Energy-Efficient Data Center ... Myth or Reality?

"Greening"

A New Business Imperative

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APC | MGE
Critical Power and Cooling Services

Inefficiencies Create Consumption

- Computing inefficiencies > more servers
- Server inefficiencies > more power and cooling
- Power and cooling inefficiencies > more kW-hr power consumption

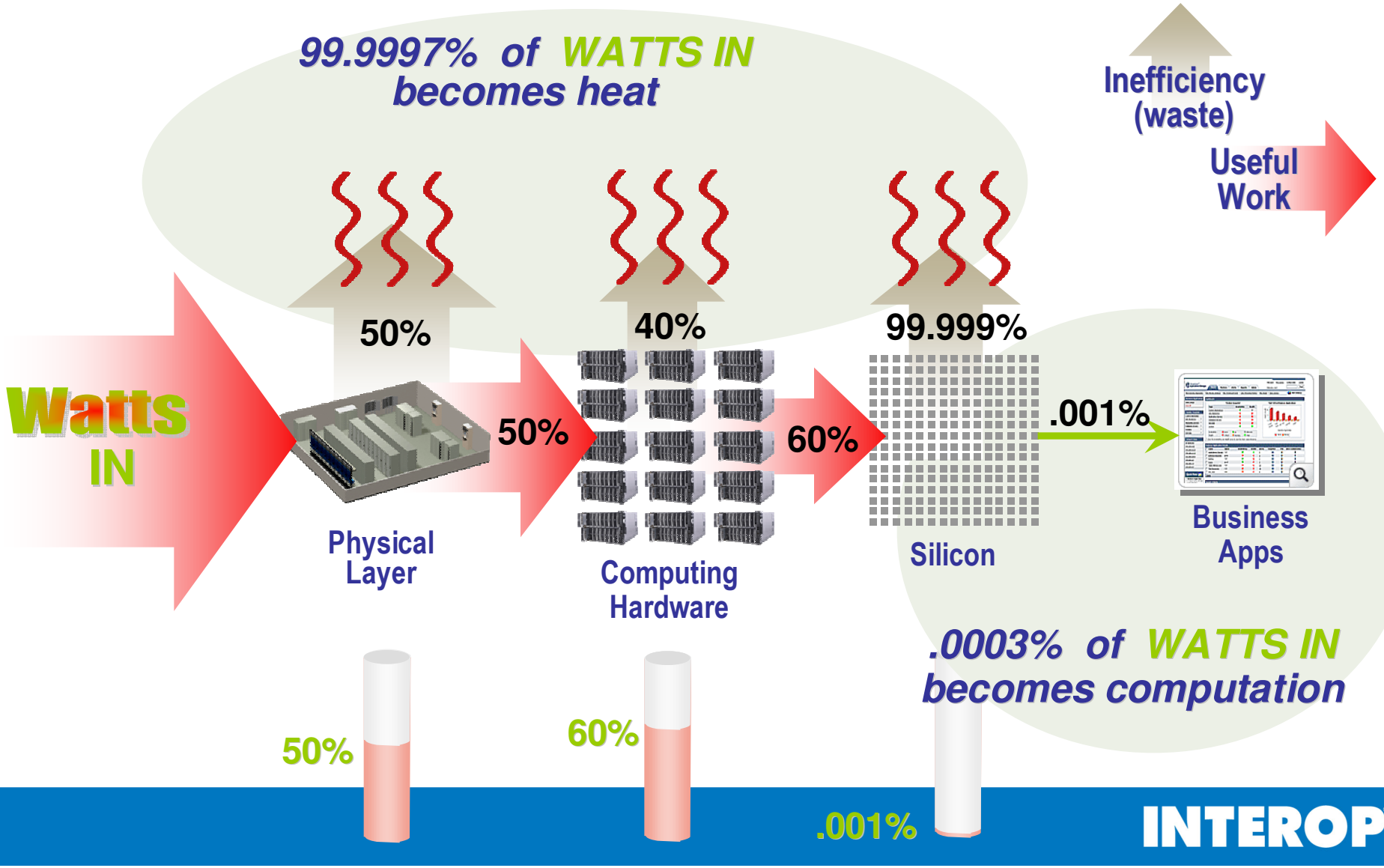
Inefficiencies drive both power consumption and material consumption

Typical Consumption of a 1MW Data Center

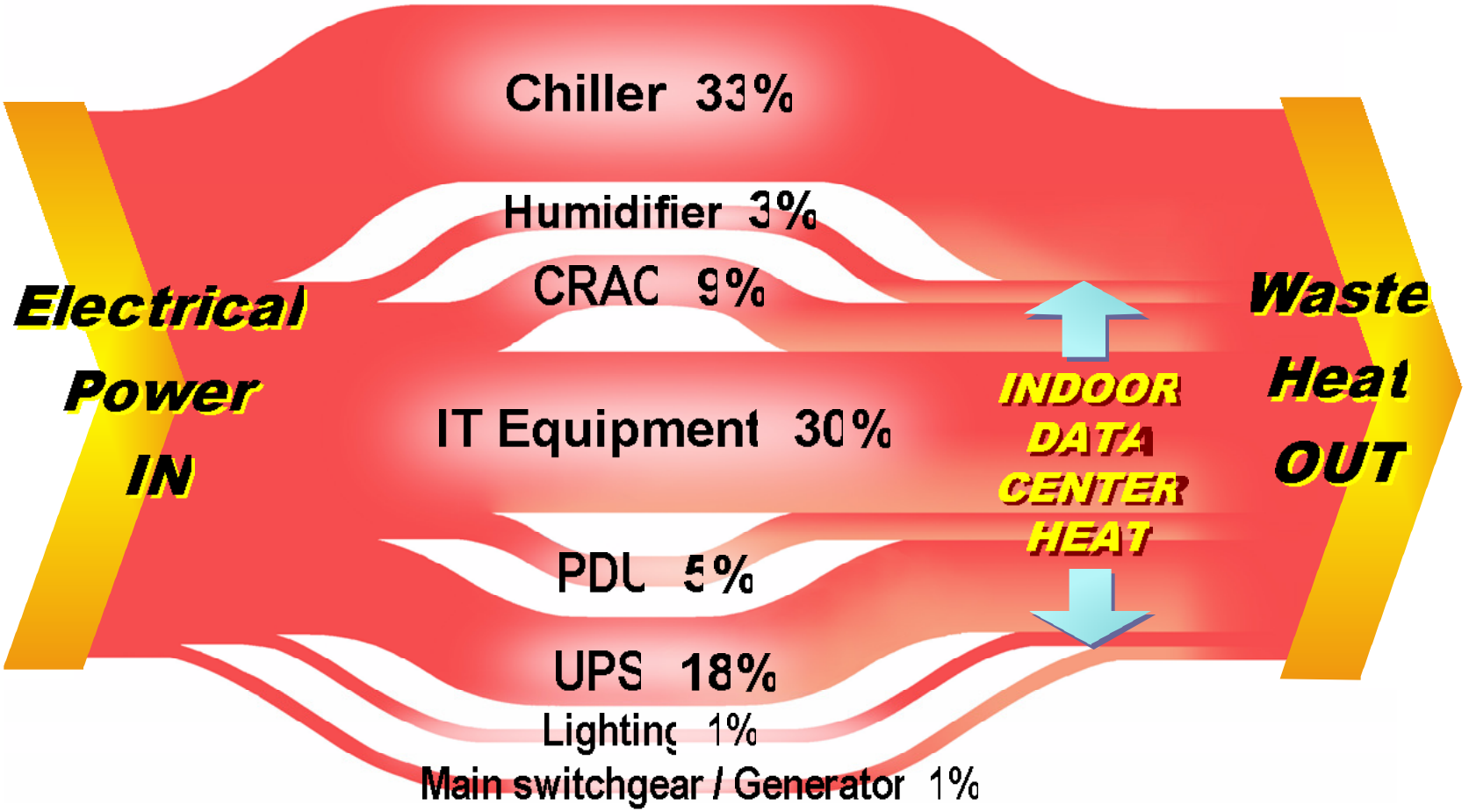
- 177,000,000 kW-Hr of Electricity
- 60,000,000 Gallons of Water
- 145,000 lbs of Copper
- 21,000 lbs of Lead
- 33,000 lbs of Plastic
- 73,000 lbs of Aluminum
- 12,000 lbs of Solder
- 377,000 lbs of Steel
- 32,000,000 kW-Hr of Primary Energy

*10 year life; Tier 4; Power, Cooling, Racks, and IT equipment; does not include building; includes 2 IT refreshes

Where Does Hardware Inefficiency "Go"?



Power Flow in a Typical Data Center



5 Elements of an High Efficiency Data Center Power & Cooling Architecture

1. Ultra high efficiency UPS
2. High nominal voltage AC power distribution
3. InRow™ cooling
4. Scalable power and cooling equipment
5. Power and cooling capacity planning and management software

Element # 1: Ultra High Efficiency UPS

- New double-conversion inverter technology
  - MOSFET/IGBT hybrid inverter
  - 3-state inverter
  - Symmetrical low proximity-effect inductors
- Inverter design reduces proportional losses by over 50% compared with historical designs
- Low loss control, drive, and snubber circuits reduce no-load loss by 70% compared with historical designs
- Efficiency further improved by using scalable UPS power modules
- By-product is that UPS is also virtually silent

Element # 2: High Nominal Voltage AC Power Distribution

- Distributes voltage to loads at 400/230 instead of conventional US 208/120
- Eliminates the need for PDU transformers and associated losses
- Reduces copper wire size requirements
- By-product is that 4,000lbs of copper and 30,000lbs of iron in PDUs are saved per MW, reducing floor loading and saving space
- Details in APC White Paper #128

High V DC vs. High V AC Architecture

	High V DC benefit vs Traditional Design	High V DC benefit vs New High Efficiency Architecture
UPS/Rectifier	5%	None
Power Distribution	5%	None
IT Load	2.5%	2.5%
Total Advantage	**12.5%**	**2.5%**

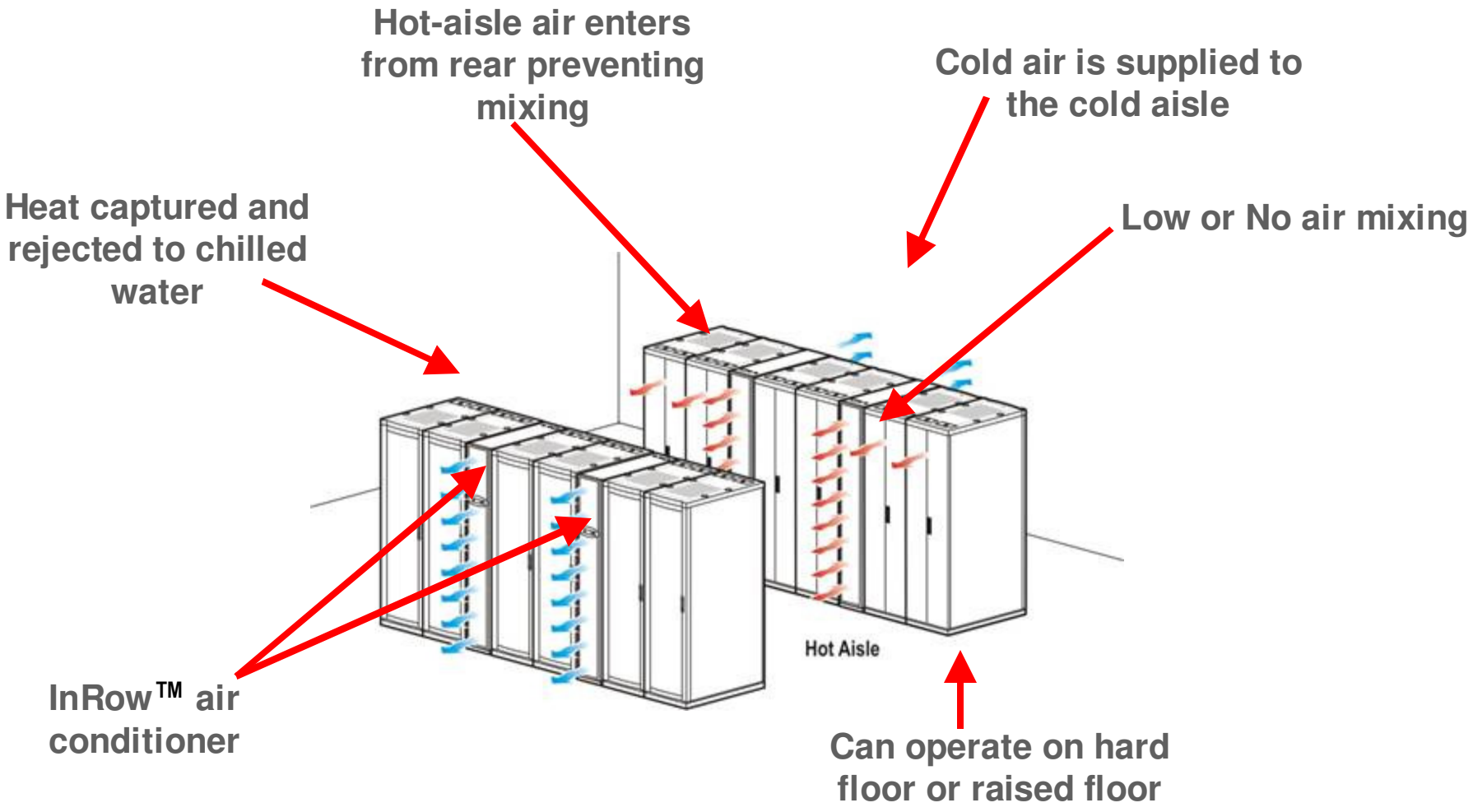
The hypothetical efficiency benefits of DC can be obtained today using available AC technologies

Element # 3: InRow™ Cooling

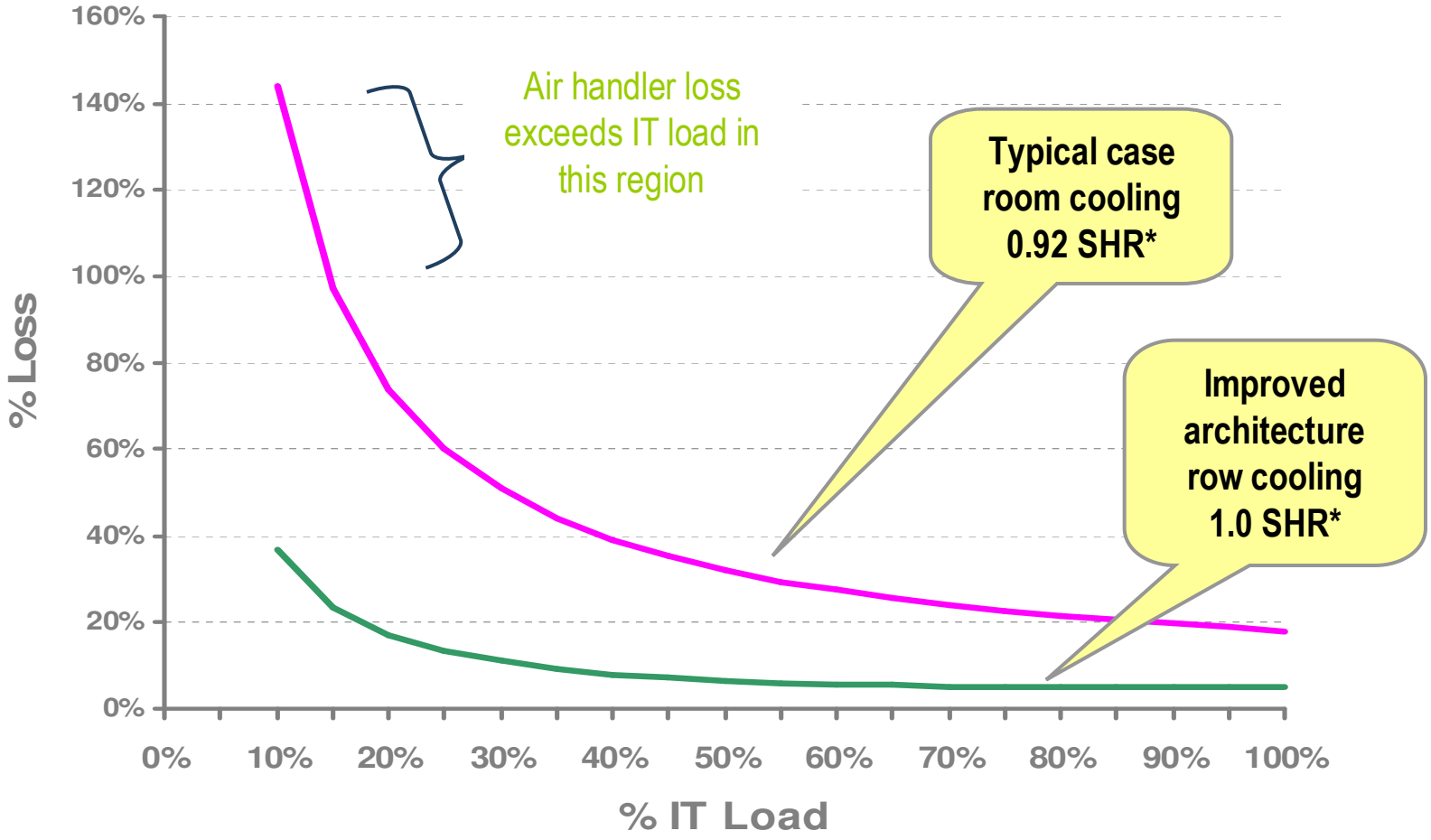
- Cooling systems are placed within IT rows instead of at the room level
- Inherently higher power density capability than room designs
- Fan power is reduced by 50%
- Needless dehumidification / rehumidification is eliminated (saving millions of gallons of water per year per MW). Hi ΔT is good!
- Need for high-bay areas and raised floors are reduced or eliminated (particularly for small installations)
- Cooling capacity can “follow” IT loads that move due to Virtualization / server power management
- Low mixing of Cool Air back into CRAC w/ Low ΔT!

Electrical savings possibility: 7-15%

Basic InRow™ Design



Air Handler + Humidifier Loss Comparison



* Sensible Heat Ratio

Coordinate Air Conditioners

- Many data centers have multiple air conditioners that actually fight each other "Demand Fighting"
- One may actually heat while another cools
- One may humidify while another dehumidifies
- The result is gross waste
- May require a professional assessment to diagnose

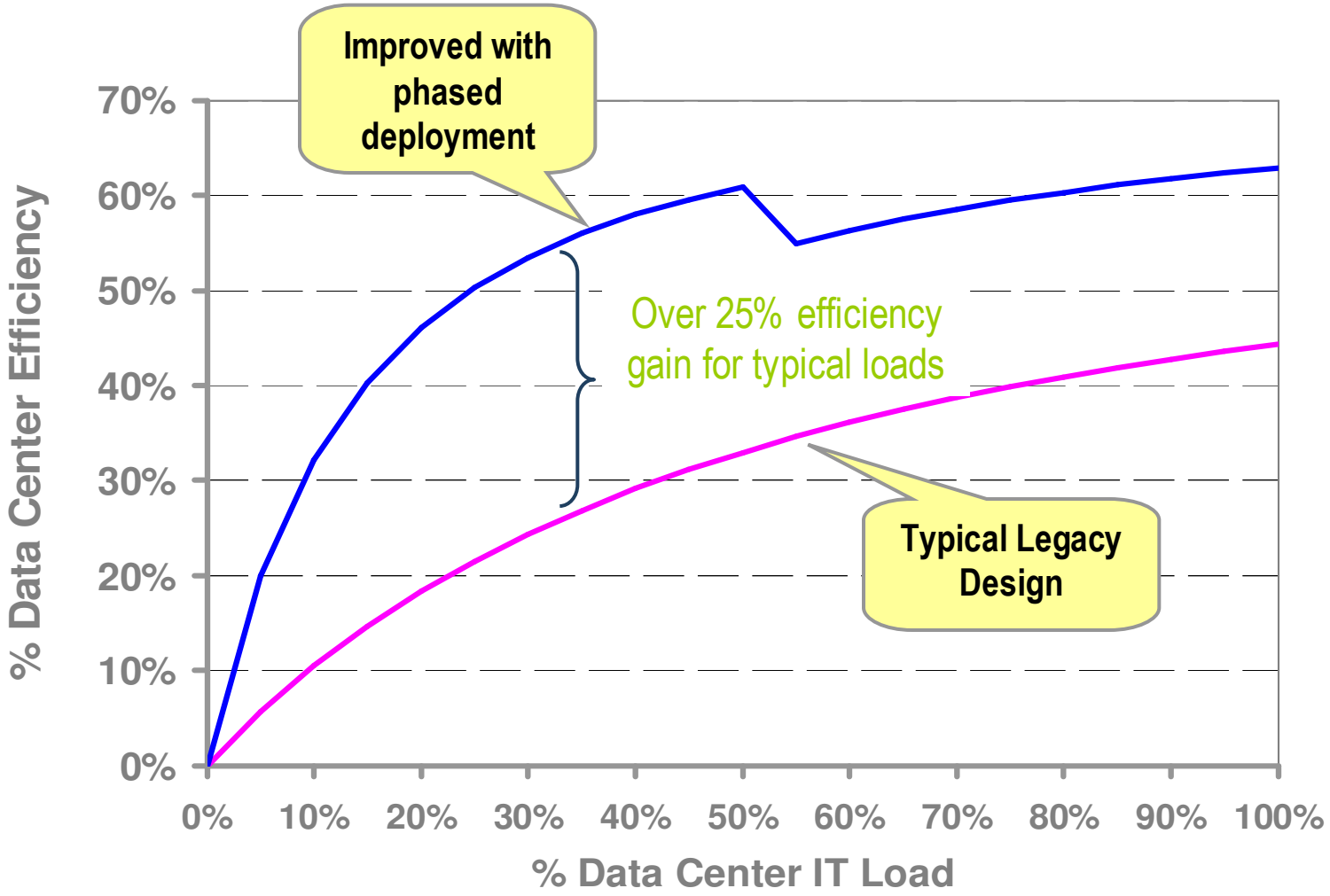
For any data center with multiple air conditioners

Electrical savings possibility: 0-10%

Element # 4: Scalable Power & Cooling

- Over half the power and cooling losses in a data center are *fixed* and do not vary with the IT load (the efficiency degrades as the load declines)
- Oversizing is therefore a primary contributor to inefficiency
- Virtualization and server power management will make this problem worse, as power and cooling are sized to peak IT loads that are not typical
- New power and cooling devices that can scale in capacity and/or be managed to a zero power state, reducing the fixed losses

Efficiency Gain of Improved Architecture



Model using actual equipment loss values, 2N power, N+1 CRAH, Legacy .92SHR, Chiller/Cooling Tower, SE US location

Element # 5: Power & Cooling Capacity Planning & Management Software

- Efficiency is improved when more IT load can be supplied by the same power and cooling equipment
- Stranded or unusable power and cooling capacity is often created within data centers by unmanaged change
- Virtualization and server power management will make this problem worse, as power and cooling are sized to peak IT loads that are not typical
- New power and cooling devices that can scale in capacity and/or be managed to a zero power state, reducing the fixed losses

Five Elements Combine to Deliver Major Improvement of Data Center Efficiency

- Efficiencies can be determined for real designs when the topology and the device efficiency curves are known
- APC operates a data center efficiency model using the principles described in APC White Paper #113
- Actual device data is used in the calculations
- Calculations were performed for a 1 MW, 2N Power, Dual Power Path, N+1 CRAH, Single Path Cooling Tower system

Loss Characteristics for a Data Center Design

	Legacy Design	New High Efficiency Architecture
Power system fixed losses	25%	4.2%
Power System proportional losses	6.9%	1.3%
Cooling system fixed losses	48%	27%
Cooling system proportional losses	28%	18.7%

The improved architecture delivers dramatically reduced losses, especially fixed losses

Performance of the New High Efficiency Architecture

- Efficiency is IT power / Total input power
- Efficiency gains of 20% are achieved over a broad range of power
- At 30% IT load, the efficiency increases from 25% to 53%, which is a pickup of 110% in computed efficiency, corresponding to a 28% reduction in losses
- Each of the 5 elements contributes significantly to the calculated gains

Data Center Efficiency Facts
(Do You Know)

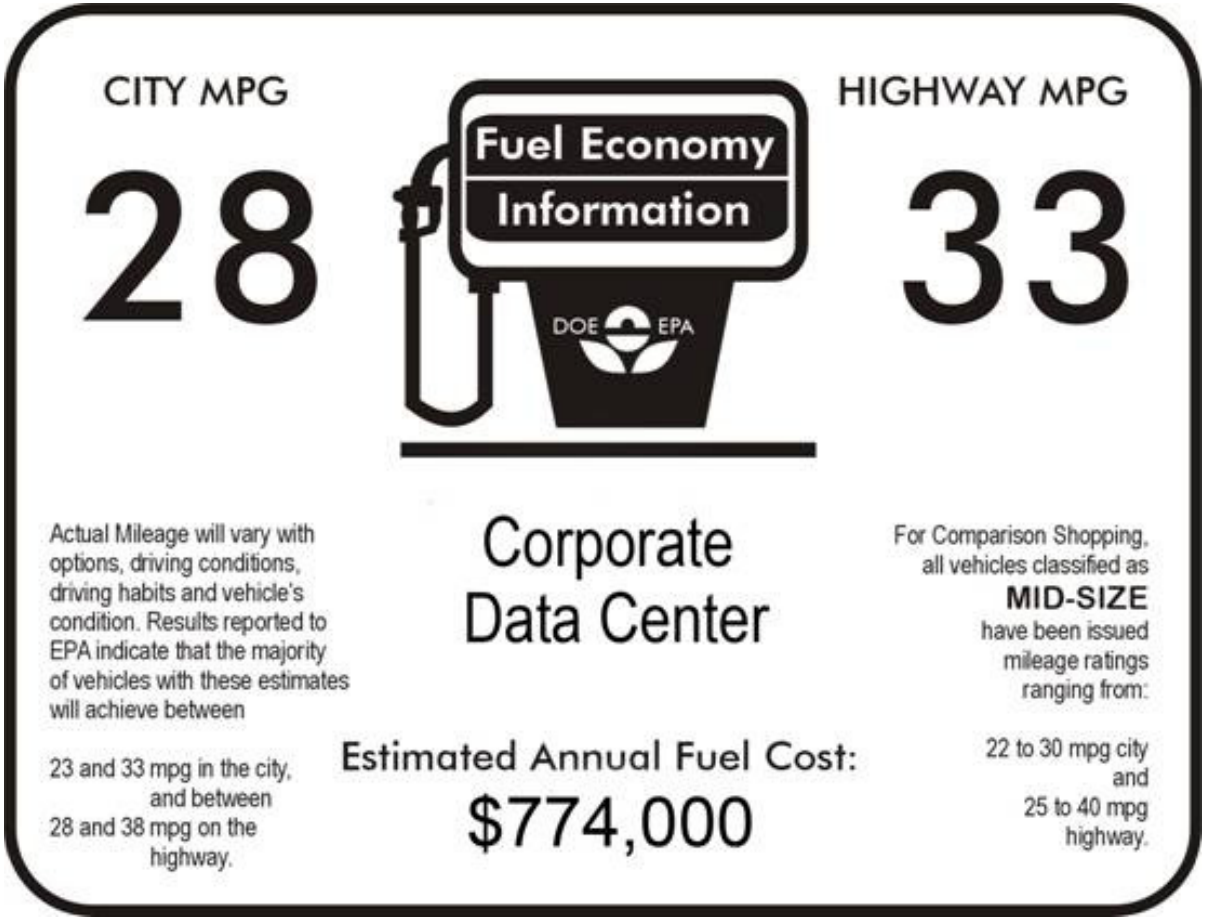
- A diesel generator's engine water heaters will consume MORE electricity every year than it will ever generate under emergency use! (average$14,000/year of electricity per generator)
- An inefficient 20Ksq. Ft. Data Center lighting system will add $69,000 electric cost to your bill and consume the equivalent of 5 – 30kw server Racks from your available power delivery system!
- A Modular High Efficiency UPS will SAVE $9,600 per year on electricity PLUS an additional $11,600 for cooling all equal to an additional 30kW server Rack
- A Hot Gas By-pass installed in a cooling system, will automatically negate most efficiency savings by automatically bringing on an artificial load!

What is the Future?

- This coming generation of UPS are so efficient that further gains will have little effect on data center efficiency
- The ability of power and cooling systems to handle IT loads with both high density AND dynamically varying power will be mandatory
- Real-time measurement of data center efficiency will be available soon
- Standardized designs with system-level efficiency specifications will become available
- Reduction in consumption of raw materials will become as important as efficiency improvements

Technology and design tools to dramatically increase data center power and cooling efficiency are available now

Questions?


CITY MPG
28
Fuel Economy
Information
DOE
EPA
HIGHWAY MPG
33
Actual Mileage will vary with options, driving conditions, driving habits and vehicle's condition. Results reported to EPA indicate that the majority of vehicles with these estimates will achieve between
23 and 33 mpg in the city, and between 28 and 38 mpg on the highway.
Corporate
Data Center
Estimated Annual Fuel Cost:
$774,000
For Comparison Shopping, all vehicles classified as
MID-SIZE
have been issued mileage ratings ranging from:
22 to 30 mpg city and 25 to 40 mpg highway.

Thank You