"The US economy could expand more than 70% through 2030 and use 11% less electricity than in 2008 because of energy efficiency advances associated with semiconductor technologies. By our calculations here, the cumulative net electricity bill savings enabled by semiconductors might exceed $1.3 trillion through 2030."

Data Center Overview

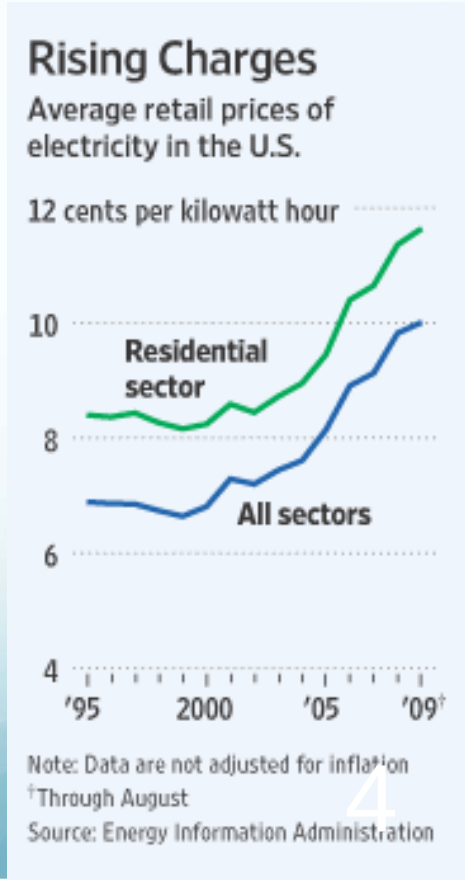
- Industry Organizations
  - UpTime Institute
  - ASHRAE
  - 7x24
  - Green Grid
  - Climate Savers
  - AFCOM
  - Data Center Dynamics
  - SVLG
  - Data Center Pulse
- Types of data centers
  - Corporate
  - Co-location (Retail)
  - Wholesale
  - Enterprise
- Industry Efforts
  - Energy efficiency
  - Metrics
  - Technology

Data Center Industry Facts

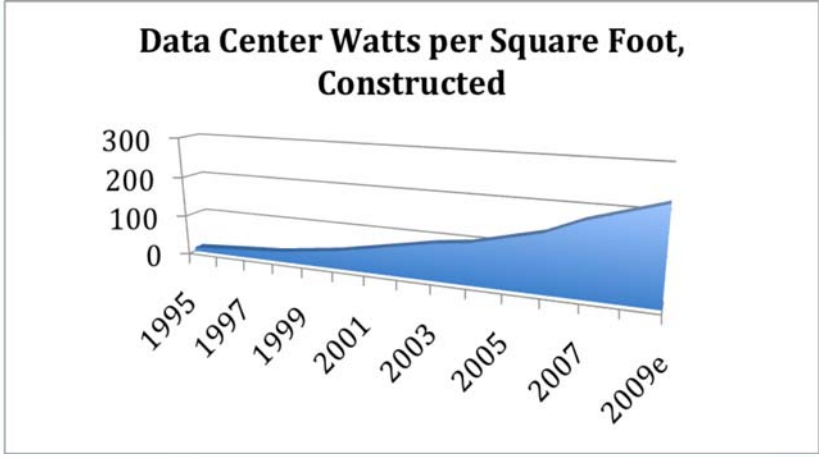
- In 2006, 3% of U.S. electricity consumed by ICT
- >20,000 data centers in the US by 2011 will require >5 fully loaded Diablo Canyon nuclear power plants
- EPA report forecasted data center energy-use will double every ~5 years
- Growth is rapidly outpacing efficiency improvements.
- 4.1 billion cell phones worldwide, 2/3 are in developing nations. India alone annually adds ~ 100 million new cell phone users each year

The Energy Facts

- Data centers in the US by 2011 will spend over $23 billion annually on electricity
- US Government spends over $1 billion annually on energy for data centers and expected to increase to between $2.5 to $4.5 billion by 2020.
- Utility costs on path to double about every 11 years
- About $1m/year/MW @ $.10/kWh to power
- Energy is the largest driver of 10-year NPV



Technology facts



- Watts/SF increased 10x in 10 years
- Processors in last 5 years = 25x perf, 6x energy
  - Semiconductors have achieved a 10 fold-decrease in watts per Gigabyte per second in the last 10 years
- Hardware cost equal or more money to run then buy
- Refresh rates decreasing from roughly 4 to 2 years
- It costs roughly $10m/MW of IT load to build a data center
- Networking energy will increase from 10% to as much as 50% by 2013

Findings for IT equipment

EPA Scenario	PSRR
Historical Trends	N/A
Current Trends	1.08:1
Improved Operations	***1.08:1***
Best Practice	***2:1***
State-of-the-Art	***5:1***

1. Holistic IT transformation initiatives deliver larger impact in our studies

2. Companies need to better demonstrate aggressive IT infrastructure reduction
   - Yet to fully harness virtualization and rationalization
   - Must consider storage and networks

Consolidated R&D PSRR 2.1:1
Consolidated Production PSRR 3:1

EPA's PSRR, and % adoption of power management & energy efficient servers based on expert estimates

Energy Efficiency in Design

- Average PUE reduced from >2 to ~1.5; good below 1.1
- Metrics: DCiE, PUE, Green Grid, others; more coming
- Good, Smart Design should cost less
  - Cooling, where it's all at
    - Air economization
    - Water economization
    - Fan HP reduction
    - Close coupling
  - Electrical
    - Rotary or super-efficient UPS
    - NO transformers! (or high-efficiency)

Findings for Site Infrastructure

EPA Scenario	PUE
Historical Trends	2.0
Current Trends	1.9
Improved Operations	***1.7***
Best Practice	***1.3***
State-of-the-Art	***1.2***

1. High efficiency site initiatives exist today

   Participants start PUE 1.2-1.6
2. Legacy retrofits can almost be as efficient as new commissions

   E.g., applying measured results

   Air management + VFDs + water-side economizer in a legacy retrofit results in a 0.23 contribution to PUE

   High efficiency chilled water plant + modular cooling in a new data center results in a 0.21 contribution to PUE

Consolidated Legacy PUE 1.355
Consolidated New PUE 1.265

EPA's PUE based on expert estimates

Energy Efficiency in Operations/Retrofit

- Good, Smart Operations only costs less
  - Hot/cold aisle separation
  - VFDs on CRAC
  - Ducted or raised returns
- Software
  - Virtualization
  - Server power management
  - Better controls
- Hardware
  - Data De-Duplication and SSDs
  - Memory
  - EnergyStar
  - Highly-efficient Power supplies

Energy Saving Ideas

- Measure holistically, not on per unit savings
- Focus on server and other hardware reductions
- Look at work output ratio to energy use increase
- Consider shutting off hardware
- Retail data centers = infrastructure
- Customer owned & operated on work to energy
- Focus on small sites, including cell towers, phone switching centers, data center closets

New Trends

- EPA EnergyStar
  - servers, storage and networking
- DoE
  - DC Pro, LEADER, $50m in new R&D, training, demos
- The Cloud
- Containers
- Optical networking, even within the box
- Water Efficiency
- Carbon Legislation

A few things to think about

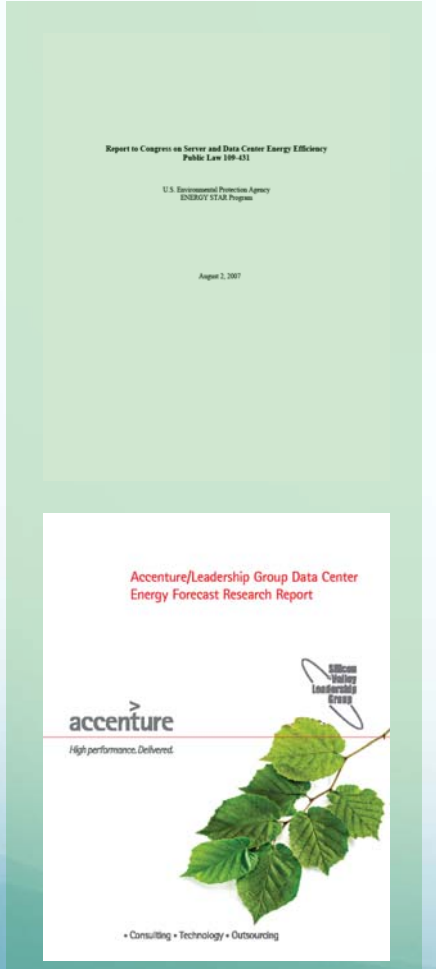
- 75% of server energy is for parallel machine energy, within and between other servers
- A large portion of ICT energy consumption is in small installations such as mobile phone towers, server closets, and neighborhood facilities
- Demand Response program in development and LBNL is looking for demonstration partners
- I’m looking for your energy-efficiency demos

Silicon Valley Leadership Group's Data Center Demonstration Project

- US EPA Energy Star Report published in August 2007 presented energy use of datacenters and extrapolated energy savings based on adoption of identified technologies
- Data Center Demonstration Project took the initiative to validate the energy savings suggested within the EPA report by conducting case studies in commercial environments of study participants
- First Summit with validated case studies occurred in June of 2008, second summit October 2009; third is planned for October 2010
- This study is unique in that 3rd party industry data centers implemented these initiatives and revealed the energy savings

Many organizations have provided support throughout this effort, including LBNL, PG&E, CEC, SVLG, CIEE, end-user data centers, technology partners, summit hosts and others.

Year 1, The Report



This report is a companion to the EPA report

Answers the call-to-action from the EPA report

> ***"Objective, credible information is needed about the performance of new technologies and about best practices as well as the effect of both on data center availability"***

Compares the energy estimates of the EPA report with measured results

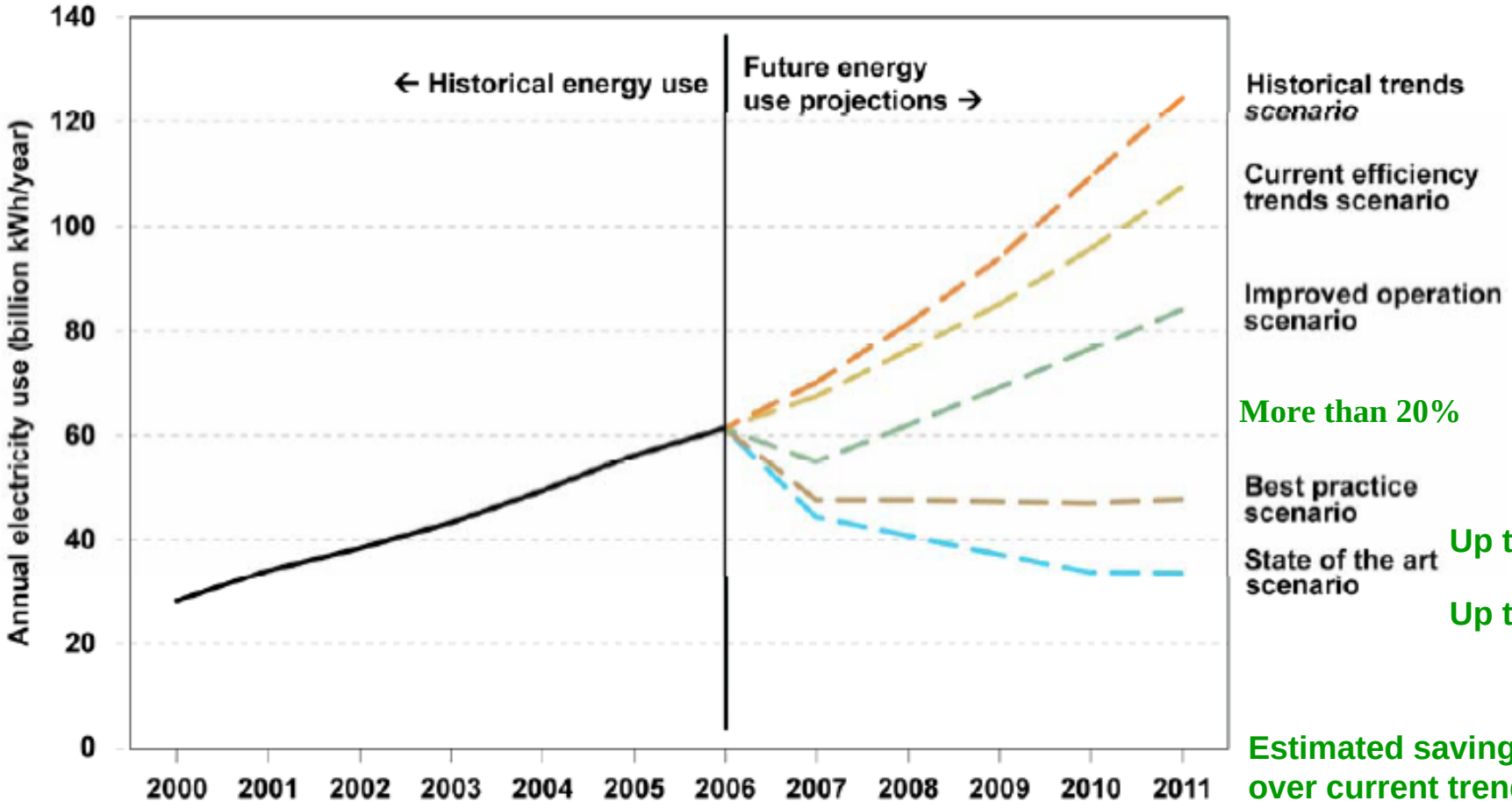
- To encourage increased adoption of energy saving initiatives
- To help shape potential standardization, regulation, or certification around energy use
- To demonstrate commitment of data center operators to environmental responsibility
- To drive others to increase their energy efficiency

EPA Report documents U.S. servers and data center energy use

Scenario	Electricity Consumption	Electricity Costs	Environmental Impact
Today (2006)	Use about 61 billion kWh Doubled since 2000 1.5% of total U.S. consumed More than U.S. TVs Equivalent to 5.8 million average U.S. households	Costs $4.5 billion annually	Peak load on power grid is equivalent to the output of 15 power plants.
Current Trends (by 2011)	**Use nearly doubles to more than 100 billion kWh**	**Costs $7.4 billion annually**	**Requires an additional 10 power plants**
EPA Scenarios (by 2011)	**Annual savings of approximately 23 billion to 74 billion kWh over current trends**	**Reduces costs by $1.6 billion to $5.1 billion annually**	**Reduces peak load by equivalent of up to 15 new power plants** **Reduces 15 to 47 MMTCO$_2$**

EPA Energy Projections
Can we achieve these results?

In the best practice scenario, energy use reduced below the 2006 level



EPA report p10

Case Study Coverage At-a-glance

Initiative	Improved Operations	Best Practice	State of the Art
Data Center Site Infrastructure Projects			
Data Center Cooling			
Data Center Airflow Management		X X	
Free Cooling in Large Scale Data Centers	X		X X
Data Center Cooling Optimization		X	
High Efficiency Chilled Water Systems		X	
Modular Cooling Systems		X X	X X X
Wireless Sensor Network Adaptive Cooling			X
Data Center Power Distribution			
High Efficiency Power Transformation		X X	
High Voltage AC Power			X
High Efficiency Stand-by Power Systems		X X	
IT Infrastructure Projects			
Consolidation and Optimization			
IT Computing Resource Optimization		X	X
IT Consolidation and Virtualization	X	X	
Server Power Characterization & Modeling			X

Demonstration Scenarios

IT Initiatives used for Production and R&D Data Centers

Production
Consolidation

R&D
Consolidation
Resource Optimization

Demonstration Scenarios

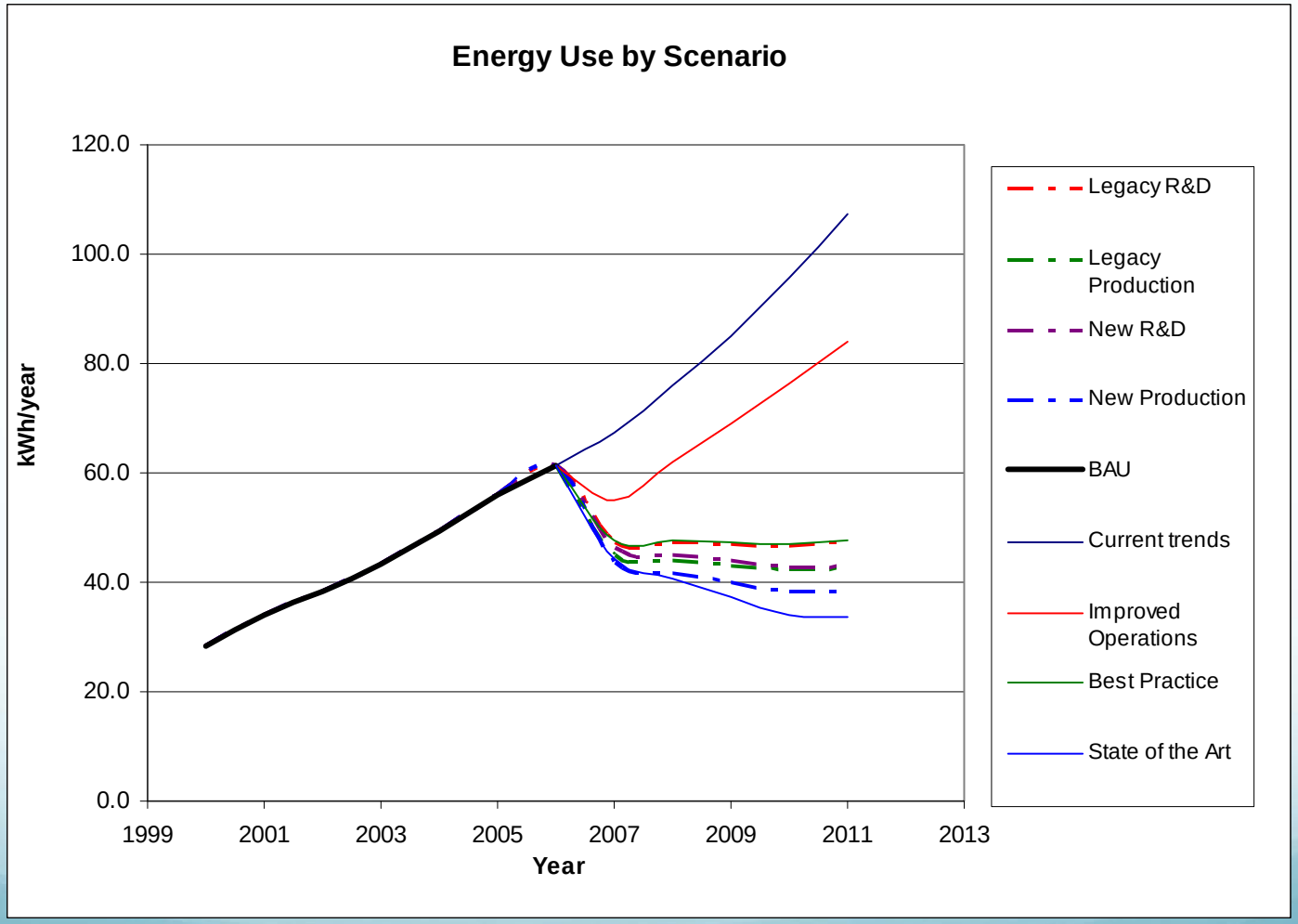
Legacy Production	**New Production**
Legacy R&D	**New R&D**

Legacy Retrofit
Variable Fan Drives
Air Management
Water-side economizer
Right-sizing power, cooling

Newly Commissioned
Air side economizer
High efficiency chilled water plant + Modular cooling
High efficiency standby power
High efficiency PDU

Site Initiatives used for Legacy and New Data Centers

Comparison with EPA results
We can achieve Best Practice



By 2011, significant savings over 2007 trends

Legacy retrofits

- Savings of 59.9 to 64.6 billion kWh/year annually
- Up to $4.5 billion saved annually
- 40.9 $MMTCO_2$ reduced (more than 7 million cars) annually

New commissions

- Savings of 64.2 to 68.9 billion kWh/year annually
- Up to $4.8 billion saved annually
- 43.6 $MMTCO_2$ reduced (almost 8 million cars) annually

Summary

- Data centers continue to be large energy consumers

  Costs about $3 billion annually

- Best practice levels defined in the EPA report are achievable
  - IT initiatives offer large savings
  - Yet to fully harness virtualization & rationalization
  - Site technology near state-of-the-art
  - Legacy upgrades can nearly match new commissions in terms of efficiency

Implement today's technologies and have significant impact

Reduces carbon dioxide emissions by up to 8 million cars