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Improved Data Center Energy Efficiency and Thermal Performance by Advanced Airflow Analysis

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Advanced Indoor Environmental and Energy Solutions for Mission-Critical Facilities

Objective

Telecom and data center owners and operators are looking for designs that improve the energy efficiency *and* the thermal performance of their facilities. Advanced airflow analysis has the capacity to meet these seemingly contradicting goals.

The purpose of "air management" is to elevate the return air temperature and reduce the system airflow rate with unchanged or improved electronic equipment intake temperatures. The objective of this presentation is to demonstrate the importance of air management and the use of advanced airflow analysis.

An example highlights the benefits of investing in upfront airflow analysis before proceeding to the final design of the telecom or data center facility.

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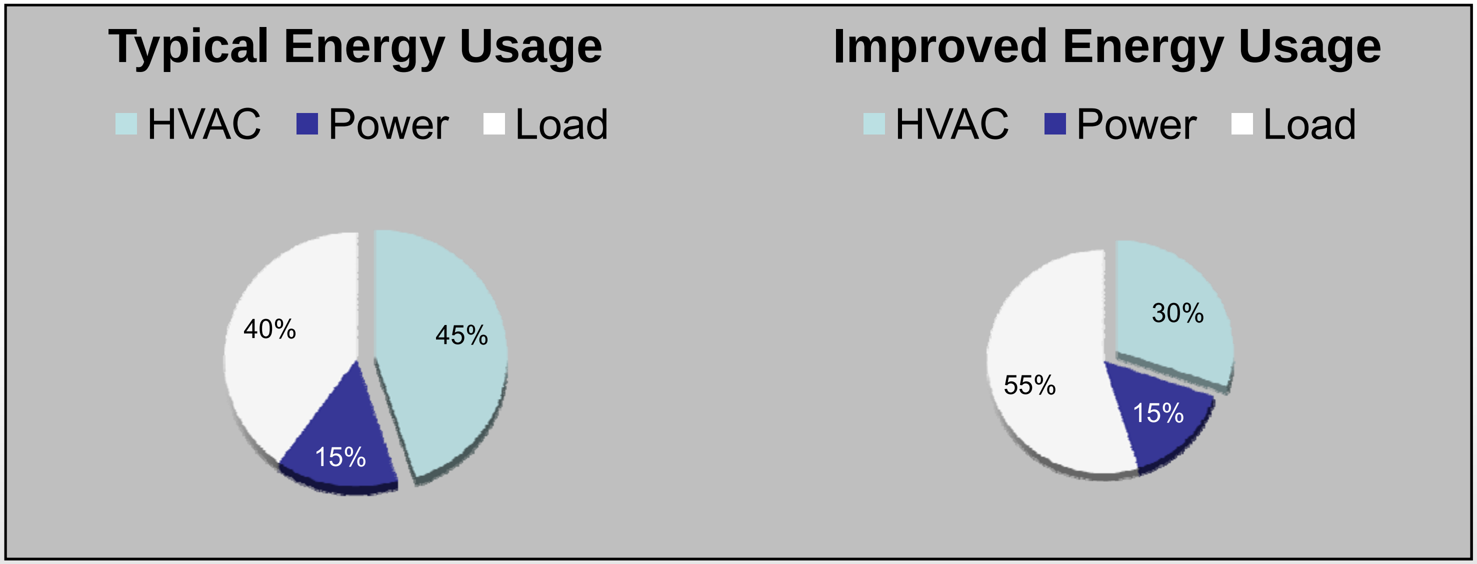
First: Energy Performance

Key to successful air management is to avoid mixing cold supply air with equipment hot exhaust air. Depending on the climate, air management may allow greatly improved energy efficiency. The “load” slice should represent the majority of the electric budget.



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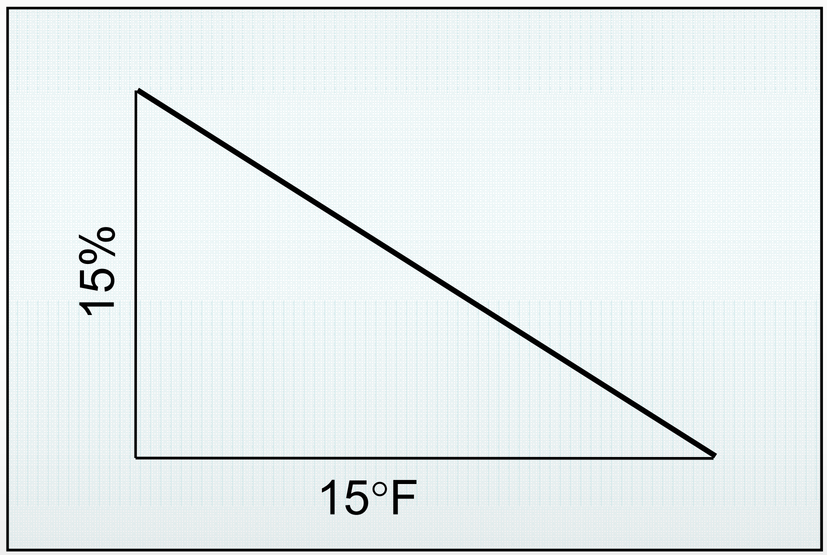
Higher Chiller Efficiency

An elevated return air temperature allows the facility chillers to operate at higher energy efficiency (and higher capacity).

Annual Energy Cost



Return Air Temperature

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Higher Economizer Utilization

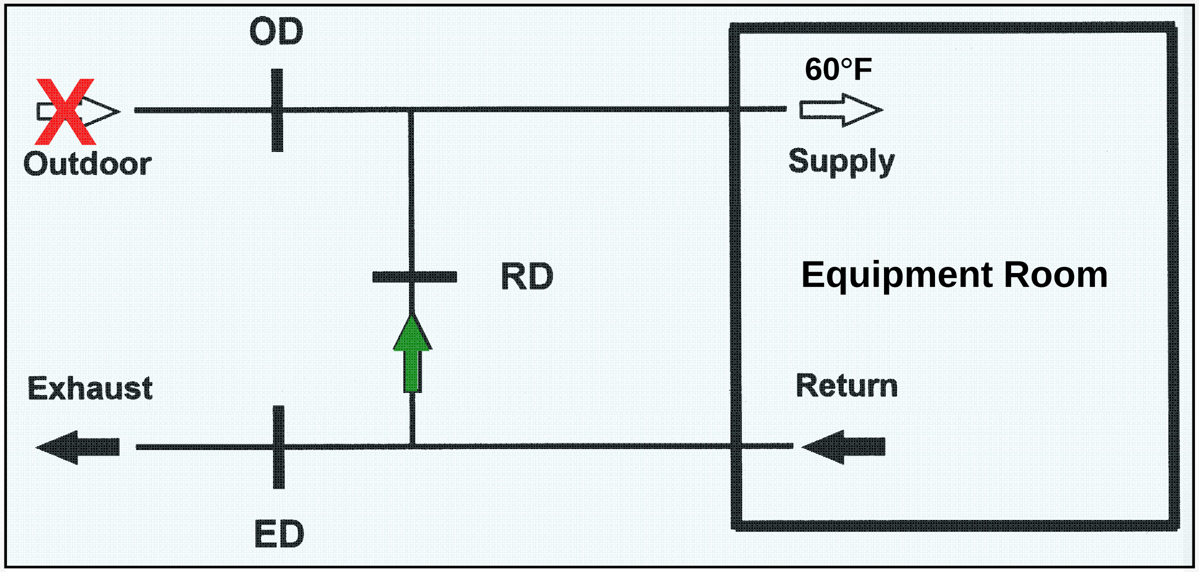
An elevated return air temperature also allows better utilization of air-side economizers (free cooling) which further reduces the energy usage.

So, what is an air-side economizer? First, it is not a piece of equipment, but rather a control sequence for adjusting the amount of outdoor air that is admitted into the facility.

Damper Position 1

No Free Cooling (minimum OA)

OAT>RAT



San Francisco	OAT	RAT	Air Management	Outside Air
	<80°F	70°F	Poor (ΔT=10°F)	Sometimes
	<80°F	80°F	Good (ΔT=20°F)	Always

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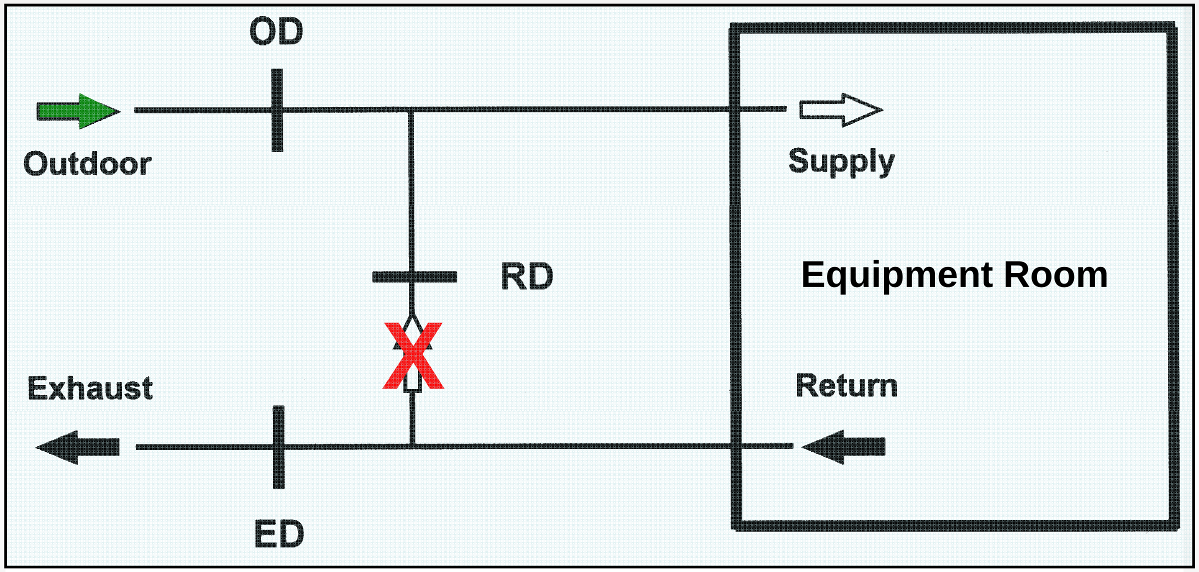
Damper Position 2

Partial Free Cooling (100% OA)

OAT<RAT
OAT>SAT



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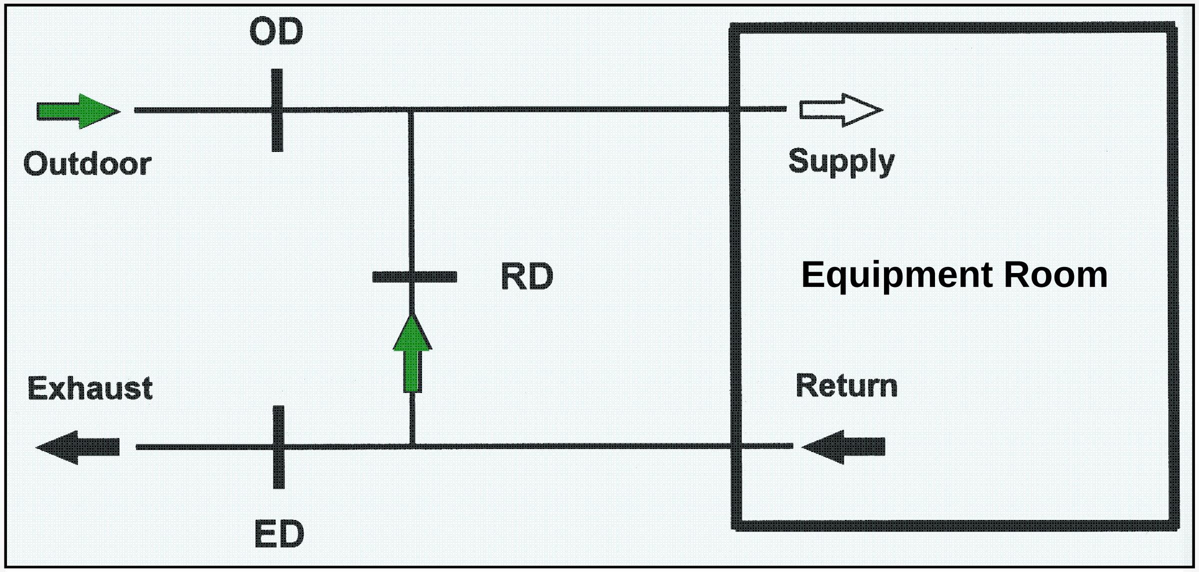
Damper Position 3

100% Free Cooling (<100% OA)

OAT<SAT



Air-side economizers are not only dependent on the return air temperature but also the supply air temperature and the outdoor conditions (climate).

Lower Airflow Rates

Finally, an elevated return air temperature allows reducing the system airflow rate, which translates into less fan power and fan energy:

Fan Energy ~ Airflow^3

Air Management	**Airflow Rate**	**Fan Energy**
Poor (ΔT=10°F)	1.0 (reference)	100% (reference)
Good (ΔT=20°F)	0.5	12%

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Energy Metric: Introducing RTI

The Return Temperature Index (RTI) is a measure of the energy performance of the air management system. RTI=100% maximize the return air temperature and minimize the system airflow rate.

$$RTI = \frac{RAT - SAT}{\Delta T_{Equip}} 100 \; [\%]$$

RAT	**Return Air Temperature**
SAT	**Supply Air Temperature**
ΔT_{Equip}	**Increase Across Equipment**

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Interpretation of the RTI

The Return Temperature Index (RTI) is also a measure of the excess or deficit of supply air. A depressed return temperature (RTI<100%) indicates that air is by-passing the racks, and an elevated temperature (RTI>100%) indicates air recirculation.

Interpretation	RTI
Target	100%
Recirculation	>100%
By-Pass	<100%

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Example

A number of HVAC systems and air-distribution systems were analyzed for optimal design based on energy and thermal considerations. Three of these systems are shown on the next three slides.

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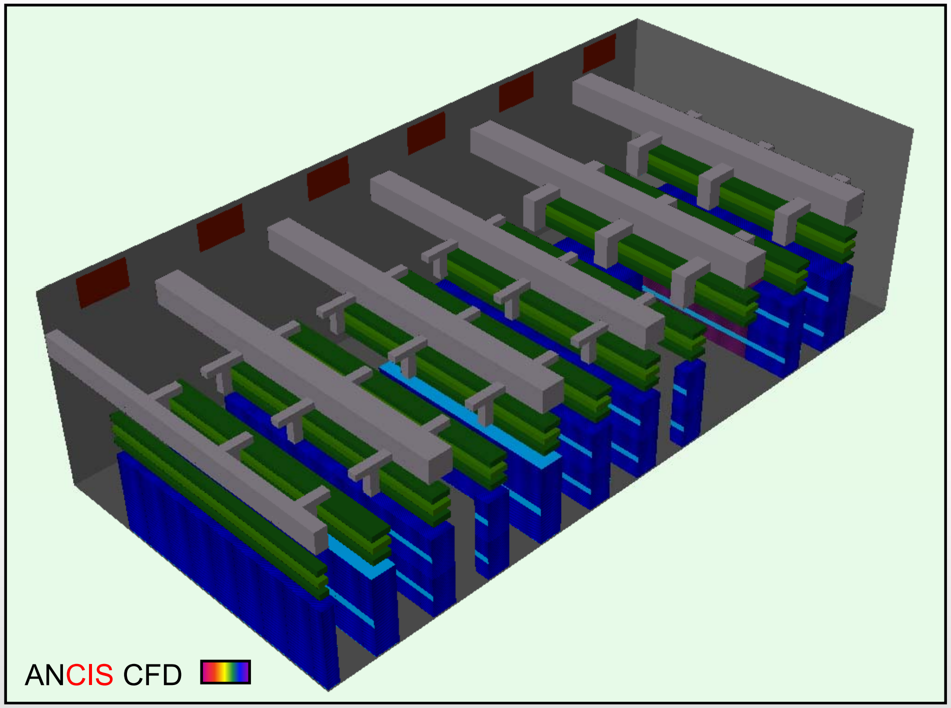
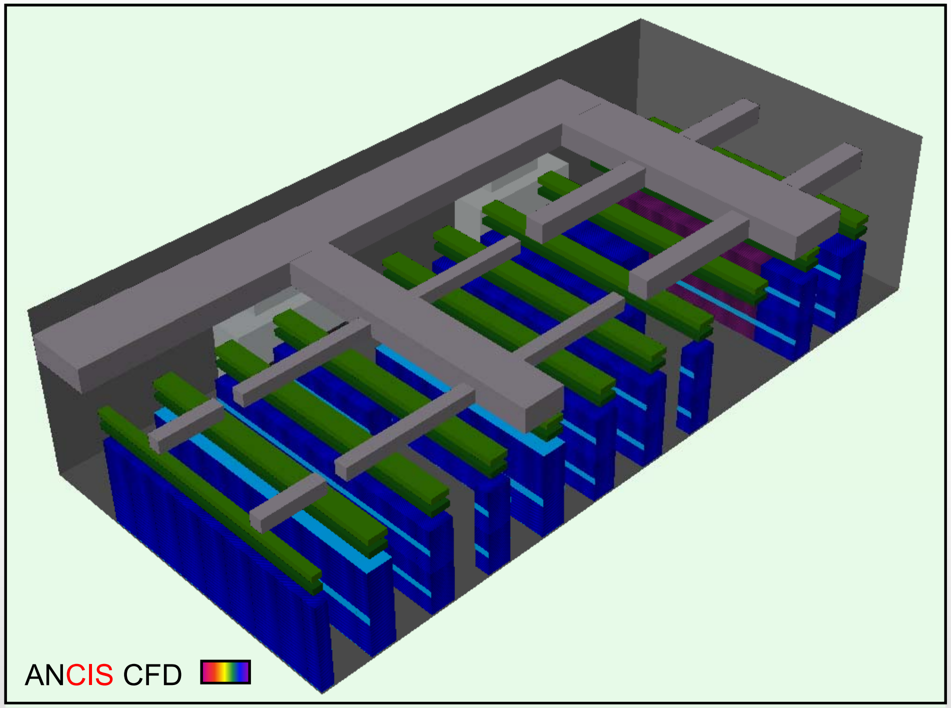
Central Air Handler, Over-Head Air

System "X":
Central air-handler with ducted vertical over-head air distribution.



CRAC Units, Over-Head Air

System "Y":
CRAC units with ducted vertical over-head air distribution.



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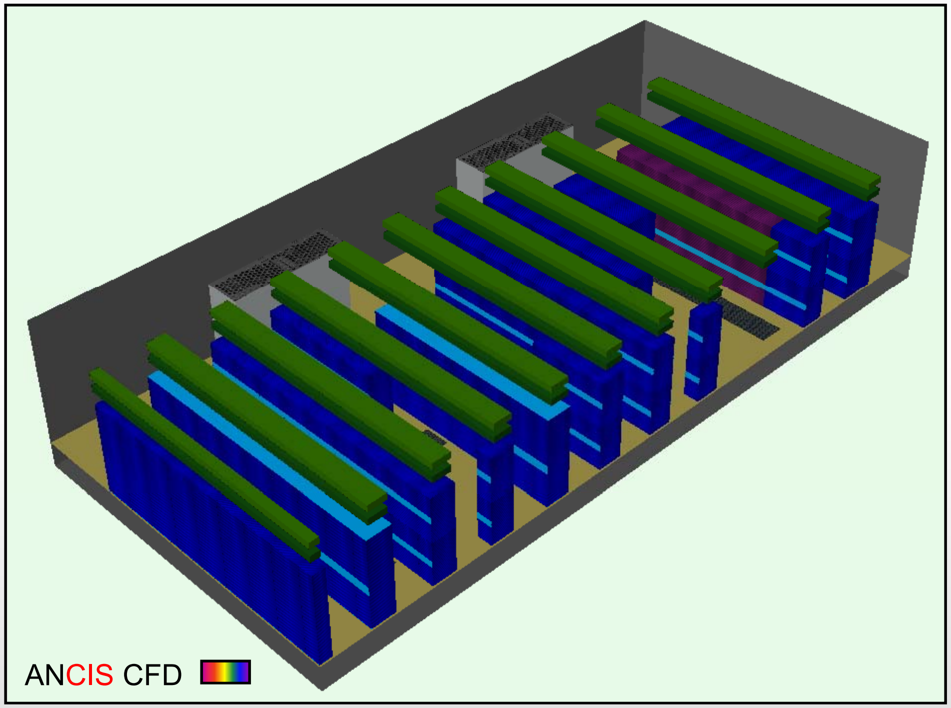
CRAC Units, Under-Floor Air

System “Z”:
CRAC units with raised-floor vertical under-floor air distribution.



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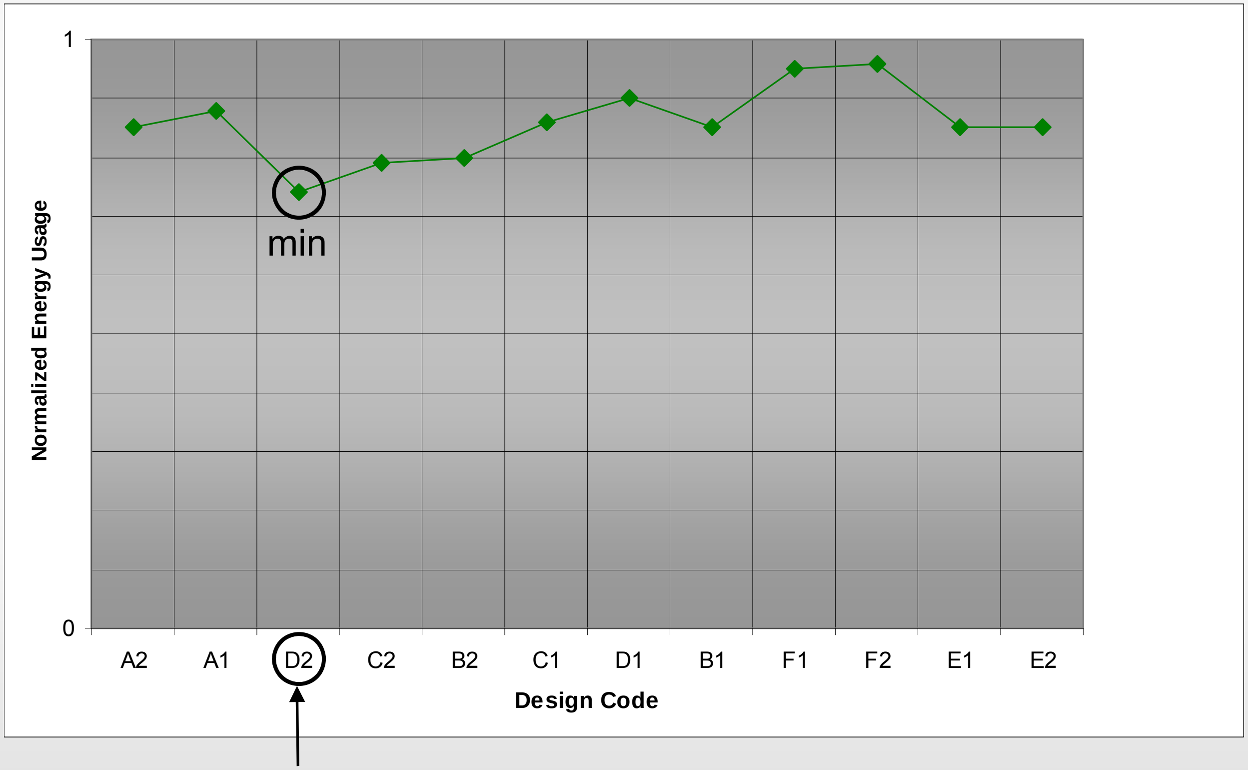
Energy Performance

Normalized energy usage vs. different systems provides a summary of the energy performance.



System D2 provides best energy efficiency

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Second: Thermal Performance

Energy-efficiency measures, however, must not adversely impact the thermal environment. Poor thermal equipment conditions may lead to problems with reliability and longevity.

Therefore, the system with the best energy efficiency (D2) may not be the best overall solution. The thermal conditions should be evaluated as well.

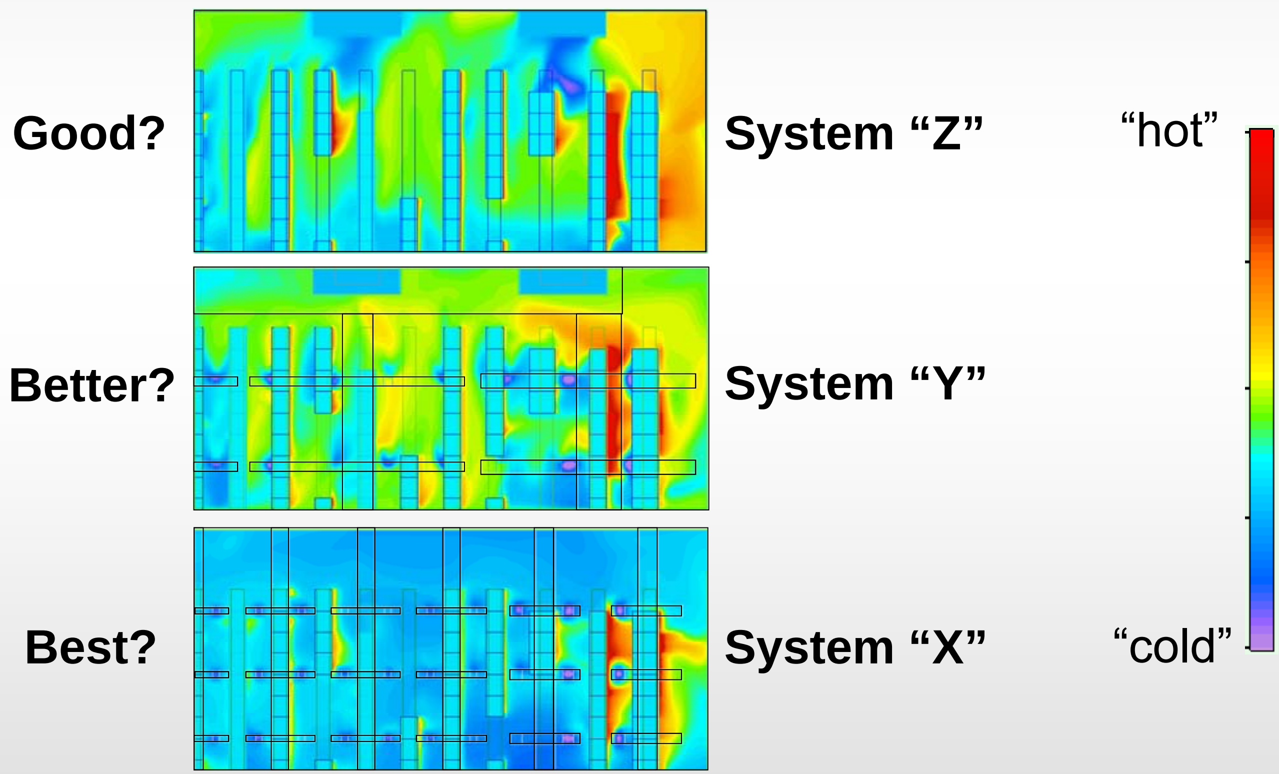
Thermal Conditions

The equipment <u>intake</u> temperature is the only important room temperature for air-cooled electronic equipment.

Monitoring any other room temperature will result in less accurate operation. But, most of today's Computer Room Air-Conditioning (CRAC) units measure the return air temperature.

CFD Modeling

Computational Fluid Dynamics (CFD) modeling provides a wealth of information but how do we sort things out?



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Temperature Specifications

The recommended and allowable intake temperatures depend on the selected temperature specification. Selecting a specification is a prerequisite to determining the quality of a thermal solution.

	Telecom NEBS	**Data Center ASHRAE Class 1**
Recommended **(facility centric)**	18°–27°C (65°–80°F)	20°–25°C (68°–77°F)
Allowable **(equipment centric)**	5°–40°C (41°–104°F)	15°–32°C (59°–90°F)

Telcordia 2001 and ASHRAE 2004

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Thermal Metric: RCI

The Rack Cooling Index (RCI) is a measure of compliance with the selected temperature specification. RCI = 100% mean ideal conditions; total absence of over- and under-temperatures, all temperatures are within the recommended range.

Rating (ASHRAE Class 1)	RCI
Ideal	100%
Good	≥96%
Acceptable	91-95%
Poor	≤90%

Herrlin 2005, free download at www.ancis.us

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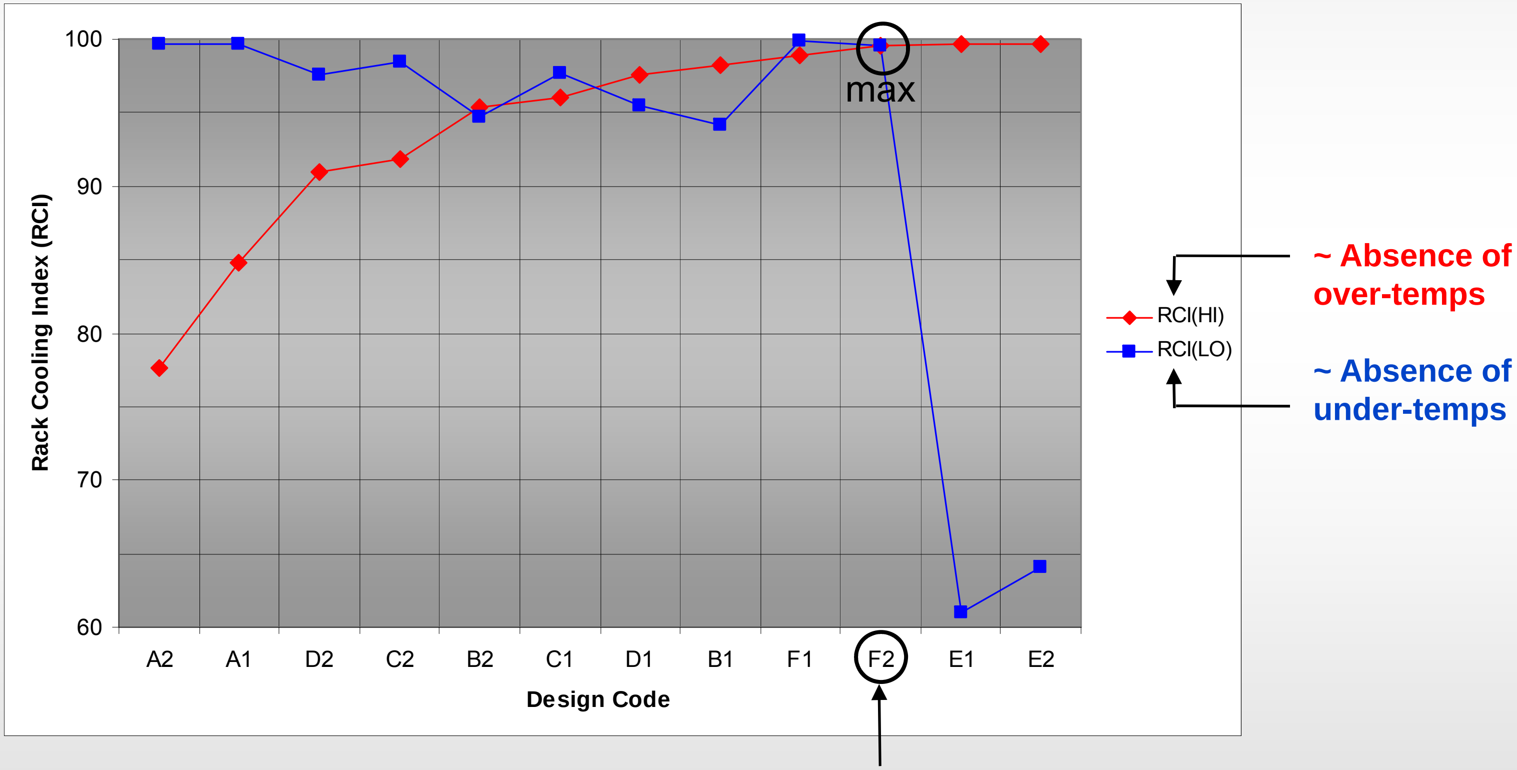
Thermal Performance

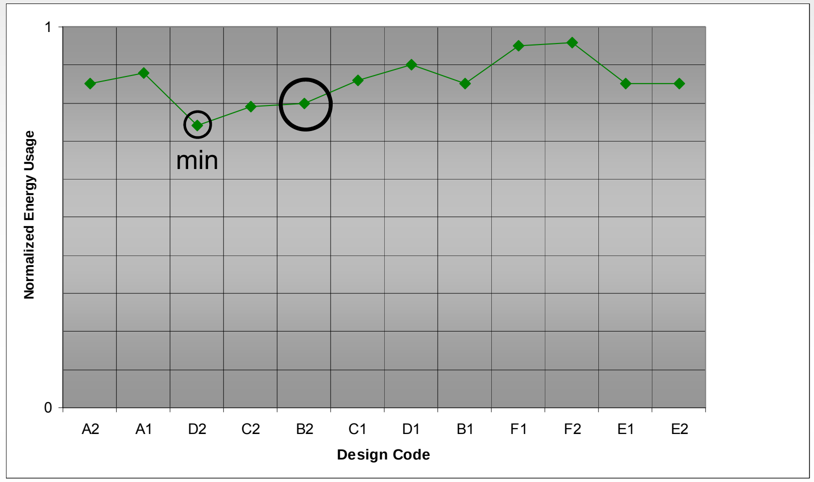
Rack Cooling Index (RCI) vs. different systems provides a summary of the thermal performance.



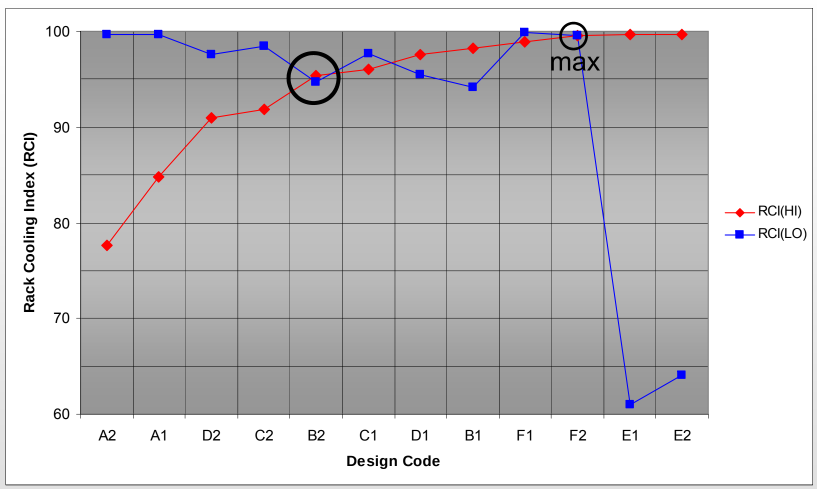
System F2 provides best thermal performance

Finally: System Selection

Project Target:
Energy < 0.8



Project Target:
RCI > 95%



Based on the project targets, <u>System B2</u> was selected

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Summary

Proper air management in telecom and data centers is imperative for optimal energy and thermal management.

Airflow analysis provides an understanding how well an air-management solution will perform prior to being implemented.

Rack Cooling Index (RCI) and Return Temperature Index (RTI) are two effective tools for optimizing air management.

Investing in advanced airflow analysis before proceeding to the final system design phase pays off handsomely.

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Thank You!

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