# IBM **“Green Computing”**

**IBM Green update with a focus on Energy Efficiency**

April 19, 2008

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V4



Highmark and IBM - #1 Green IT User and Vendor

COmputerWorld Feb. 15, 2008

# Topics

- **Why Green IT**
- **Best Practices**

- **Key Factors for a Successful Implementation**
- **Lessons Learned**

- **What is ahead**
- **Next Steps**

- **Additional Topics**

# Why Green IT? Why ***GO GREEN?***

- **Cost**
- **Sustainability**
- **Best Alternative**

# IT organizations are challenged by operational issues

*"Enterprises report that IT operational overhead = up to 70% of IT budget and growing . . . leaving precious few resources for new initiatives."*

*IDC, Dec 06*

*Challenges*

***Costs & Service Delivery***

- Rising costs of systems and networking operations
- Explosion in volume of data and information
- Difficulty in deploying new applications and services

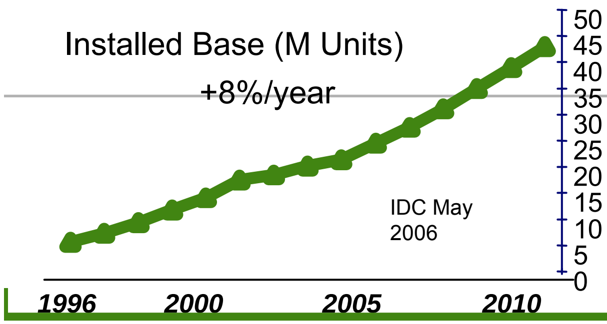
***Business Resiliency & Security***

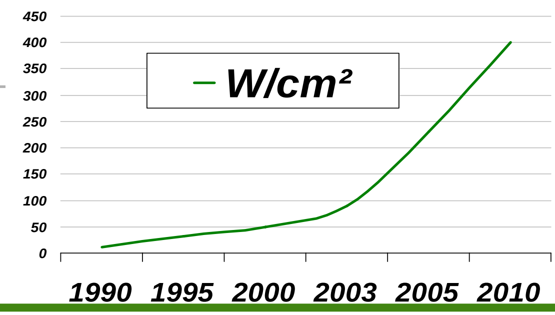
- Security of your assets & your clients' information
- Landslide of compliance requirements
- Systems and applications need to be available

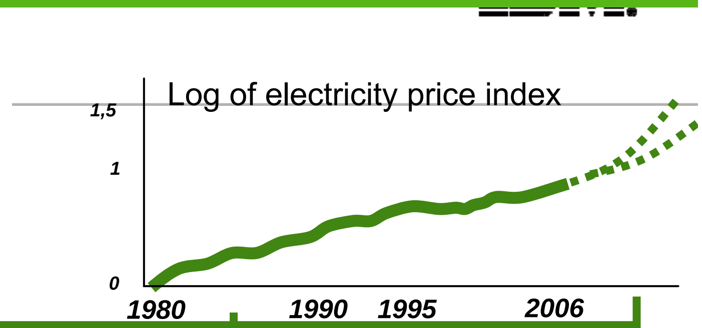
***Energy Requirements***

- Rising energy costs & rising energy demand
- Power & thermal issues inhibit operations
- Environmental compliance & governance mandates

## Increased number of servers | Increased processor consumption | Increased cost of electricity

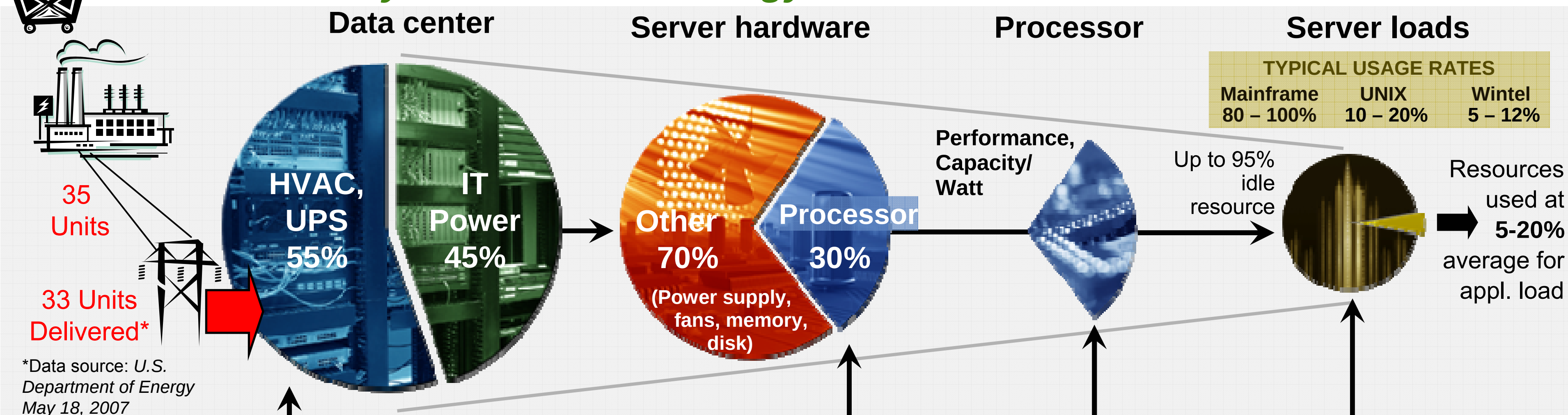




## *Energy has become significant part of the Total Cost of Operations, Why now? How is energy in the Data Center consumed?*

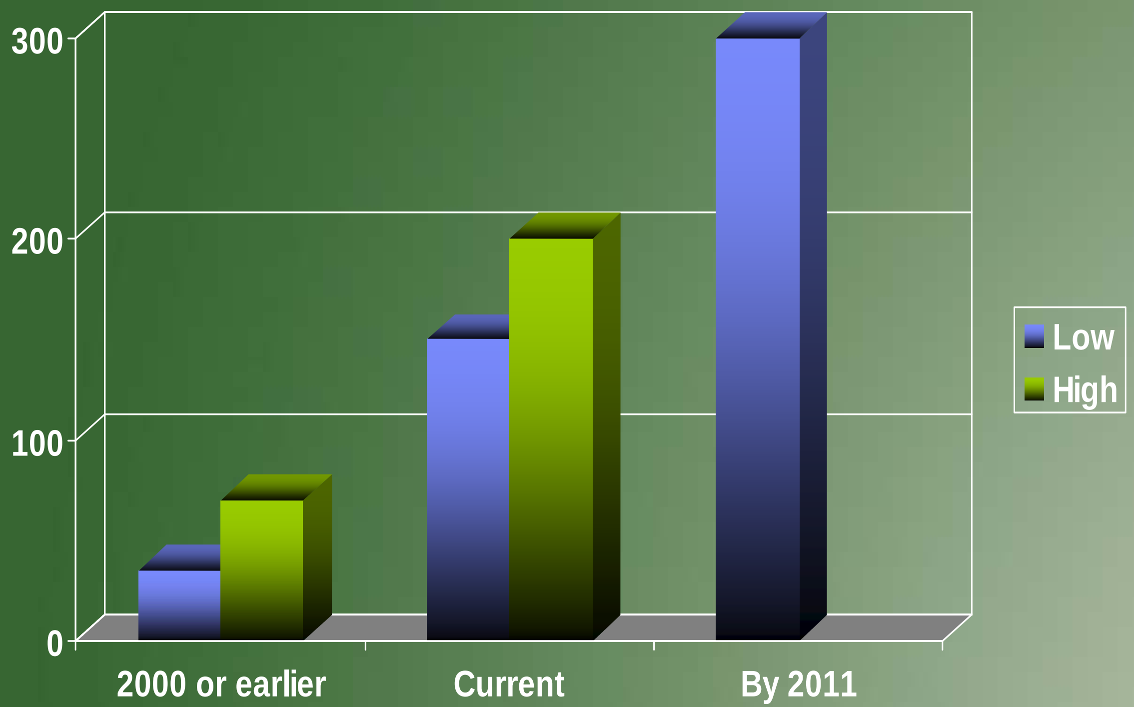



| How to improve efficiency | **Reduce cooling/UPS needs vs. energy going in servers, capture heat at source** (Potential gain 10%) | **Higher efficiency infrastructure, power management'** ( $\geq$ 3yrs older is good target ) | **Reduce consumption @ chip level** ( Cap power usage ) | **Reduce idle/unused capacity which still consumes energy** (Utilization 5 to 20 % gain) |
|---|---|---|---|---|
| | ***More efficient cooling and energy supply*** | ***Better server hardware design*** | ***Advanced processor design + process*** | ***Enhance resource usage rate (consolidation/virtualization)*** |

# IT energy crisis

- **During the next 5 years, most datacenters will spend as much on energy as they do on hardware**

***Data center watts/sq. ft.***




*Doesn't include energy needed to remove heat…*
*can increase overall power requirements by 80% to 120%*

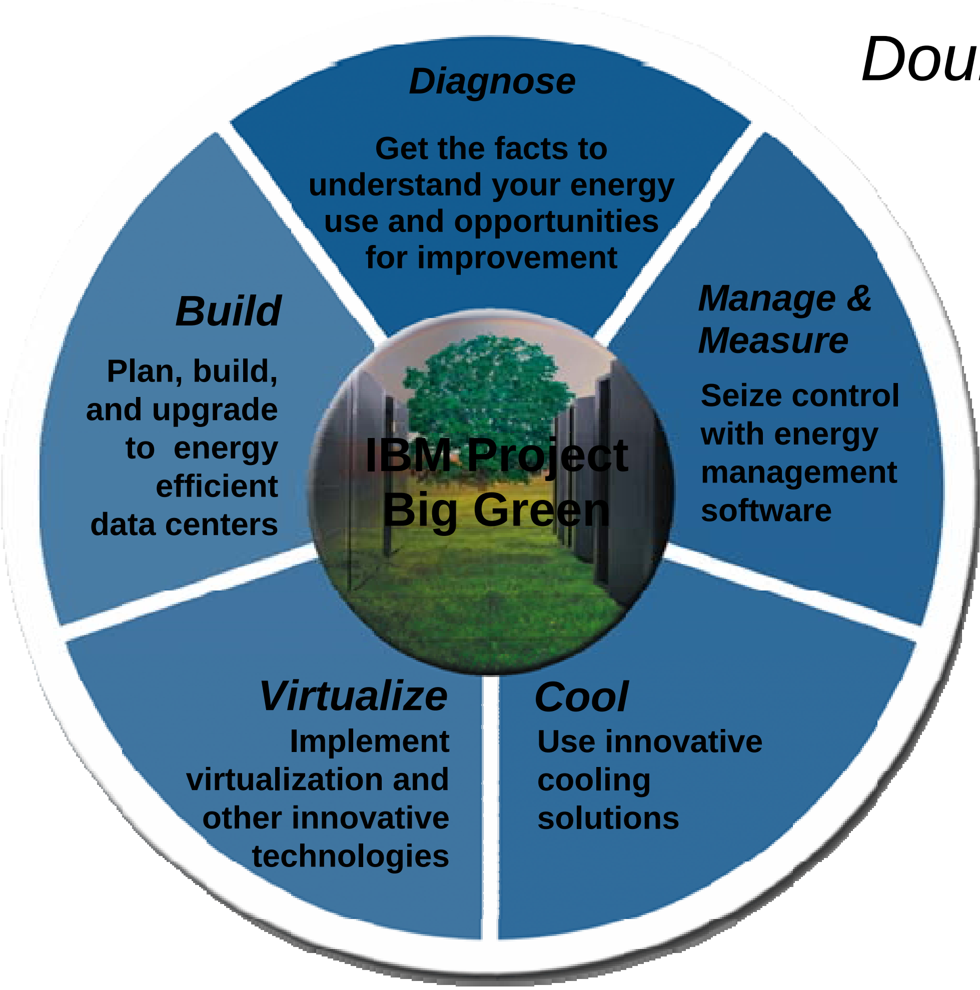
*Source: Gartner, "U.S. Data Centers: The Calm Before the Storm," ID #G00151687, September 25, 2007*

# Roadmap for Energy Efficiency in Data Centers -Advice from EPA

| Scenario / Percent Energy Savings | IT Equipment | Site Infrastructure (Power and Cooling) |
|---|---|---|
| ***Improved operation*** 20% | • Continue current trends for server consolidation<br>• Eliminate unused servers<br>• Adopt "energy-efficient" servers to modest level<br>• Enable power management on 100% of applicable servers<br>• Assume modest decline in energy use of enterprise storage equipment | 30% improvement in infrastructure energy efficiency from improved airflow management |
| ***Best practice*** 45% | All measures above plus:<br>• Consolidate servers to moderate extent<br>• Aggressively adopt "energy-efficient" servers<br>• Assume moderate storage consolidation | Up to 70% improvement in infrastructure energy efficiency from all measures in "Improved operation" scenario, plus:<br>• Improved transformers and uninterruptible power supplies<br>• Improved efficiency chillers, fans, and pumps<br>• Free cooling |
| ***State-of-the-art*** 55% | All measures above plus:<br>• **Aggressively consolidate servers**<br>• **Aggressively consolidate storage**<br>• **Enable power management at data center level of applications, servers, and equipment for networking and storage** | Up to 80% improvement in infrastructure energy efficiency, due to all measures in "Best practice" scenario, plus:<br>• Direct liquid cooling<br>• Combined heat and power |

Source: EPA Response to Congress for Public Law 109-431, 08/07/07

# Five building blocks provide the tools to operational savings and business growth. SUSTAINABILITY




*Double your IT capacity*

- **In the same energy footprint**

*Reduce operational costs*

- **40-50% energy savings**
- ***M / yr savings***

*Positive environmental impact*

- ***1,300 less cars or 3.5M less pounds of coal***

**Going green impacts the pocketbook and the planet.**
***IBM offers a comprehensive approach***

# Best Practices

- David Anderson's Top 10 list

- Consolidation / Virtualization
- Energy Efficient Equipment
- Energy monitoring and management

- IT Equipment
- Facilities / Infrastructure

- Role of Applications
- Process
- SOA

# Best Practices for a Sustainable “Green: Data Center

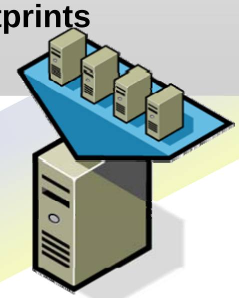
1. Begin with an Enterprise goal in mind.  Create lasting greenness.
2. Exploit virtualization to reduce the number of servers and improve flexibility.
3. Exploit virtualization to reduce the amount of storage networking equipment.
4. Use integrated approach to server consolidation to optimize savings
5. Drive to high utilization rates.
6. Consolidate on large servers.
7. Eliminate redundancy but keep high availability and Disaster Recovery capabilities.
8. Measure and put the costs of energy where they are incurred.
9. Use the concept of hierarchical storage
10. Use the latest equipment and prepare to operate ***NOT*** BAU.

# Evolution of data center energy efficiency

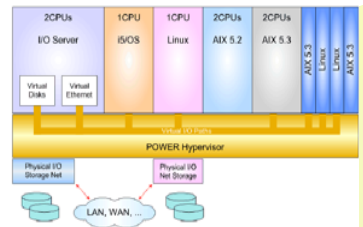
- Consolidate many centers into fewer
- Reduce infrastructure complexity
- Improve facilities management
- Reduce staffing requirements
- Improve business resilience (manage fewer things better)
- Improve operational costs

***Centralization***

- Consolidate many servers into fewer on physical resource boundaries
- Reduce system management complexity
- Reduce physical footprints

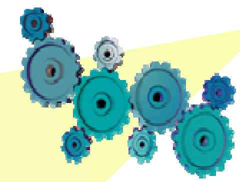


***Physical Consolidation***




***Virtualization***

- Remove physical resource boundaries
- Increased hardware utilization
- Allocate less than physical boundary
- Reduce software licensing costs



***Application Integration***

- Migrate many applications into fewer images
- Simplify IT environment
- Reduction of operations resources
- Improve application specific monitoring and tuning

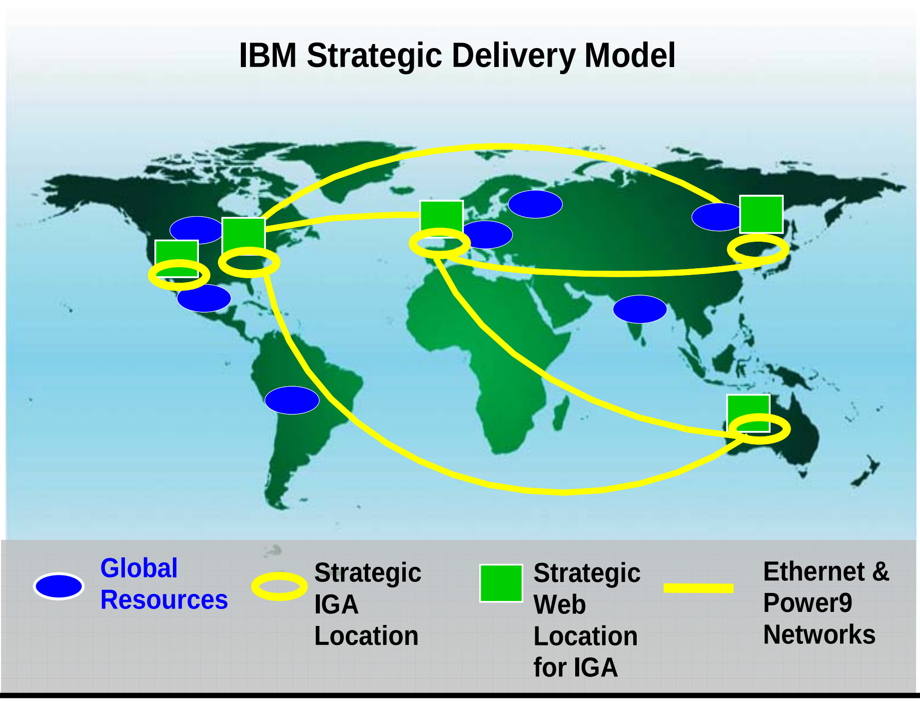
# IBM's Transformation: An Ongoing Journey

## Data Center Efficiencies Achieved

- Consolidation of infrastructure
- Application consolidation/reduction
- Enterprise architecture optimization
- Global resource deployment

TECHNOLOGY

| IBM Metrics | 1997 | Today |
|---|---|---|
| CIOs | 128 | 1 |
| Host data centers | 155 | 7 |
| Web hosting centers | 80 | 5 |
| Network | 31 | 1 |
| Applications | 15,000 | 4,700 |




## Next Level of Infrastructure Challenge

- Floor space challenges in key facilities
- Underutilized assets in outdated Web infrastructure
- **Continued infrastructure cost pressure**

# IBM offerings 2008
# Aimed at all aspects of energy efficiency

## Energy Solutions

- Data Center Stored Cooling Solution
- Optimized Airflow Assessment for Cabling
- Scalable Modular Data Center
- Data Center Relocation and Consolidation Data Center Facilities Design

## Energy Assessments

- IT Systems Energy Efficiency Assessment
- IT Systems Energy Rationalization Study
- Data Center Energy Efficiency Assessment
- Accelerator for Rationalization
- IBM Optimization and Integration Services: Server Consolidation
- Server and Storage Power/Cooling Trends and Data Center Best Practices
- Data Center Thermal Analysis and Optimization Facilities Integration
- Data Center Health Audit for IT

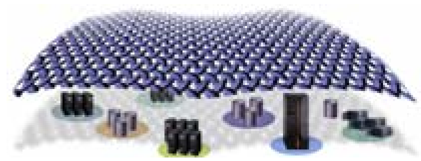
## Energy Management

Tivoli

PowerExecutive/ AEM
***For trending and capping***

Tivoli Provisioning and Monitoring ***Actively moving workloads and power up/down resources and aligning workloads***

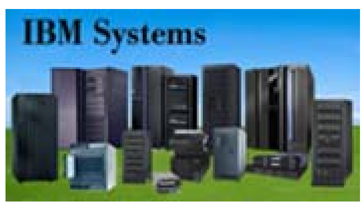
IBM Systems Director Family



**Virtualization *on IBM Systems and IBM System Storage drives utilization up and annual power cost down***

## Energy Technology

BladeCenter ®
***Open, Easy, Green***




IBM power supplies
***Measurement built in***

IBM System Storage™
***Increases utilization and energy efficient ILM***

X-Architecture™
***System x designed for efficiency***

Rear Door Heat Exchanger
***Thermal management innovation***

Power Architecture ™
***Processor efficiency management for System i and System p***

**IBM z/Architecture™ System z™ *lean and green leadership***

IBM Blue Gene
***#1 efficient system in Green 500 list***

## If you can't remember 30 Green solutions remember 3 or 4

- **Consolidation / Virtualization**
- **Exploitation of new energy efficient Technologies**
- **Active Energy Management (AEM)**

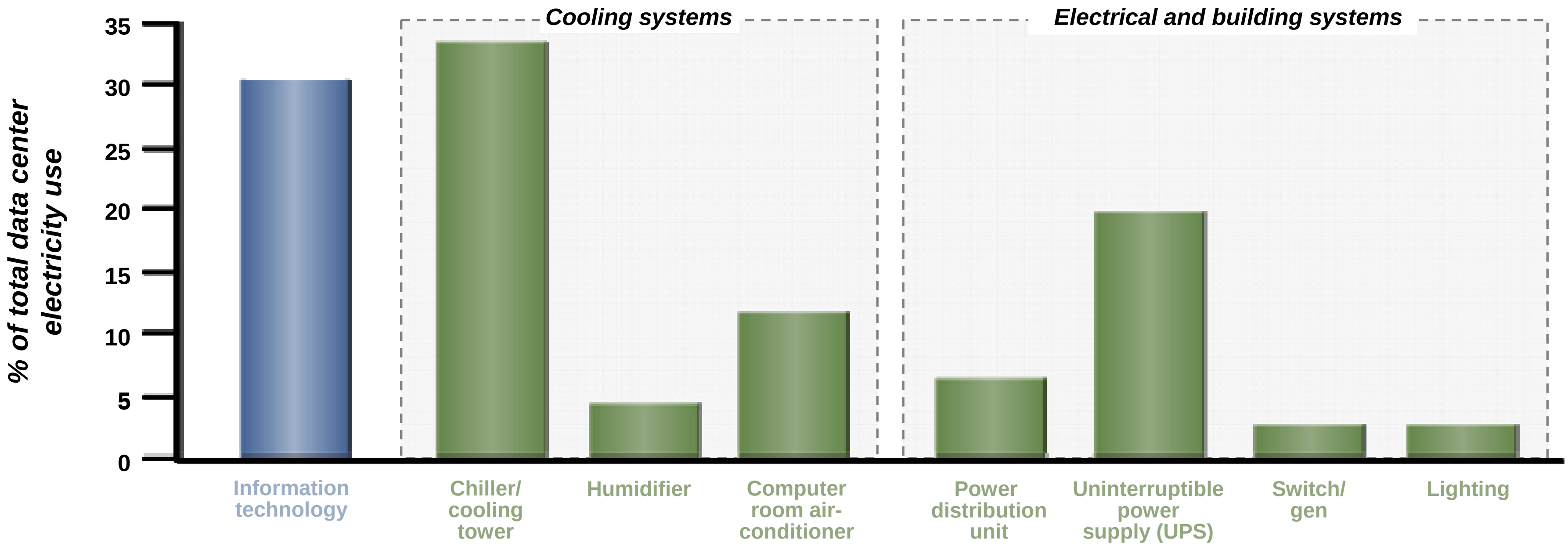
Managing your

Application Portfolio

can be very green

# Where does the energy go?

***The data center energy challenge affects both the physical data center and the IT infrastructure. IBM can help address both.***




*Power use*

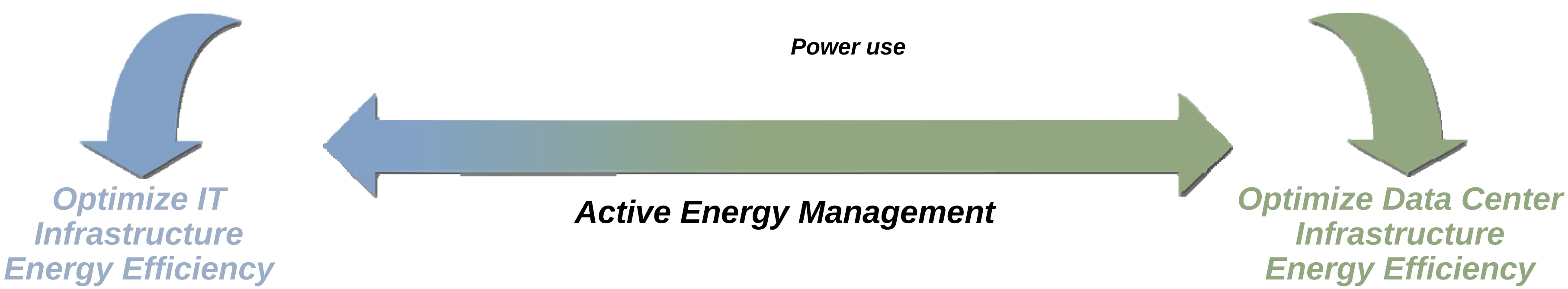




Chart and data source: American Power Conversion Corporation (APC) white paper, Implementing Energy Efficient Data Centers, #114, by Neil Rasmussen, 2006.

# Learn from others : Green IT Users in the news

- No. 1 Green IT HIGHMARK : LEEDs certified Data Center. Underground water storage, virtualization exploitation of mainframe virtualization

Discovery Channel : Energy Efficiency is part of Every Purchase Decision

First National of Nebraska : Fuel Cell technology, consolidation onto System z IFLs, virtual PC's

PERKINS + WILL : Every office has a Green team and a Green Operations Plan for 6 areas ( transportation, office water use, office energy use, office consumables, indoor air quality, office renovations and new construction).

SNOHOMISH COUNTY PUD PUBLIC UTILITY DISTRICT NO. 1 Snohomish Public Utility District: EZ GPO control power management settings using resident API's. Turn off put equipment to sleep.

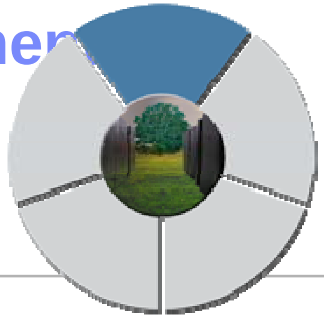
WWF World Wildlife Federation : Energy saving designs for servers, notebooks and desktops

# Learn from others

- WELLPOINT : Utilize IBM for best practices an “green” tape
- Ryder : Know who is using, i.e. every KW / sq ft.
- austinenergy.com : Dynamic management with Customer partnership
- Marriott International Inc. : Virtualization of IT equipment and Underground Facilities
- MONSANTO imagine : Consolidate to fewer data centers and virtualize
- WACHOVIA : SOA and using managed services reduced power consumption by a factor of 5.

Source: ComputerWorld top Green IT Users and Vendors Feb. 15, 2008

# Diagnose – Data Center Energy Efficiency Assessment



***Provide facts to reduce energy consumption by 53% annually***

***Client requirements***

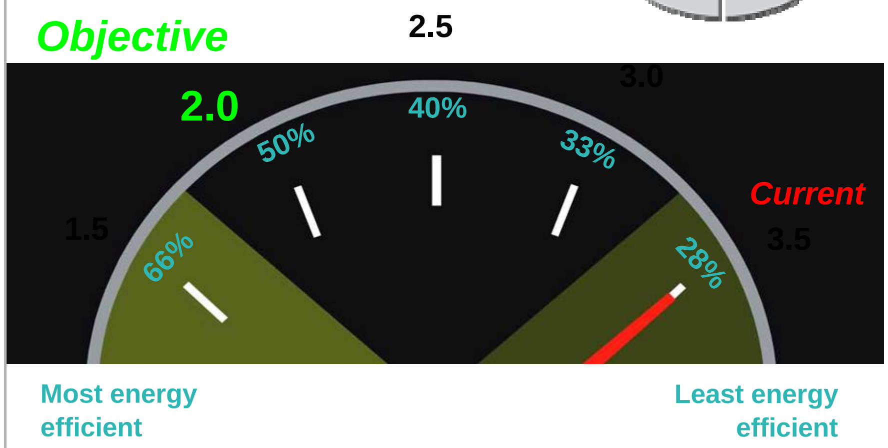
- **Support IT growth with an existing 5,000 sq ft center**
- **Improve data center energy efficiency & reduce costs**

***Solution***

- **Comprehensive, fact-based analysis**
- **Evaluate cooling system components, electrical systems and other building systems**
- **Provide baseline metric (MPG) for data center energy efficiency**
- **Deliver roadmap of cost justified recommendations**

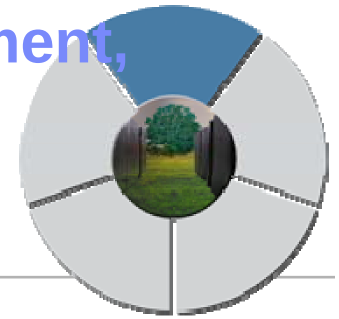
***Benefits***

- **Up to 53% annual energy savings**
- **40% annual savings on actions with < 2 year payback / $125-170K annual energy savings**




| Improvements | Cost ($K) | Payback |
|---|---|---|
| Reduce recirculation & bypass of cooling air | < 5 | < 1 year |
| Increase CRAC air discharge temperature | < 5 | <1 year |
| Adjust indoor temperature & relative humidity | < 3 | <1 year |
| Turn off CRAC's where no IT equipment load | < 1 | immediate |
| Improve UPS efficiency | 40-140 | 1-2 years |
| Consider transferring IT loads to two PDUs | Varies | varies |
| Implement occupancy sensor light controls | < 5 | 1.5 years |
| Variable speed fans | 200 | 6 years |
| Variable speed scroll compressors | 300 | 18 years |
| Total | 60 - 700 | 1 To 18 years |

# Diagnose – Data Center Energy Efficiency Assessment, IBM Lexington



***Extend useful life of an 40K square foot center with 15% energy savings from physical infrastructure efficiencies***

***Client requirements***

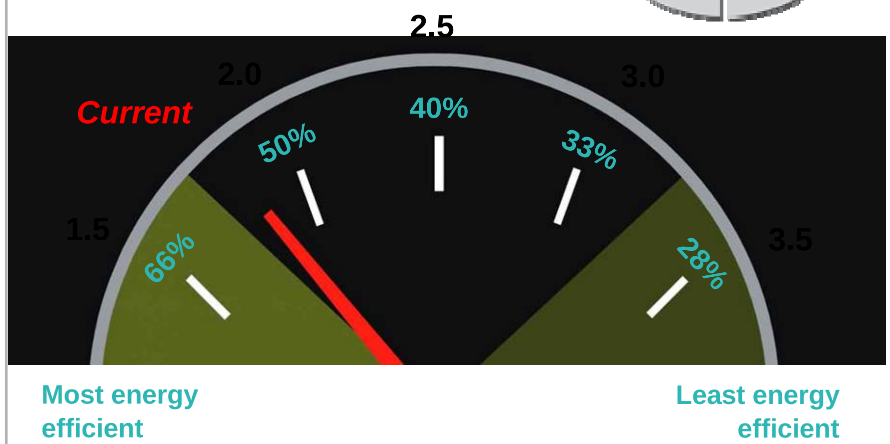
- **Not able to grow energy and cooling capacity in existing 40K square foot data center**
- **Need to reduce energy used by physical infrastructure to grow IT equipment**

***Solution***

- **Comprehensive, fact-based analysis**
- **Evaluate cooling system components, electrical systems and other building systems**
- **Provide baseline metric (MPG) for data center energy efficiency + Deliver roadmap of cost justified recommendations**

***Benefits***

- **15% annual energy savings from physical infrastructure + $55-65K annual energy savings in an efficient center**
- **All investments have < 2 year payback**




| Improvements | Cost ($K) | Payback |
|---|---|---|
| Air management improvements: floor gaps, blanking plates, tile placement | < 5 | < 1 year |
| Align servers using hot / cold aisle techniques | <10 | < 1 year |
| Increase chilled water temperatures | < 5 | <1 year |
| Increase supply air temperatures from CRAC's | < 3 | <1 year |
| Re-commission water side economizer for "free cooling" | ~ 50 to 100 | < 2 years |
| Total | 75 - 125 | < 2 years |

# IBM Boulder Green Data Center

***Add 72,000 square feet to a highly resilient center to include energy efficiency as a design point . Commissioning in 2Q08***

## IT Related

*Design / Build*

- Economies of scale – 300,000 sq ft
- Power Density - 90 watts / sf (modular to 140)
- Best Practices Equipment Layout
- Minimize Single Points of Failure
- Tier 3 design point

*Operate*

- Virtualized High Utilization Workload
- Demand modeling for future requirements
- Three dimensional 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
- Waterside Economizers
- DC CRAC Motors

*Electrical*

- Modular power density expansion options

*Other building systems*

- Energy Efficient Lighting
- High "R" Value Insulation

## Industry Related

*LEED Certification*

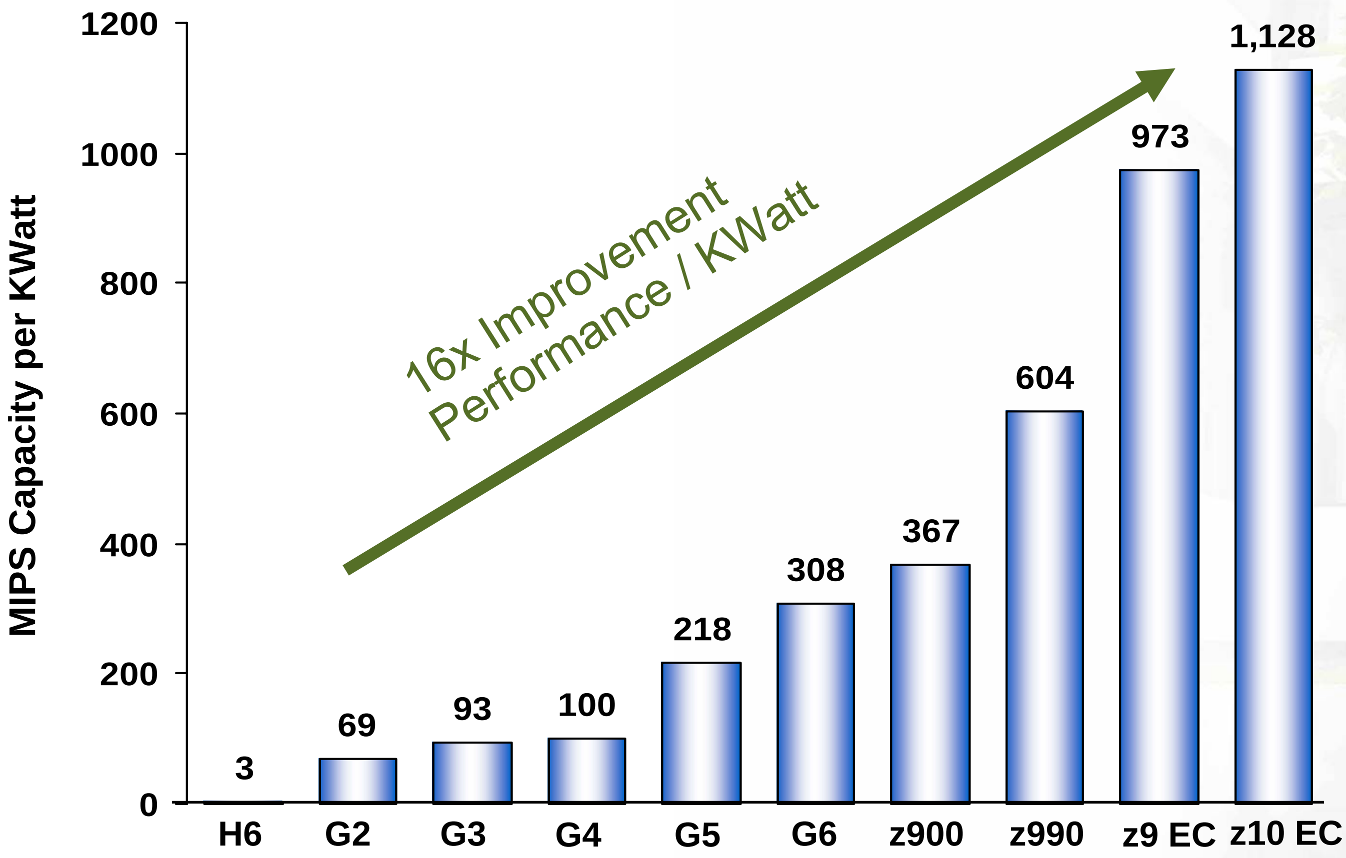
*Energy Management Programs ($700K)*

- Power Company Rebates
- Government Incentives
- Renewable Energy Certificates

*Environmental Programs*

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

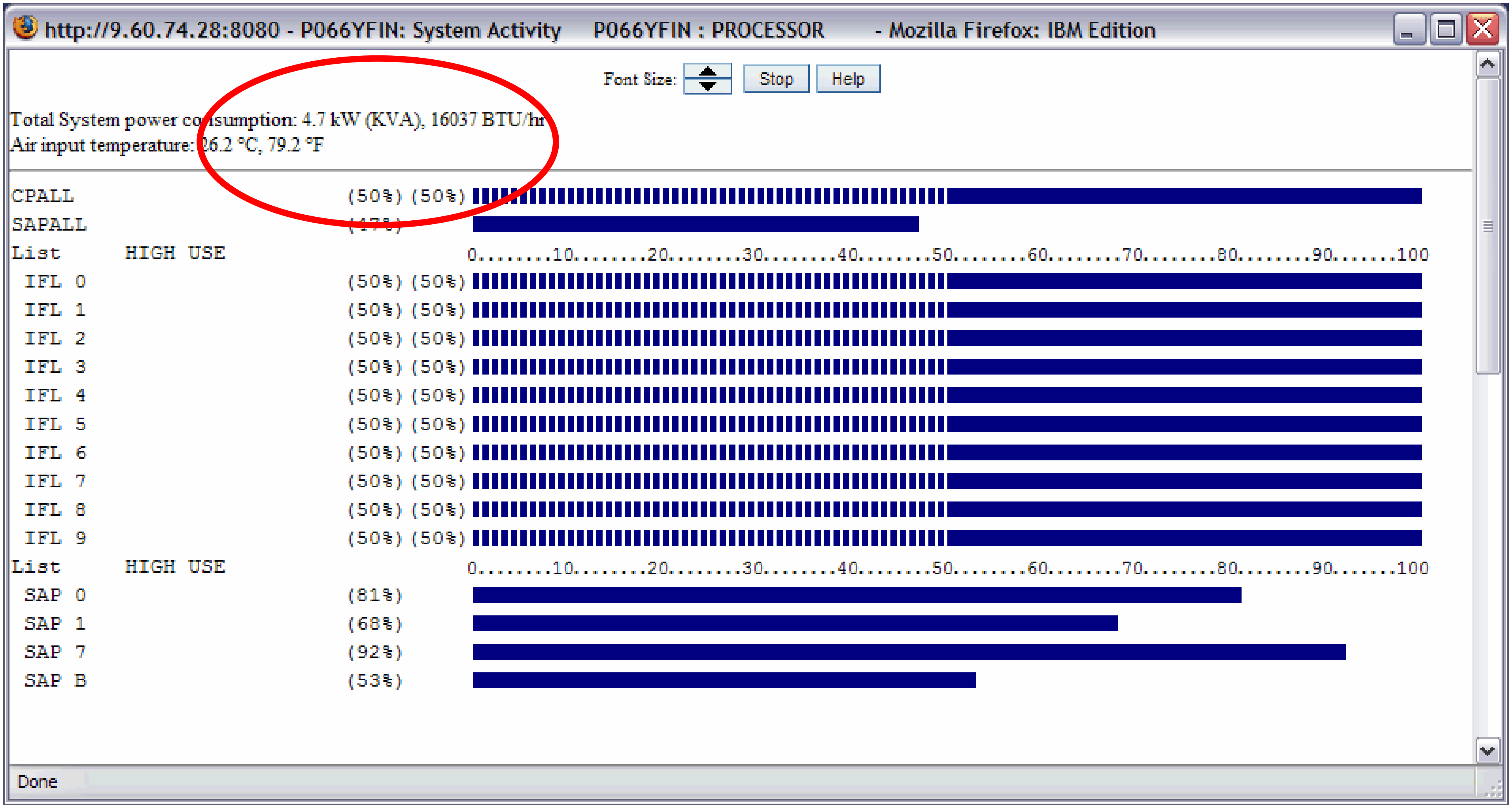
# System z10 EC is Cost Effective <u>and</u> can help you **Go Green** by delivering *highly energy efficient technology*




***1/24 the Energy Use in 1/5 the Floor Space****

* Comparison is versus x86 Blade servers without virtualization, reflecting a current-day consolidation.

# System Activity Display with Power Monitoring



# IBM Systems Director Active Energy Manager Introduction

- **IBM Systems Director Active Energy Manager (AEM) is an energy management solution building block that returns true control of energy costs to the customer**
- **AEM is a cornerstone of the IBM energy management framework and is leading edge in the Industry**
- **In tandem with chip vendors Intel and AMD and consortiums like the Green Grid, AEM supports the IBM initiative to deliver price performance per square foot**
- **AEM runs on Windows, Linux on IBM System x™, Linux on IBM System p™, and Linux on IBM System z. Refer to its documentation for more specific information.**

# Lessons Learned

- Data Centers can reduce the power they use
- Virtualization works
- Many new technologies can improve infrasructure efficiencies

# IBM System Storage Tape Libraries

- Tape storage has lowest energy cost per TB
  - Tape libraries consume less power and require less cooling that spinning disks
  - Tape libraries are fully automated to allow backup operation to occur during 'non-peak' hours when energy cost are lower
- Provides lowest cost storage option for long term data archiving or when real time access to data is not required

# Virtualize – IBM Data Centers

***Improve operational efficiency and risk management while reducing energy usage by 80%***

### *Client requirements*

- **Needed to reduce systems management complexity**
- **Needed to increase stability, availability, and provide world-class security**
- **Improve operational costs and energy efficiency**

### *Solution*

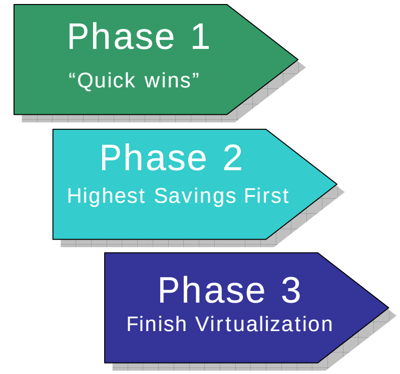
- **Consolidate 3,900 servers to 33 System z mainframes**
- **Migrate servers delivering largest savings first**
- **Eliminate assets with lowest utilization first**
- **Aggregate by customer work portfolio to leverage strong customer buy-in**
- **Focus on freeing up raised floor space**
- **Provision new applications to the mainframe**

### *Benefits*

- **Annual energy usage reduced by 80%**
- **Total floor space reduced by 85%**

**Initial priority for consolidation to Linux on System z**

# IBM Virtualization Progress




- **Established phased approach for quick wins**
- **Migrated initial servers from ‘early adopter’ teams**
  - Inventoried more than 4000 servers
  - Over 500 images deployed (migrated and new)
- **Comprehensive project plan and management system in place**
  - Integrated business priorities with transformational objectives
  - ‘Work in progress’ approach to maximize server migrations
  - Pipeline, process, technical, finance and communications support
- **Developed internal business case and cash flow analysis using specific server costs, detailed labor analysis, migration expense**
- **Technical solution, education plan and operational plan developed**
- **Highest level of support from IBM senior executive team**

# Several factors are used in the analysis to determine which workloads to move

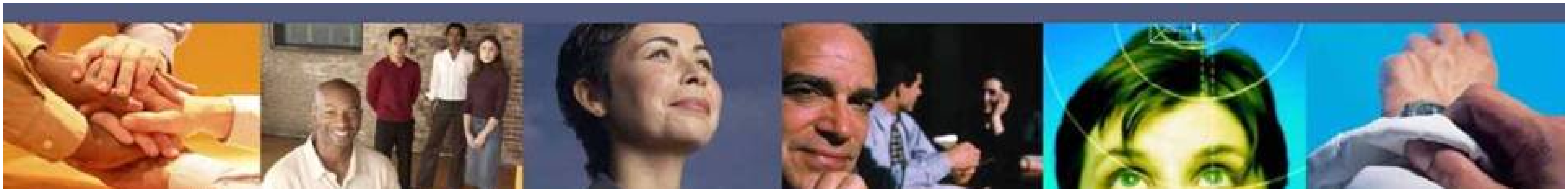

- **Servers delivering large saving**
  - Old technology: servers, storage, network
  - Servers with low utilization
  - Servers that free up contiguous space
  - Locations with high cost of energy and space

- **Lower cost migrations**
  - New deployments
  - Servers/applications with planned change
  - Associated servers
  - Lower complexity, fewer dependencies

- **Business aspects**
  - Criticality and Impact to the business
  - Business cycles
  - SLA

# Critical Success Factors

- **Sponsor with an enterprise view**
- **Strategic investment for migration**
- **Clear goals, dedicated team, inclusive leadership for execution of migration**
- **Leveraging talent and capability across all of IBM to drive rapid results**



# Virtualize – IBM Data Centers

***Improved operational costs up to 70% with aggressive distributed platform virtualization***

## *Client requirements*

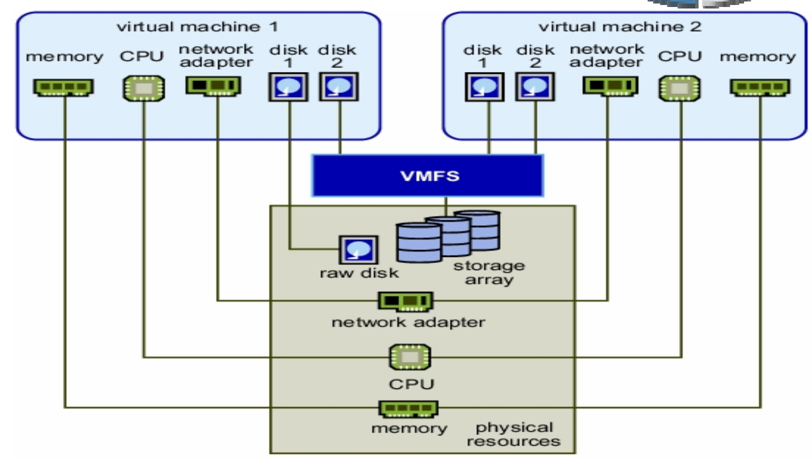
- **Improve IT equipment utilization**
- **Reduce IT hardware requirements**

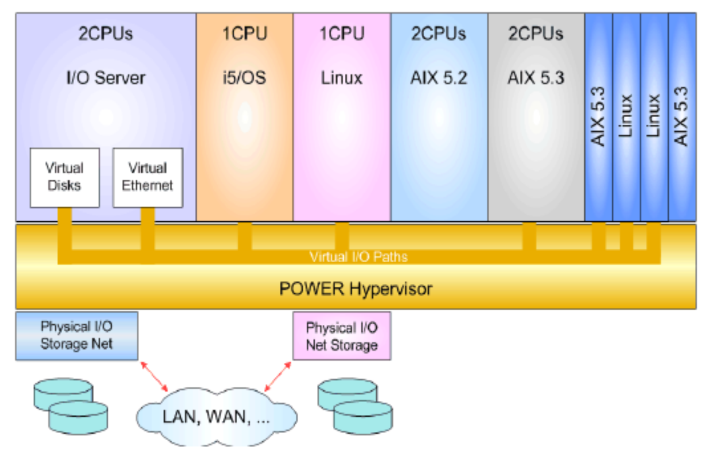
## *Solution*

- **Advanced POWER Virtualization (APV) and VMWare**
- **Reduced number of physical servers**
  - Wintel from 11,000 to 1,500
  - UNIX from 8,500 to 1,500
- **Three times improvement in server utilization**
- **Formed a Virtualization Center of Excellence to implement best practices across geographies**

## *Benefits*

- **Operational savings of up to 70%**
  - Space, power and cooling, maintenance, software support and personnel costs

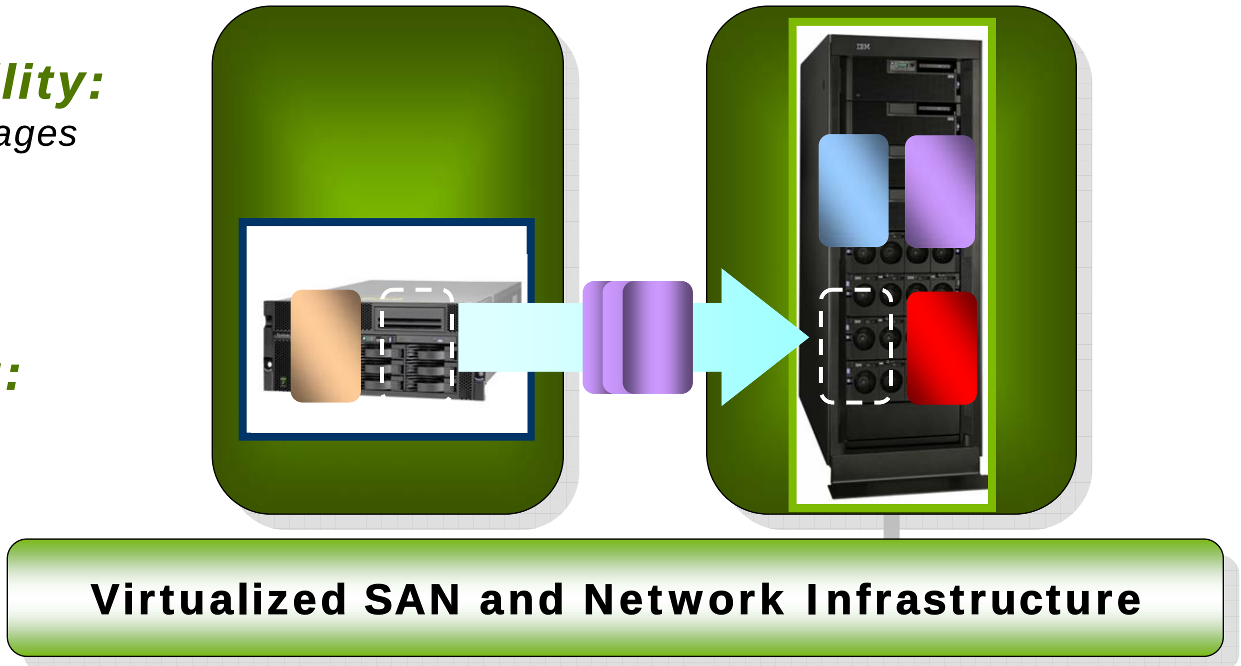


# PowerVM Live Partition Mobility

***Move <u>running</u> UNIX and Linux operating system workloads from one POWER6 processor server to another!***

- ✓ ***Continuous Availability:***
  *eliminate many planned outages*
- ✓ ***Energy Saving:***
  *during non-peak hours*
- ✓ ***Workload Balancing:***
  *during peaks and to address spikes in workload*



# IT Cost Savings powered by z/VM Virtualization on z10 EC

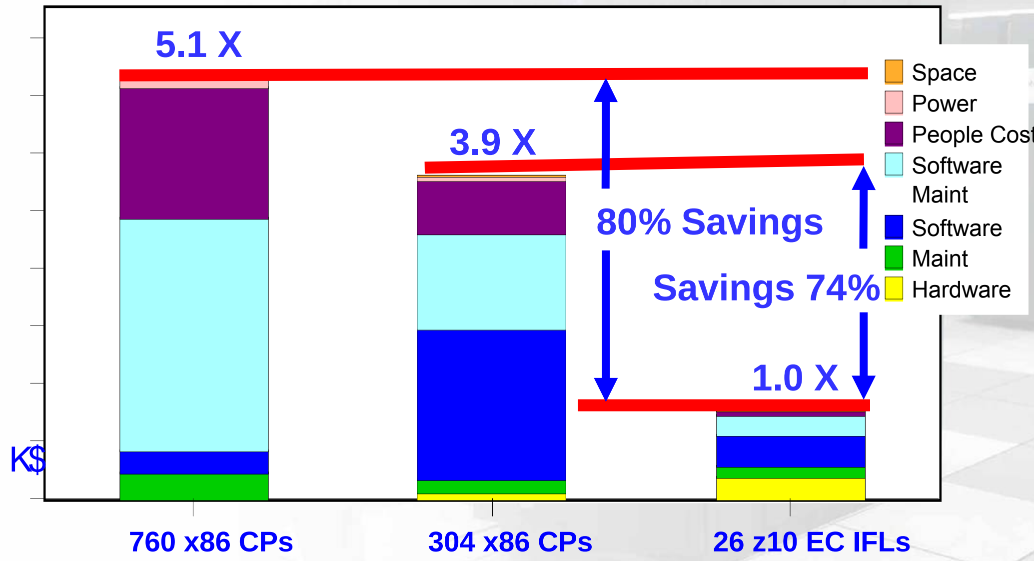
***Your IT Cost may vary:***

- **91% Less Hardware**
  - 304 x86 Processor Cores vs 26 IFLs
- **Potential for dramatic reductions in software expense for processor based licenses**
- **Reductions in power and cooling**
  - **81% Savings in KWatts and Energy Costs in this scenario**
- **30% Less Space**
- **93% People savings**
- **Increased processor utilization**
- **Industry leading Security**

***Energize your IT savings with z10 EC.***

**Consolidating 760 Linux servers**
**z/VM versus x86 Virtualization**
Oracle DB Workload
3-Year Total IT Cost

**$29.5M Savings versus x86 without Virtualization**




**x86 w/o Virtualization** | **x86 Virtualization** | **z/VM Linux on System z10 EC**



* All performance information was determined in a controlled environment. Actual results may vary.

# Cool – Data Center Stored Cooling, IBM Bromont

***Implement innovative cooling technology to reduce operational costs from the largest data center energy user by 45%***

### *Client requirements*

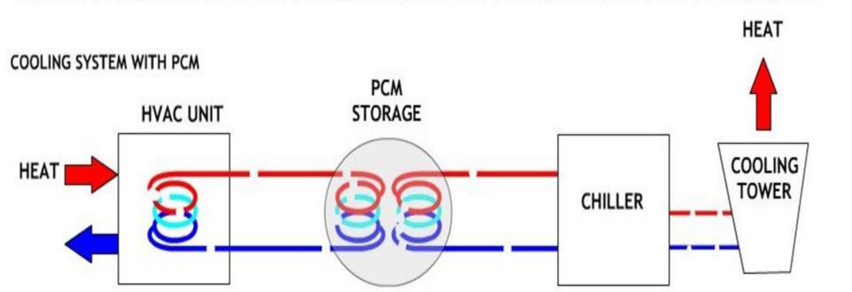
- **Identify and attach the largest areas of energy consumption**
- **Reduce energy consumption and operating costs of chiller plant supporting Bromont (Quebec, Canada) site**

### *Solution*

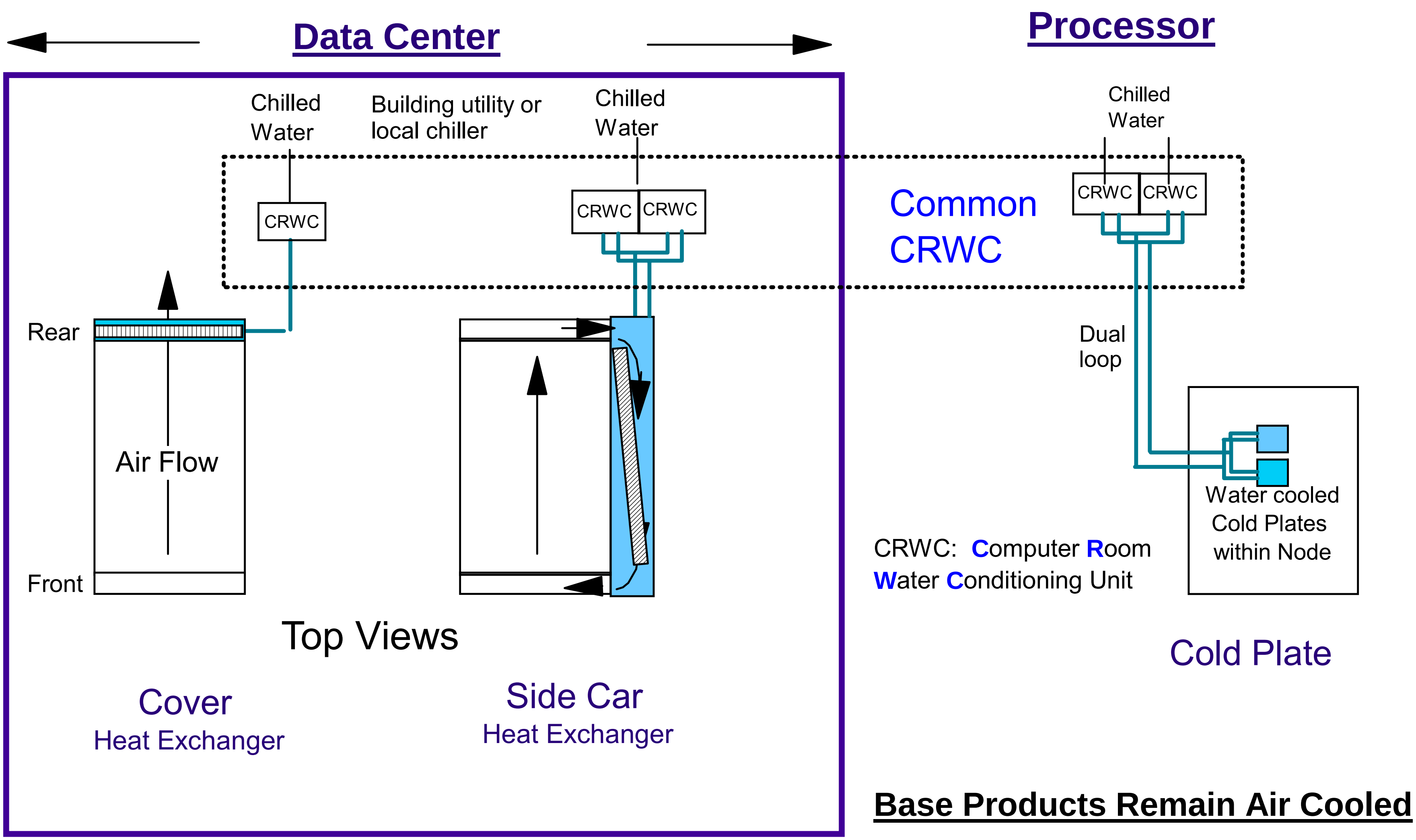
- **Install "Cool Battery"**
- **Increase chiller utilization by storing cold for use throughout the day**
- **Leverage environment - free cooling**

### *Benefits*

- **Reduced chiller plant energy cost by 45%**
  - **Over 5.3 million kwhr per year**
  - **Demand reduction of approximately 1 MW**
- **Avoided need to install additional chiller**
- **Environmentally-friendly, non-toxic, no-maintenance**



# Server level: Rack / Data Center Liquid Cooling
# Water the enabler for SMP growth with energy efficiency

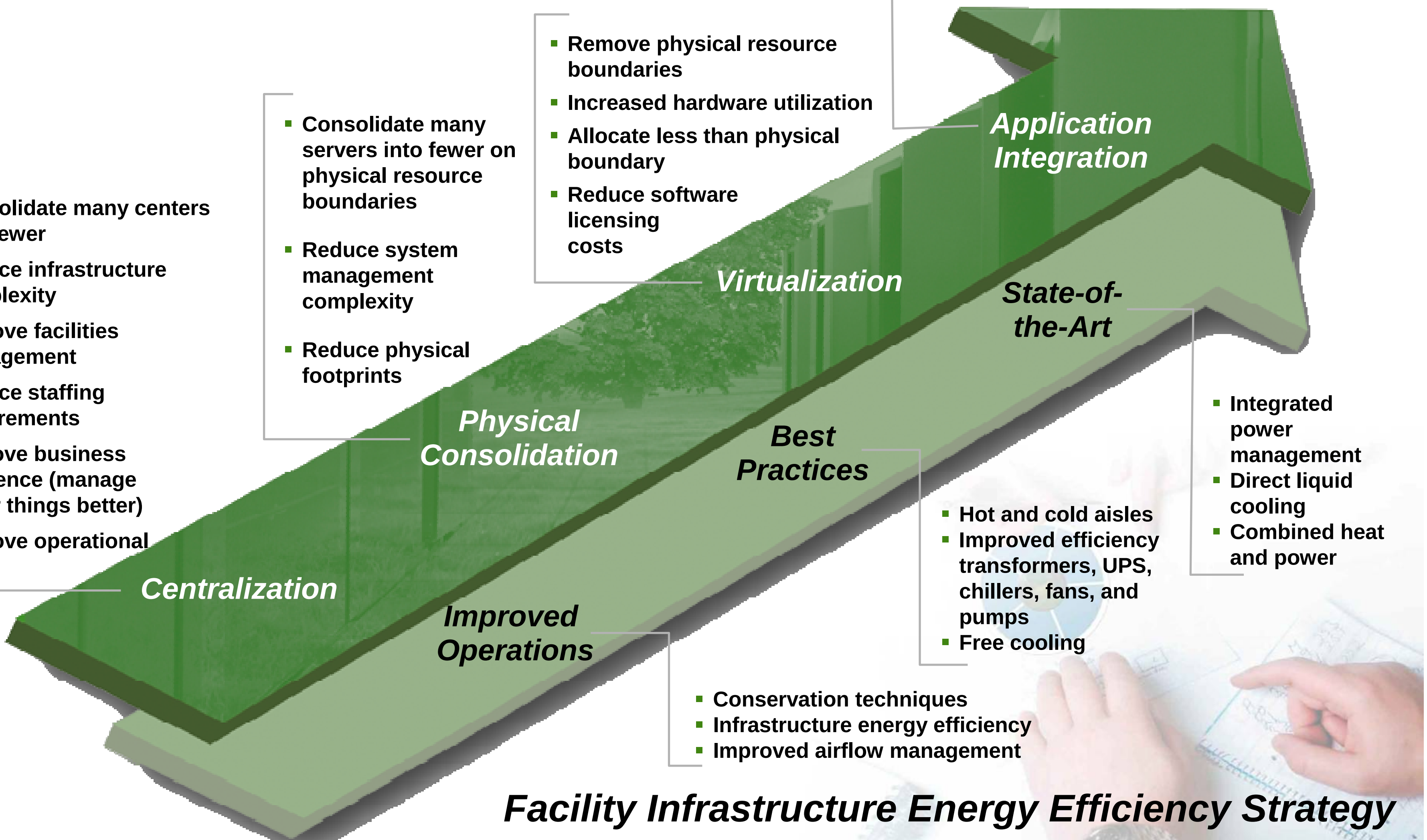



**Base Products Remain Air Cooled**

At least 15% energy savings on cooling energy by switching from air to water

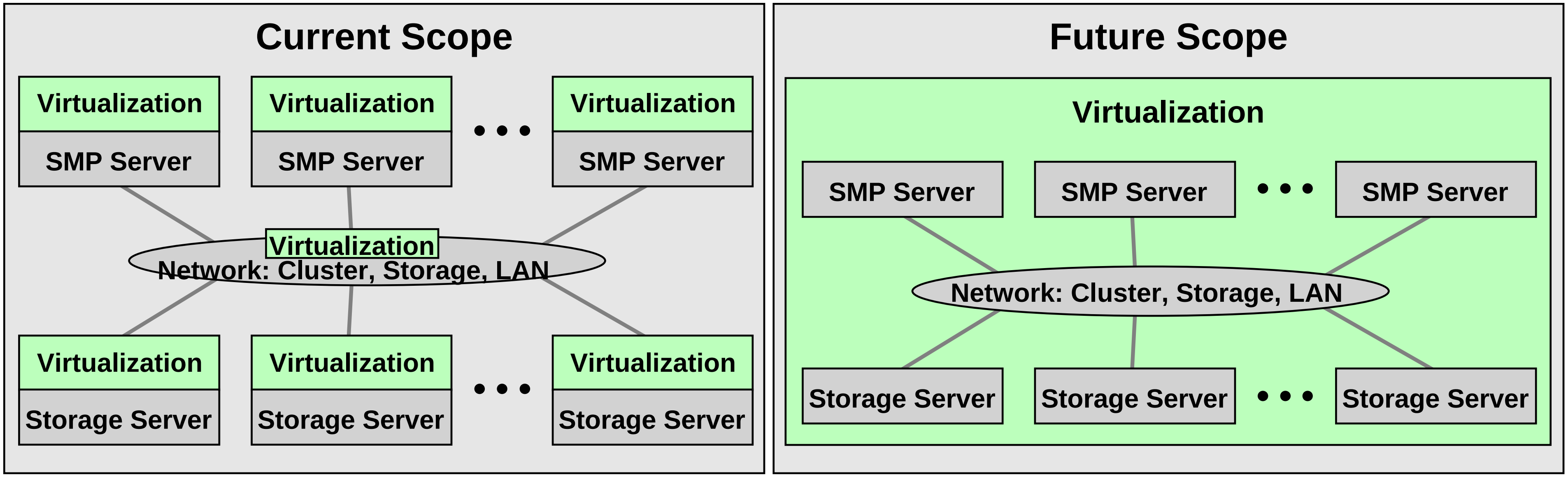
# IBM's Data Centers

## *IT Infrastructure Energy Efficiency Strategy*




## *Facility Infrastructure Energy Efficiency Strategy*

# The Scope Of Virtualization Will Increase

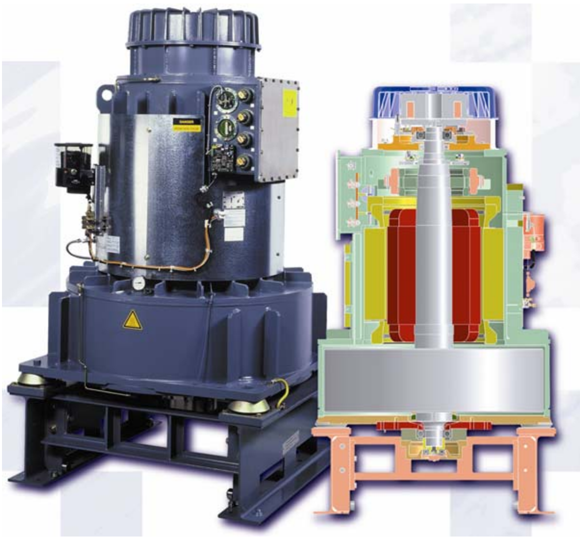



- Server virtualization will be extended in scope from single servers to aggregations of servers, storage, and network components.
- Traditional view of virtualization:
  - **Make a large system look like many – partitioning technology**
- Evolving to the next level:
  - **Make many small systems look like one from a management perspective**

## The future of Virtualization and Green

# Futures

- **Facilities**
  - Use of Flywheel / fuel cells to replace UPS batteries
  - Use of on site power generation to make utility feed the backup power source; reuse waste heat
  - Use noise cancellation materials
- **Information Technology**
  - Aggressive green server consolidation and virtualization
  - Processor, server, and rack level power management
  - Data center level power management
- **Both**
  - Implement recommendations of EPA report to Congress
    - Energy Star metrics for server efficiency
    - Server level power management
    - Direct liquid cooling
    - Improved air flow management
  - SPEC transaction power metrics
  - Green grid data center level energy efficiency metrics
  - Integrate Facilities and IT Equipment Operation to Optimize Cooling Delivery & Energy Usage



Flywheel as kinetic energy storage

# Changing landscapes - new technologies will need to be harnessed

# The New Enterprise Data Center

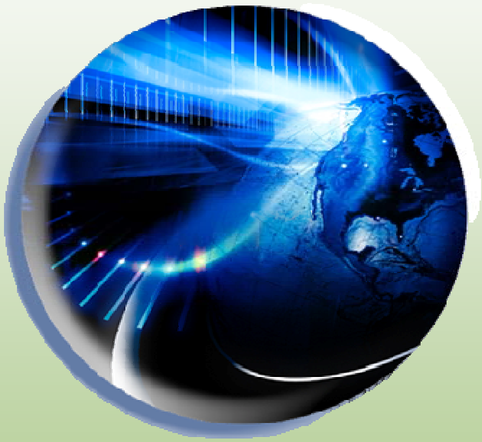

- **New economics:** Virtualization breaks the lock between IT users and IT resources
- **Rapid service delivery:** Service management enables visibility, control and automation to deliver quality service at any scale
- **Aligned with business goals:** Real-time integration of transactions, information and analytics - and delivery of IT as a service

# Stages of adoption

**Simplified**

**Shared**

***Dynamic***



# Summary

- **Companies in every industry are exploiting advanced technology to gain competitive advantage**
- **Infrastructure complexity and rising energy costs are driving higher operational costs for companies and constraining their growth**
- **The New Enterprise Data Center offers an evolutionary new model for efficient enterprise IT delivery addressing this changing landscape**

# The New Enterprise Data Center has far reaching benefits –

- ***Triple asset utilization***
- ***Provision new resources in minutes***
- ***Eliminate 80% of outages***
- ***Up to 60% heat reduction***
- ***Reduce floor space by 80%***
- ***Reduce disaster recovery time by 85%***

**reallocating resources from operations to innovation**

# What are the elements of a Green Program?

1. **Substantive**
   **Goals set and documented results reported across our business**

2. **Verifiable**
   **Transparent with 3rd party verification**

3. **Sustainable**
   **Partnerships and collaboration to demonstrate leadership**

4. **Check yourself against others**

climatecounts.org

IBM examples

IBM has reduced CO2 emissions by 44%

Annual corporate environmental reports for past 17 years

CLIMATE LEADERS
U.S. Environmental Protection Agency

Neuwing Energy Ventures

Chicago Climate Exchange

Energy Efficiency Certificates

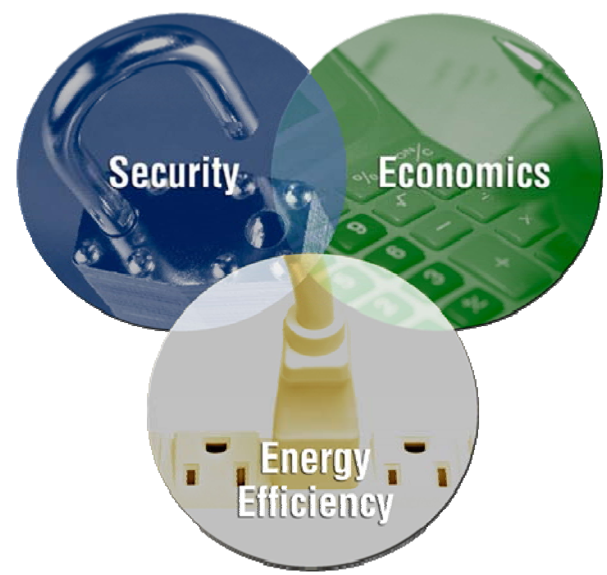
USEPA
Climate Protection Award
1998 and 2006

The Climate Group

Green Power Purchaser Award

# How can you help to Green Data Centers, save Costs and maybe the Earth?

- **Reduce waste and inefficiencies**
- **Power down resources when not in use**
- **Push Utilization levels to manageable limits**
- **Include Energy Consumption in Business Case**
- **Take a Holistic approach to System Evaluations**
- **Conduct a “Green Assessment”**
  - Green Initiative
- **Build a roadmap to an Optimized IT Infrastructure**
  - Create a plan from which tactical decisions can be made
  - Leverage IBM OIT Offerings

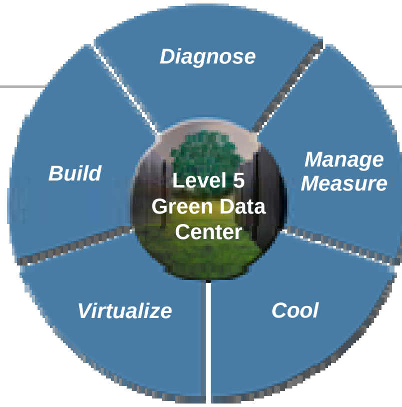


# Thank You

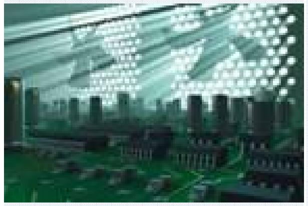
# Additional Details

- Energy Reduction Opportunities
- IBM Solutions
- Energy Efficiency and Carbon Management / SW
- Active Energy Manager
- Typical Power

# Benefits of a Green Data Center




## Green should
## Optimize IT and use our planets resources wisely

| | From | To |
|---|---|---|
| ***Financial***  | Rising global energy prices | Ability to accurate view baseline energy cost |
| | Squeeze on IT budgets | Cost savings from more efficient energy use |
| | Constraints on IT growth | Relax budgetary pressures to allow growth |
| ***Operational***  | High density server systems | More computing performance per kilowatt |
| | Exploding power & cooling cost | Shift energy to cool / energy to operate ratio |
| | Systems availability risks | Extend the life of IT equipment |
| ***Environmental***  | Corporate social responsibility | Meaningful energy conservation |
| | Lack public image | Improved public image |
| | Improve employee moral | Positive contribution to the Green movement creates a good place to work |

# Potential Energy Efficiency Opportunities Table 3-6

- **Computing software** Design software to avoid excess code and inefficiencies treat CPU cycles as a finite resource) Provide developer tools to help improve efficiency of software Enable shifting of computational load among systems for maximizing energy efficiency Upgrade applications no longer supported on latest technology and/or operating systems, allowing removal of legacy servers Implement virtualization to allow consolidation of server and storage hardware
- **IT hardware (computing, storage and network)** *Operational Improvements* Turn off (ideally remove) dead, obsolete, or excess equipment Turn off or power-manage equipment that won't be used for extended periods of time (e.g., development systems not in active use, systems for future expected increases in activity, etc.) Enable power-management features on existing equipment (e.g., frequency voltage scaling) Maximize utilization of storage capacity through shared data storage, data compression, and data de-duplication Accept high-efficiency power supplies over full operating range including DC-DC conversions) or directly accept moderate DC voltage Digitally control power supplies to better match output to load Use high-efficiency variable speed fans (within IT equipment) Reduce energy use at lower utilizations (whether the resource is processing capacity, memory, communications, or etc.). Applies to individual systems and to clusters. Improve microprocessors to lower leakage current, increase system integration, etc. Use storage virtualization and massive array of idle disks (MAID) technologies to allow storage power Use centralized servers (large systems to improve sharing of computer resources Improve hardware support for virtualization Use built-in power monitoring
- **Electrical Systems** Use high-efficiency power distribution (i.e., higher-voltage AC or moderate-voltage DC (50-600 VDC)) Use premium-efficiency motors in fans and pumps Use high-efficiency UPS units over full range of load Use rotary-based UPS units Right size power distribution and conversion to optimize efficiency Use on-site generation with grid as back-up

# Potential Energy Efficiency Opportunities Table 3-6 continued

- **Heat Removal** Improve airflow management (i.e., use hot/cold aisle configuration or penetration sealing) Adjust environmental conditions (temperature and humidity set points) to allow wider range while still meeting manufacturer specifications Optimize data center airflow configuration using visualization tools (computational fluid dynamics modeling or infrared tomographyUse high-efficiency variable-speed air-handler fans and chilled water pumps Use variable-speed chillers Use variable-speed, primary-only chilled water pumping Use high-efficiency chiller and chilled water supply motors Use high-efficiency CRAC units Use air-side economizers (outdoor air) when outdoor conditions permit (preferably in mild climate locations) 54 (operation) ) (server count Use water-side economizers (cooling tower) when outdoor conditions permit (preferably in mild climate locations) Commission infrastructure systems to ensure set points are at proper values, sensors are in calibration, airflow is within design tolerances, etc. Rebalance air-handler system after significant IT reconfiguration Size systems and configure redundancy to maximize efficiency e.g., use redundant air-handler capacity in normal Increase chilled water supply and return temperature difference to reduce chilled water flow Optimize chilled water plant (cooling tower) Reuse waste heat for space heating Use direct liquid cooling (water or other dielectric liquid with currently available technologyi.e., in-rack or in-row cooling) and emerging technology (i.e., in-chassis or chip-level)
- **Controls and Management** Use system management hardware/software that enables powering down (to sleep and/or off) parts of server clusters during times of low utilization Dispatch non-time-sensitive computational operations to reduce peak computing load and allow reduction of total Provide for standard reporting of power use, platform temperature, and processor utilizations to assist operators in understanding and managing energy use in their data centers Use shared computing models, such as grid computing Optimize cooling controls to dynamically match the cooling supply to the IT heat load Dynamically optimize the assignment of work across the data center to ensure maximum efficiency Monitor power in real time
- **Distributed Generation** Use combined heat and power Use renewable energy (e.g., photovoltaic panels) Use fuel cells
- *Each opportunity is not necessarily applicable to all data centers

# Cool – Georgia Tech University Supercomputer Center

***Innovative design using IBM cooling technologies to support highest computational performance and save $780K in costs***

## *Client requirements*

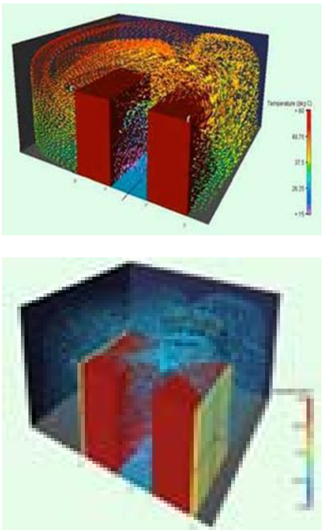
- **Highest possible computational performance**
- **Address heat output from ultra-dense blade servers**
- **Limited by budget and floor space**

## *Solution*

- **IBM System Cluster 1350 with 1,000 IBM BladeCenter® LS20 nodes each with 4 AMD Opteron cores**
- **Combines standard air conditioning and IBM Rear Door Heat eXchanger**
- **Unique data center design with open floor titles on cold aisles and directional baffles**

## *Benefits*

- **Maximum LINPACK performance of 8.5 TFlops**
- **Saved an estimated $780,000 in total data center costs**
  - 10-15% reduction in operating costs
  - 55% reduction in air conditioning requirements
  - 50% lower airflow requirements for less disruption and less noise



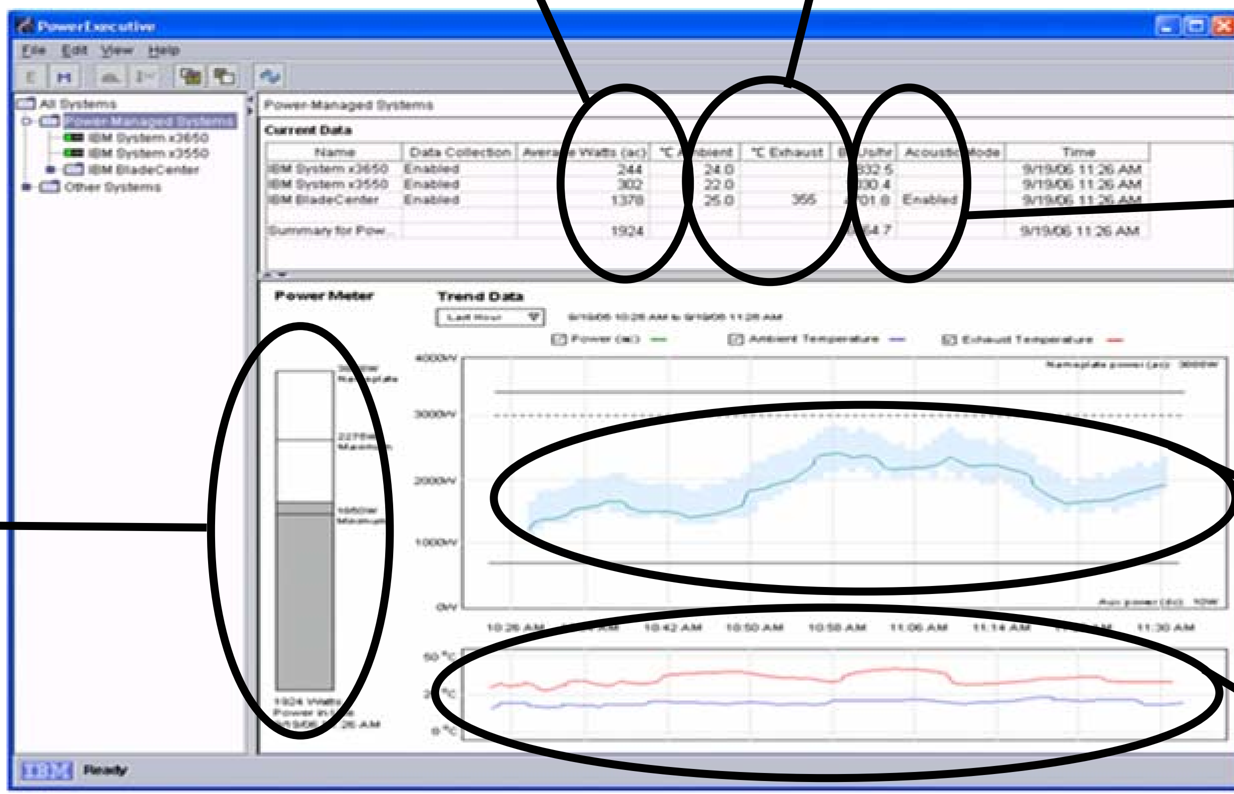
*“Our innovative data center design, allied with the IBM technologies, enabled us to pack a huge amount of computing power in a compact space.…more cost effective and environmentally friendly than a traditional design while offering the same compute power.”*

# Measure and Manage: Measure, trend, cap

Use **IBM Director Active Energy Manager** to meter actual power usage and produce trend data for any single physical system or group of systems.

**Compare actual vs. name plate power at system level**

**View inlet and exhaust temperature**




**Track heat emitted**

**Compare rack actual power vs. label power**

**Trend power use over time**

**Trend temperature over time**

## What are Energy Efficiency Certificates (EECs)?

- Also known as White Tags
- A new tradable attribute similar (but different process) to RECs
- Represents the value of energy not used (conserved) in Data Centers or other facilities' efficiency programs
- An emerging method to verify your programs by a 3rd party
- Created through the implementation of energy conservation projects on the demand side

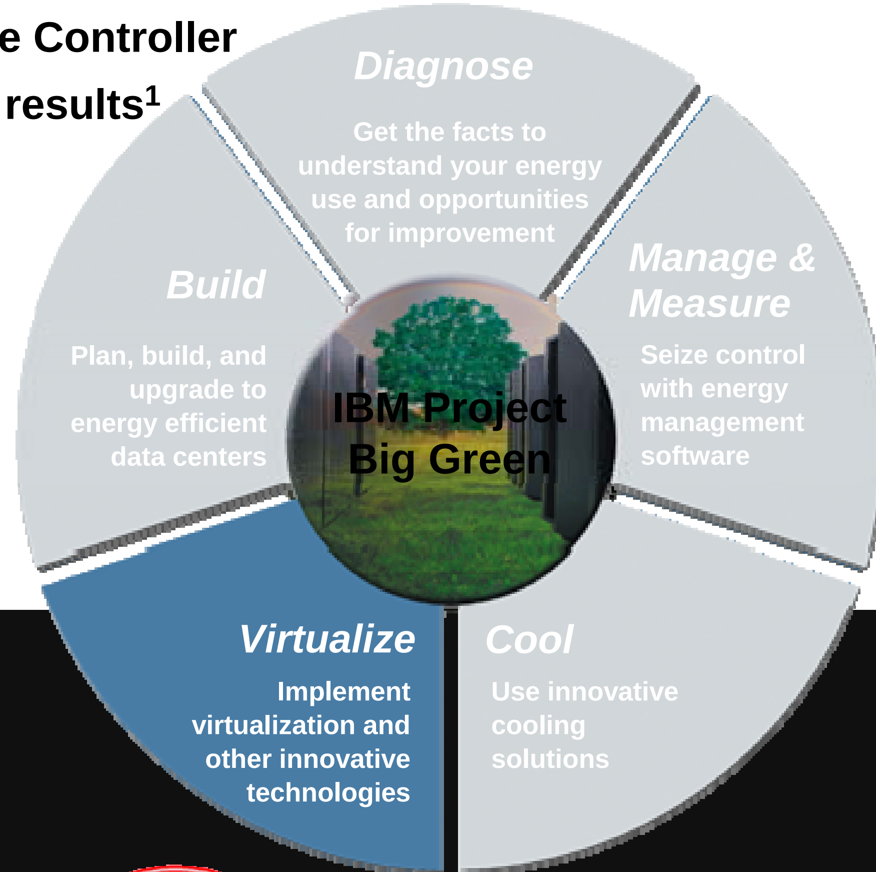



# Virtualize – Implement virtualization and other innovative technologies

- *IBM and our clients are seeing results from virtualization of servers and storage*
  - **Double storage utilization with SAN Volume Controller**
  - **Up to 10:1 are typical server consolidation results[1]**

*"Energy efficiency is the number one priority for PG&E as we work with our customers to meet our environmental goals. We're thrilled to partner with IBM to pilot energy efficiency innovations that can help our customers save money and protect the environment by further reducing their energy use."*

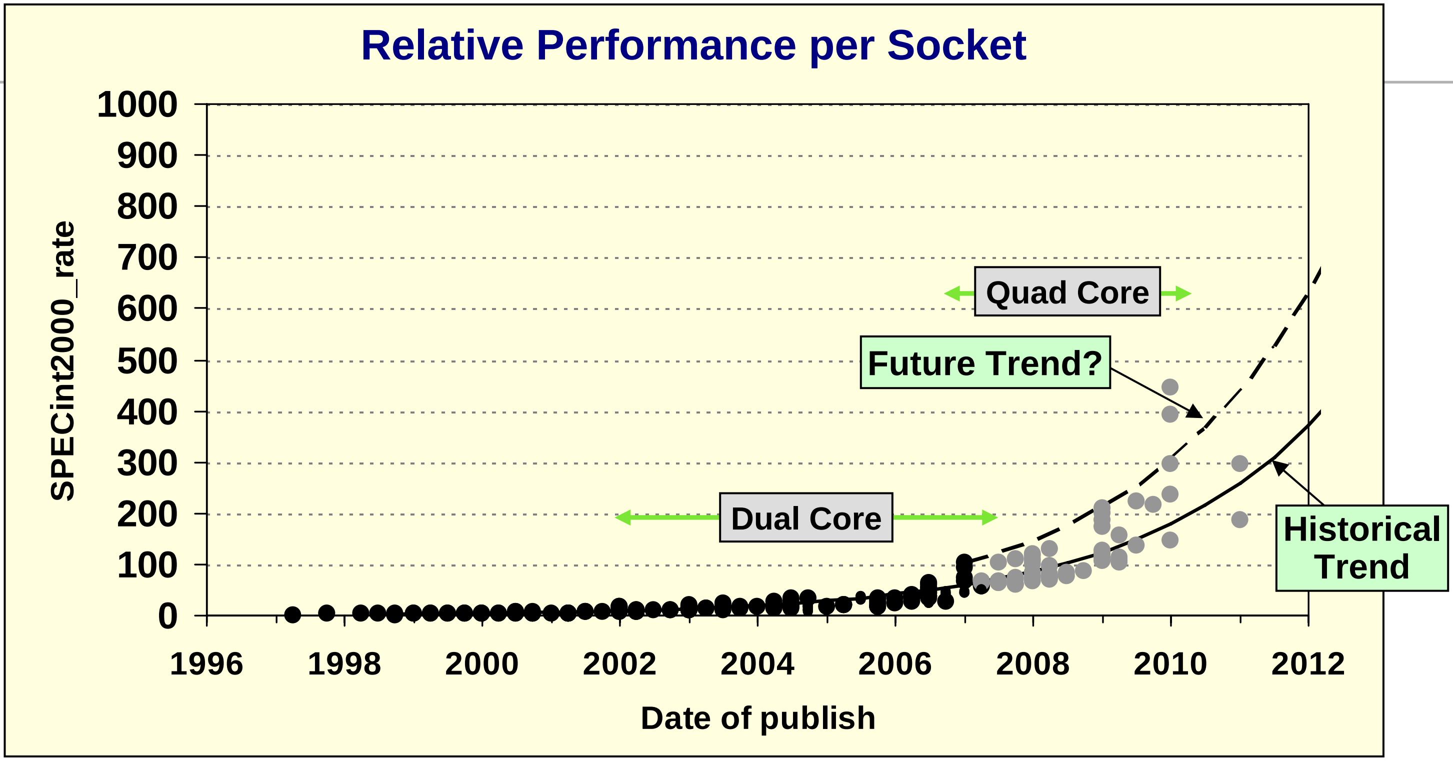
Brad Whitcomb,
VP, Customer Products & Services,
PG&E





 1. Gartner, *Toolkit: The Impact of Virtualization on Data Center Facilities*, G00148020, June 2007.

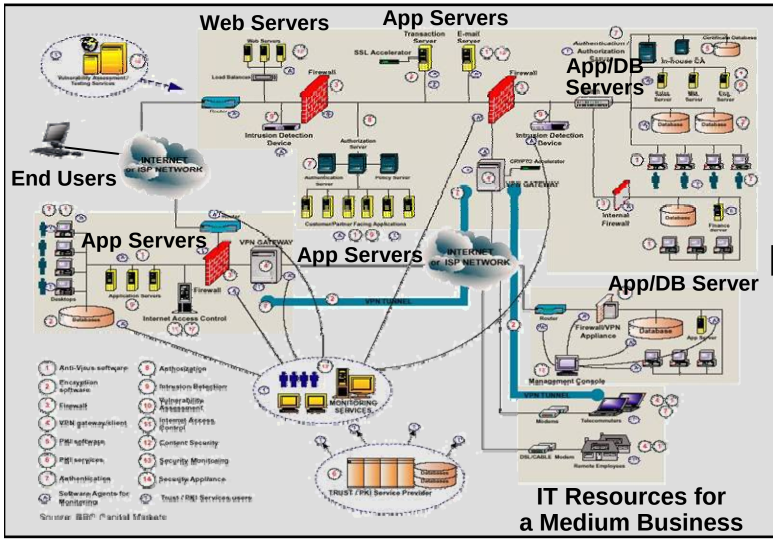
# Increasing Performance/Chip Will Foster Virtualization




- **If an IT organization does not virtualize, they will purchase large amounts of capacity that they will never use, and waste energy.**
  - Performance per chip is getting very large, very fast.
  - Parallelism per chip (cores and threads) is exceeding individual workload capabilities.
- **Any overhead created as a result of virtualization will be easily covered by the growth in CPU performance.**
- **Thus, the increasing microprocessor performance per socket will both drive and enable the growing use of virtualization.**

## IT with Future Virtualization and Mgmt. Software

### IT Without Virtualization




- Rigid configurations
- Fixed resources per server
- Low server utilization
- Wasted energy and floor space
- New HW impacts SW assets
- Servers managed individually

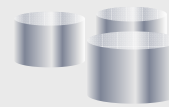
### Future Virtualized IT

**Virtual Environment**

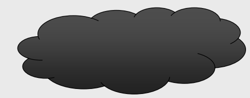
- Virtual resources are easier to deploy, grow, move, …
- Virtual resources and their configurations are decoupled and insulated from physical environment

Virtual Clients

Virtual Servers



Virtual Storage



Virtual Networks

**Virtualization**

**Decouples Virtual and Physical Environments**

**Physical Environment**

Blades

SMP Servers

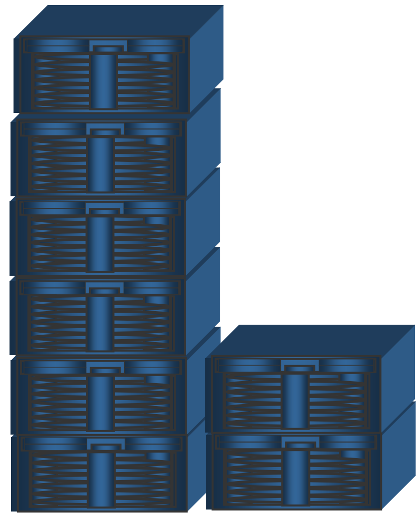
Storage Servers and Storage

Network Hardware

- A new era is dawning in which virtualization with new management software will significantly reduce IT costs and energy consumption
  - and fulfill "on demand" / SOA needs.
- **This will play out via incremental enhancements to existing data centers.**

# Go Green and Save up to $16.5K per year on energy costs with one System p 550 Express and PowerVM technology!

***You can consolidate eight non-virtualized Sun Fire V490 systems at 20% utilization into one System p 550 servers at 60% utilization with PowerVM technology***



- ***87% fewer cores dramatically reduces per core SW costs***
- ***89% less power consumption***
- ***90% less space***

- **64 total cores @ 2.1 GHz**
- **$18,396 annual energy costs @ $0.10/kWh**

- **8 total cores @ 4.2 GHz**
- **$1,840 annual energy costs @ $0.10/kWh**


See next page for full substantiation detail
Based on SPECint_rate2006 8-core comparison as of Jan. 29, 2008. www.spec.org

# Help lower your energy usage: Virtualized BladeCenter JS22 Express configuration vs. non-virtualized Dell PowerEdge 860 configuration[1]

- Fourteen BladeCenter JS22 Express blade servers, each with 12 GB memory, IBM POWER6 4.0 GHz processor, chassis, switches and storage is estimated to consume **79,802 KWhr/year[2]**
- Three racks of 112 Dell PowerEdge 860 servers each with a Dual Core Intel Xeon 2.13 GHz processor, 1 GB memory and 2 x 80 GB SATA drives is estimated to consume **186,589 KWhr/year[2]**

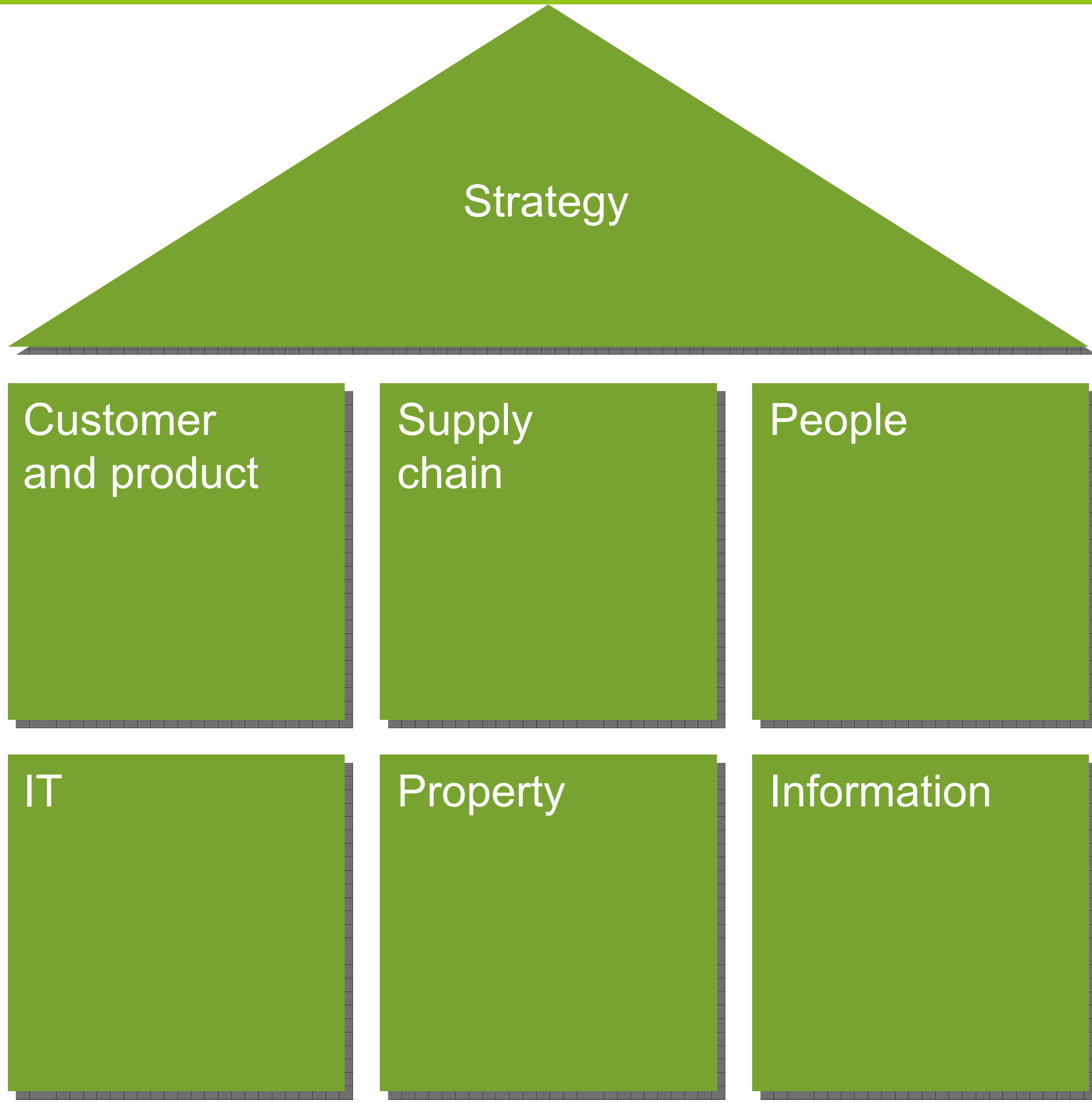
**Potential for electricity usage savings for power and cooling**

- ***IBM BladeCenter JS22 Express configuration estimates are up to 57% less energy annually[2]***

(1) (2) Additional information can be found at the following Web site: http://www.ibm.com/systems/p/hardware/notices/webtier.html

# House of Carbon





# Optimised IT Environment Maturity Model (Green Enablement)

IBM


Main Menu

Operations Management

IT Operations

Operations Strategy

Facilities Management

Architecture

Development

Development Management

Business Management Requirement

Business Requirement Definition

Business Requirement Strategy


Controllable Green IT Service

Energy efficient Datacenter

Virtualisation & Management of IT environment

Energy aware IT Optimisation leading to Consolidation

| | LOGICAL CONSOLIDATION | PHYSICAL CONSOLIDATION | DATA CENTER CONSOLIDATION | GREEN DATA CENTER |
|---|---|---|---|---|
| Process & Tools | •Development of enhanced Systems Management Tools to manage both physical and virtual systems & assets<br>•Common Reporting | Enhancement to key process:<br>• Configuration& Asset<br>• Performance & Capacity<br>• Problem & Incident<br>• Service Level & Availability | •Optimisation of Process Development of new process<br>•Establishment of environmental monitoring | •Development of Enhanced Systems Management across<br>•environment for optimal use |
| Technology | •Implement Virtualisation for Sustained benefits<br>•Enable application consolidation | •Reduction in disparate systems<br>•Increased server & storage utilisation<br>•Tiered Storage | •Reduced requirements for power across an enterprise<br>•Greater concentration of IT – reducing physical footprint<br>•Improved Cabling/Racking | •Ability to control/optimise power/<br>•Performance ratio<br>•Improve Cooling Heat exchange –<br>•Recycle – optimise power consumption |
| Services | •Enablement of Virtualised Services<br>•Optimisation of Services across applications/databases | •Reduction in the number of services & applications<br>•Concentration of services to key operational centers | •Greater definition/granular of Service from concentrated Environments<br>•Re- focusing on daily service window | Business Services tuned to power efficiency<br>Services operating at most efficient times |
| Organisation | •Respond to growing business demands with virtualised resources<br>•Increased consolidation of operations & staff | •Increased consolidation of staff<br>•Opportunity to regionalize by function – Global Resource | •Reduced requirement for travel to DataCenter<br>Optimised Global Operations | Minimal staff working within the Data centre<br>Remote access and working & operations |

Optimised IT Environment Maturity Model (Green Enablement)

Main Menu
Operations Management
IT Operations
Operations Strategy
Facilities Management
Architecture
Development
Development Management
Business Management Requirement
Business Requirement Definition
Business Requirement Strategy

# Energy & Carbon Management Issues Guide

- 6 Brands offering 90 aligned solutions across 68 key IT issues
- Client Issue: Start Point: Solution: End Point: Engagement Activity: Product
  - Operations Management
  - IT Operations
  - Operations Strategy
  - Facilities Management
  - Architecture
  - Development
  - Development Management
  - Business Management Requirements
  - Business Requirements Definition
  - Business Requirements Strategy

Tivoli software
WebSphere software
Lotus software
Information Management
Rational software

# A comprehensive suite of solutions that can help drive the energy and carbon agenda for our clients

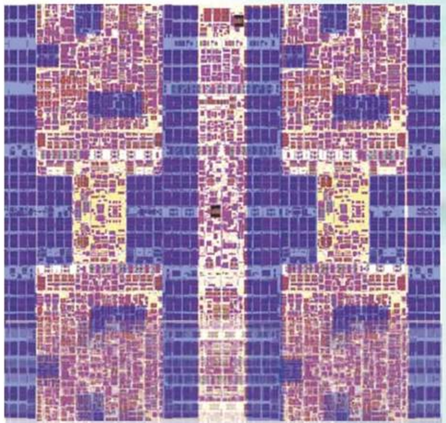
- Solutions that encompass many aspects our clients are addressing
  - Developing smarter software
  - Monitoring IT and Facilities as a holistic eco system
  - Collaboration tooling for saving travel and time
  - Smart modelling of leaner more carbon efficient processes
  - Integration to hardware and infrastructure
  - Supporting DCoF initiatives
  - Detailed meta data, and converged asset management
- Experience within the industry at deploying software based solutions that meet business demands

# Making high performance a reality

- **New Enterprise Quad Core z10 processor chip**
  - 4.4 GHz - additional throughput means improved price/performance
  - Cache rich environment optimized for data serving
  - 50+ instructions added to improve compiled code efficiency
  - Support for 1MB page frames

- **Hardware accelerators on the chip**
  - Hardware data compression
  - Cryptographic functions
  - Hardware Decimal Floating point

- **CPU intensive workloads get performance improvements from new core pipeline design**



**Enterprise Quad Core z10 processor chip**