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Tapping the Energy Efficiency Opportunities in Information Technology Infrastructure

Presented to:

American Council for an Energy Efficient Economy
Energy Efficiency as a Resource Option
Denver, CO
September 26, 2011

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While large data centers represent a significant opportunity for energy efficiency (EE), the related IT infrastructure represent a big opportunity for utility and upstream programs.

- Market
- Opportunities
- Program Options
- Conclusions & Recommendations

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In 2006, data centers consumed an estimated 61 billion kWh (1.5% of U.S. total electricity), while other IT devices use even more.

- This is more than the electricity consumed by the nation's color televisions and similar to the amount of electricity consumed by approximately 5.8 million average U.S. homes.[1]
- Since 2006, the growth of data center energy use has continued to grow, despite an economic slowdown and major efficiencies such as virtualization.
- It is estimated that data centers now use 2% of all electricity use for the U.S. and 1.3% of electricity worldwide.[2]

[1] *Report to Congress on Server and Data Center Energy Efficiency* (2007).

[2] Koomey, Jonathan. *Growth in Data Center Electricity Use 2005 to 2010* (2011).

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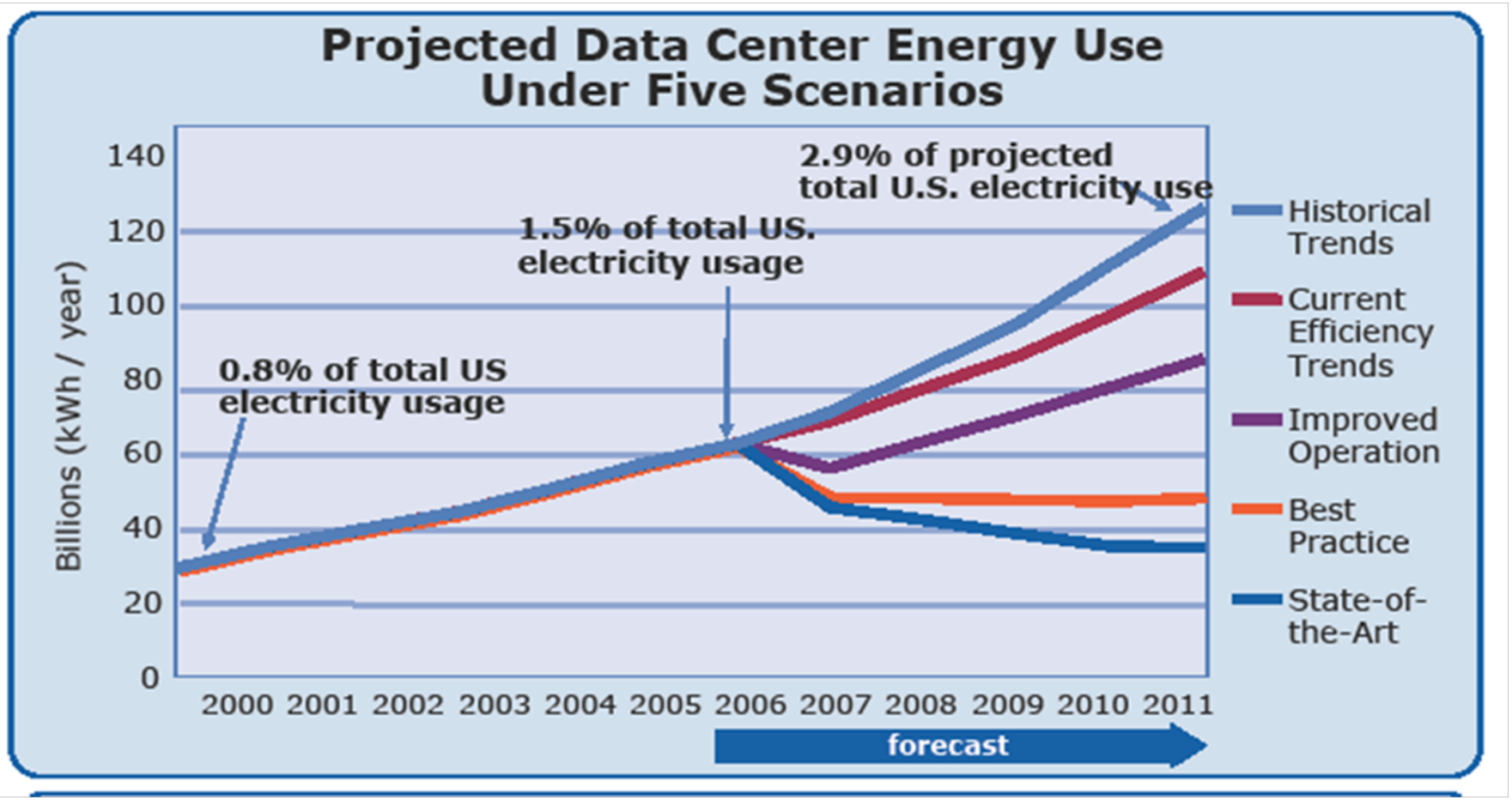
Large data centers are probably tracking the improved operation scenario due to innovation, commitment of major companies and that electricity is the major operating expense



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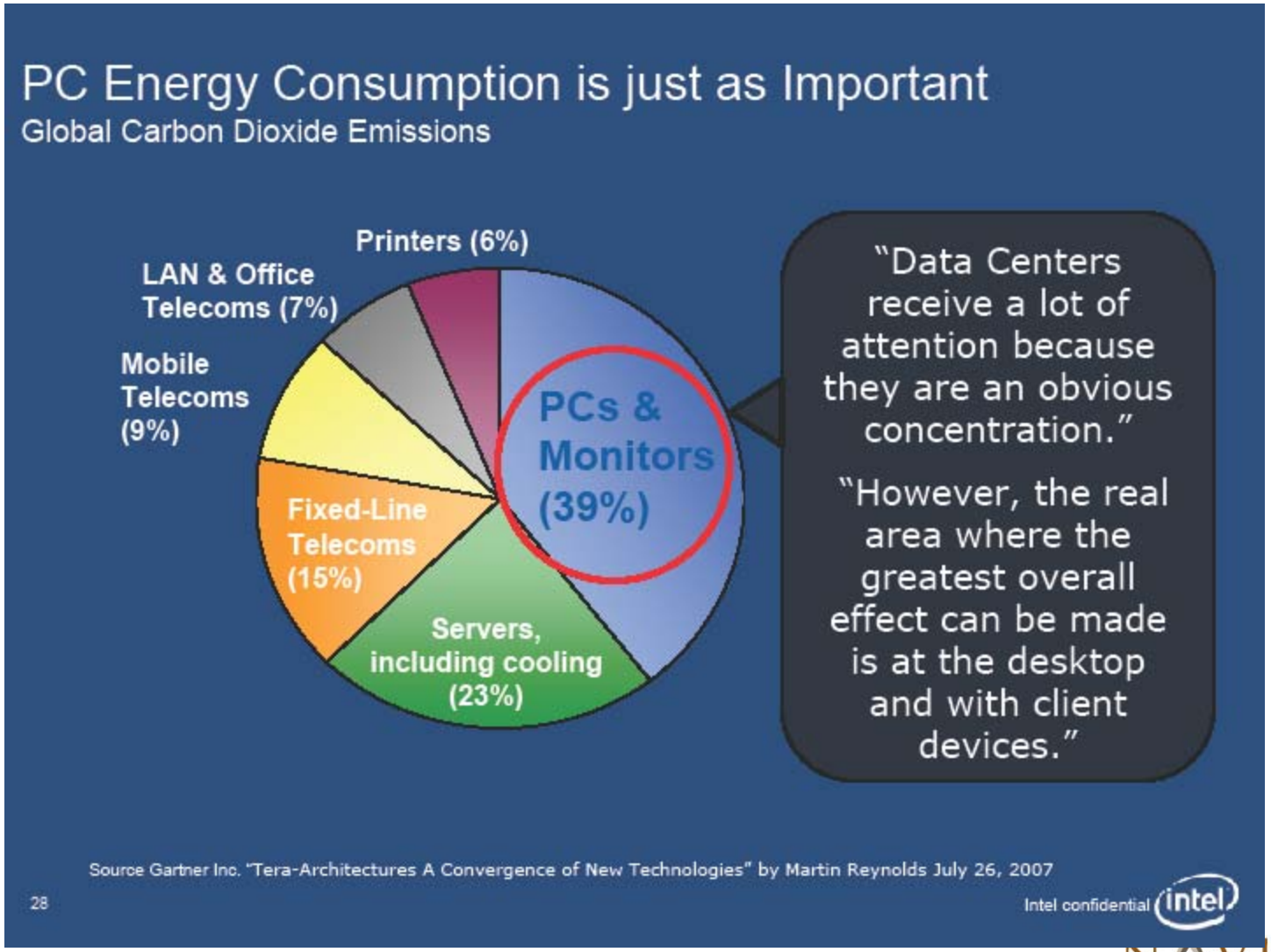
Although large data centers grab the headlines, many server spaces are much smaller in scale, and network devices are a major consumer and opportunity.

- The size of server spaces vary widely from server closets (< 200 ft^2) with one or two servers to enterprise level data centers (> 5000 ft^2) with hundreds
- As a result, while some energy savings opportunities are available to all data center types, some are limited to larger or smaller facilities.
- At least as much attention should be directed to network connected devices.

Network connected devices use at least as much energy as services and represent a major opportunity.



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Office equipment is now the third largest and fastest growing energy end-use in office buildings.

- Office equipment accounts for 18% of electricity in California's small and large offices:
  - 66% is contributed by computers and monitors.
  - 17% is contributed by other office electronics, such as printers and copiers.

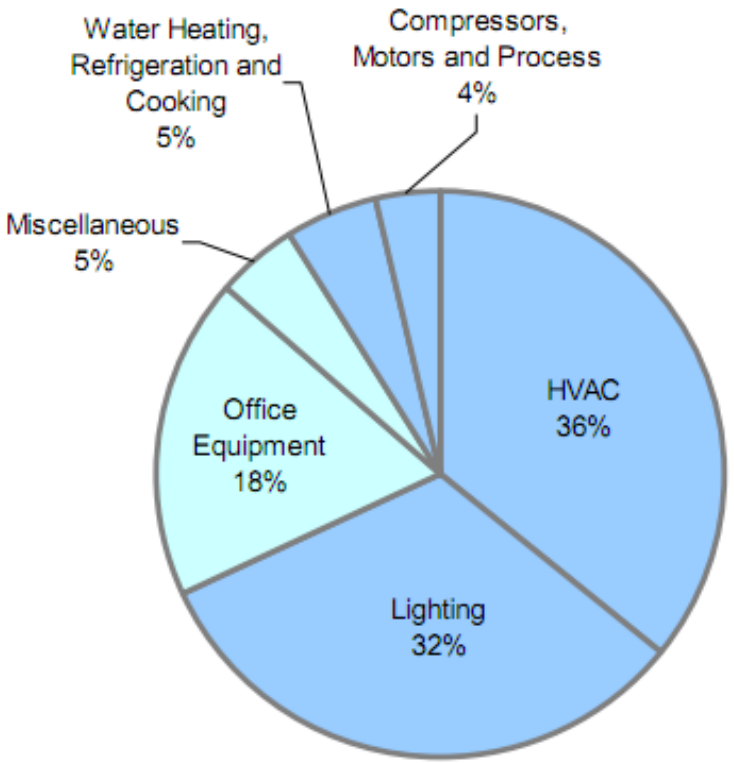

Figure 1. California's office electricity consumption
Source: California Energy Commission, 2006

Source: California Commercial End-Use Survey

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There are a broad array of opportunities, some emerging, for reducing the energy usage in data centers and networked devices.

Cooling	Electrical	IT
• Air management • Hot/cold isle setup • Free cooling • Centralized air handlers • Low pressure drop systems • Fan efficiency • Cooling plant optimization • Direct liquid cooling • Right sizing • Heat recovery • Building envelope	• UPS* and transformer efficiency • High voltage distribution • Premium efficiency motors • Use of DC power • Standby generation • Right sizing/redundancy • Lighting • On-site generation • Power supply efficiency	• Standby/sleep power modes • IT equipment fans • Virtualization • Load shifting • Power management • Thin clients • Remote monitoring

*Uninterruptible power supply

List derived from DOE presentation by William Tschudi, LBNL (2008)

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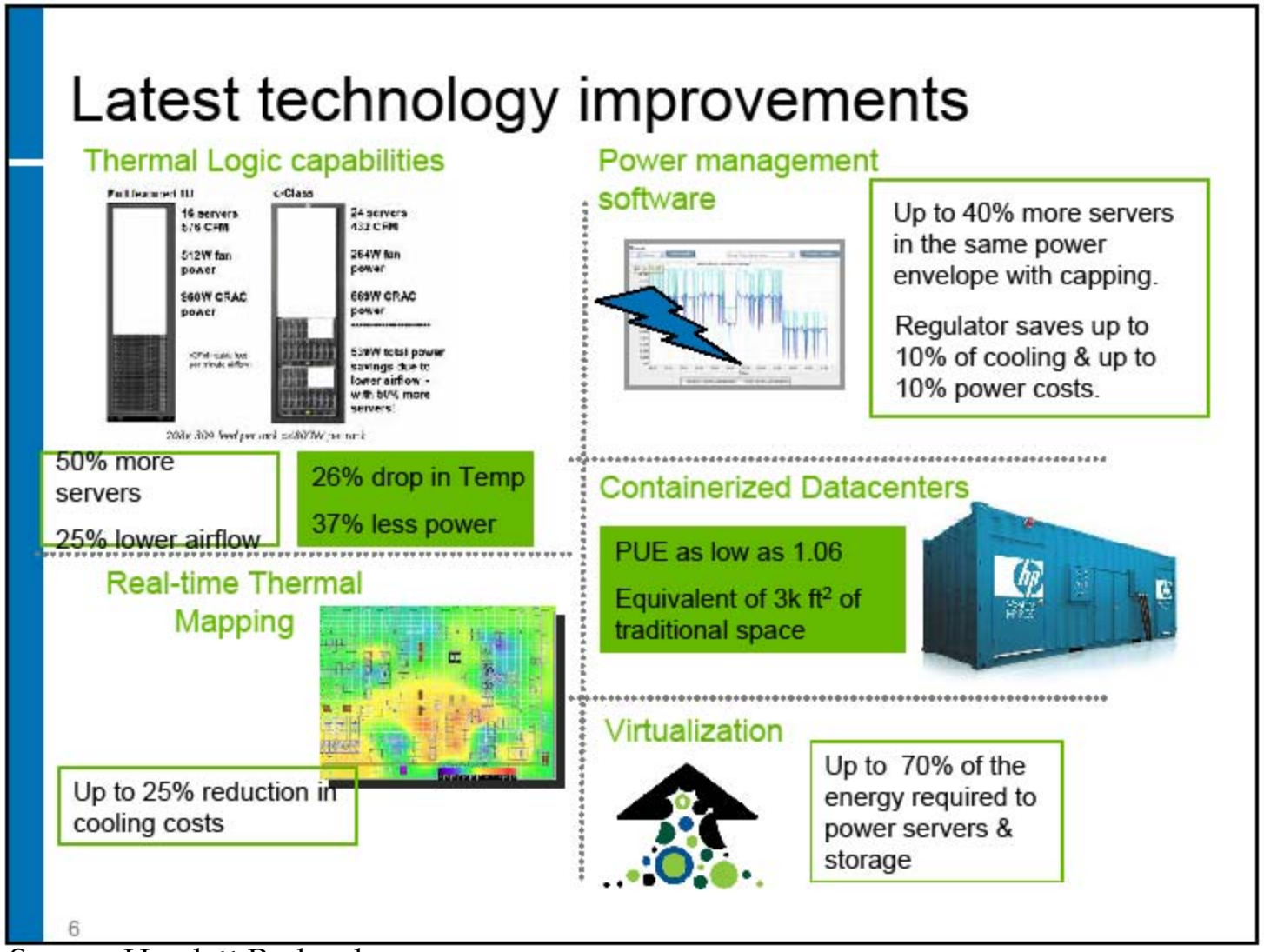
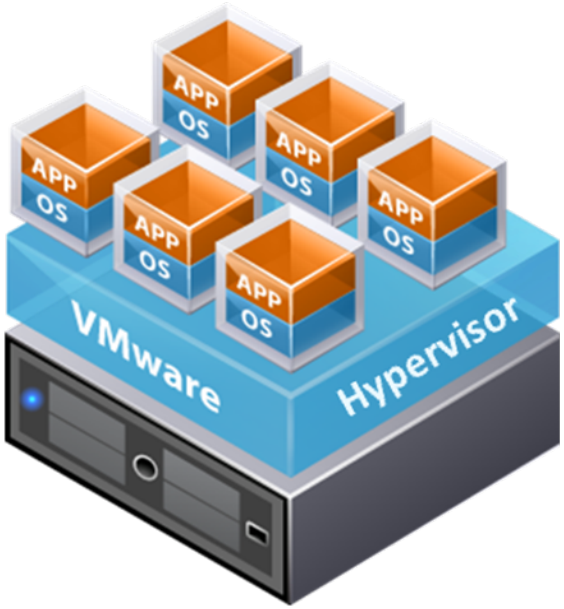
Innovations are addressing all aspects of the data center energy usage.



Source: Hewlett Packard

Virtualization, is being rapidly adopted by large data centers, but opportunities remain in server rooms and in powering down low utilized servers.

- Volume servers typically operate at an average processor utilization level of only five to 15 percent.
- At such low utilization levels, these servers will consume anywhere from 60 to 90 percent of their maximum power. [1]
- Virtualization allows many physical servers operating at low utilization levels to be replaced with fewer servers that provide the same services and operate at higher average utilization levels.
- Virtualization is made possible by *hypervisor* software which allows a single server to host many virtual OS instances.



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Many opportunities around virtualization remain, despite the high adoption rates among the major server farm operators.

Cost Effectiveness

- Virtualization has been shown to be highly cost effective, providing reduced server energy, cooling energy, and O&M costs.
- Our analysis for the BPA found virtualization to be cost effective even for smaller applications, such as an office building wishing to consolidate five physical servers to one.

Free-Ridership Debate

- PG&E and BC Hydro have ended their virtualization rebate programs, citing free ridership issues.
- Organizations such as the Green Grid and other data center experts argue that virtualization is being adopted primarily by larger tech savvy operations and that there are still plenty of opportunities for smaller data centers and office buildings.1

Server Management

- Recent surveys indicate that 10% of servers are idle after virtualization and that there are additional savings opportunities from managing idle servers.

[1] The Green Grid, *An Analysis of Server Virtualization Utility Incentives*, http://www.thegreengrid.org/library-and-tools

Improved UPS systems will yield (low) savings but developing technologies could be promising.

Description of Concept
A portion of all the power supplied by the UPS to operate the data center equipment is lost to inefficiencies in the system. Several options are available to improve efficiency: Improved battery UPS system design, flywheel-generator systems, and fuel cell-based UPS systems.
Technology Status/Risk Issues
• Improved battery systems are commercially available • Flywheel systems are commercialized and rapidly maturing but reliability is unproven • Fuel cell systems are available but still developing • **Time to market:** Currently available but continuously developing
Market Development Issues
• **Cost:** Low incremental cost for improved battery systems; flywheels and fuel cells are more expensive • **Key Non-Energy benefits:** Potential reliability improvement during power failure • **Risks and market barriers:** Unfamiliarity of new technologies & methods to data center operators

References: http://hightech.lbl.gov/documents/DATA_CENTERS/06_DataCenters-PGE.pdf

Improved data center design offers relatively low incremental costs with equipment available today.

Description of Concept
Improved data center design can include improved air flow design, centralized air handling systems, and variable CRAC compressors. Methods of improving airflow include hot aisle/cold aisle design, airside economizers, pressurized cold aisle compartments, flexible barriers, ventilated racks, and optimized supply/return configuration. Centralized air systems use larger motors and fans, and can be more efficient than traditional designs.
Technology Status/Risk Issues
• Design-based solution • Currently available • Time to market: Current
Market Development Issues
• Cost: Varies depending on items implemented. Relatively low incremental cost, retrofits more expensive • Key Non-Energy benefits: Better temperature control, reduced maintenance, increased comfort for employees • Risks and market barriers: Awareness among data center operators, low incentive for designers and contractors

References: http://hightech.lbl.gov/documents/DATA_CENTERS/06_DataCenters-PGE.pdf

Direct liquid cooling offers many benefits beyond energy savings. Limited commercialization exists.

Description of Concept
Direct liquid cooling refers to a number of different cooling approaches that all share the same characteristic of transferring waste heat to a fluid at or very near the point it is generated, rather than transferring it to room air and then conditioning the room air. With savings of 30% or more in cooling energy.
Technology Status/Risk Issues
• Cooling coils are currently available, others are still in development • Maximum energy savings realized in combination with a waterside economizer or free cooling • **Time to market:** Current (cooling coils), 1-2 yrs for others
Market Development Issues
• **Cost:** Relatively low for data centers with chilled water; very expensive if chilled water system is not present • **Key Non-Energy benefits:** Higher rack power-densities (W/sf), reduced operating costs • **Risks and market barriers:** Frequent rack reconfiguration can make chilled water piping a challenge. Also leaks or condensate could damage electronic equipment.

References: http://hightech.lbl.gov/documents/DATA_CENTERS/06_DataCenters-PGE.pdf

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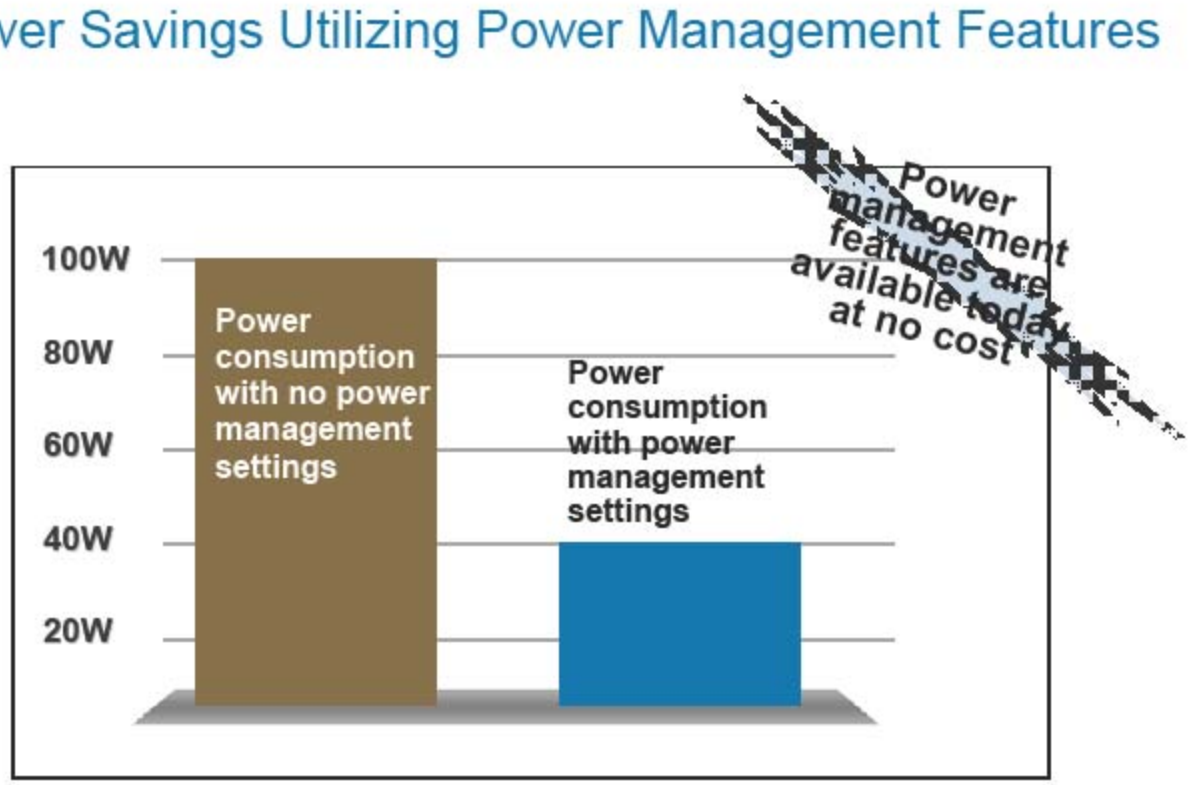
Remote command and control of CRAC units can optimize cooling based on variable server needs.

Description of Concept
A remote monitoring system combined with VFD CRAC units can improve cooling energy efficiency by 30%. Adaptive cooling techniques can optimize cooling to only the areas with the highest loads, thus reducing the amount of wasted energy. Combined with a virtualization or power management system, the entire data center can operate optimally by only utilizing and cooling servers that need to be operating, and leaving the rest of the facility on low-power standby.
Technology Status/Risk Issues
• Design-based solution • Currently available
Market Development Issues
• **Cost:** Varies depending on items implemented. Relatively low incremental cost, retrofits more expensive • **Key Non-Energy benefits:** Better temperature control, reduced maintenance, increased comfort for employees, enhanced clarity on M&V for rebate programs • **Risks and market barriers:** Awareness among data center operators, low incentive for designers and contractors, complexity for data center operators

References: http://hightech.lbl.gov/documents/DATA_CENTERS/06_DataCenters-PGE.pdf

New network power management system offer significant savings without the drawbacks associated with old "sleep mode" technologies .



Utilizing Standby setting alone can reduce power consumption by over 60%

climate savers smart computing

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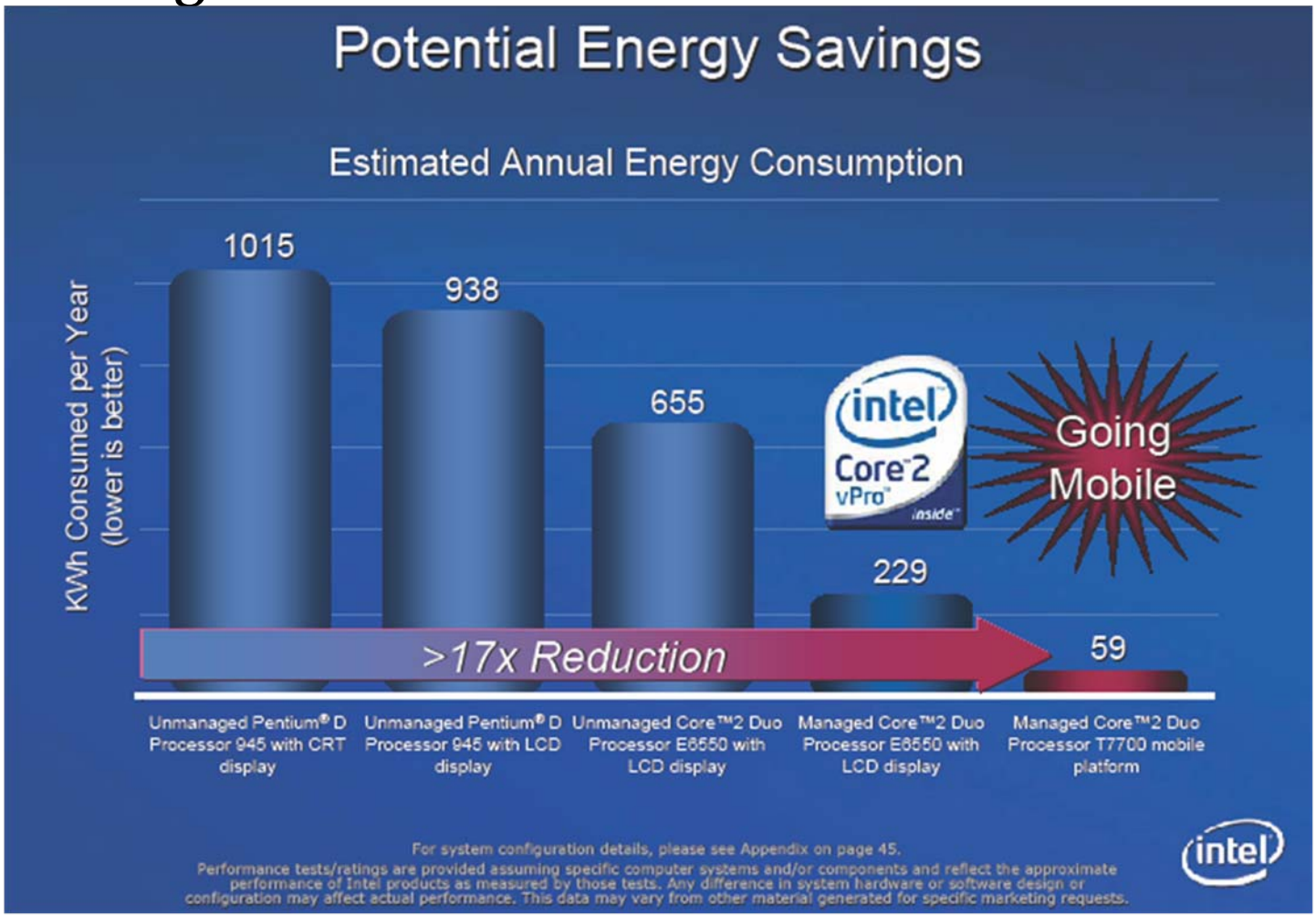
Conversion of desktops to laptops and thin clients provide large potential savings even relative to new processors with power management.



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Smaller data centers, especially server rooms and closets, may not have dedicated HVAC systems, thus savings opportunities are focused on IT equipment and the related infrastructure.

- ***Server power management (PM)*** adjust power usage to match the processor's activity level.
- ***Powering down*** -Where continuous PM features are not an option, powering servers down at night and on weekends.
- ***More efficient IT equipment*** – Specify efficient equipment, such as servers, regulators and UPS systems.
- ***Massive Array of Idle Disks (MAID)*** systems conserve energy by keeping frequently accessed hard drive disks spinning and rarely used discs idle.
- ***High-efficiency power supplies***. Use the 80 PLUS performance specification when purchasing power supplies.
- ***Virtualization*** – Server virtualization allows one server to act as multiple servers, serving multiple functions.

Many utilities now offer rebates and incentives related to the following data center technologies.

- Cooling system improvements
  - High efficiency equipment (chillers, pumps, fans, etc.)
  - VFD's
  - Air- and water-side economizers ("free cooling")
- Energy efficient computing equipment
- Virtualization/consolidation
- Airflow control systems
- High efficiency UPS and power distribution systems
- 80 Plus power supplies for personal computers (upstream incentive)
- Premium efficiency LCD monitors (midstream incentive)

Some early adopting utilities, such as PG&E, BC Hydro, and Austin Energy have offered additional data center rebates and incentives.

- Efficient data storage technologies, including Massive Array of Disks (MAID)
- Retro-commissioning programs for airflow management
- PC management software
- Thin client and zero client systems
- Remote monitoring
- Other customized technologies

Data Centers, servers, and network connected devices represent a significant and growing energy efficiency opportunity.

- **Market**
  - For most utilities, the best opportunities is in server rooms and networked connected devices.
  - Most opportunities are at least quasi-customized.
  - Technologies are rapidly evolving – monitor, pilot and case studies.
- **Program Strategy**
  - Support & partnership in Climate Savers and Green Grid may be best strategy to support market transformation for large data centers.
  - Outreach, sales approach and messaging is unique and different from conventional EE technologies – need segment specialist.