No Power, No Cloud
Belady’s Anomaly
Belady’s First Anomaly
Agenda

1. Mega Trends
2. Data Center Trends
3. MS Data Centers
4. Challenges
5. Opportunities
6. Final Words
Putting in Perspective

100 W - You, sitting there, reading.

1000 W
1 kilowatt (kW) = 1000 W

1 MW = Domestic kettle

100000000 W
1 megawatt (MW) = 1000 kW

1 GW = Diesel locomotive / wind turbine.

100000000000 W
1 gigawatt (GW) = 1000 MW

1 TW = World power consumption, 1890

1 terawatt (TW) = 1000 GW

Source: Saul Griffith
Global Consumption

18 TW today!
Expected to increase >40%
by 2035

Source: Saul Griffith
Global Consumption

Sun’s Incident Rays
162,000 TW

We have plenty of power!

18 TW today!
Expected to increase >40% by 2035

Source: Saul Griffith
However there is another dimension!
However there is another dimension!
Temperature Changes around the world in the last quarter of the 20th century

Trends in °C per decade

Source: Saul Griffith
“Weather” you believe this or not...doesn’t matter.

What matters is that our business will be in the cross hairs of government regulators

Source: Saul Griffith
It’s already happening!

Congress Passed Public Law 109-431
Dec 2006
EPA to study and promote IT Efficiency
EPA provided response August 2007

Outcome: EPA Energy Star Program
• Energy Star for Servers - May 2009 release
• Energy Star for DCs - Jan 2010 release

http://www.energystar.gov/index.cfm?c=prod_development.server_efficiency

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Emerging in other countries as well such as:
• EC CoC
• UK’s CRC

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Emerging in other countries as well such as:
• Build on existing ENERGY STAR platform's methodology similar to existing ratings (1-100 scale)
• Usable for both stand-alone data centers and data centers housed within office or other buildings
• Assess performance at building level to explain how a building performs, not why it performs a certain way
• Provide users with additional resources to help determine next steps after receiving an energy performance rating
• Offer the ENERGY STAR label to data centers with a rating of 75 or higher

Expression of Interest forms due to data center operators begin collecting data
- July 2008: Participants submit first month of data (as soon as it is collected)
- Quarterly 2008 – 2009
  - Interim data submitted
  - EPA holds update web conferences
- June 1, 2009: Submit final data
- January 2010: EPA launches rating in Portfolio Manager (subject to change)
Why the Regulators Care?

Figure ES-1: Total electricity use for servers in the U.S. and the world in 2000 and 2005, including the associated cooling and auxiliary equipment

Today Globally 1.6 to 2.0%
The EPA Report Shows that with Efficiency Improvements DC power footprint will go down

This assumes demand doesn't change
It’s Actually an Economics Problem and not a Technology Problem Called Jevons’ Paradox

As the cost for Computation goes down, the demand goes up!

Source: C. Belady, Mission Critical Magazine
http://www.missioncriticalmagazine.com/CDA/Articles/Features/BNP_GUID_9-5-2006_A_10000000000000340120
Costs in today’s data centers

DC Costs have eclipsed Cost of IT

Most construction costs scale with Power.

(source: The Uptime Institute)

Belady, C., “In the Data Center, Power and Cooling Costs More than IT Equipment it Supports” Electronics Cooling Magazine (Feb 2007)
Costs in today’s data centers

DC Costs have eclipsed Cost of IT Costs in today's data centers. Most construction costs scale with Power.

My Thesis:

1. Everything Scales with power
2. Low Cost and Sustainability are the same thing

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Belady, C., “In the Data Center, Power and Cooling Costs More than IT Equipment it Supports” Electronics Cooling Magazine (Feb 2007)
Generation 2/3 – Data Centers
Each data center is approximately 10 times the size of a soccer field. With each at about 40MW.
Generation 3 - Chicago Data Center

- $500M+ investment
- 1.5 million man-hours-of-labor
- 3000 construction related jobs
- 3400 tons of steel
- 707,000 sq ft
- 190 miles of conduit
- 1.5 million man-hours-of-labor
- 2400 tons of copper
- 7.5 miles of chilled water piping
- 26,000 cubic yards of concrete
Generation 3 - Chicago Data Center

$500M+ investment
1.5 million man-hours-of-labor

Each data center is approximately 15 times the size of a soccer field
And ...
....Uses Containers

7.5 miles of chilled water piping
26,000 cubic yards of concrete
Challenges in the future

- Keeping costs down
- Increased Global Demand will drive up energy prices and cause shortages.
- Electric Grid is already strained
  - Grid capacity is growing 1%/yr ➔ DC power growing 15%/yr
- Rising costs due to Climate change, carbon taxation, etc.
- Hard to find large blocks of power
- Power Availability may not be there when you need it.
- Renewable power is not persistent – need backup (costly)
  - Storing power is expensive and not sustainable at scale
  - Batteries have not seen breakthrough
We need to be Proactive!
The DC industry has been anything but that!

For Cloud Computing to succeed we need to change:
• Know where you are - Monitoring and measurement
• Simplify
• Scale
• Commoditize
• Integrate
Monitoring and Measurement
Industry Current State of Affairs

Data Center power Footprint
Doubling every 5 years (EPA Study 2007)

17% Data Centers track total Carbon Footprint (DCUG 2009)

15% Data Centers Measure overall efficiency (DCUG 2008)

Average Data Center Efficiency has a PUE = 2.0 (LBNL & EYP)
Tools for changing business needs

Scry is used for:
- Tracking Power
- Tracking Server Utilization
- Tracking Carbon
- Tracking Data Center Utilization
- Billing and cost allocation
Simplification
Simplification - Data Center of the Future?

Driving to a simplified data center

From Science Project

To Reality

In addition we are driving vendors from 68-77F ➔ 50-95F
How a Simple Low Cost Data Center Works

Video can be viewed at:
Scale
Microsoft’s Datacenter Evolution

Datacenter Co-Location
Generation 1

Quincy and San Antonio
Generation 2

Chicago and Dublin
Generation 3

Generation 4 Modular Datacenter

Future Generation
Microsoft Research XCG

Server Capacity

Rack Density and Deployment

Containers Scalability and Sustainability

IT PAC Time to Market Lower TCO Scalable Datacenter

Facility PAC
Examples of Container Computing
Chicago DC – SCALE!

- Can deploy at scale
- Energy and Material Conservation
- Plug and Play – (CBlock Spec)
- Drives Innovation
- Abstracts away religious wars in competitive bid
  - AC versus DC
  - Air versus Liquid
- Cost can include maintenance
- Creates an environment to drive competition around efficiency
- Allows for easy cost and performance measurement
- Flexibility to move to new technology
- Moves cost from upfront investment to server deployment
- Software and hardware system integration
Deploying Server in Chicago

Video can be viewed at:
Commoditization
Commoditization drives lower cost

1912 Rolls Royce Silver Ghost

Hand Built

Assembly Line

Ford Model T
Gen4: Microsoft’s Future

Video can be viewed at:
Microsoft’s Future Datacenters

- Reduce time to market by >50%
- 30% - 50% more cost effective for the same class of service
- Outstanding PUE
- Utilize more renewable building materials
Microsoft’s Future Datacenters

- No mechanical cooling
- Ultra-efficient water utilization
- Relentless focus on renewable materials

- Near-JIT deployment
- Low initial capital investment
- Scale with business demand
- Deploy 1 to 10,000+ servers at a time
Integration - Reflecting on the Past

BUT...
At Microsoft, whatever you see today, you won't see tomorrow!
XCG - Cloud Computing in the Future

My Team is Rethinking IT....
...Integration from the Chip to the Utility
XCG - Cloud Computing in the Future

Its really about integration across the whole stack

Make the cloud compelling!

Hardware  Software  Applications  Security
Final Words

- Sustainability = Low Cost
- Expect that there will be massive Integration of the cloud infrastructure driven by TCO advantage
- Low Cost will drive demand up (Jevon’s Paradox)
- HPC is uniquely positioned to help change the industry twofold
  - Solve difficult problems ahead of us.
  - Continue taking risks with technology adoption but in new dimensions
- Power Availability and Security will be key in the future
Thank You
Additional resources
Microsoft's Best Practices for Sustainability

**Best Practices for Efficiency**  
*Published February 2008*

1. Engineer the data center  
2. Optimize holistically  
3. Optimize provisioning  
4. Monitor & control real time.  
5. Drive Efficiency Culture  
6. Measure PUE  
7. Control Temp & Airflow  
8. Eliminate the mixing  
9. Use economizers.  
10. Share with Industry

http://download.microsoft.com/download/a/7/b/a7b72ab1-ca17-4589-923a-83b0ff57be6d/Energy-Efficiency-Best-Practices-in-Microsoft-Data-Center-Operations-CeBIT.doc

**Top 10 Business Practices**  
*Published April 2009*

1. Drive goals with incentives.  
2. Focus on resource utilization.  
3. Use virtualization  
4. Quality with compliance.  
5. Embrace change mgmt  
6. Understand App workload  
7. Right-size your servers  
8. Evaluate and test servers.  
9. Limit Number of SKUs  
10. Use competitive bids.

Resources on outside air data centers

**Data Center in a Tent using outside air**

**Intel White Paper using outside air**