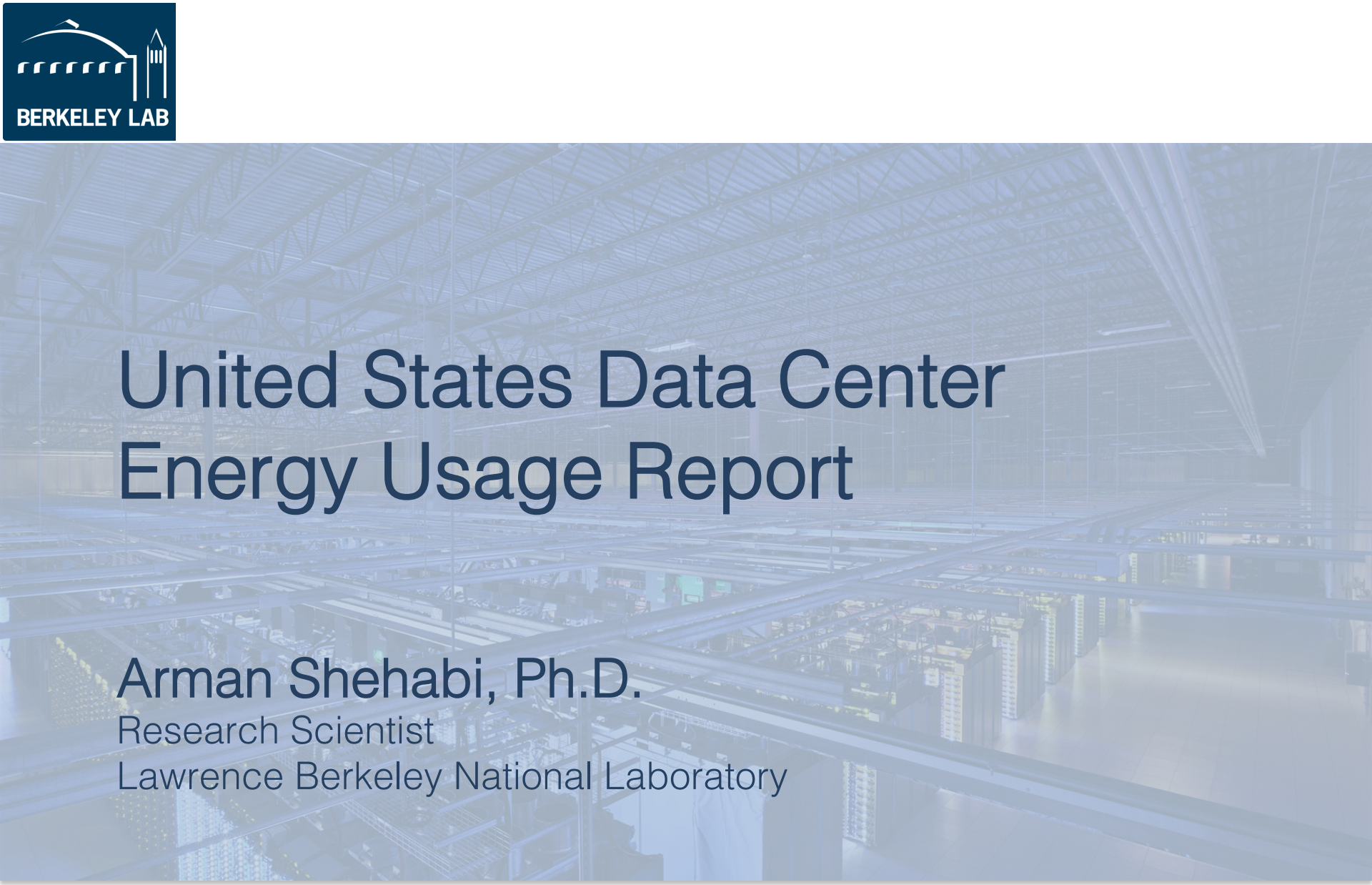


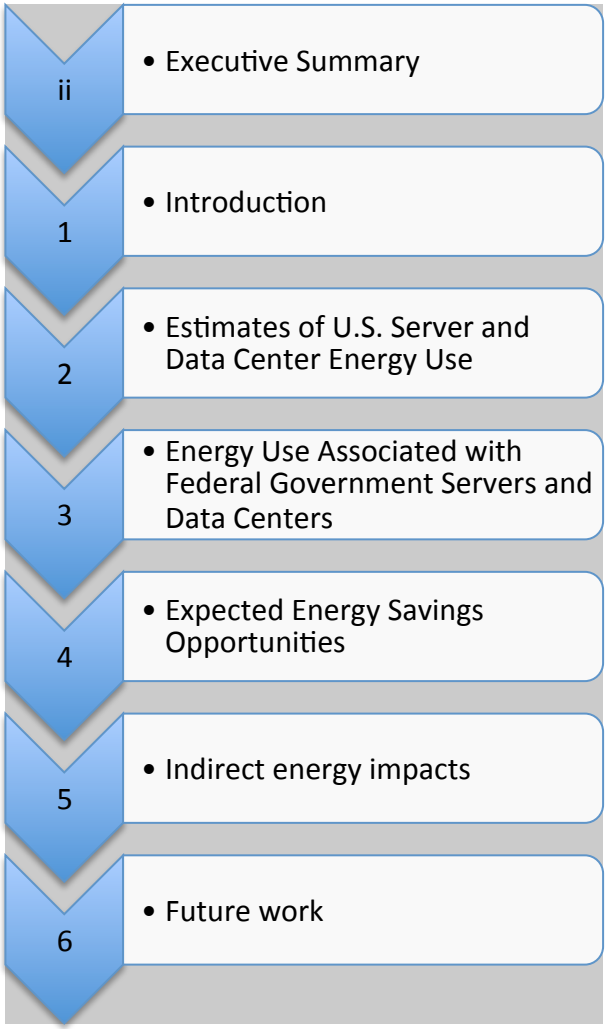
United States Data Center Energy Usage Report

Arman Shehabi, Ph.D.
Research Scientist
Lawrence Berkeley National Laboratory

DCD Webscale
San Jose, CA
July 20, 2016

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



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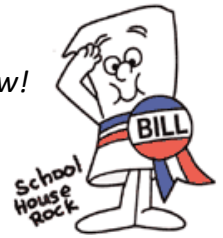
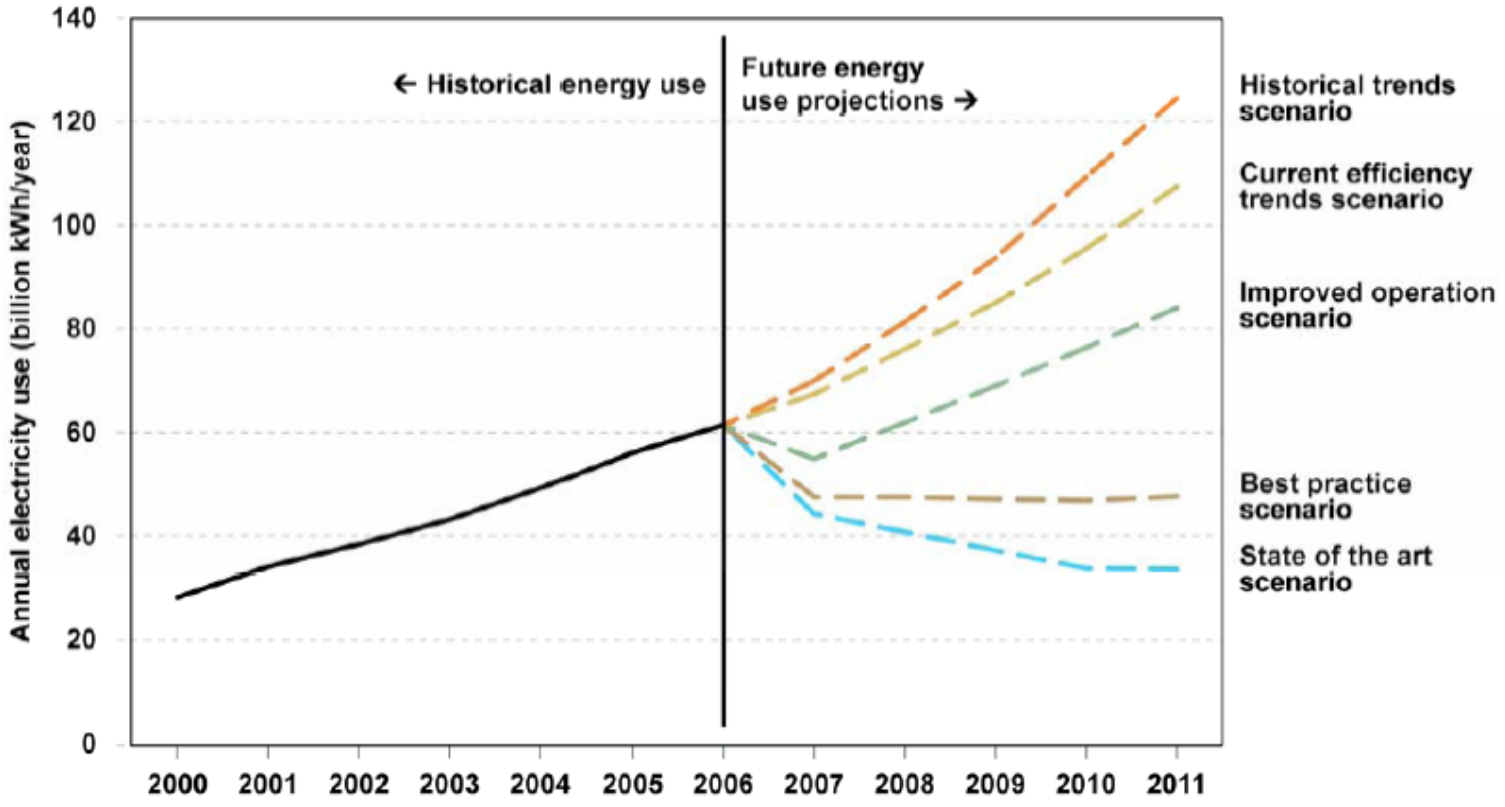
Data center energy projections in 2007

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

Senate Bill 3684 becomes a law!





Brown et al., 2007, *Report to Congress on Server and Data Center Energy Efficiency Public Law 109-431*

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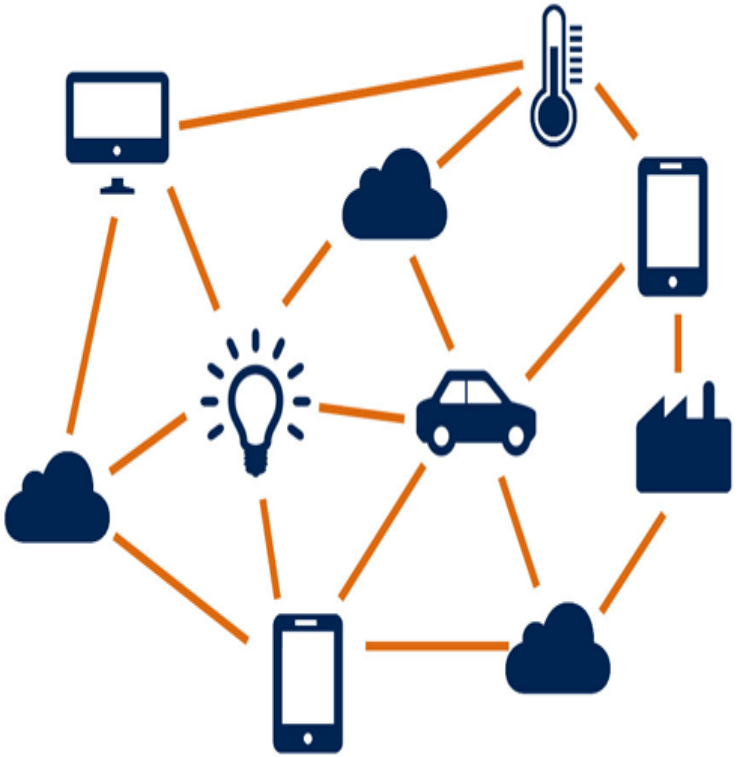
Data Center Landscape Different than 2007

- 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



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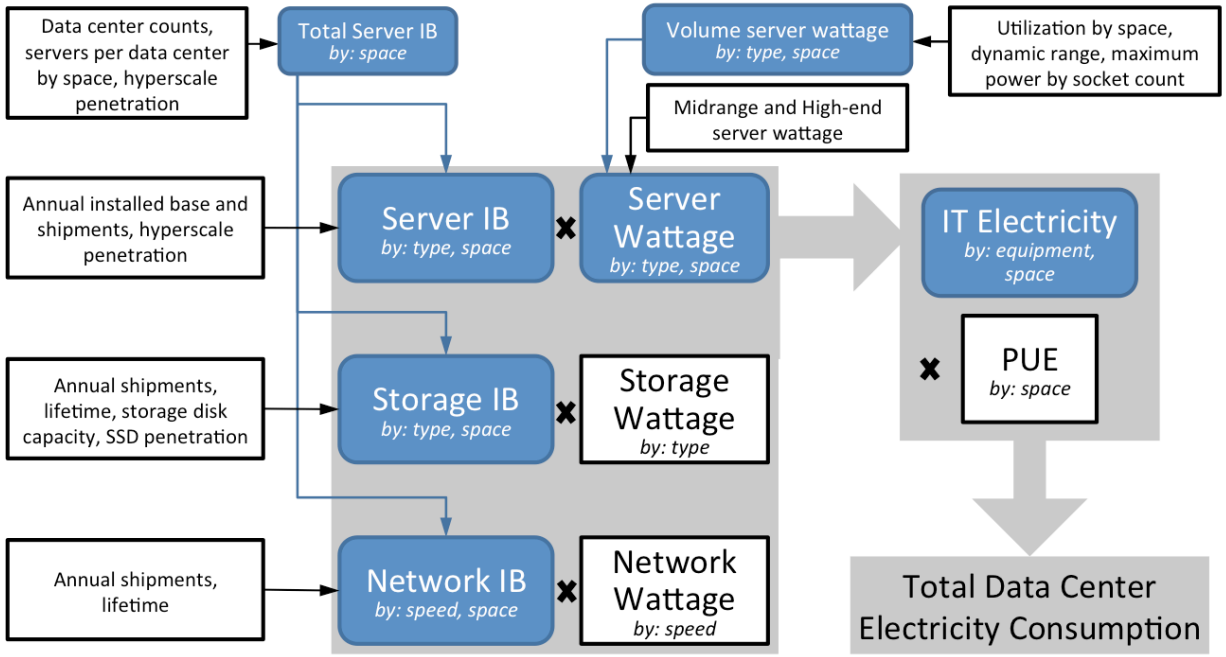
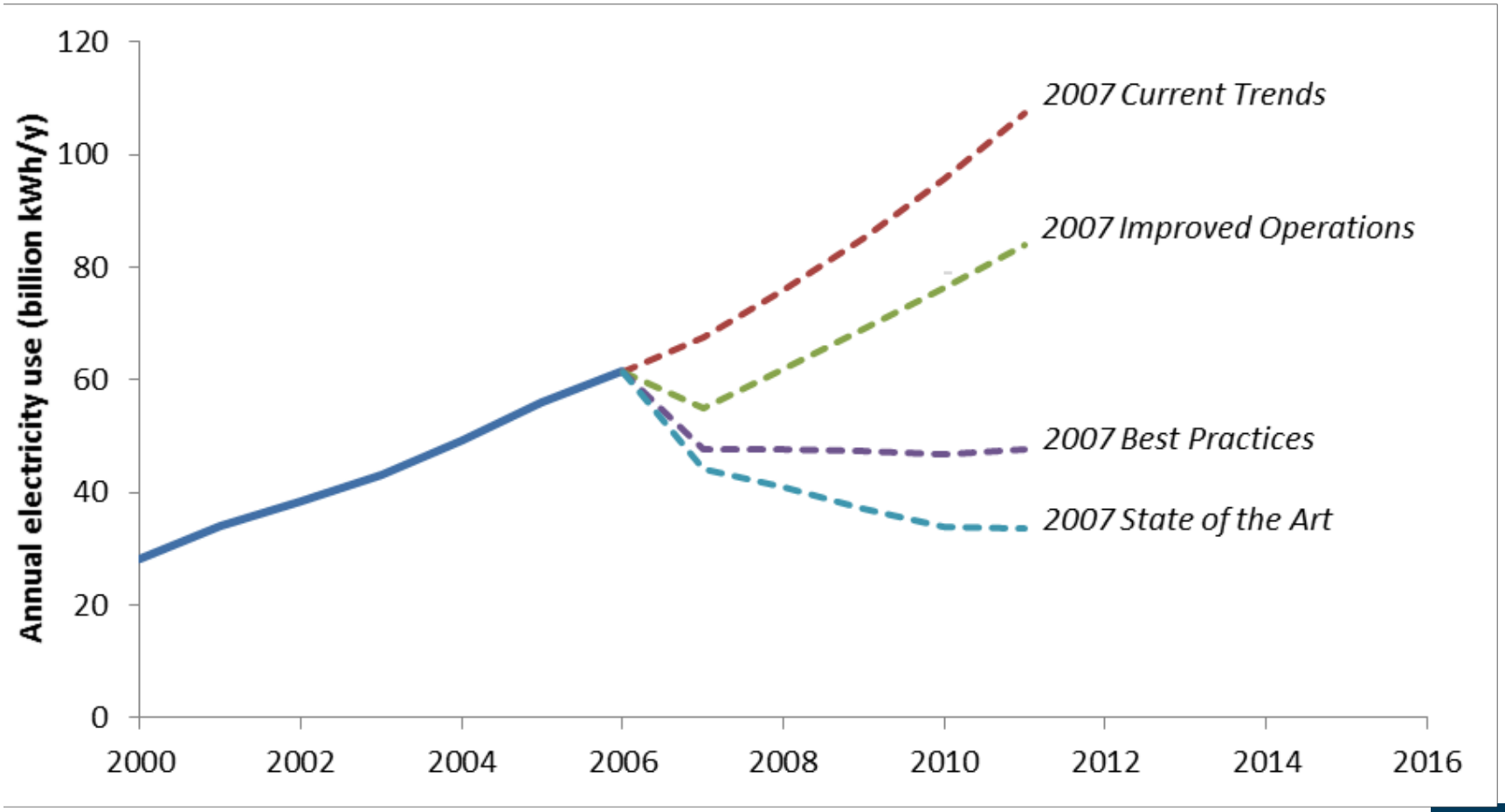
Research Approach

- 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

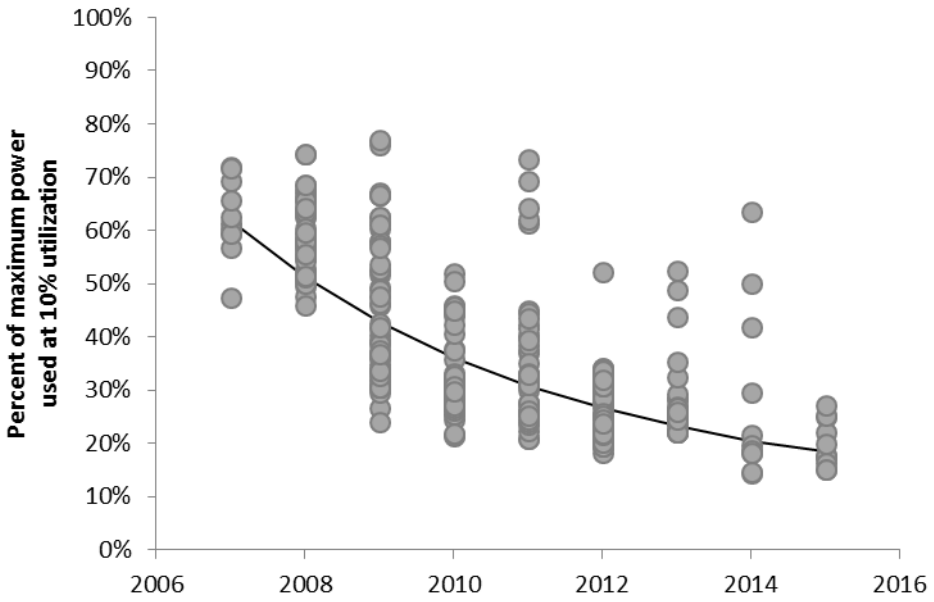


Energy Use Estimates



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

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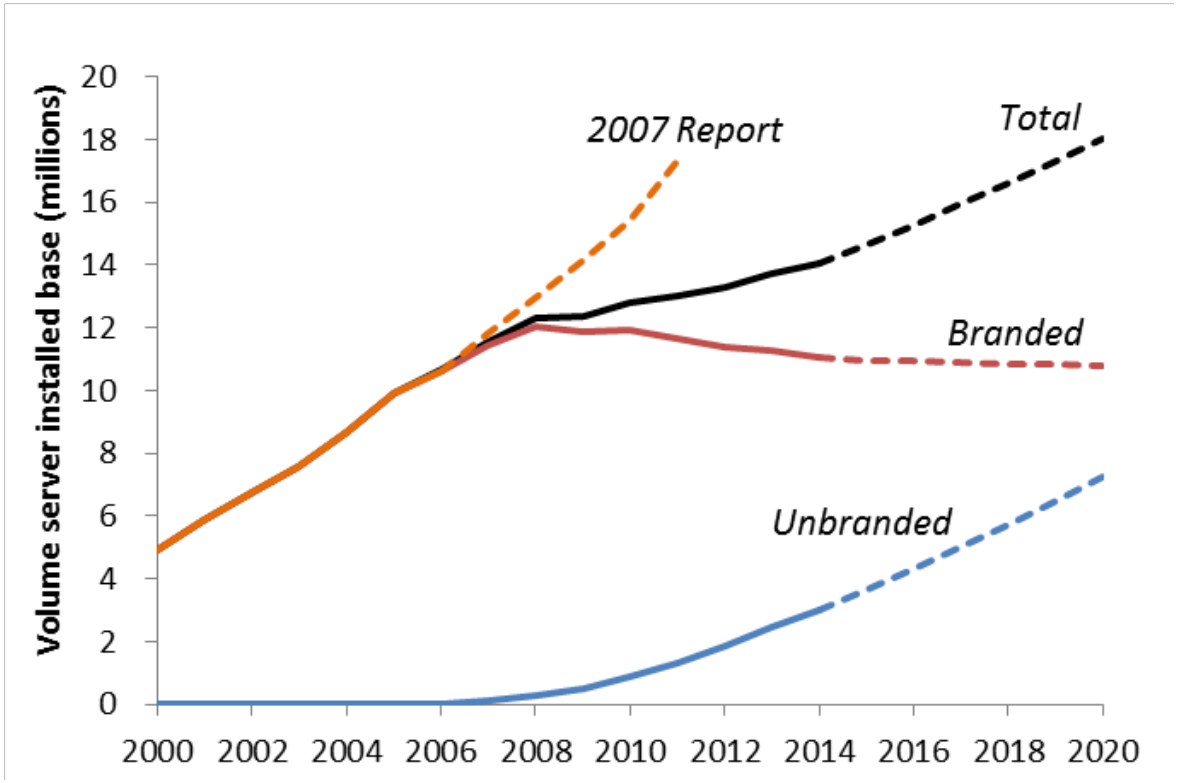
Key Observations

- 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



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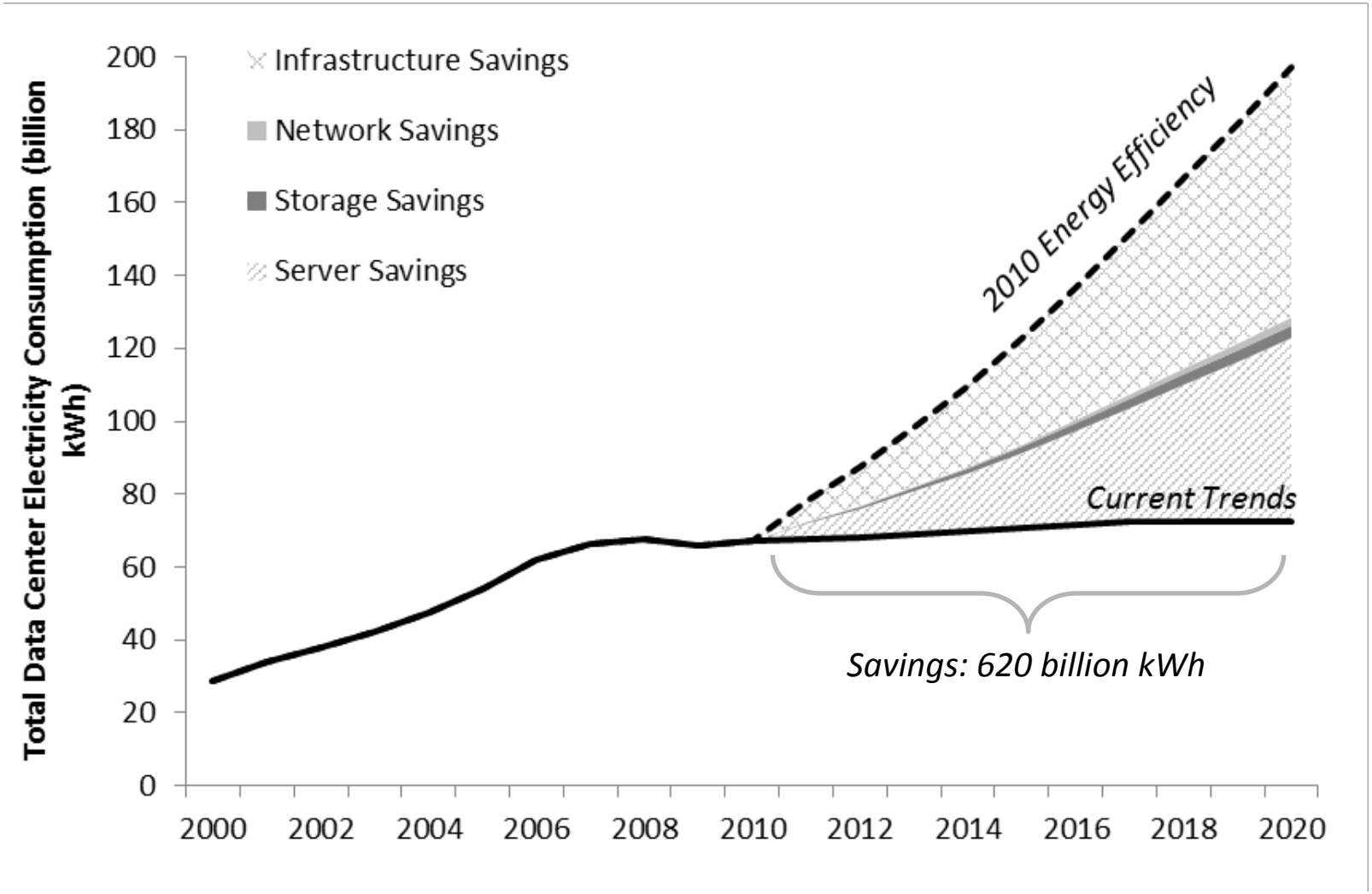
Energy Use Estimates



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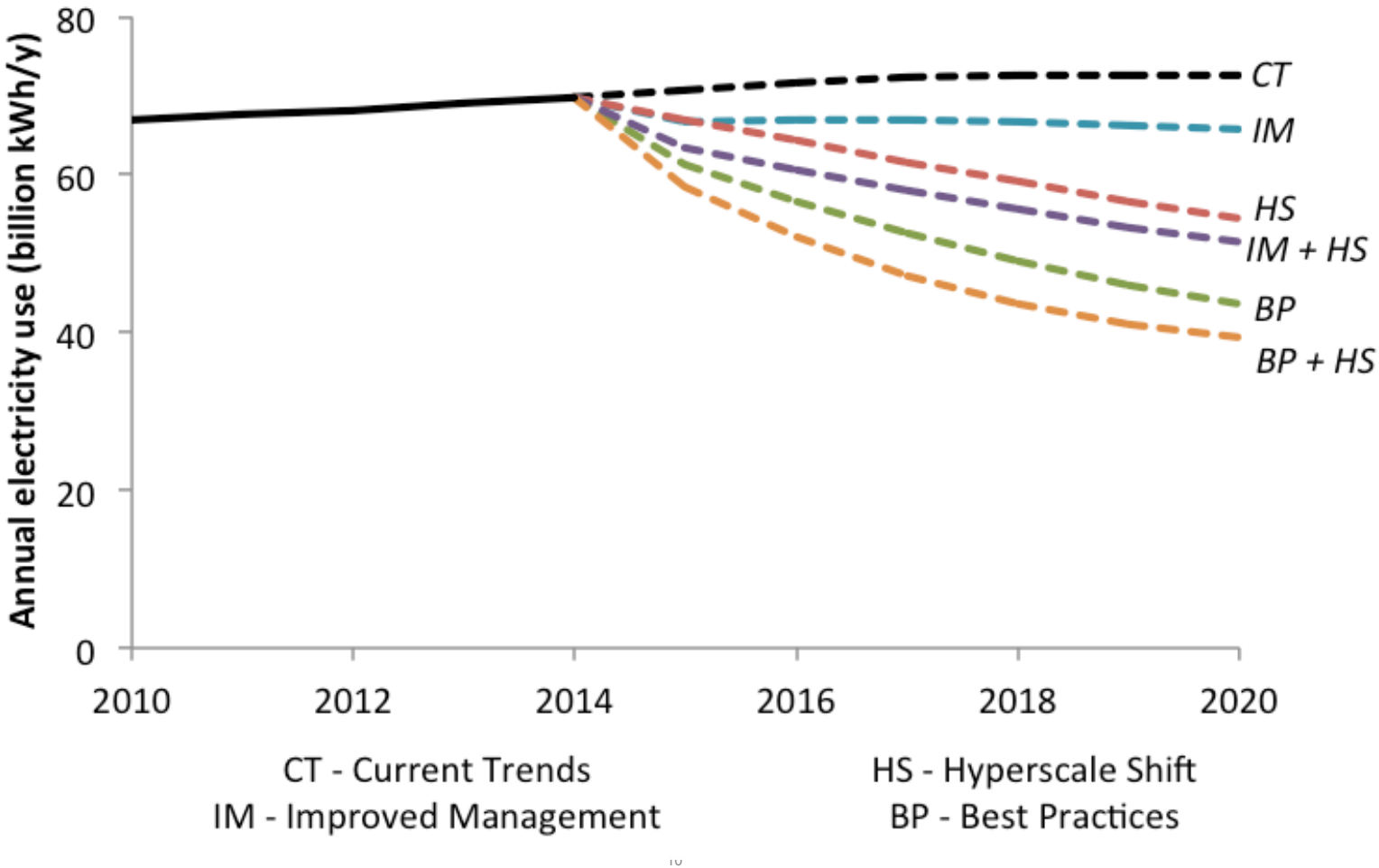
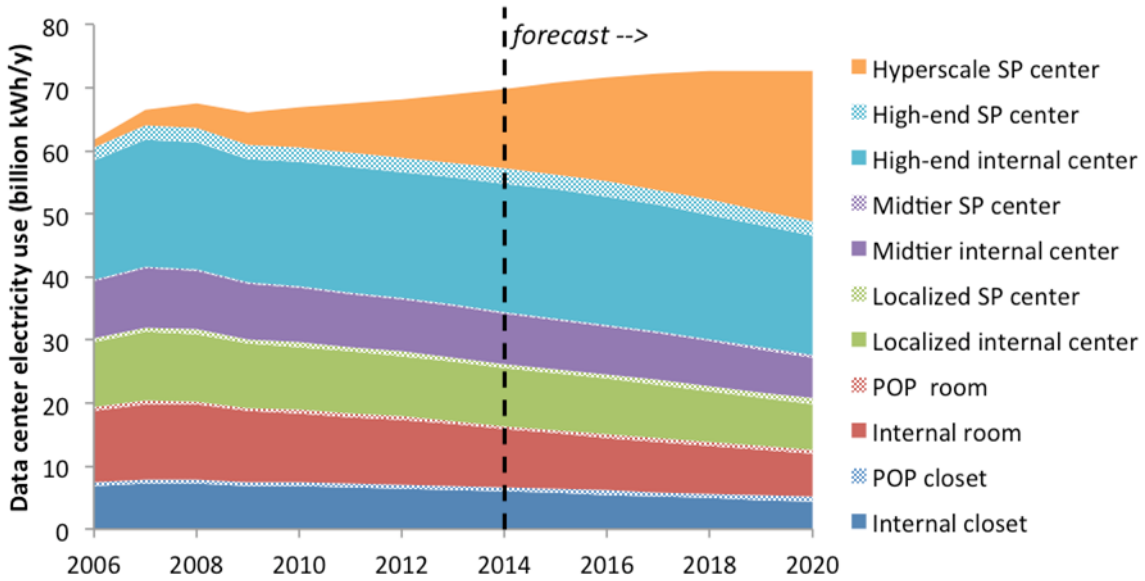
Efficiency Scenarios



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:

Arman Shehabi	Environmental and Energy Impact Division, Lawrence Berkeley National Laboratory
Sarah Smith	
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Nathaniel Horner	Climate and Energy Decision Making Center, Carnegie Mellon University
Inês Azevedo	
William Lintner	Federal Energy Management Program, U.S. Department of Energy

- Review Reviewers (industry, advocates, government)
- DOE Federal Energy Management Program

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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.

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- 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?

Ali Heydari

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?

George Goodman

- 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)