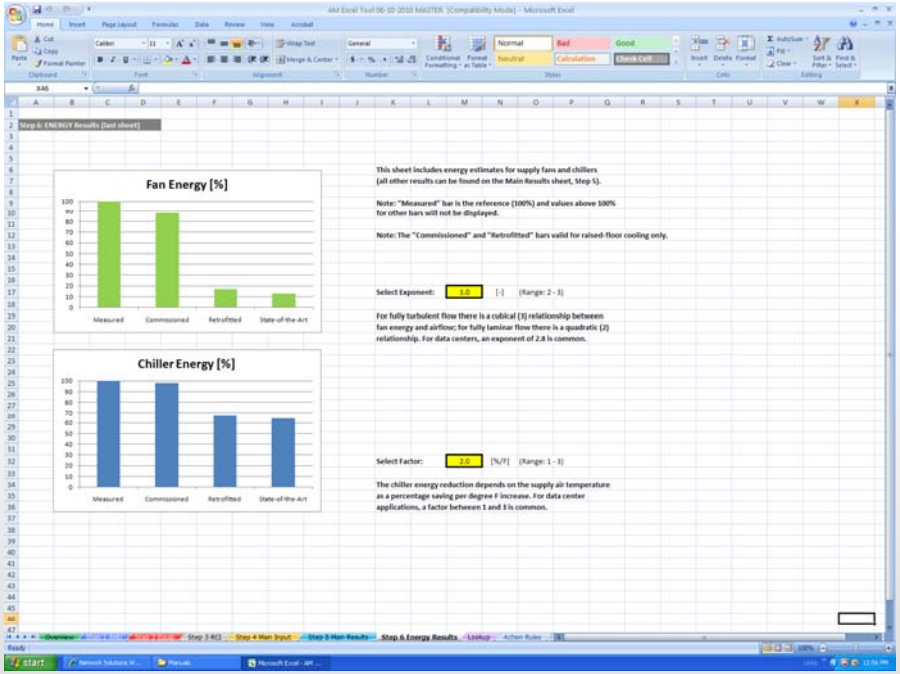
Energy Impact of Air Management

Finally, the percentage energy reduction for fans and chillers are provided on the last sheet.

70-90%

15-25%

Not including economizers



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Supporting Information

DOE Air Management Tool has three manuals:

- User's Manual
- Engineering Reference
- Data Collection Guide.

Learn more through the DOE DCEP Program.

DCEP Program: http://www1.eere.energy.gov/industry/datacenters/dc_cep.html

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Summary

- Single thermal interface between room and IT-equipment
- Importance of Air Management: Thermal, energy, and capital
- Environmental requirements from ASHRAE and NEBS
- RCI metric for demonstrating compliance
- Unique DOE Air Management Tool
- High typical energy savings
- Web links throughout presentation.

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THANK YOU

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About the Author: Magnus K. Herrlin, Ph.D., is President of ANCIS Incorporated (www.ancis.us), San Francisco, CA. He is prime developer of the DOE Air Management Tool and lead of the DOE Data Center Energy Practitioner (DCEP) Program.

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