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PROMOTING EFFICIENCY IN DATA CENTERS

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According to a Ziff-Davis survey of almost 1200 key players in the data center industry,[1] more than two-thirds (71%) of the data center operators/owners identify information technology (IT) power, cooling, or both as the primary issue facing their data center, but 62% of the respondents reported that neither IT power consumption nor cooling concerns had affected server purchases in the preceding twelve months. There are three areas of potential public interest activity to focus on: 1.) Assessment of markets and savings potentials, 2.) barrier busting/market transformation, and 3.) research, development and demonstration.

I. ASSESSMENT OF MARKETS AND SAVINGS POTENTIALS

1) Segment market for servers and data center facilities by characterizing
   - Server capabilities (computation, storage, throughput)
   - Server energy use as a function of computing performance
   - Server installed base, shipments, retirements
   - Efficiency of power delivery and backup systems
   - Efficiency of cooling systems
   - Total floor area of data centers of different types, correlated with above data
2) Analyze (existing and emerging) technologies to improve efficiency for all components of the system, including hardware, software, and organizational improvements
   - Incremental improvements
   - Clean-slate, whole-systems redesign
3) Identify and analyze perverse incentives and other barriers to improved efficiency

II. BARRIER BUSTING/MARKET TRANSFORMATION

1) Metrics & Benchmarking:
   - Encourage manufacturers to measure energy use associated with performance benchmarks and to share that information with customers and the public at large (see EPA protocol released November 3, 2006)
   - Extend data center benchmarking activities to the National level, including detailed submetering of power use, power factor, network traffic, data flows, environmental conditions, and server utilization.
   - Develop a national benchmarking database
   - Identify and publicize best practices today

[1] <http://kz.sun.com/teleweb/x64-factor/Ziff_Power_and_Cooling_IT_survey.pdf>.

- Document financial savings for energy saving measures

2) Policies/programs: Attack perverse incentives and other barriers by aligning private incentives with societal goals. Most market participants accept current incentives as outside their control, but catalytic action from Government can change that in many cases

   - Demonstration projects (like LBNL DC demo)
   - Procurement by governments and businesses (Federal data centers can justify efficiency innovations based on cost savings alone, and then serve as examples to catalyze private sector innovation. These facilities can also be an important source of data on power use and other data center attributes)
   - X-prize/golden carrots: Prizes worked for rockets and refrigerators, they could work here also.
   - Energy Star, LEED, and/or other labeling strategies
   - Utility incentives and information programs

3) Capacity building: An integrated and highly targeted program patterned after the successful Laboratories for the 21st Century Program (see http://www.labs21century.gov/)

   - Partnerships (including high quality/specialized technical assistance)
   - Education and training (including conferences, workshops, telephone forums, peer to peer exchanges)
   - Tool kit (including benchmarking, best practice guides, case studies, and design guides and tools)
   - Outreach (e.g. articles in trade publications to publicize best practices)

4) Emerging technology evaluation and demonstrations (e.g. demonstrate and test emerging cooling solutions such as liquid cooling at the component, rack and row level)

5) Integration: Promote the integration of IT, facilities, financial, and management representatives into what the Uptime Institute calls integrated critical teams

6) Liaison with professional and trade associations: Work with data center user groups (like 7x24, Critical Facilities Roundtable, Data Center Dynamics, Uptime Institute, TechTarget, ASHRAE, and AFCOM) to disseminate the latest research on best practices

III. RESEARCH, DEVELOPMENT, AND DEMONSTRATION OF NEW TECHNOLOGIES, SYSTEMS AND PROCESSES

1) Software

   - Shift computational loads between computers to optimize processor power
   - Shift location of processing to reduce heat (within the same data center) or to reduce peak demand (from one geographical location to another)
   - Improve the efficiency of computer code

2) Improve efficiency of IT equipment (every kWh saved directly saves another kWh in cooling and infrastructure)

- Power conversion within servers (e.g., extending 80plus to servers, DC power, AC to the chip))
- Computational load flows (e.g. integrating power management with varying computing demands)
- Improved technologies (e.g. multi-core processors, new semiconductor materials,
- Clean-slate redesign of servers, storage devices, and network equipment

3) Improve the efficiency of the building and data center infrastructure
   - Adoption of ASHRAE thermal guidelines
   - Advanced air management to increase supply temperature and delta T (to increase cooling system efficiency and reduce fan horse power)
   - Advanced cooling systems at the component and rack level (e.g. enabling the move to liquid cooling)
   - Establish the science for use of outside air ("free") cooling of IT equipment and technologies to mitigate the risks (e.g. on board particle counters, and early warning sensors) along with tools to estimate energy savings with this technology.
   - Power distribution systems (reduce conversion losses, e.g. facility-wide 380V DC powering)
   - Pilot full-scale installations of DC power in operating data centers; develop consensus for distribution voltage; develop standard connectors and power strips for DC
   - Uninterruptible power systems (e.g. improve batteries, flywheels, and reduce conversion losses)
   - Back up power systems and distributed generation (improving reliability and efficiency) including use of renewable energy and fuel cells
   - Advanced energy storage technologies for peak demand reduction and backup power
   - Cooling systems (e.g., variable speed drives, high performance configurations including tower side economizers)
   - Lighting (e.g., lights out operation, DC powering, lighting controls, more task-directed lighting versus wide-area lighting)
   - Advanced data-center-specific commissioning

4) Improve integration for design, procurement, and operation of data centers
   - Integration of players (e.g. IT, facility, financial, and management representatives should be included in what the Uptime Institute calls "Integrated Critical Teams")
   - Integration of systems (e.g. rack cooling, and DC powering)
   - Clarify and expand the environmental operating ranges of IT equipment to decrease required HVAC energy consumption (to conform with ASHRAE guidelines)

5) Develop energy efficient high performance computers (HPC), (e.g. Government super computers) and improve energy efficiency of HPC facilities

   - The federal government operates many of the world's most powerful and energy-intensive computers. These super computer facilities represent the cutting edge of computational science and often deploy technology that later enters the commercial market. Energy efficiency needs to play a stronger role in the development, procurement, design, and operation of these computers and facilities. A small investment, e.g. 5% of the energy expenditures, could yield significant returns, not only for the facilities themselves, but for the entire industry.