United States Data Center Energy Usage Report

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Project Overview of Data Center Report

- Current and projected data center energy use through 2020
- Includes main authors of the 2007 Data Center Report to Congress
- Additional chapter on “indirect effects” (e.g. telework)
- Draft report sent out for review to corroborate assumptions
  - Reviewers included industry and advocates
  - Comments from about 30 companies
  - Nearly 300 individual comments
Data center energy projections in 2007

Report to Congress on Server and Data Center Energy Efficiency Public Law 109-431

Brown et al., 2007, Report to Congress on Server and Data Center Energy Efficiency Public Law 109-431
Emergence of cloud computing and social media
  - IP traffic increasing 20% annually

Dominance of “hyperscale” data centers

Growth in data storage
  - 20x increase since 2007

Internet of Things capabilities

New IT equipment
  - “Unbranded” ODM servers
  - Solid state hard drives
  - Faster network ports
Research Approach

- Leverage existing data center model, and update with
  - IDC, SPEC, ITI data for IT equipment characteristics & shipments
  - IT & infrastructure assumptions from lit review, industry feedback

- Disaggregate “product” data center operations

- Energy projections under four scenarios
  - Current Trends
  - Improved Operation
  - Best Practices
  - HyperShift
Energy Use Estimates

Graph showing annual electricity use (billion kWh/y) from 2000 to 2016, with four lines representing different scenarios:
- 2007 Current Trends
- 2007 Improved Operations
- 2007 Best Practices
- 2007 State of the Art
Key Observations

- Servers are improving in power scaling ability
  - Servers typically operate at 10-50% utilization
  - Increased power scaling reduces average power demand

- Large reduction in physical server demand within data centers
  - Increase virtualization and consolidation has tempered increase in annual server shipments

SPEC workbook data
Key Observations

- Nearly all server shipment growth since 2010 occurred in servers destined for large hyperscale data centers
  - Hyperscale data centers typically operate more efficiently
  - Growing percentage of overall data center activity
Savings: 620 billion kWh
Efficiency Scenarios

![Graph showing efficiency scenarios from 2010 to 2020. The graph indicates the annual electricity use (billion kWh/y) with lines representing different scenarios: CT - Current Trends, IM - Improved Management, HS - Hyperscale Shift, IM + HS, BP - Best Practices, BP + HS. The x-axis represents the years from 2010 to 2020, and the y-axis represents the annual electricity use in billion kWh/y.]
Future Challenges & Opportunities

Data center closet clunkers:

• Improving/removing closet and other poorly operated smaller data centers

Beyond 2020:

• Established efficiency measures (consolidation, power scaling, low PUE) to eventually hit upper limit

• Computational/storage demand only increasing
Acknowledgments

• Report Authors:

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• Review Reviewers (industry, advocates, government)

• DOE Federal Energy Management Program
that was just cloud talk, man!
Panel

• Ali Heydari
  – Ali Heydari is Senior Technical Director and Data Center Architect at Baidu, the largest search engine company in China. He is responsible for development of cutting edge data center and server hardware technology for deployment at Baidu’s data centers in China for achieving extremely low data center.

• George Goodman
  – George Goodman is the Executive Director of the Open Data Center Alliance, coming from a long career in technology R & D, including microprocessor and system energy dynamism & efficiency.

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Panel

• Roark Hilomen
  – Roark is a Fellow at SanDisk specializing in hyperscale systems and Datacenters. He has worked at eBay, Quest, Pillar data and Intel and has done a great deal of research on datacenter efficiency, low PUE datacenter architecture, and compute and storage density.

• James Connaughton (con-na-ton)
  – James L. Connaughton is one of America’s most distinguished energy and environmental experts, as both corporate leader and prominent White House policymaker. From 2001-2009 he served as President Bush’s senior advisor on energy, environment and natural resources, and as Director of the White House Office of Environmental Policy. He then served as Executive Vice President of C3 Energy, and was recently appointed President & CEO of Nautilus Data Technologies in early 2016.
• Reaction to the report:
  – Better news than I would have expected five years ago, driven (I guess) by both improvements in IT and OT efficiency and by faster deployment of those technologies through the swell of hyperscale.
Arman’s

• Concerns and Opportunities:
  • What’s your interpretation on why these efficiency gains happened. Greater awareness, growth of hyperscale, other? This question may lead into data availability.
  • Small data center (closets/room) still represent a significant portion of the data center market, but are often the least efficient. What are some of the best ways to make this market segment more efficient? What are the barriers that need to be overcome?
  • Thinking beyond 2020, the traditional methods of improvement efficiency, reduce PUE, increase utilization, better power proportionality, have seen great improvements, but where are the limits to these measures, when will we hit them, and what will be do next?
1. IoT has the potential to change DC landscape, what is the biggest challenge facing IoT world data center development?

2. What is the trend in IoT data center development in the next 5 years?

3. How does TCO analysis help in developing IoT data center technology?

4. What are the most unique data center technologies you have seen in recent years?

5. What do you see as the distribution of OEM vs ODM technology in the IoT world data center?
• Concerns and Opportunities:
  – 1. Will the remarkable rate of change - accelerating change - and unanticipated shifts (Koomey didn't anticipate the hyper scale shift) make forward-looking estimates even more problematic?
  – 2. Better and increased sensing could give real data on which to base models, but that will likely require law-making.
  – 3. What will the anticipated increase in compute-at-the-edge require to include not so much datacenter efficiency but data use efficiency (energy to accomplish the useful compute)