Data Center Energy Efficiency

SC07 Birds of a Feather
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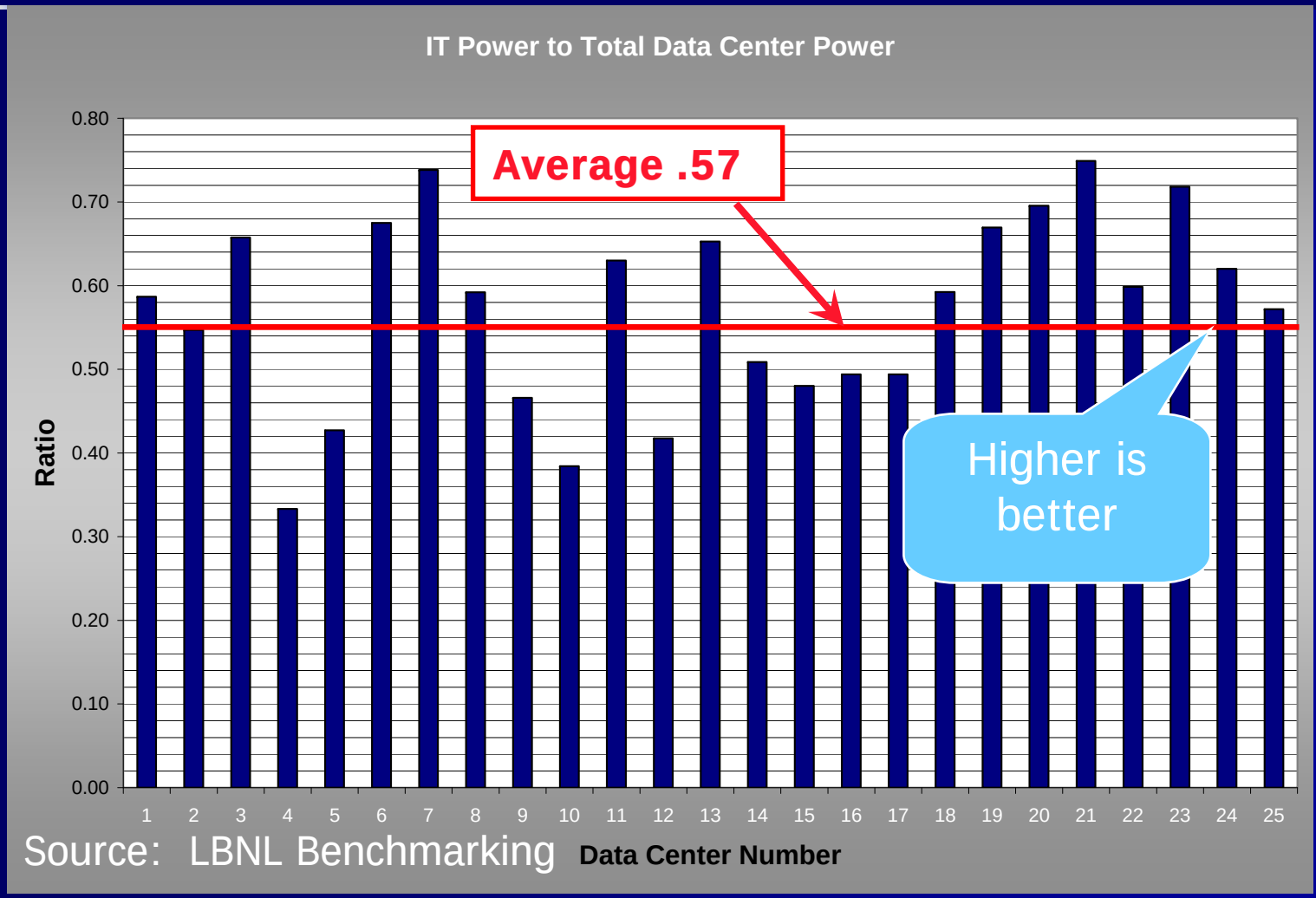
Bill Tschudi
wftschudi@lbl.gov

Benchmark results helped to find best practices

The ratio of IT equipment power to the total (or its inverse) is an indicator of relative overall efficiency. Examination of individual systems and components in the centers that performed well helped to identify best practices.

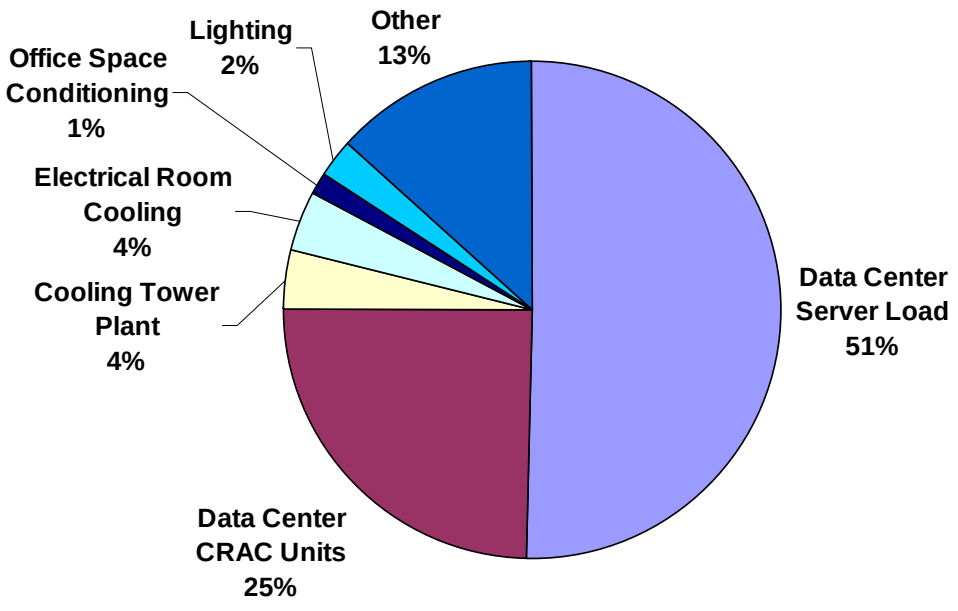
Percentage of electricity delivered to IT equipment

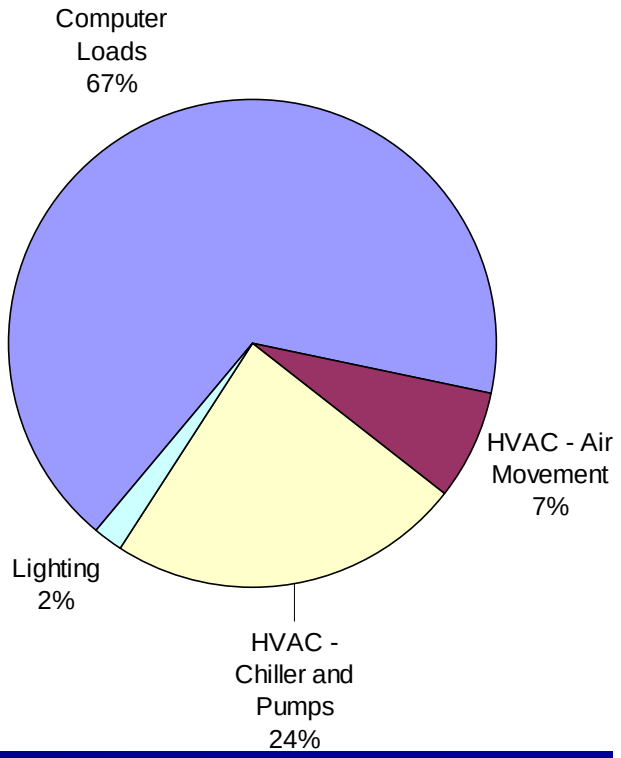


Source: LBNL Benchmarking

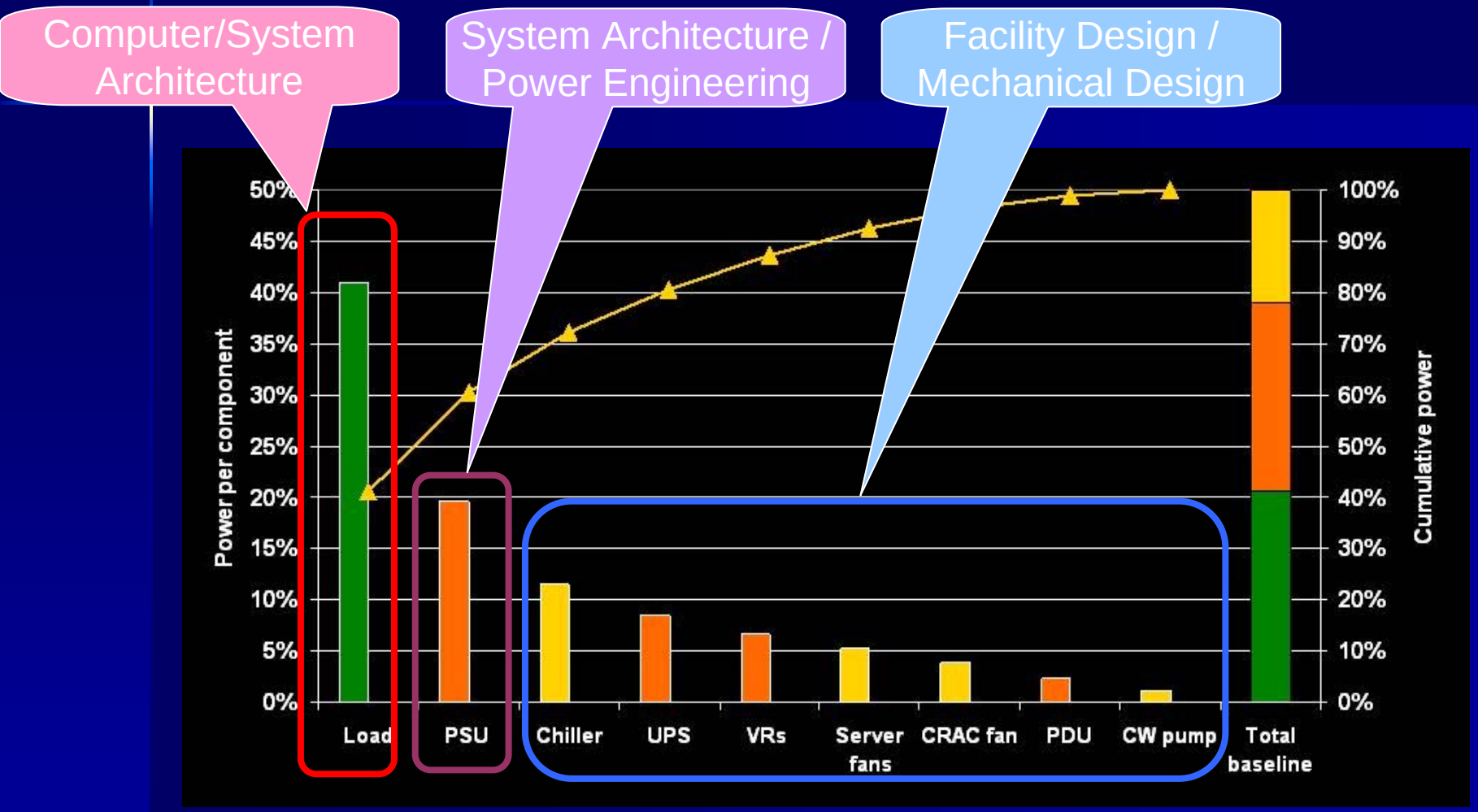
Performance varies

The relative percentages of the energy actually doing computing varies considerably.



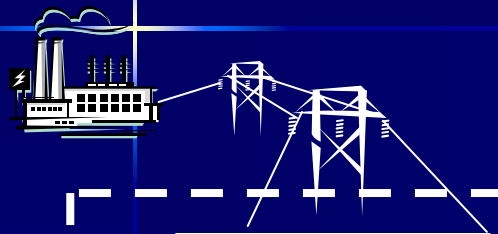


Typical power use



Courtesy of Michael Patterson, Intel Corporation

Energy efficiency opportunities are everywhere



- Load management
- Server innovation

- Better air management
- Move to liquid cooling
- Optimized chilled-water plants
- Use of free cooling

Power Conversion & Distribution

Server Load/ Computing Operations

Cooling Equipment

Alternative Power Generation

- High voltage distribution
- Use of DC power
- Highly efficient UPS systems
- Efficient redundancy strategies

- On-site generation
- Waste heat for cooling
- Use of renewable energy/fuel cells

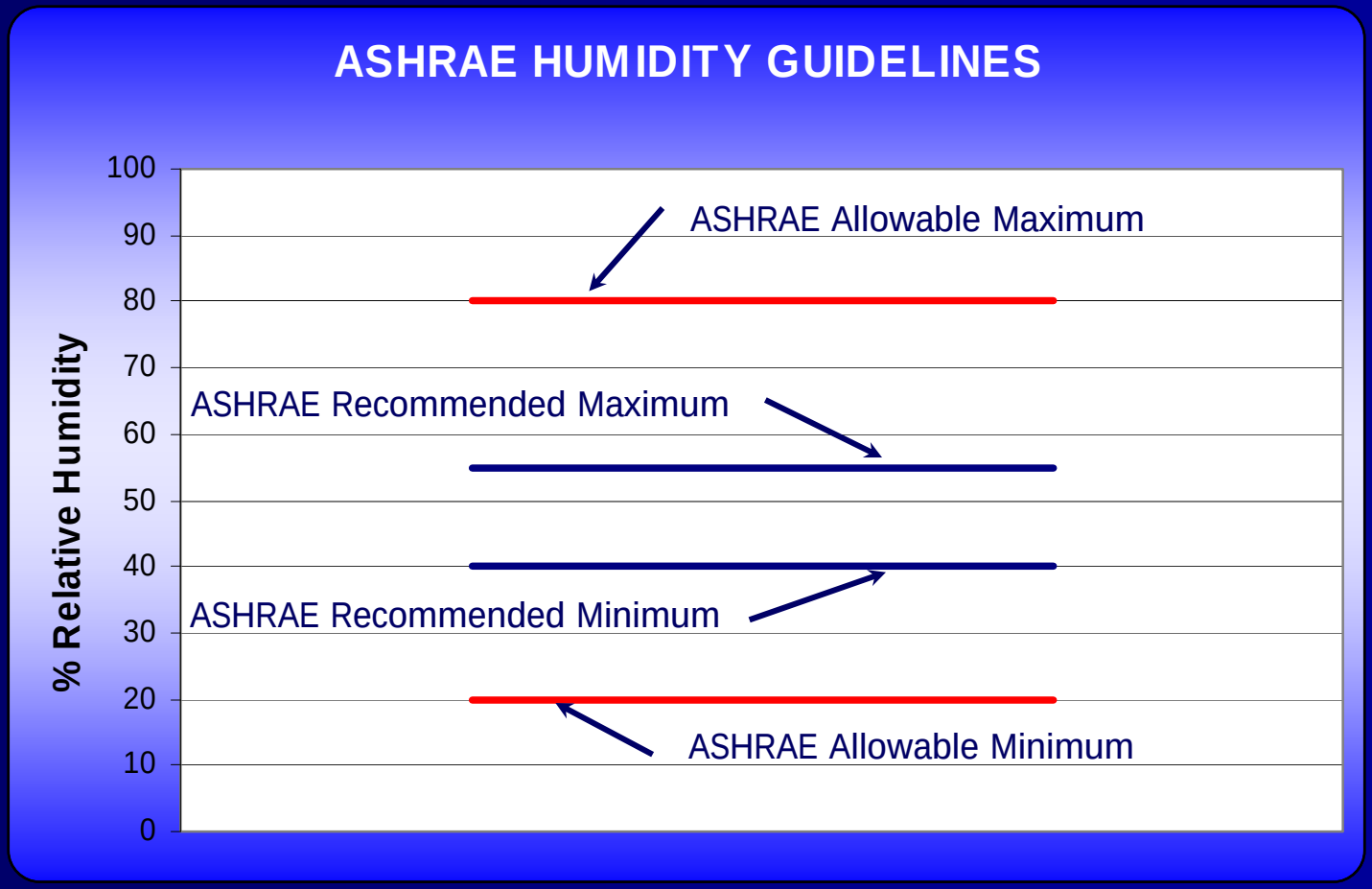
Best practices topics identified through benchmarking

HVAC – Air Delivery – Water Systems		Facility Electrical Systems	IT Equipment	Cross-cutting / misc. issues
Air management	Cooling plant optimization	UPS systems	Power Supply efficiency	Motor efficiency
Air economizers	Free cooling	Self generation	Sleep/standby loads	Right sizing
Humidification controls alternatives	Variable speed pumping	AC-DC Distribution	IT equip fans	Variable speed drives
Centralized air handlers	Variable speed Chillers	Standby generation		Lighting
Direct liquid cooling				Maintenance
Low pressure drop air distribution				Commissioning/continuous benchmarking
Fan efficiency				Heat recovery
				Redundancies
				Method of charging for space and power
				Building envelope

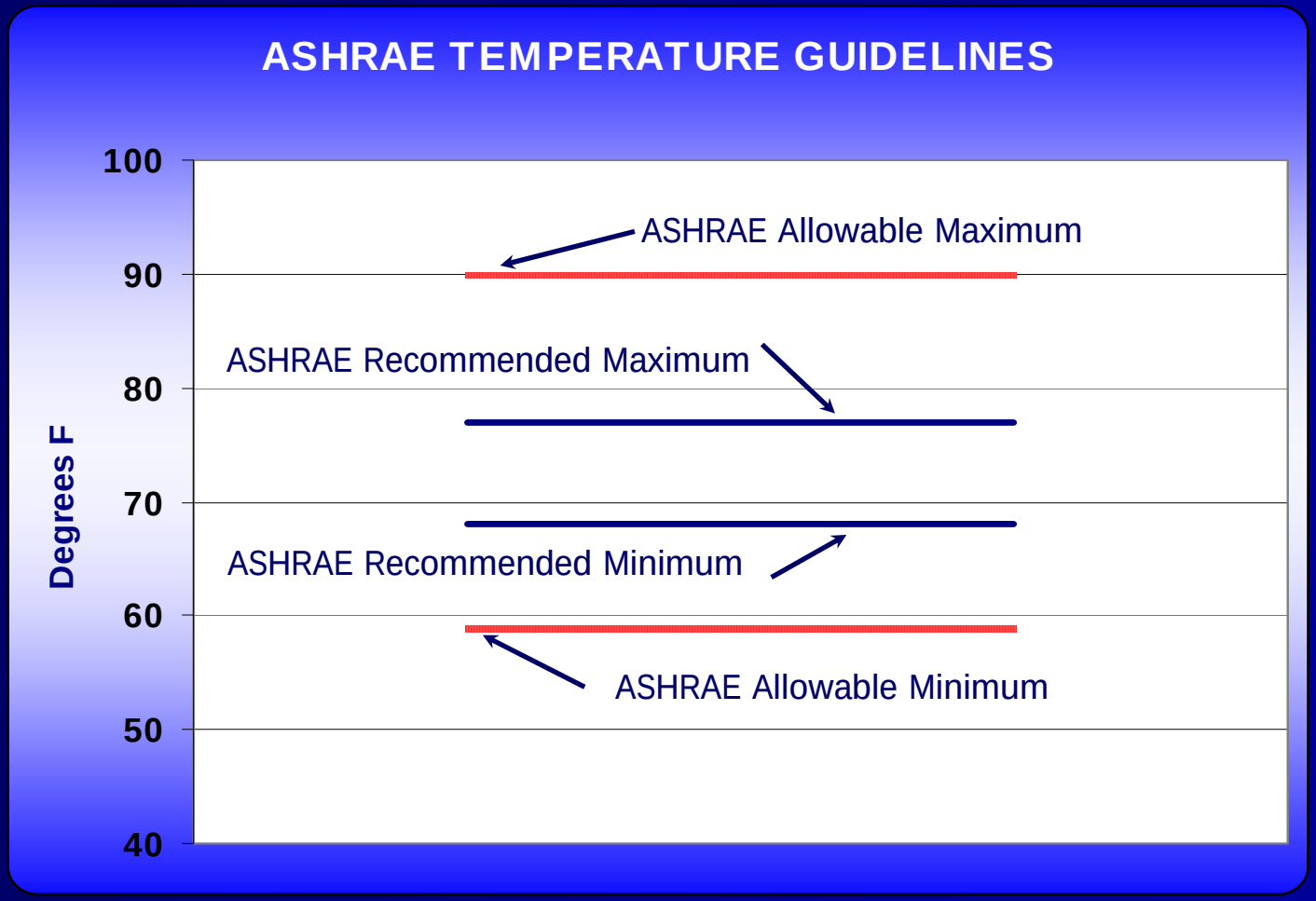
A word about appropriate environmental conditions…

- ASHRAE published thermal guidelines
  - All IT suppliers participated and agreed
  - Guidelines allow most centers to relax setpoints
  - HPC community agrees
- Recommended and allowable ranges of temperature and humidity are provided – *at the inlet to the IT equipment*
- High temperatures in the “hot aisles” and return to air conditioners are desirable.

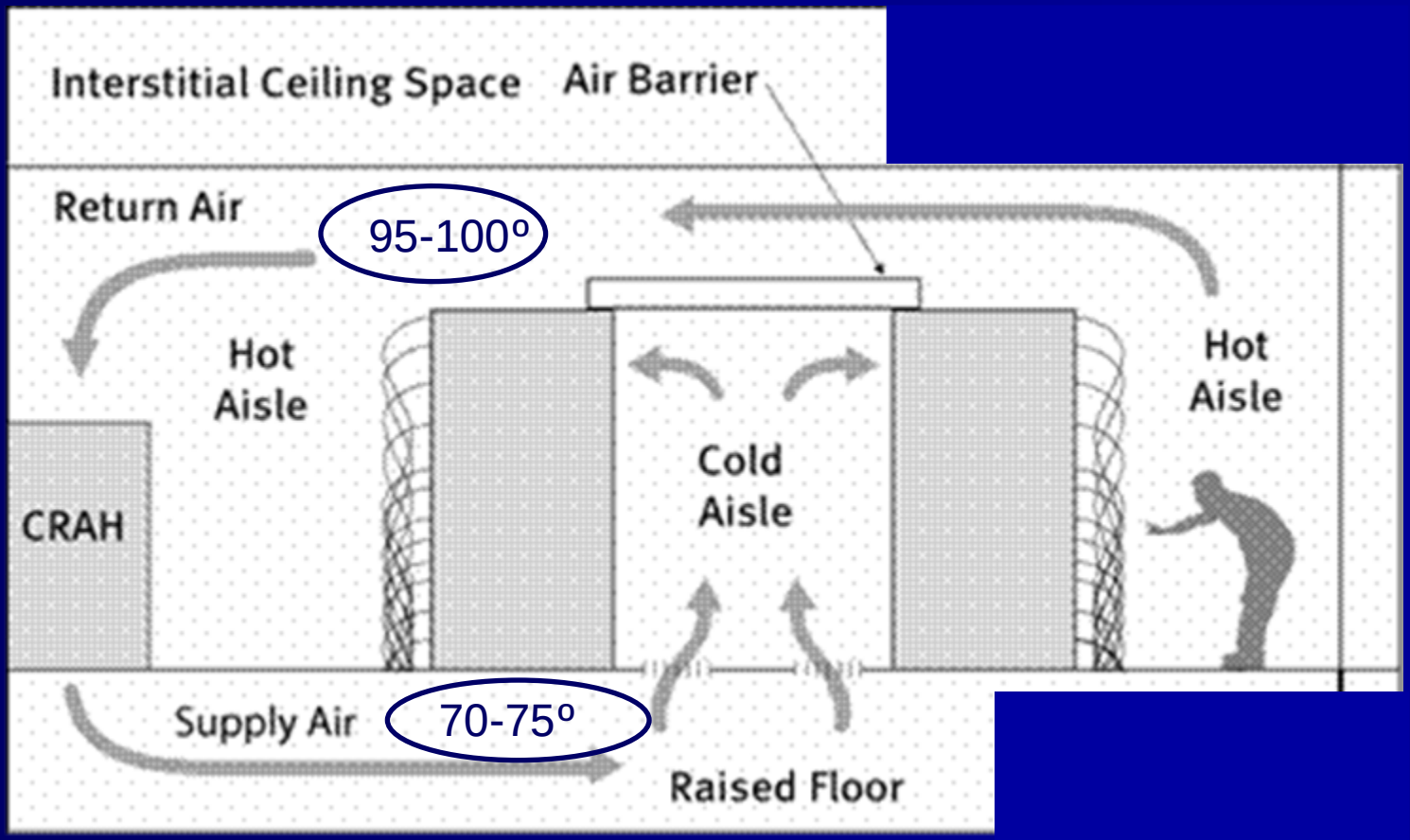
Humidity guidelines – at the inlet to IT equipment



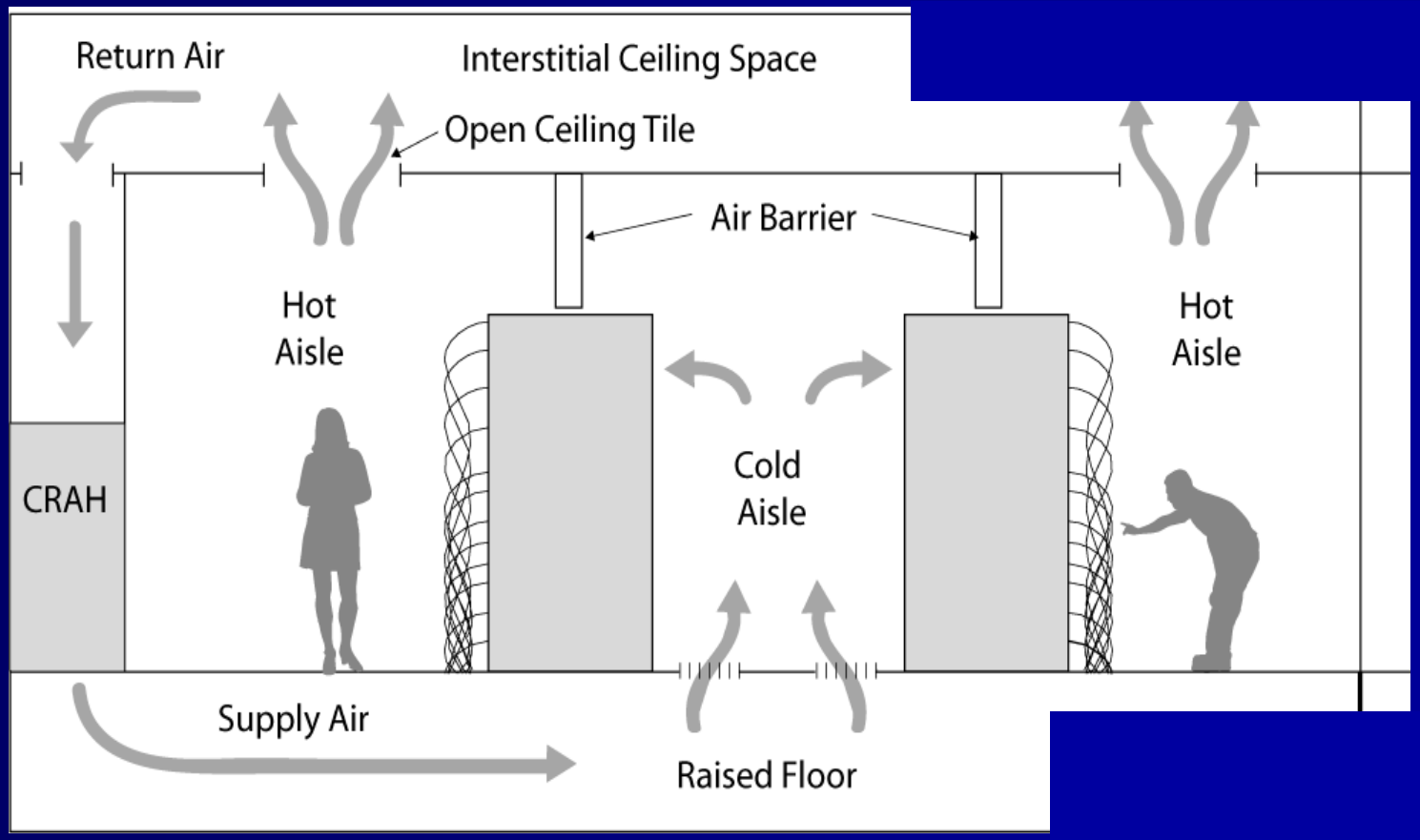
Temperature guidelines – at the inlet to IT equipment



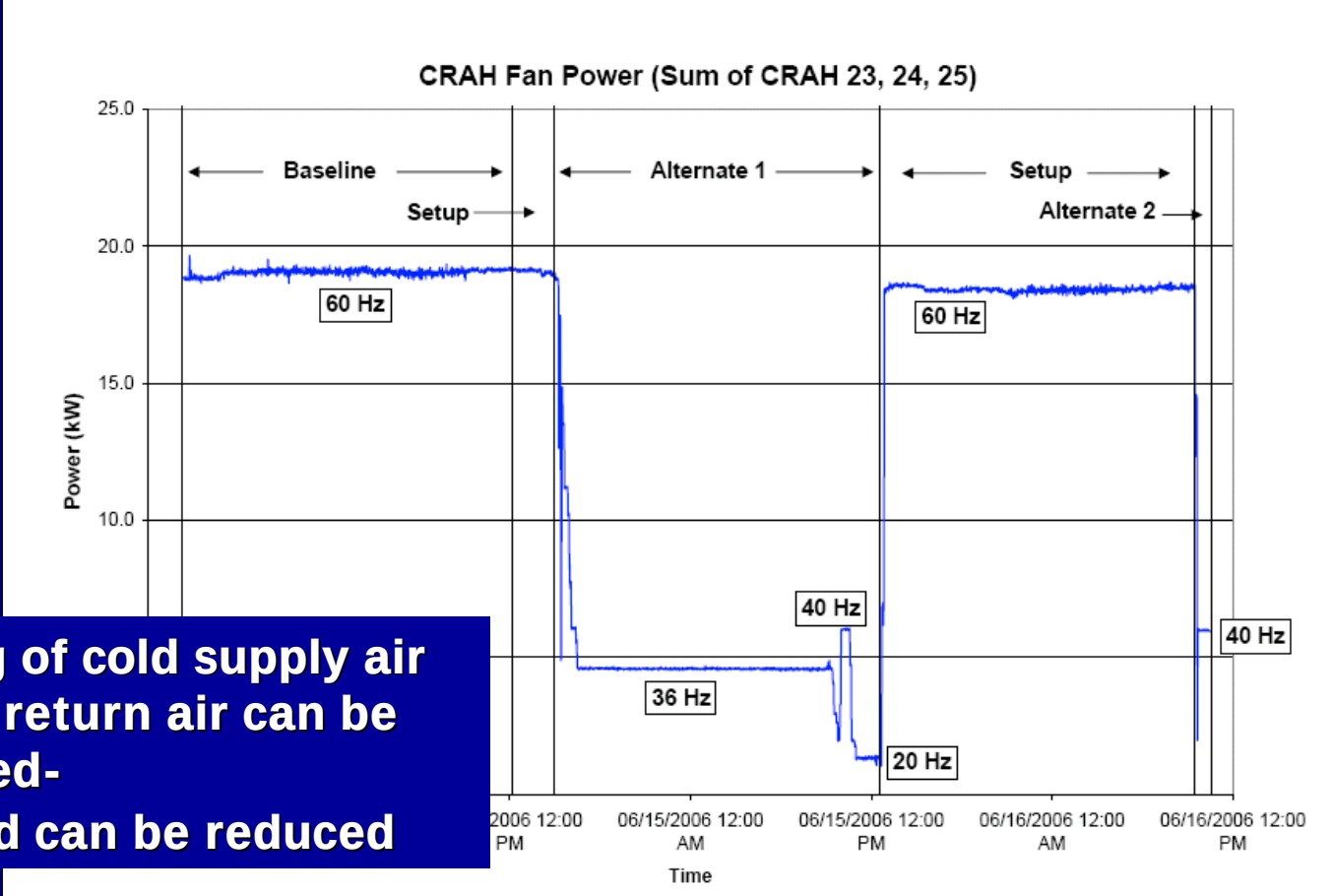
Air management best scenario – isolate cold and hot



Another isolation scheme

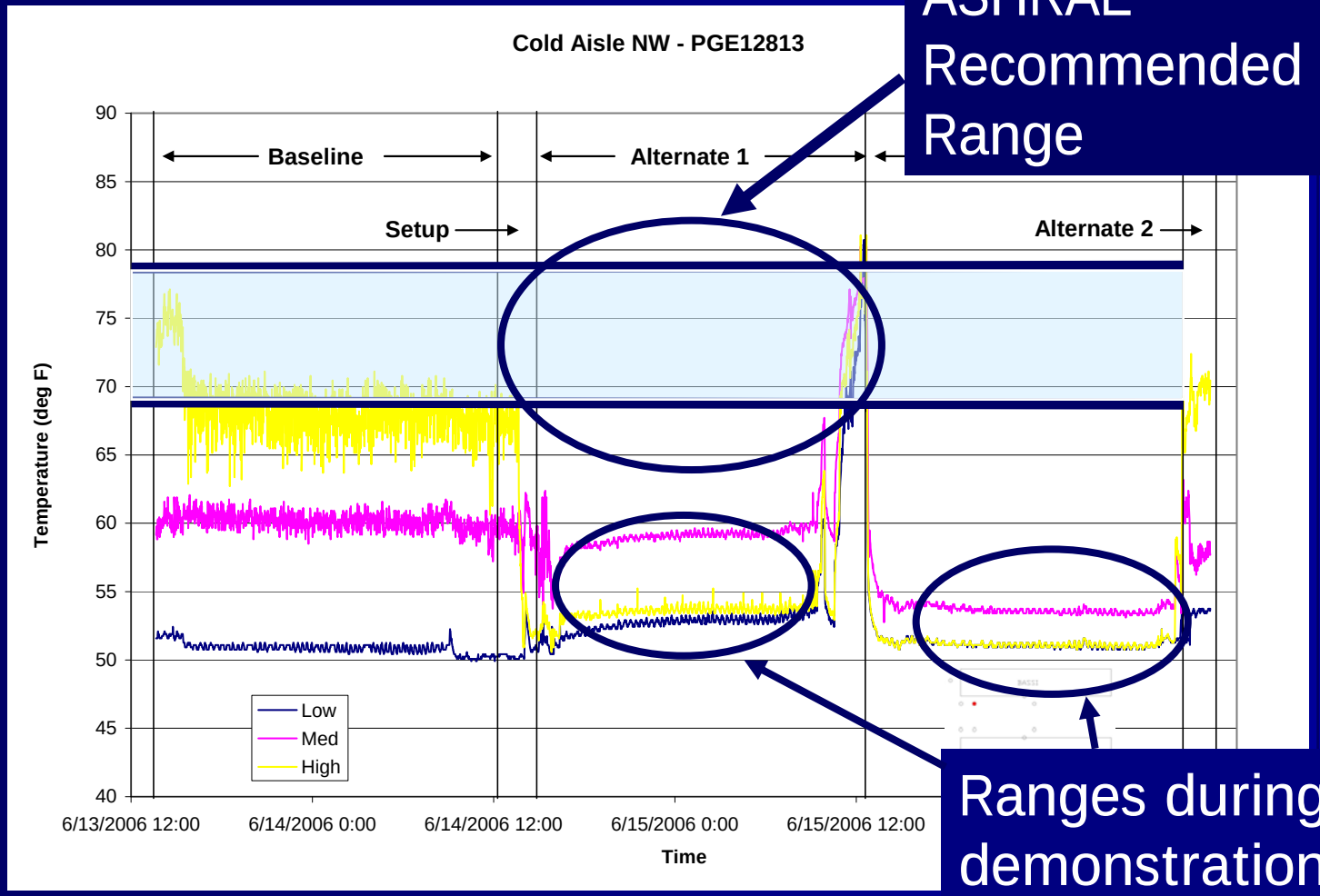


Measured fan energy savings – 75%

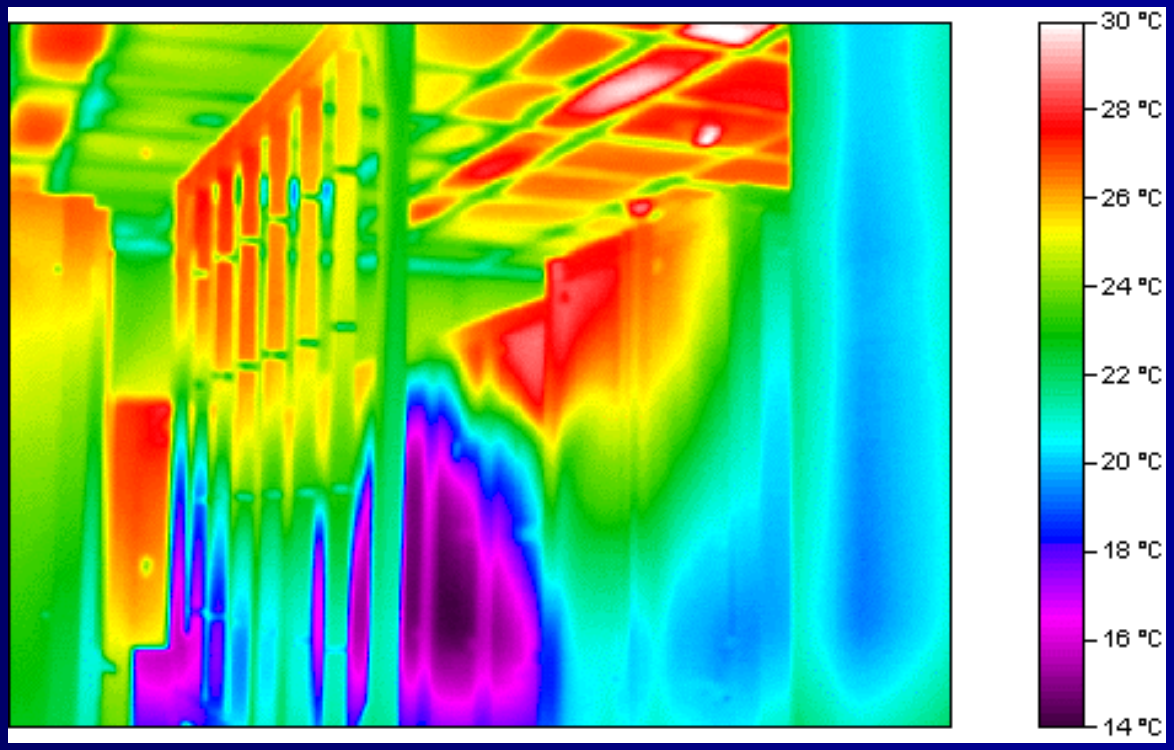


If mixing of cold supply air with hot return air can be eliminated-
fan speed can be reduced

Better temperature control can allow raising the temperature in the entire data center!



See the problem areas



Infrared thermography and CFD modeling can be used as visualization tools

Best practices – Free cooling with air economizers

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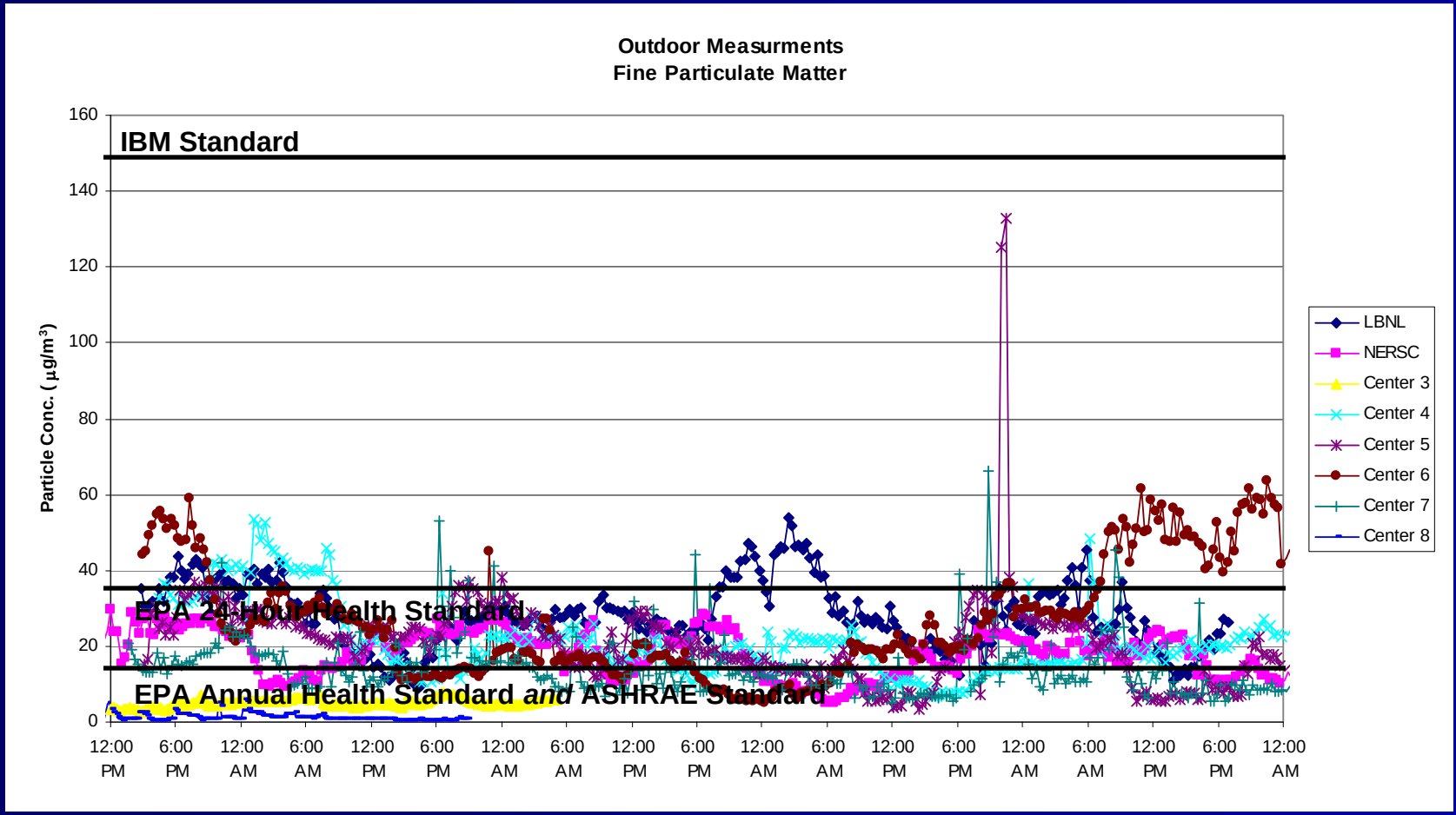
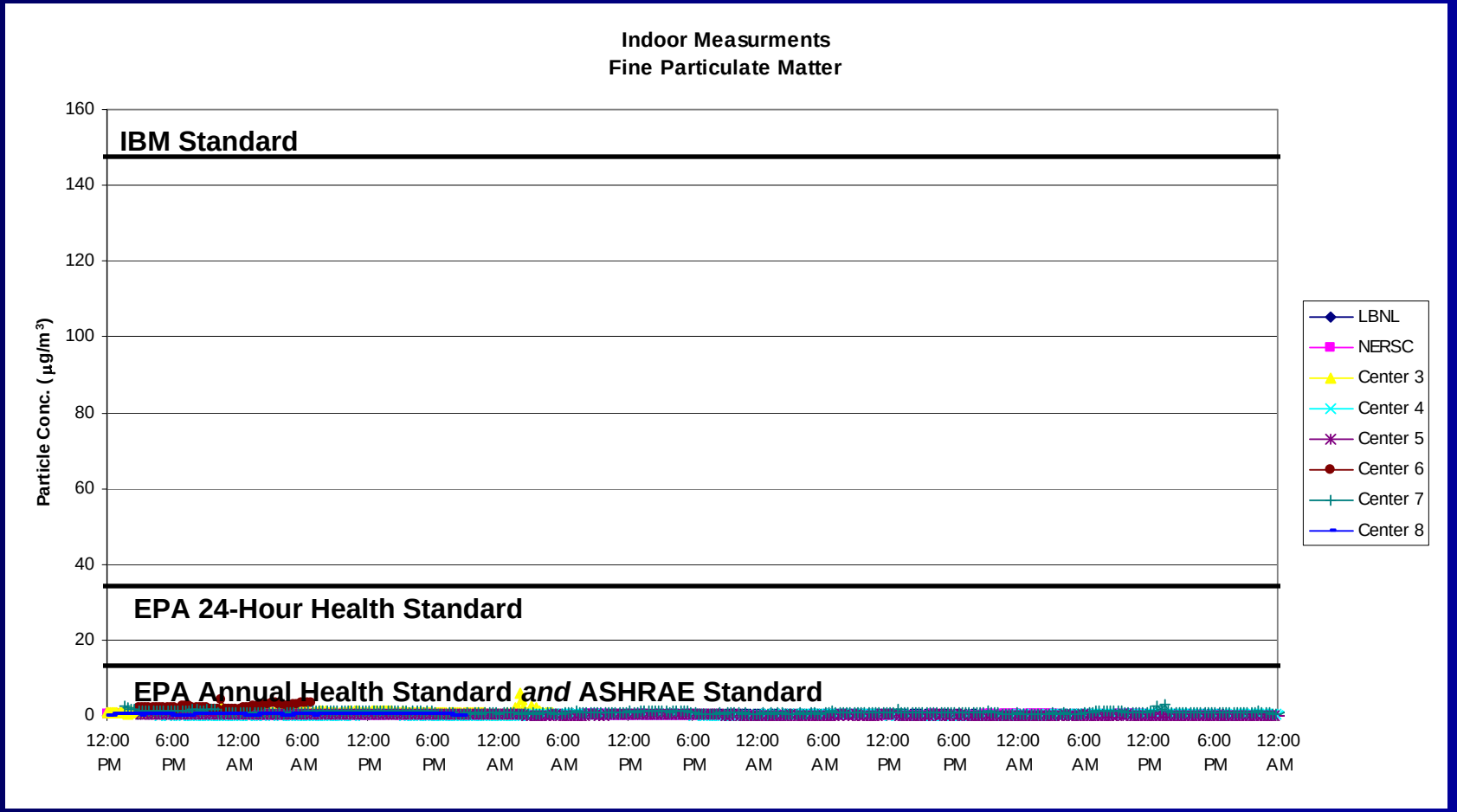
Encouraging outside air economizers

- Issue:
  - Many are reluctant to use air economizers
  - Outdoor pollutants and humidity control considered equipment risk
- Goal:
  - Encourage use of outside air economizers where climate is appropriate
- Strategy:
  - Address concerns: contamination/humidity control
  - Quantify energy savings benefits

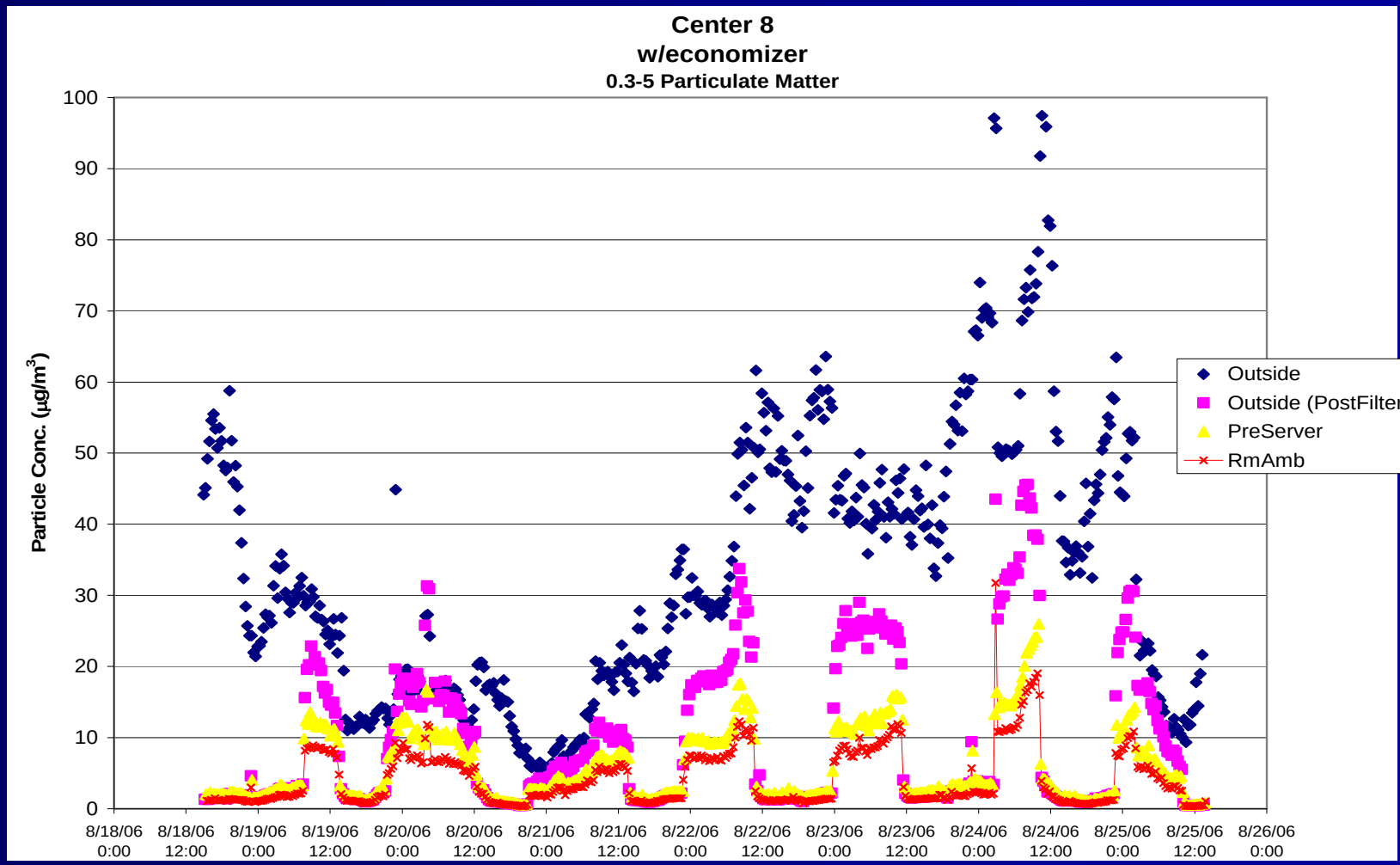
Outdoor measurements



Measurements inside the centers



Data center w/economizer

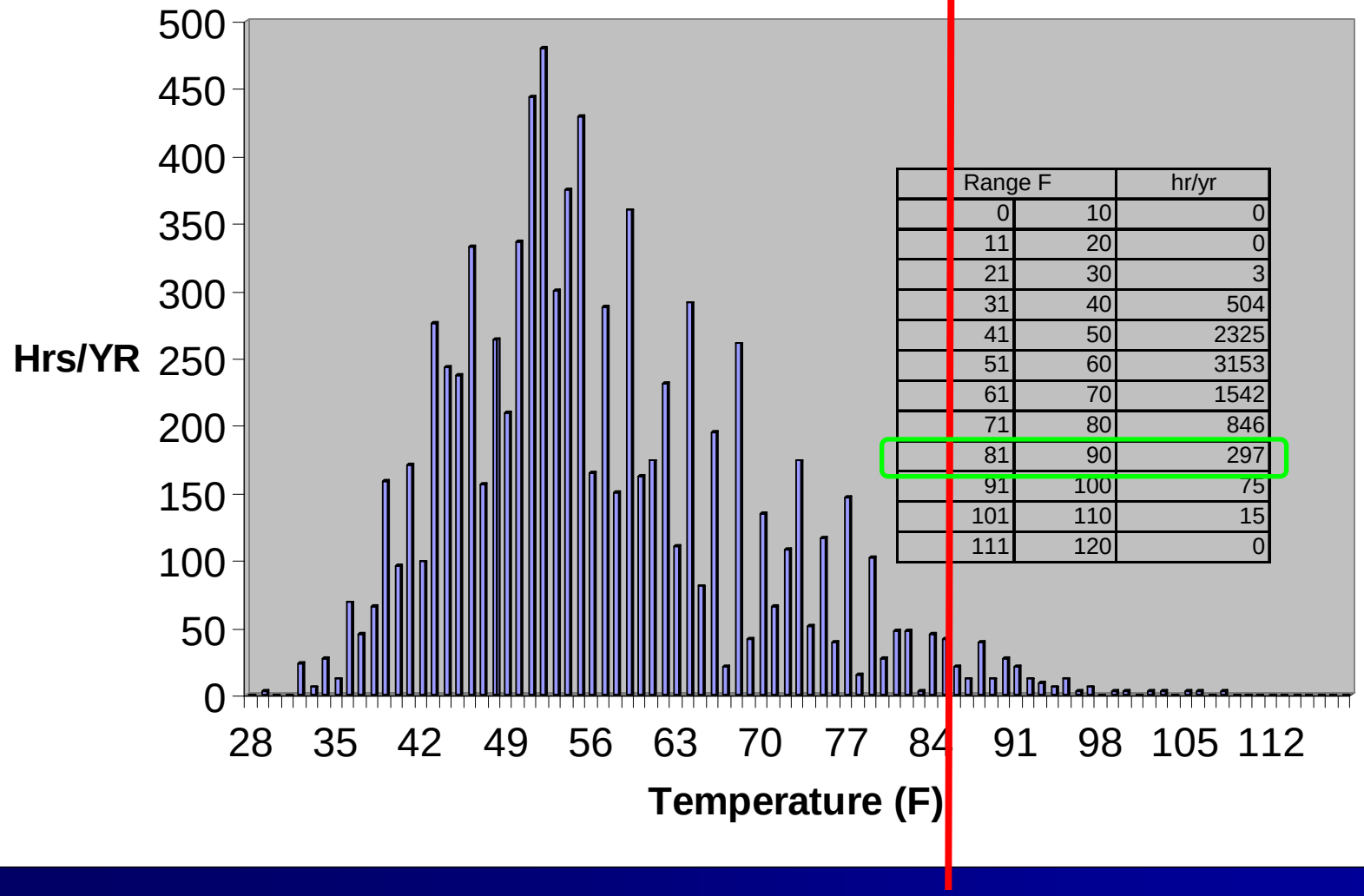


Findings

- Water soluble salts in combination with high humidity can cause failures
- New ASHRAE particle limits drastically lower than one manufacturer's recommendation
- Particle concentration typically an order of magnitude lower than new ASHRAE limits (no economizer)
- Economizers, without other mitigation, can cause particle concentration to approach new ASHRAE limits but filtration can mitigate this
- Large energy savings

Set Inlet Temperature
To upper end of ASHRAE

Berkeley Weather



	Range F		hr/yr
	0	10	0
	11	20	0
	21	30	3
	31	40	504
	41	50	2325
	51	60	3153
	61	70	1542
	71	80	846
	81	90	297
	91	100	75
	101	110	15
	111	120	0

NERSC/LBNL CRT Building Conceptual Design

DRAFT: Subject to change

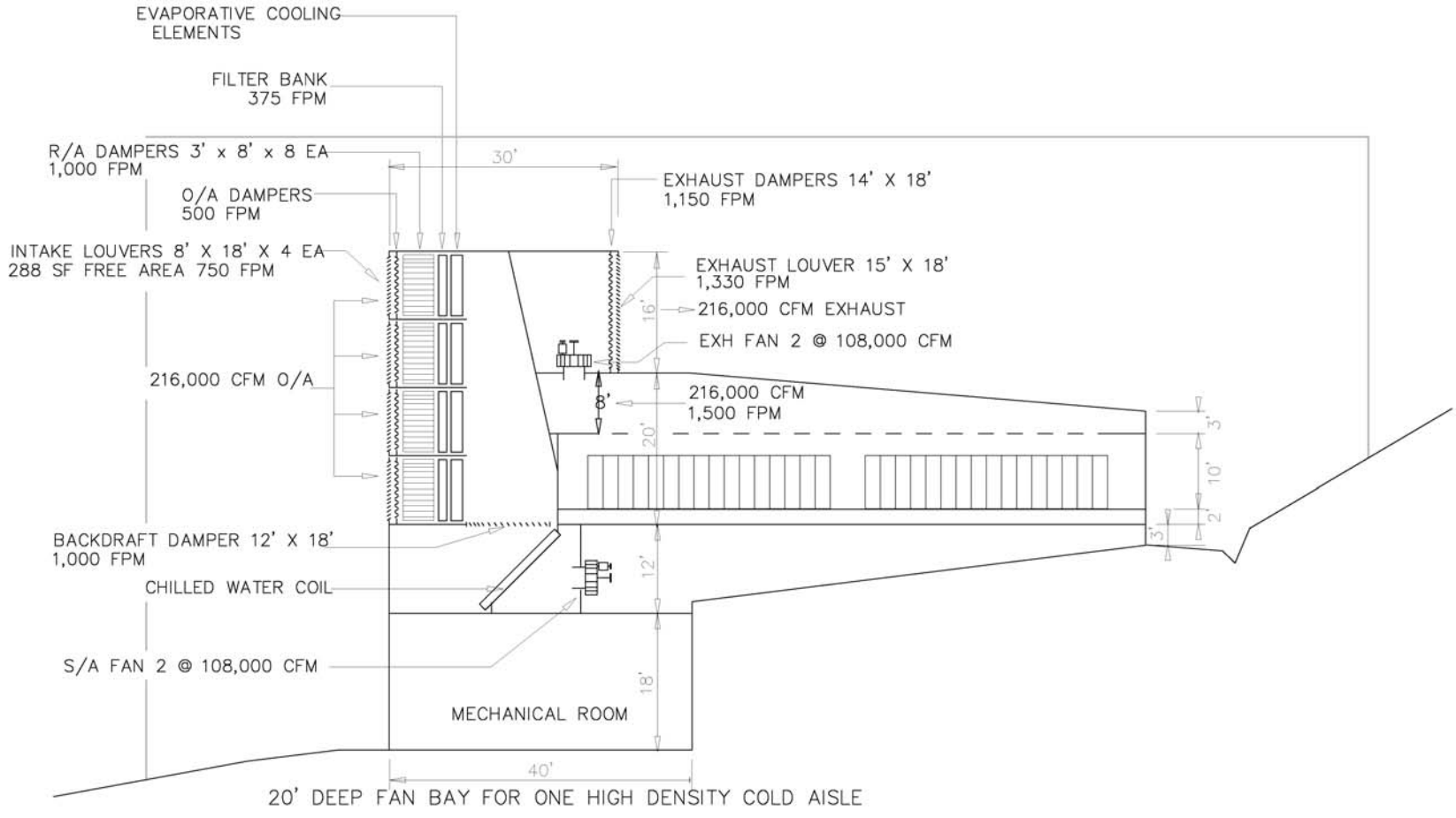
Howard Walter

Aerial View

DRAFT: Subject to change; Do not re-distribute

Schematic Design Concepts

Howard Walter



FRONT ELEVATION
LBNL DATA CENTER

Best practices – power conversion

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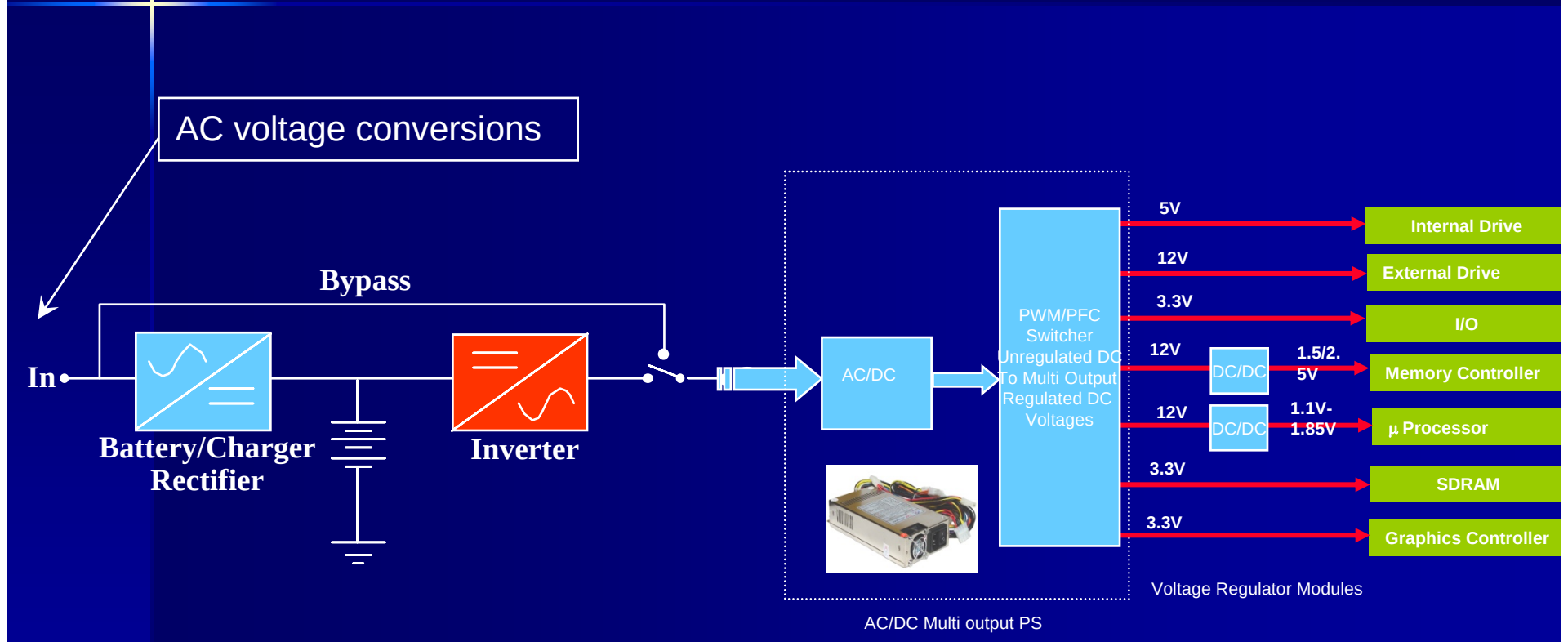
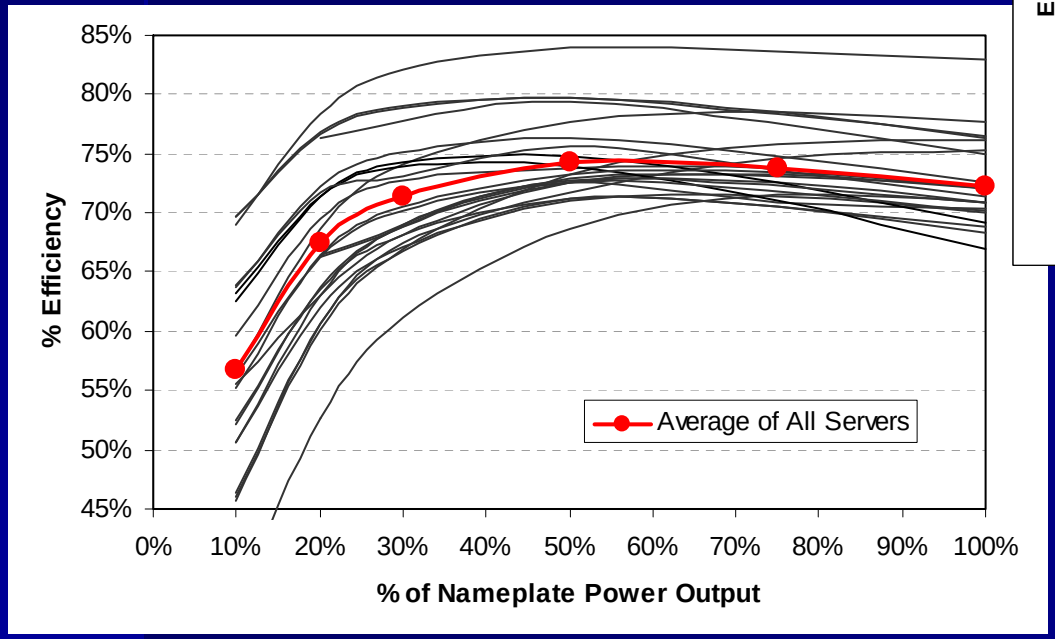
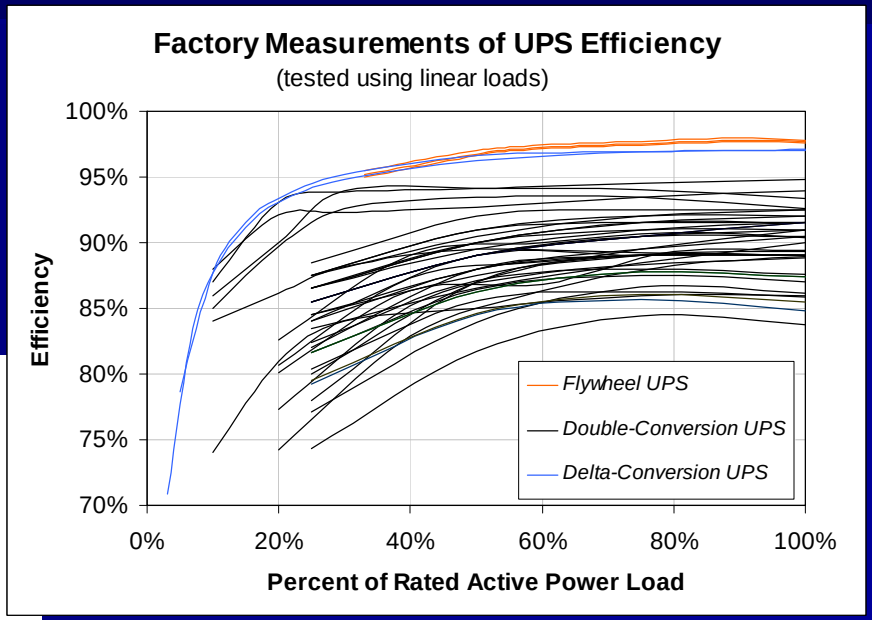
Data center power conversions



Prior research illustrated large losses in power conversion

Power Supplies in IT equipment



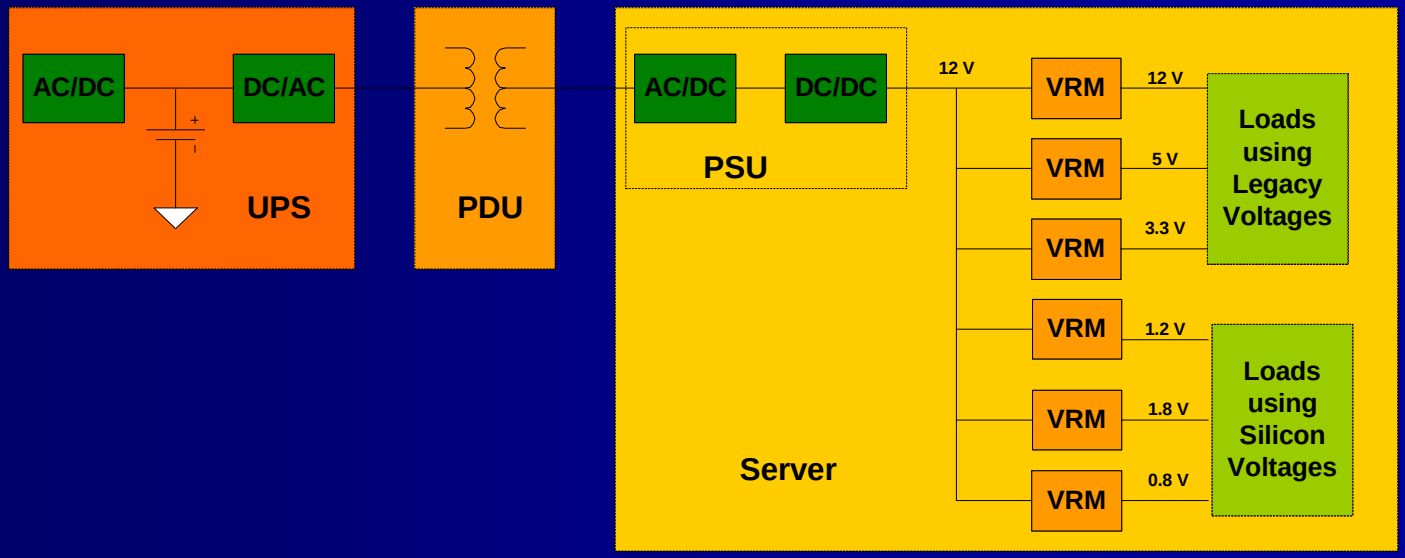


Uninterruptible Power Supplies (UPS)

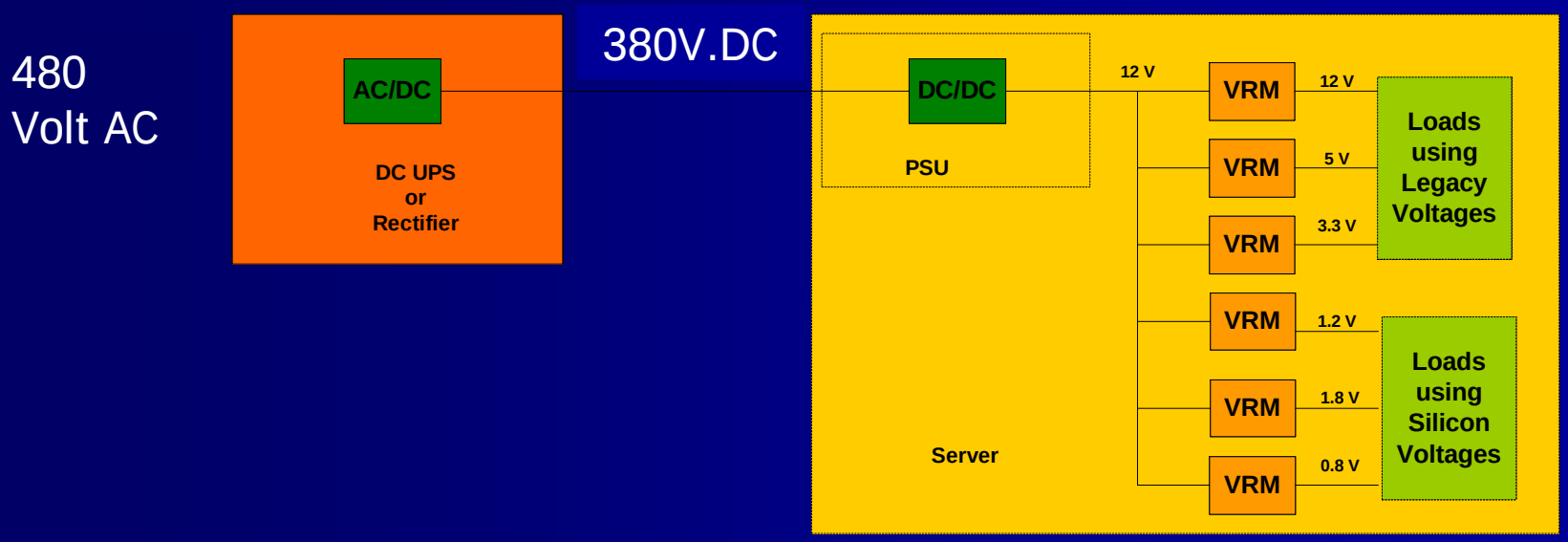
With over 25 industry partners direct DC powering of servers was demonstrated

Typical AC distribution today

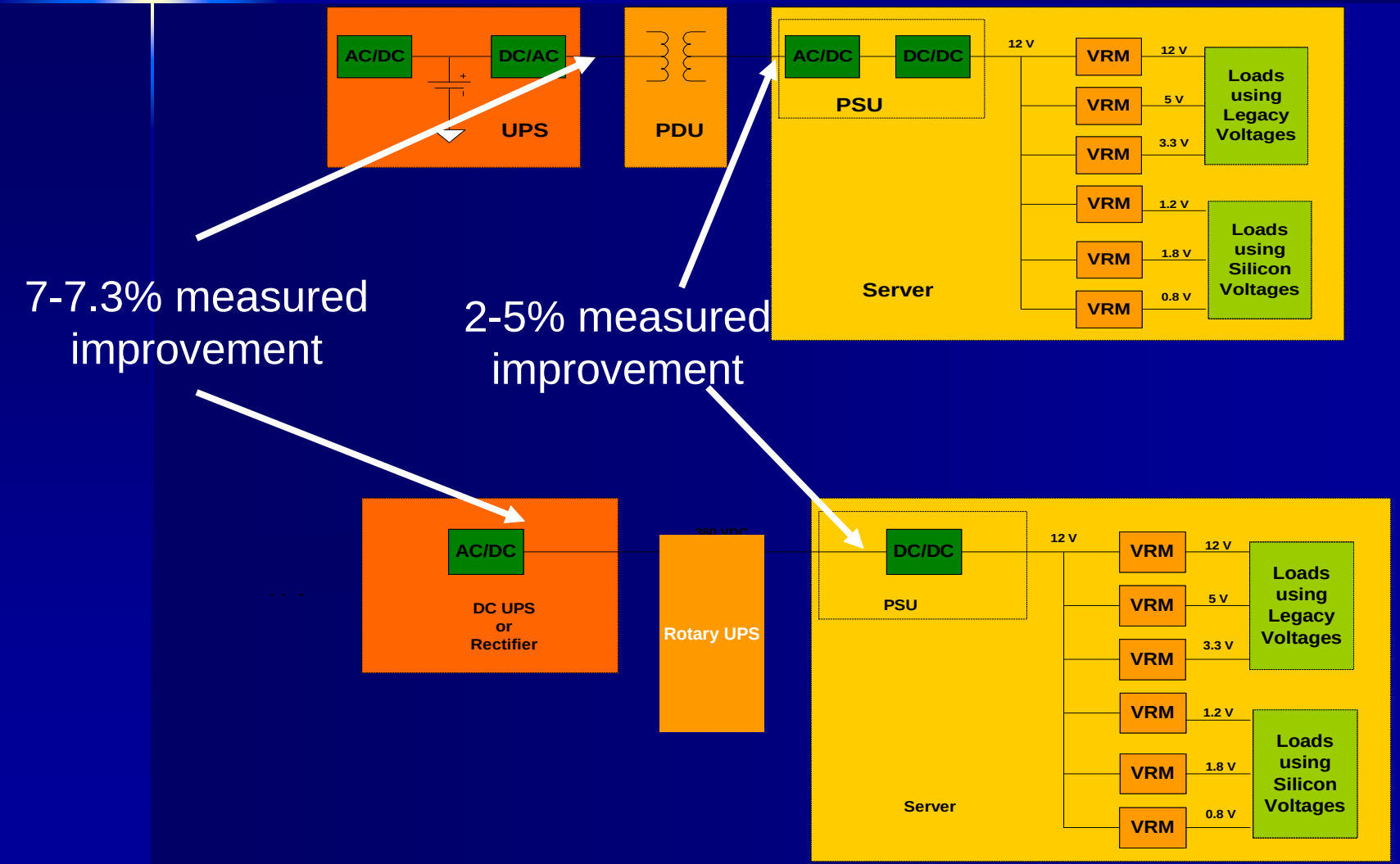
480
Volt AC



Facility-level DC distribution



AC system loss compared to DC



websites:

http://hightech.lbl.gov/datacenters/

- How soon will we get to liquid cooling? Why not doing it today?
- Why isn’t efficient distribution power more widely utilized?
  - High efficiency UPS or on-site generation
  - High voltage distribution to Rack
  - Direct DC – eliminating conversions – ease of incorporating renewable sources – available today