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Charting a Course to Energy Independence

Providence, RI
August 9-12, 2009

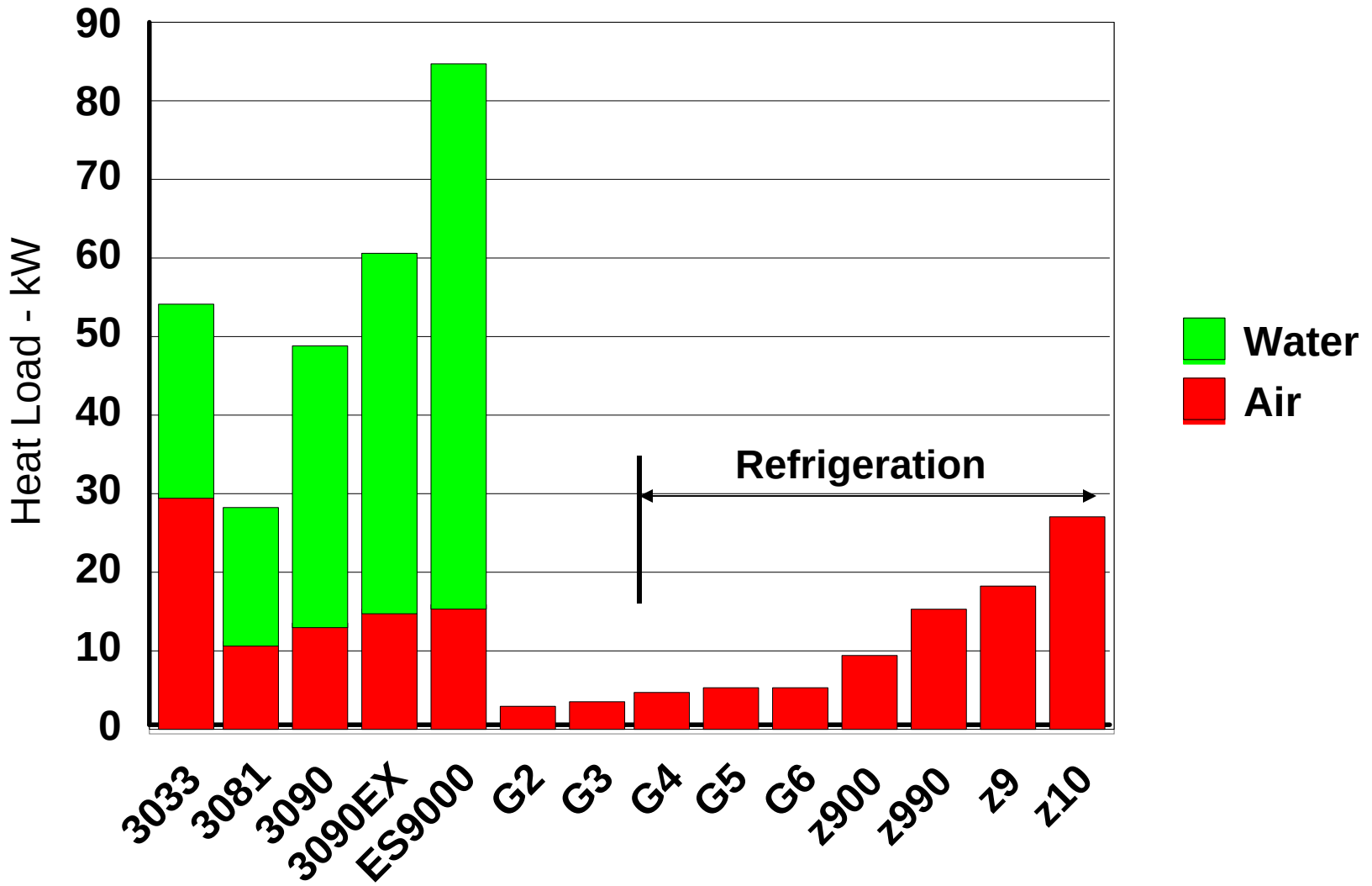
Packaging of New Servers
- energy efficiency aspects-

Roger Schmidt, IBM Fellow
Chief Engineer, Data Center Energy Efficiency

Some Discussion Points

- ✓Hardware Power & Cooling Trends
- ✓Energy Management
- ✓High Efficiency Data Centers/Clusters

Mainframe System Power Trends 1977 - present



Processor Liquid Cooling for Increased Performance

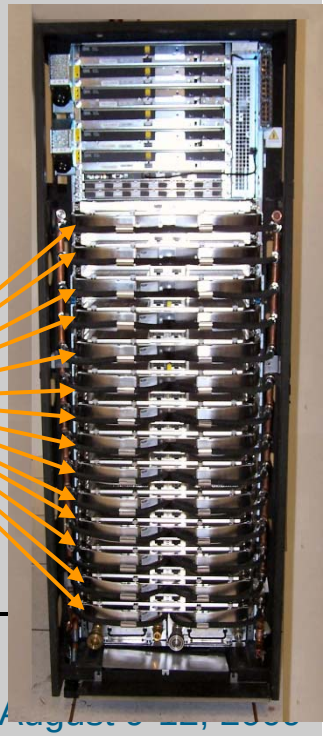
Customer Benefits

- Highest server utilization
- High performance per watt
- Extremely efficient power and cooling

Power 575 turns on the water for **Green Supercomputer**

Customer Benefits

- 80% heat load to water
- 40% energy savings via improved cooling and power efficiencies
- Up to 8. trillion floating point operations per second + 3.58 TB of memory in a single rack



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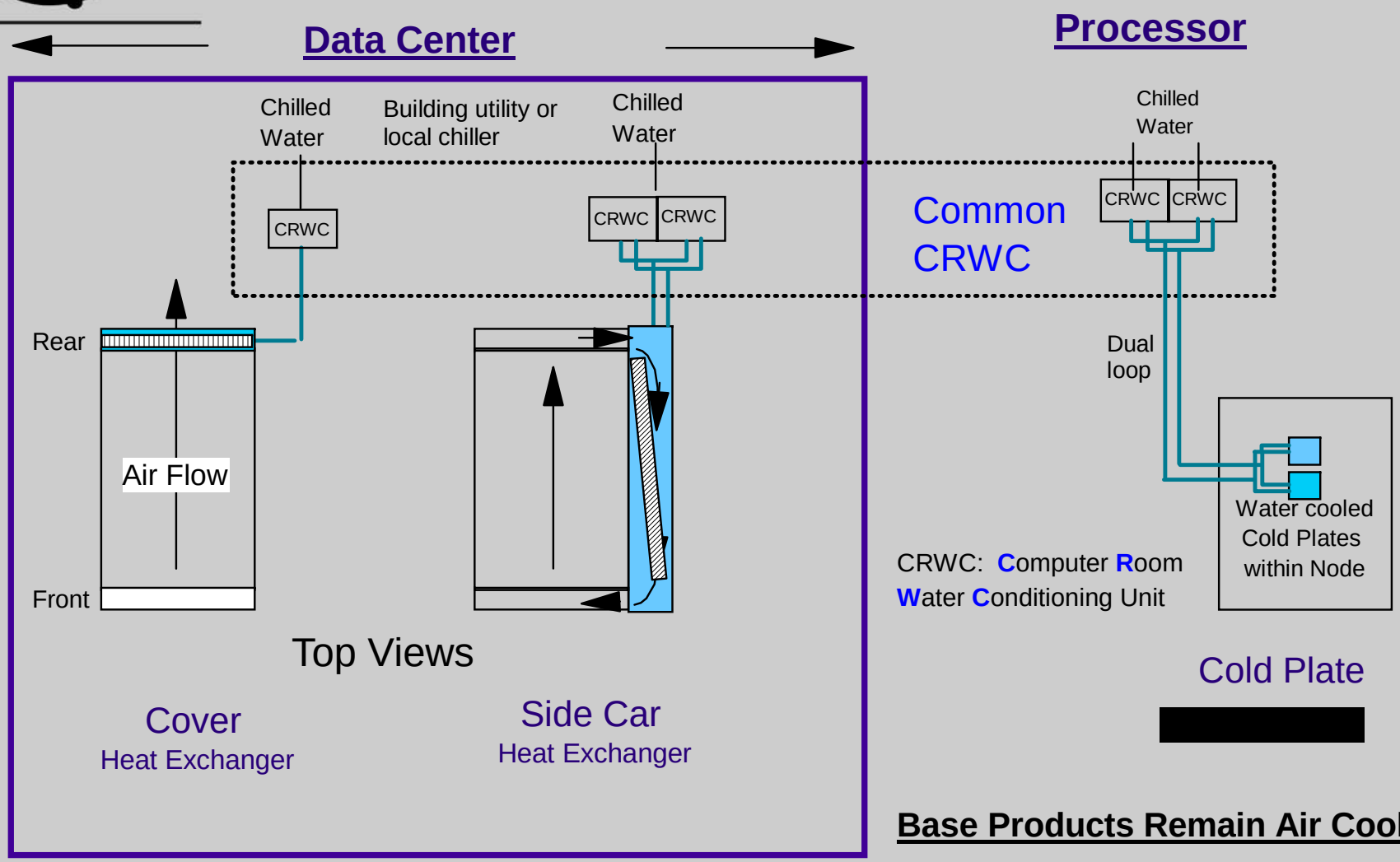
Rack / Data Center Water Cooling



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Base Products Remain Air Cooled

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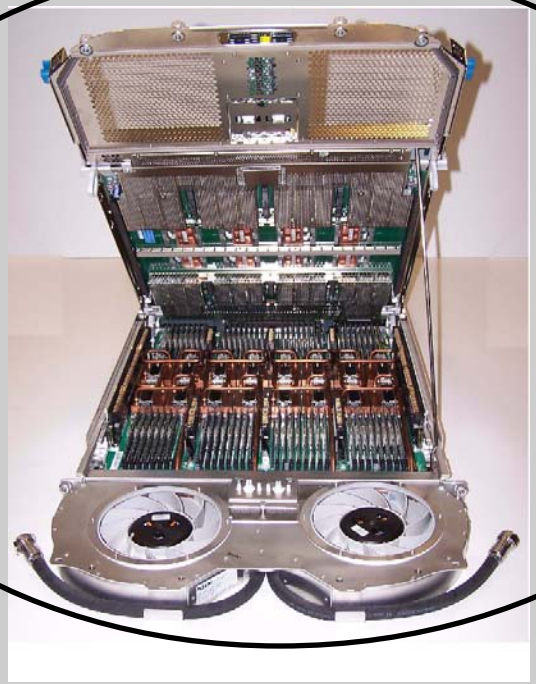
P6-p575

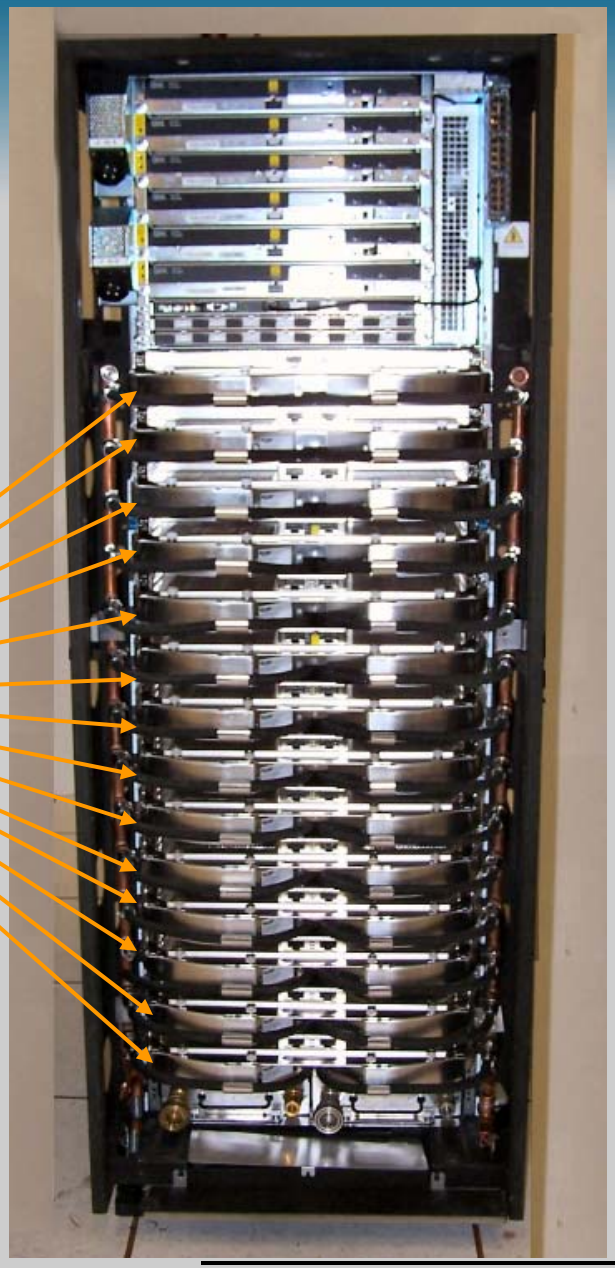
~~121.6 GFLOPs~~

602 GFLOPs

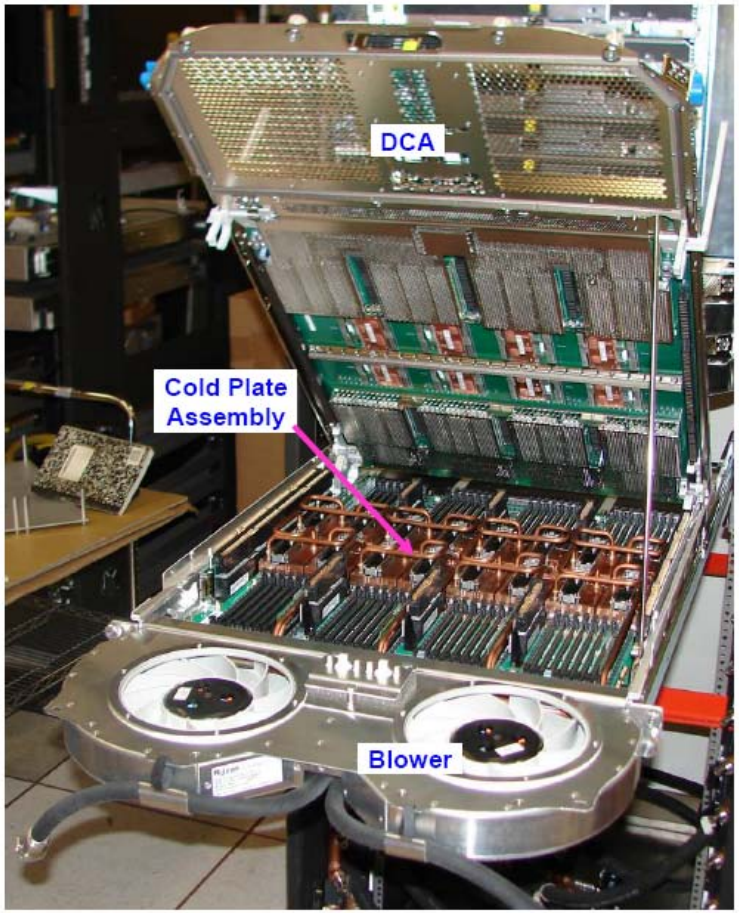


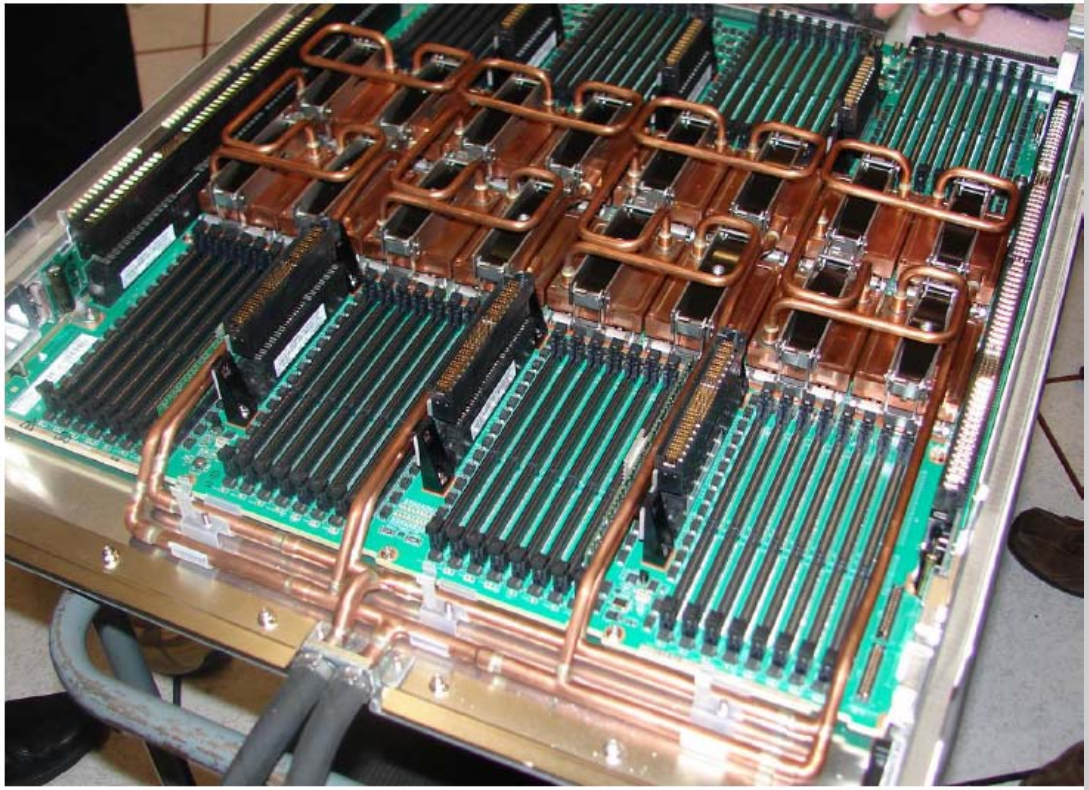
~~1.46 TFLOPs~~

8.42 TFLOPs



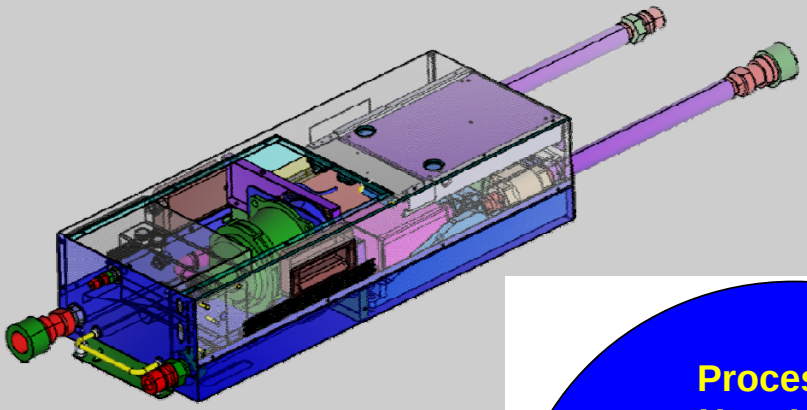
Assembled Node



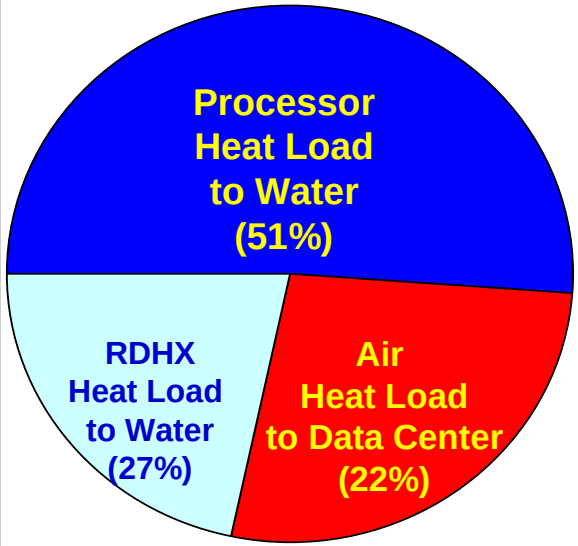


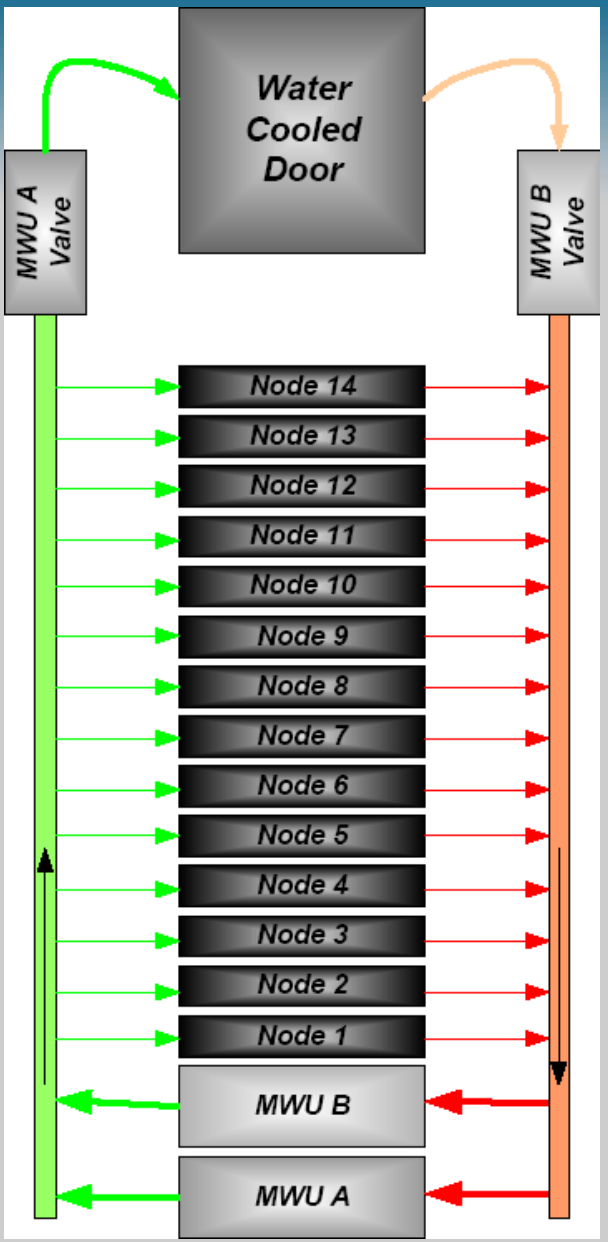
Secondary Loop

- *A Single WCU can Cool all 14 Nodes*
- *WCU's are in parallel*
- *Each WCU has a door control Valve*
- *Door is removed from loop if temperature can't be maintained*



WCU

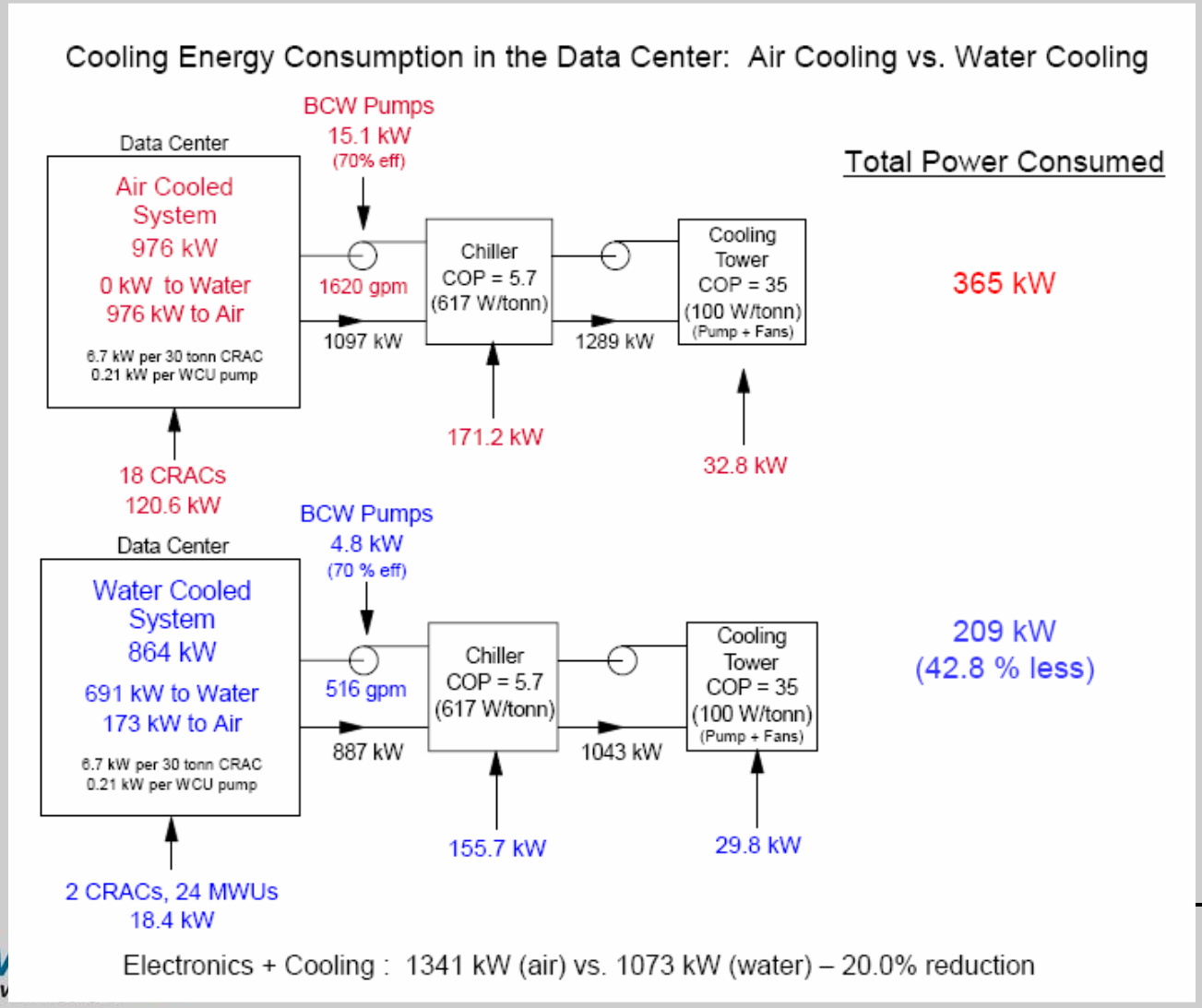




P6 575

Air vs Water

	Units	Air Cooled System	Water Cooled System
Number of Racks		16	12
Total Electronics Power	kW	976	864



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Rear Door Heat Exchanger

Leveraging Mainframe Heritage

Capabilities

- A water-cooled, heat exchanger designed to remove heat generated from the back of your computer systems before it enters the room
- Patented “rear heat exchanger” can reduce heat at the source
- Utilizes chilled water to dissipate heat generated by computer systems while requiring no additional fans or electricity!

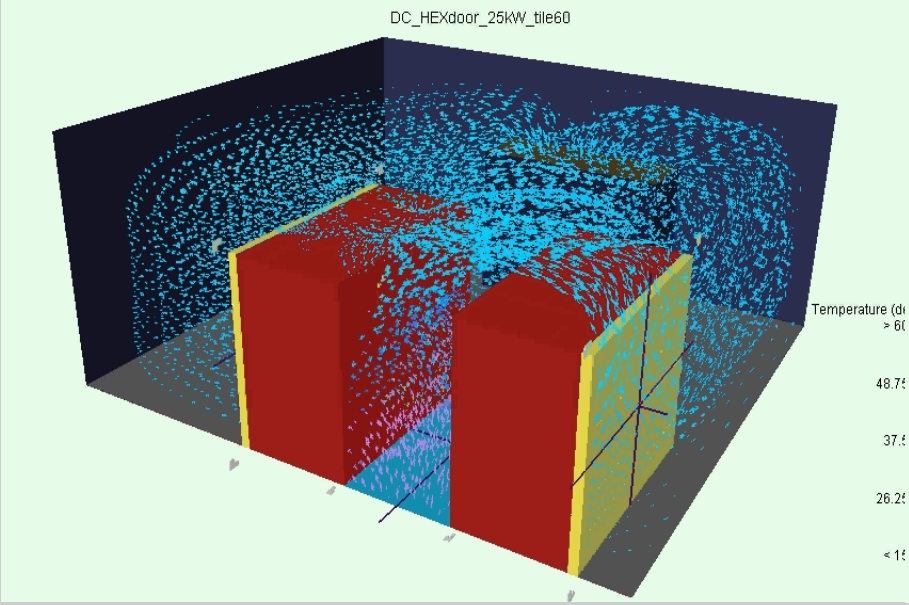
Customer Benefits

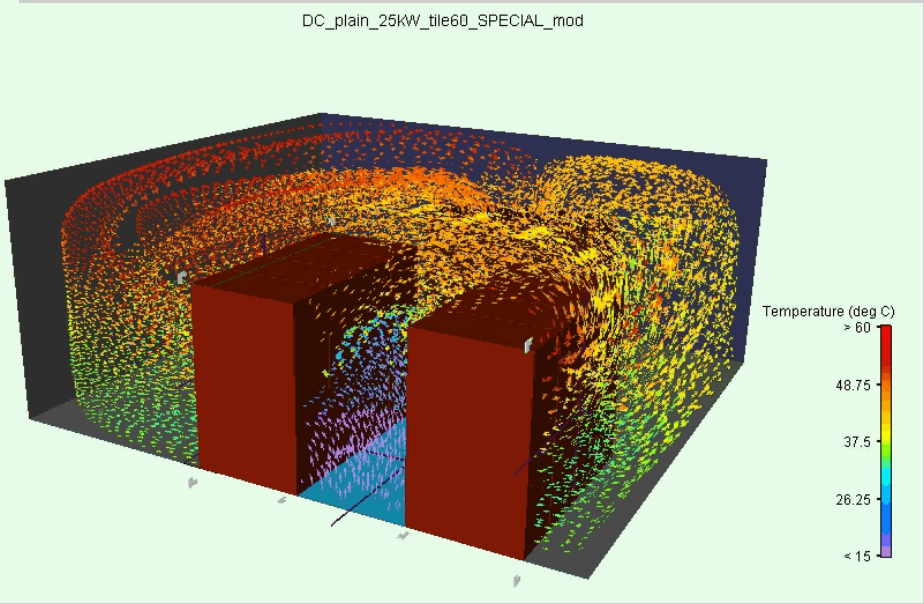
- Increase server density without increasing cooling requirements.
- Effective solution for a data center wishing to deal with computer room “hot spots,” or is at the limit of its cooling capacity, but still has useable floor space to add racks of systems.

Water cooling is 3500x more energy efficient than air

IBM uses it today in System x, iDataplex and System p

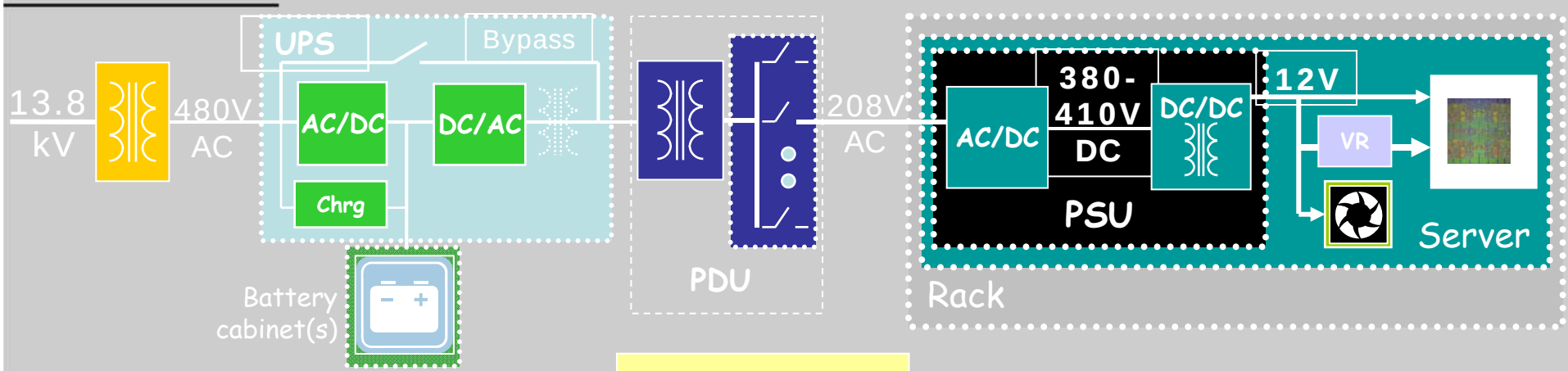
Comparison – with and without Cool Blue





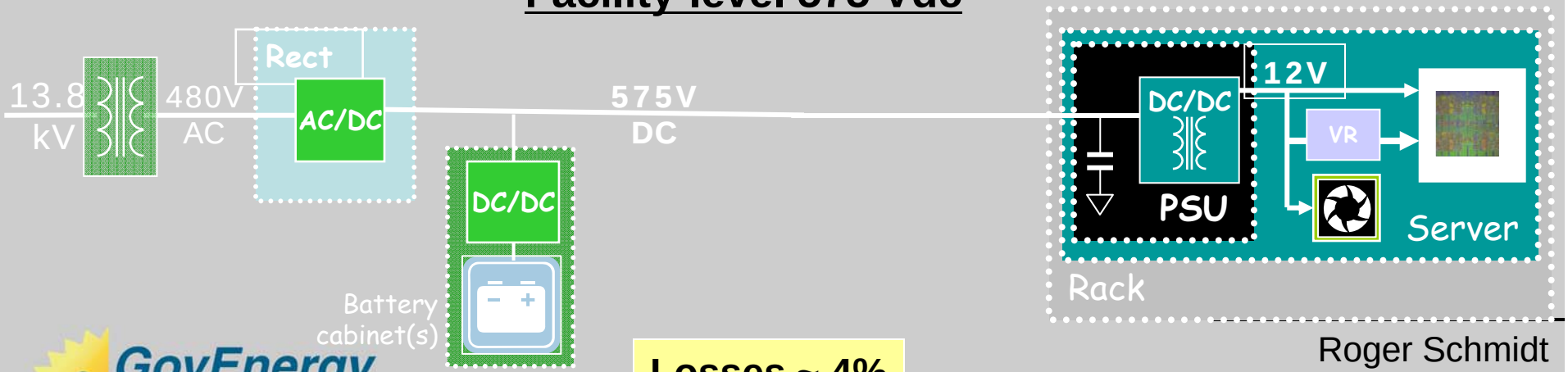
AC vs DC Distribution

Facility-level 480V/208Vac



Losses ~ 13%

Facility-level 575 Vdc



Losses ~ 4%

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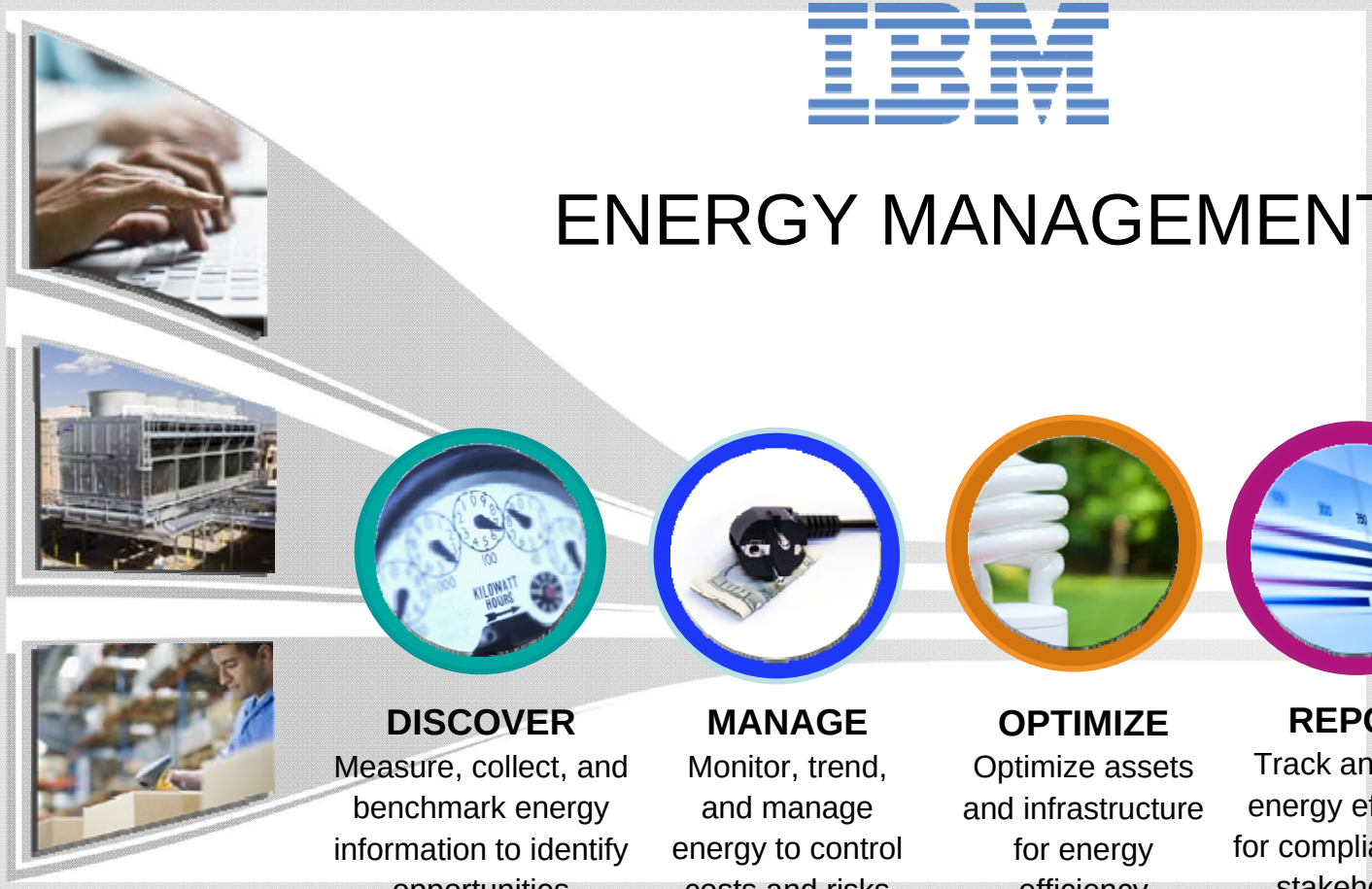
A practical approach to energy management across domains

Infrastructure Domain:

INFORMATION TECHNOLOGY

FACILITIES & PROPERTY

ASSETS



DISCOVER
Measure, collect, and benchmark energy information to identify opportunities

MANAGE
Monitor, trend, and manage energy to control costs and risks

OPTIMIZE
Optimize assets and infrastructure for energy efficiency

REPORT
Track and verify energy efficiency for compliance and stakeholders

Typical Implementation Time	0 - 3 months	3 - 6 months	6 - 9 months	On-going

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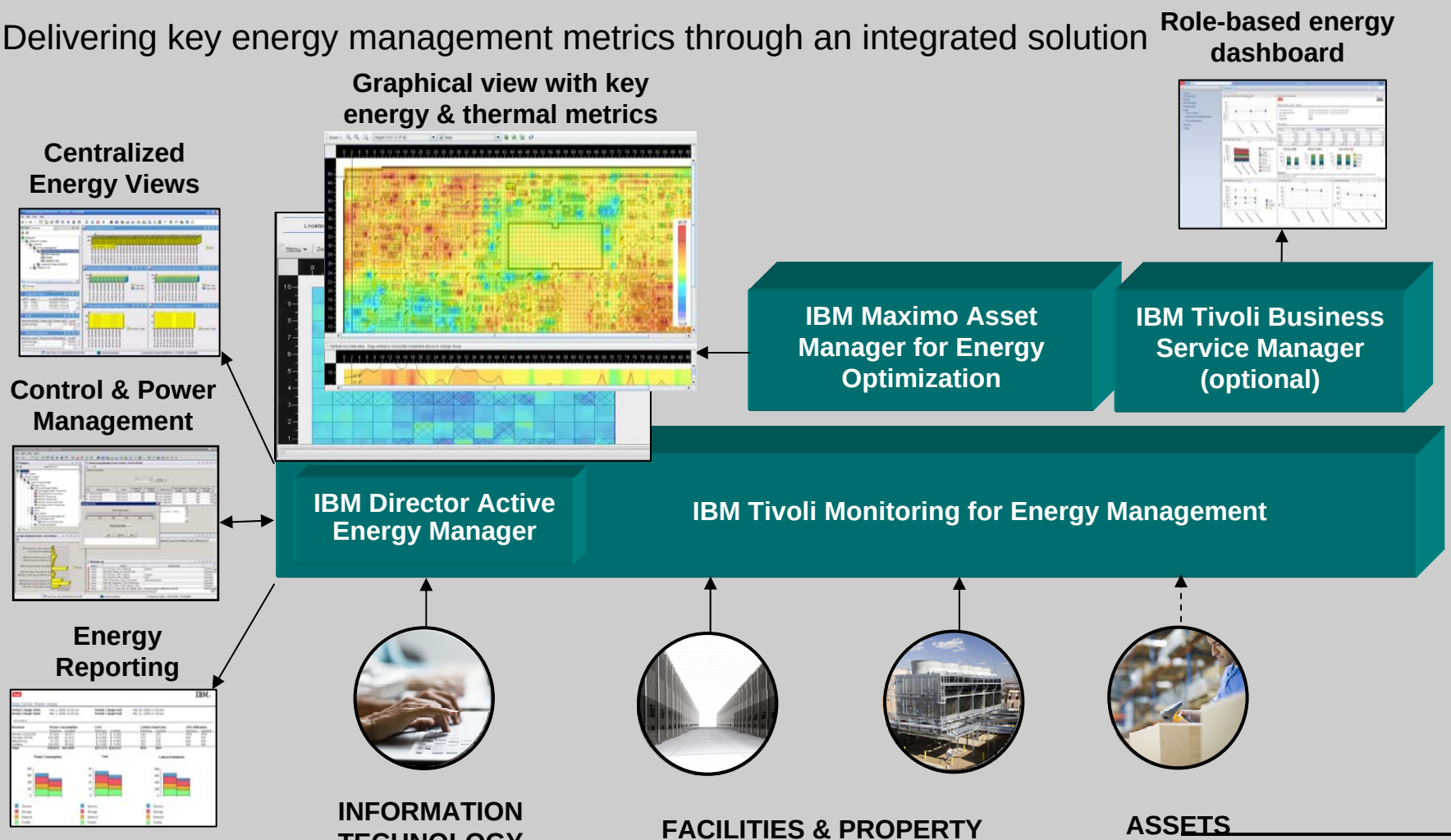
Measure & benchmark
energy and thermal performance

Delivering key energy management metrics through an integrated solution



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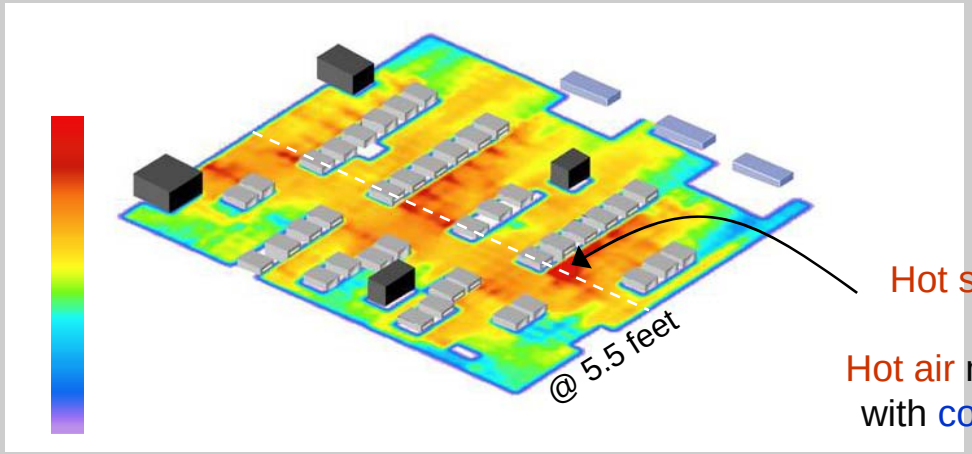
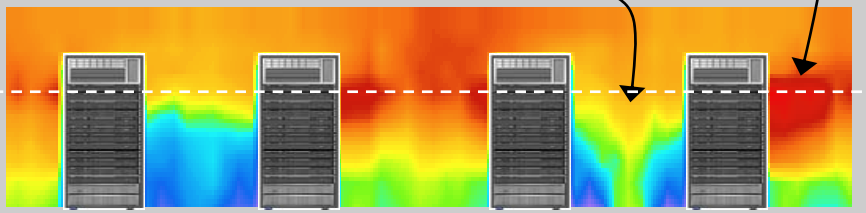
Mobile Measurement Technology

- designed to optimize DC resources to reduce up to 15% of DC energy consumption
- scans, digitize rapidly physical environment (temperature, flow, pressure etc..) of DC
- cart tool comprises sensor network, where each sensor defines a virtual unit cell
- technology is based on interworking between measurements, models and DC management



Hot spot

Hot air mixing
with cold air

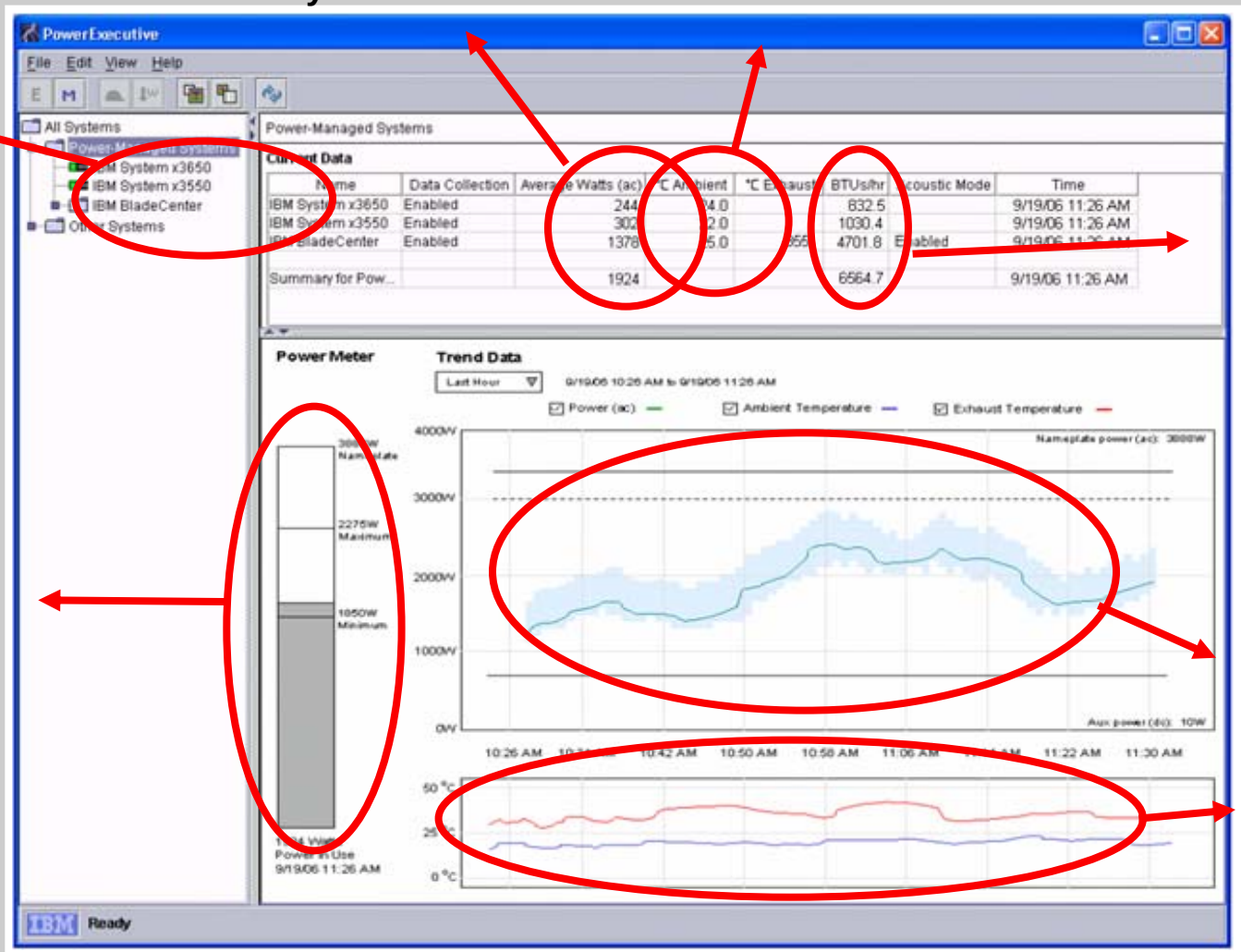


Active Energy Manager™ in action!

Compare actual vs. name plate power at system level

View inlet and exhaust temperature

Manage Power at the rack and server level



Track heat emitted

Compare rack actual power vs. Label Power

Trend power use over time

Trend temperature over time

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Boulder Data Center Expansion – Building 003

Objective - Add 72,000 square feet (6689 m^2) to a highly resilient data center, with energy efficiency as a design point

IT Related

Design / Build

- Economies of scale – 300,000 sq ft or 27,870 m^2
- **W2W Power Density - 90 watts/sf (969W/m^2) (modular to 140W per sf / 1,507W per m^2)**
- Best Practices Equipment Layout
- Minimize Single Points of Failure
- Level 3+ design point

Operate

- **Virtualized High Utilization Workload**
- Demand modeling for future requirements
- Space and power billing
- **Low Green Grid PUE metric**
- Integrated Power Management Software
- **Liquid cooled equipment**
- Low long term TCO

Facilities Related

Cooling

- **Free cooling > 50%**
- **Chiller water Pumping/Air handling units variable speed drives**
- **Variable speed motors on CRACs and other equipment**

Electrical

- Modular power density expansion options

Other building systems

- **Energy Efficient Lighting**
- High "R" Value Insulation

Industry Related

LEED Certification Objective

Energy Management Programs ($700K)

- Power Company Rebates
- Government Incentives
- Renewable Energy Certificates

Environmental Programs

- **Wind Power Generation (1Mil KW)**
- Reduced CO_2 emissions

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Systems on the Horizon

- Sequoia-system developed and manufactured by IBM will be installed at LLNL and will start running in 2012. It will have 1.6 Million Power-Processors and 1.6 Pbytes of main memory leading to a peak performance of more than 20 Pflops

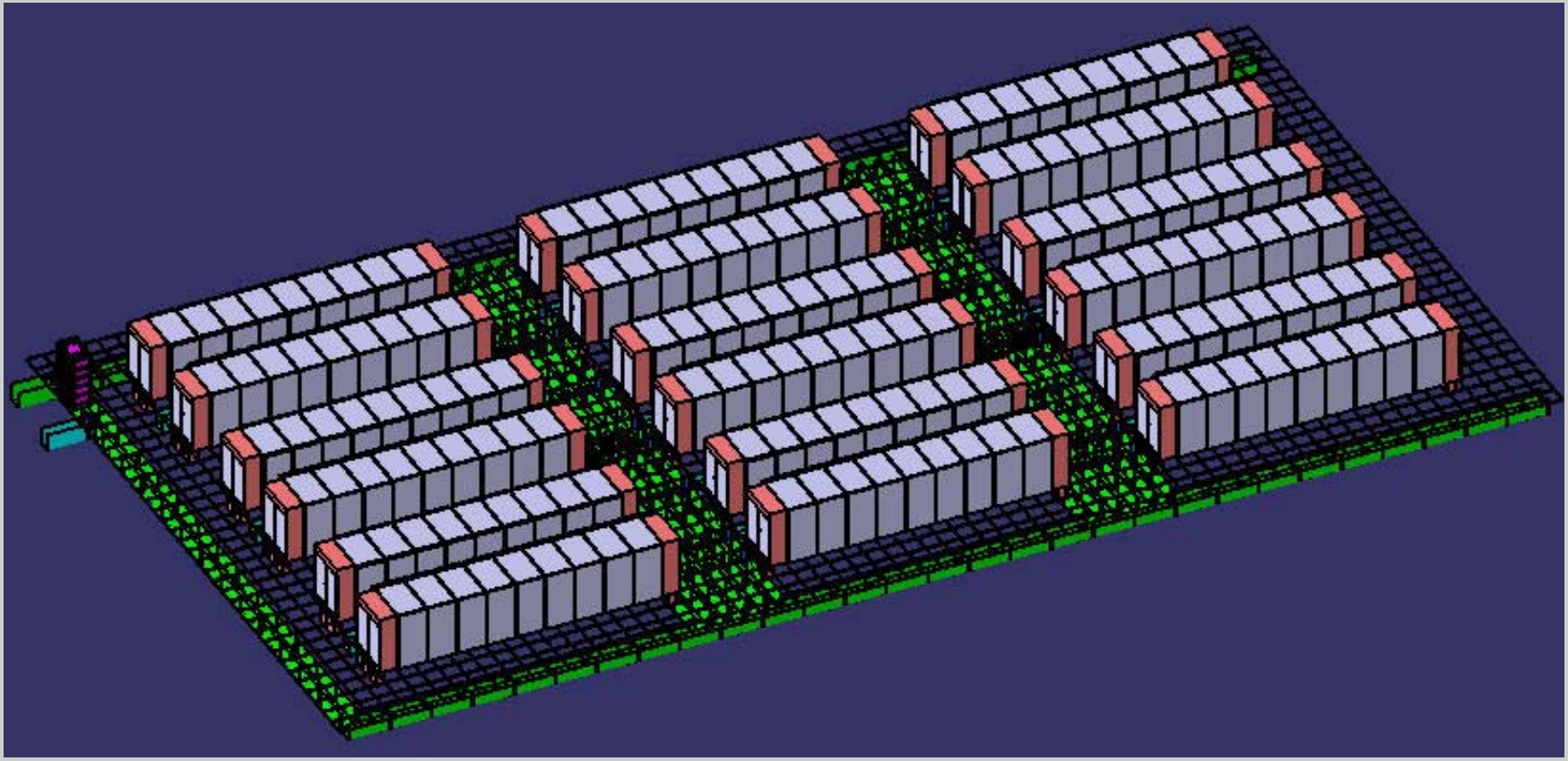
- Blue Waters at U. of Illinois/NCSA -The Blue Waters project will provide a computational system capable of sustained petaflop performance on a range of science and engineering applications. The system is built by IBM on the Power7 processor

U. Of Illinois/NCSA Green Data Center

Blue Waters will be an unsurpassed national asset, delivering sustained performance of 1 petaflop (that's 1 quadrillion calculations every second) for many science and engineering applications that researchers use every day—not just benchmarks. Blue Waters is being developed and built with a $208 million grant from the National Science Foundation and will be a resource for scientists and engineers across the country.

Blue Waters will deploy IBM's POWER7 architecture, which is based on advanced multicore processor technology.

UI-NCSA Blue Waters Computing System & the Supporting Facilities Infrastructure



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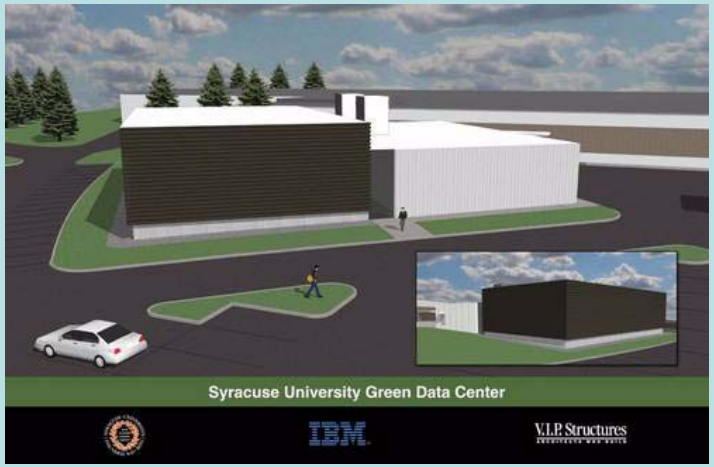
Potential Future Directions to Improve Data Center Efficiency

- Move to More Integrated Large Scale IT Equipment
  - Integrate the Network into the Server
  - Unify Storage & Servers
  - Eliminate unnecessary Data Flow & Protocol Conversions that Burn Power
  - Integration Reduces IT Equipment hardware content yielding better reliability, lower cost, & potentially better performance.

Example of Future Best-of-Breed HPC Data Center

- UI NCSA Future System
  - ✓ Approximate Compute Capacity of many PF's with high bandwidths throughout
  - ✓ ~15 MW IT equipment load facility design point
  - ✓ 98% efficient Facility Power Infrastructure to Input of System
  - ✓ 80-93% efficient Facility Cooling Infrastructure dependent on time of year
  - ✓ ~17.6 MW Total Load @ Building Input, 85% Overall Facility Efficiency
  - ✓ Compute Cabinets 100% Water Cooled
  - ✓ No Cooling required for Building Xfrms – Free Convection Cooled Outdoors
  - ✓ 480 VAC Balanced 3-phase Directly to each Rack
  - ✓ Floor Space Minimized, ~ ½ the space of densest server that can possibly be constructed using 19" Blade Packaging
  - ✓ Campus Power Substation used as integral part of Data Center Infrastructure:

Syracuse U. State-of-Art Green Data Center



"It's a perfect example of how effective cross-sector partnerships can be," SU Chancellor and President Nancy Cantor said in a news release. "IBM, NYSERDA, and SU each are bringing their strengths to the table to gain vital insight into solving crucial aspects of the intensifying global problem of increasing energy consumption that none of us could achieve separately."

- Syracuse U. Data Center
  - ✓ On site Co-generation
  - ✓ High efficiency DC
  - ✓ All liquid cooling

Summary

- ✓ Liquid cooling is back – improves overall energy efficiency
- ✓ Integrate IT functions more effectively to drive efficiency
- ✓ View IT clusters more holistically – end to end power and cooling solutions

Thank You

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