Northwest Power and Conservation Council

July 30, 2013

MEMORANDUM

TO: Power Committee

FROM: Massoud Jourabchi, Charlie Grist and Ben Kujala

SUBJECT: Potential data center Loads in the Northwest
Energy Efficiency Opportunities at Data Centers in the Northwest
Demand Response and Distributed Generation at Data Centers

As part of Council's ongoing monitoring activities in the region, this staff presentation will cover potential loads, efficiency opportunities and demand response and distributed generation at data centers.

Staff will present an update to the analysis of electric load from the data centers in the region. This presentation updates the trends in the demand for data center services, the trends in technological advances, and touches on the new loads from data centers coming into the region. During 2012 and over the first six months of 2013, the region witnessed an increase in large data center loads. Our earlier analysis put the load for large data centers in 2012-2013 at about 300-400 MW. This year's update increases that estimate to about 550 MW. This puts the region on an high load growth trajectory for data centers. It should be noted this 550 MW figure includes estimates of loads for large custom data centers such as Facebook and Google, data centers and mid-tier data centers such as; Viawest, Fortune Data Centers and Digital Realty Trust, and RackSpace which provides collocation services, but excludes smaller localized data centers loads.

The presentation will also touch on trends in data center energy efficiency and demand response activities as well as distributed generation at data centers. Data centers are being studied as sources for grid support services, as well as the capability to shift load into light load hours and to shift load to alternate locations. They are also an early application of microgrid technology and are on the leading edge of enhancing grid reliability for small branches of the larger grid.

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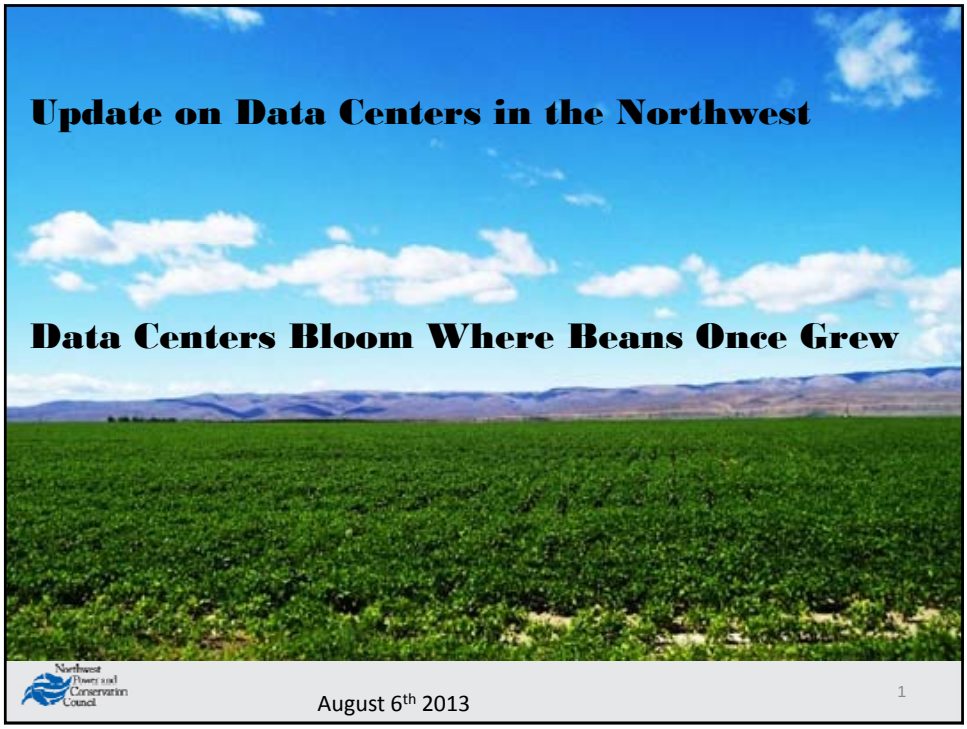
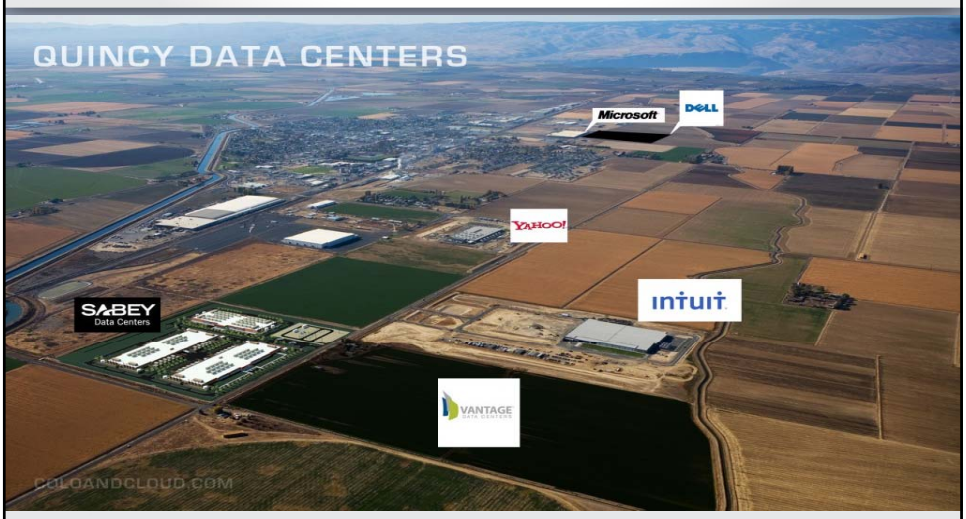


In today's Presentation

- Review of what is a data center & their sizes and functions
- Why Northwest is a favorite destination for large Data Centers.
- Current consumer and technology trends
- Load Forecast
- Conservation and DR potential
- Repeat of call for regional help

New Names in the NW Energy Landscape



ViaWest, Rackspace, Intuit, Vantage, Vmware,……

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What is a Data Center?

A Data Center or server farm is a generic label for facilities that house:

- IT Hardware
  - Servers (computers)
  - Data storage devices
  - Power supply, conditioning & backup systems
  - Communication devices (routers & switches)
- HVAC equipment that serves the hardware
- Lighting that serves the resident staff

There are a Variety of Data Center Business Types & Functions

- **Data Storage & Internet Hosting Facilities:** Server farms which perform a variety of functions
- **Internet Service Providers (ISPs):** Facilities dedicated specifically to provide access to the internet typically for resale
- **Telecommunication Switching:** Facilities dedicated to telecommunication functions like phone mobile phone
- **Corporate Data Centers:** Computer equipment wholly owned and operated by a corporation for private use
- **Managed Data Centers:** Computer equipment owned by the data center owner but leased to tenants
- **Co-Located Server Hosting Facilities:** Physical space, bandwidth, power and connections are available for rental to retail customers. Servers and storage may be owned & operated by tenants.

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There are a variety of Data Center Sizes and Business Models

	Example	Approximate Energy Consumption	% of Data Centers in the US	% of Servers in the US	Typical Location	Some of Barriers to typical utility Energy Efficiency Programs	Opportunity for Energy Efficiency
Enterprise-class/hyper Data Centers	Google, Facebook, Amazon	10-100+ MW	0.3%	28%	non-metro area	secrecy, rapid market change, split incentives, identifying key player, baseline	comprehensive customized offerings/ requires long-term relationship, market movers
Mid-Tier Data Center	Colocators, EasyStreet	10 MW or less	0.4%	15%	Metro area	less secrecy, capital constrained, split incentives, baseline and incentive	comprehensive and customized/ requires long-term relationship
Localized Data Center	Hopsital, financial institutions, Government	10-500 KW	2.5%	16%	Metro area	Harder to locate, split incentives	Customized/Prescriptive, Training and information on energy efficiency options, long-term relationship
Server closets/Rooms	Small to Mid-size Company	5-10 KW	96%	~40%	business dependent	hard to locate, Small IT resources doing many tasks, IT not core business	Perscriptive program offering

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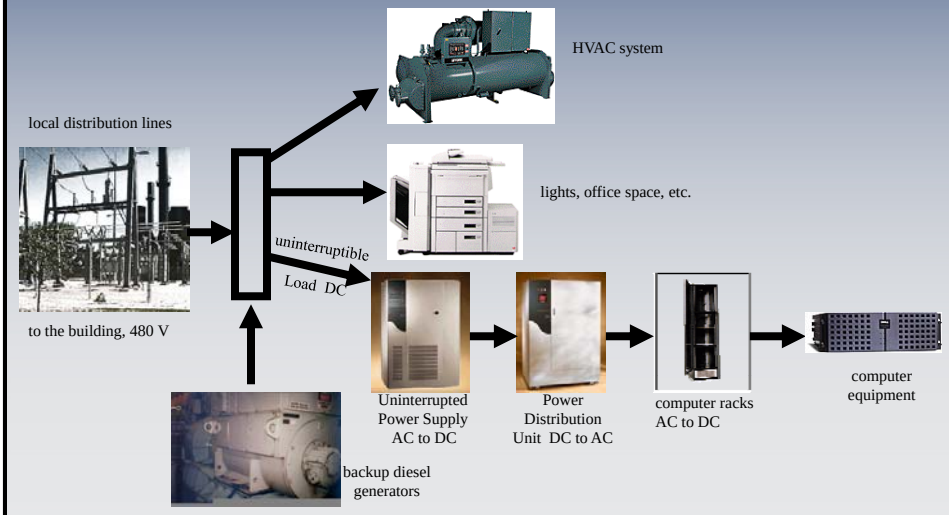
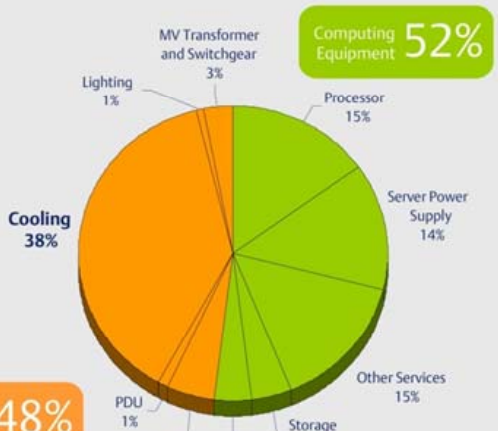
Electricity Flows in Data Centers



Jonathan Koomey, Ph.D.
Lawrence Berkeley National Laboratory

Power Distribution in Data Centers

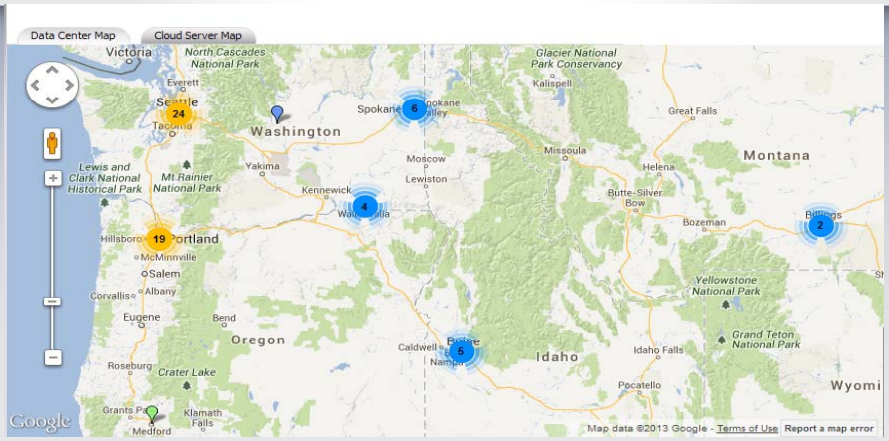
Equipment Category	Energy Consumption
Computing	588 kW
Lighting	10 kW
UPS & Distribution Losses	72 kW
Cooling Power Draw for Computing & UPS Losses	*429 kW
Building Switchgear / MV Transformer / Other Losses	28 kW
Total Power Draw	1,127 kW



* Cooling load assumes chilled water based cooling system

Extract from Data Center Market Assessment, Conducted by PECI, for Energy Trust of Oregon - 2011

Why Northwest is a favorite Destination for Data Centers?



Because of low power and land cost, availability of high speed communication , reliability of power, good reliable transmission system, generous tax policies, educated workforce, good economic development incentive (enterprise zones) and wonderful weather.

Climate Refugees?

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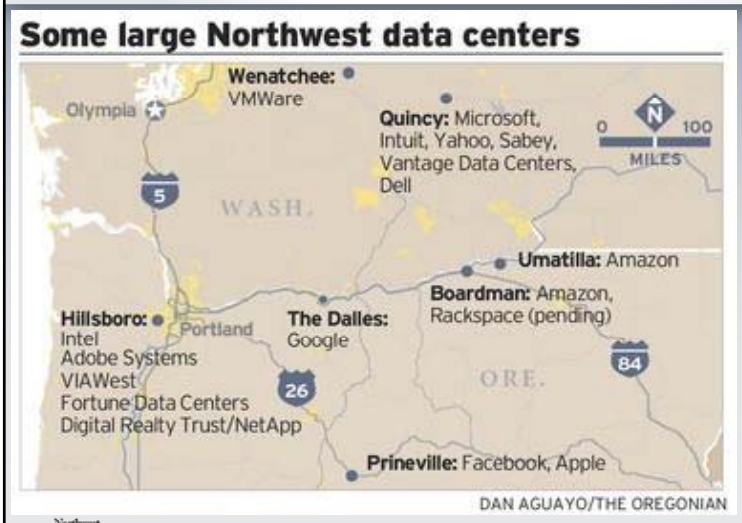
map from DataCenterMap.com July 2013

Larger Enterprise/Custom Data Centers are typically located in Smaller Towns



- Access to cheaper land
- Access to Communication networks
- Access to Power
- Access to economic development incentives
- Allowing for rapid expansion of loads

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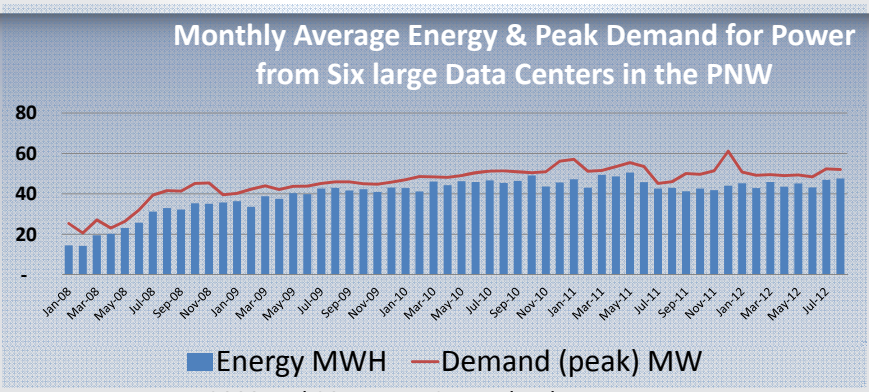
Large Data Centers have relatively flat loads

Good for electric utilities but can be risky



- Between 2008 and 2011 Data Center loads grew:
  - from 15 to 51 average megawatts of energy
  - from 25 to 61 MW of peak capacity demand
- For small utility service territories a few large data centers can be a significant load and challenging to plan for and serve.
- Typically it would take a few years before connected load is fully utilized

Data Center Loads in the NW 2011-2012

Large Data Center loads in the region represent about 5% -10% of non-DSI industrial sales

- 350 to 500 average megawatts
- As much electricity as lumber & wood products
- About half as big as Oregon's pulp and paper sector

Smaller Data Centers loads within commercial buildings represent roughly 5%-6.5% of commercial sector sales

- About 300 to 400 average megawatts

How will the future load from Data Centers unfold?

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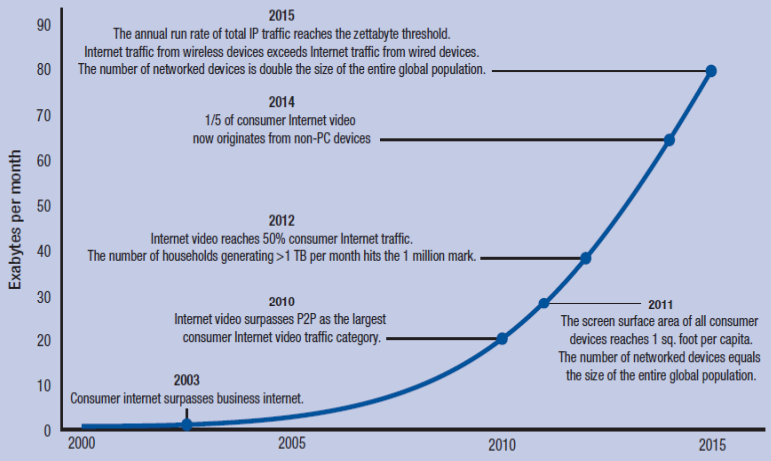
What Drives Future Demand For Data Center Services?

- Social and Technological Trends
  - Social Networking
  - On-Demand Video
  - Unknown New Applications & Services
  - Private and public clouds
  - Ultra-low power monitoring

Potential growth in net traffic
A forecast (~30-40% annual growth)



Source: Cisco, 2011.

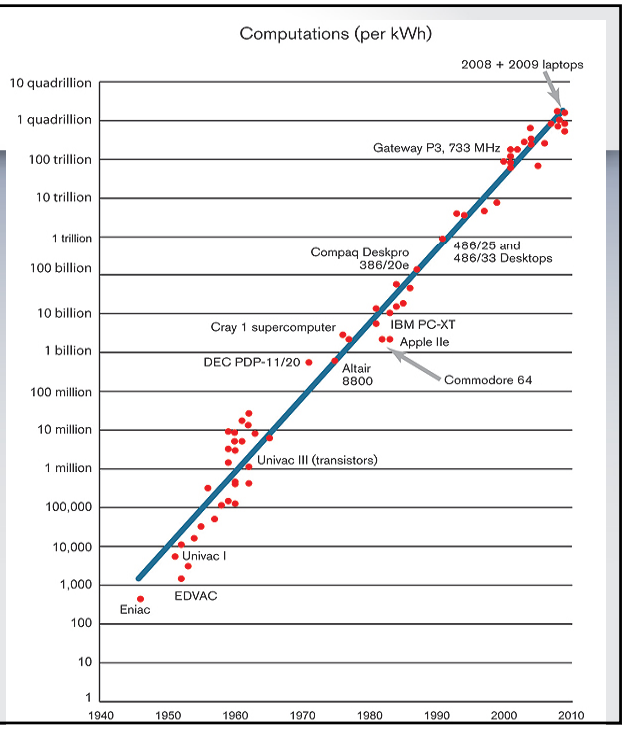
Exabyte = 10^15 bytes

Supply Technology Trends

- Processing Technology Trends
- Storage Technology Trends

Processing Efficiency Trends

- Computations per kWh have doubled about every year and a half since the 1940s
- 100 fold improvement every decade
- Enabled the existence of laptops and smart phones



What if you applied this efficiency increase to the auto industry ?

1971 – 81 MPH
2012 – 324,000 MPH

Speed Increase

1971 – 26 MPG
2012 – 130,000 MPG

Energy Efficiency

1971 – $2,500.00
2012 – $0.05

Cost

Lorie Wigle
Eco-Technology General Manager, Intel Corporation

Source: Volkswagen 1971 Super Beetle Brochure

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History and Trends in Data Storage

DNA Storage

Photo from: The National Center for Supercomputing Applications (NCSA), located at the University of Illinois at Urbana-Champaign

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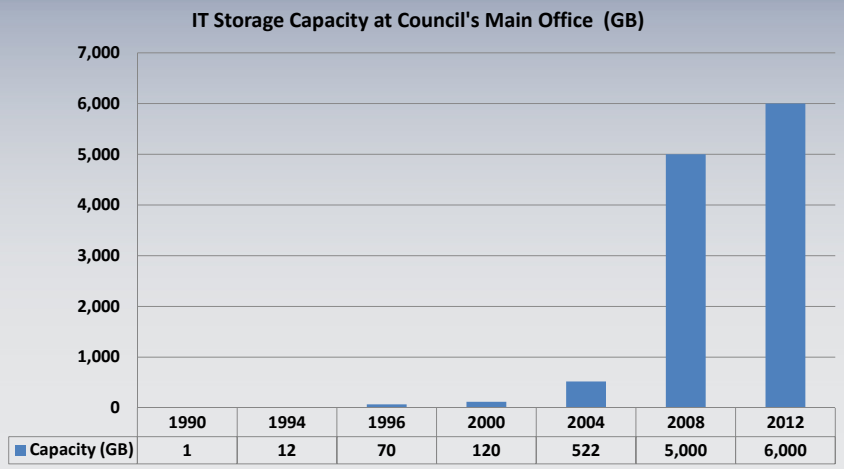
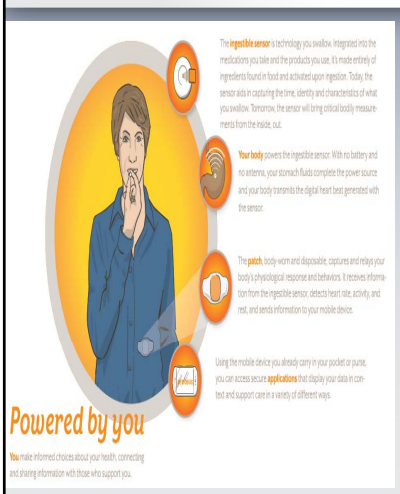
Demand For Data Storage

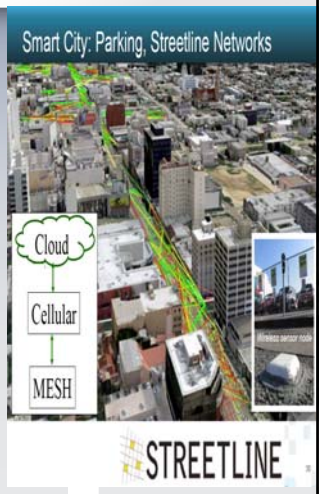
- Facebook
  - 240 billion pictures in storage
  - 350 million pictures added per day
  - 1 billion pictures during Christmas or New Year's Eve.
  - 82% of traffic is to access 8% of photos (hot storage)
  - 200 billion of photos not accessed frequently (cold Storage)
  - Multiple cold storage halls being built at Prineville facility, with each hall holding 1 Exabyte of data.
- Demand for storage doubling every 6-18 month

Example of Increase in Storage Capacity in an small office



Trends in Alternative and Ultra-low Power Applications

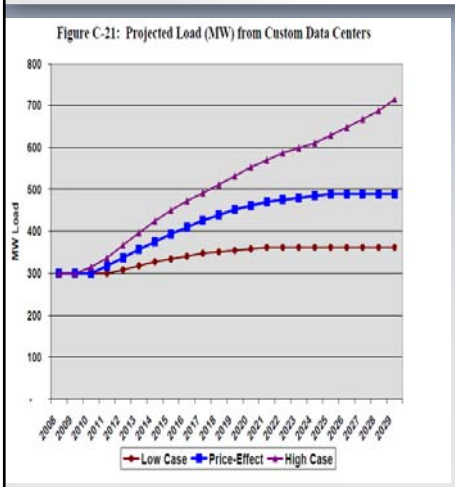




These applications and many more like them are improving economic and social efficiency.

Slide courtesy of Mark Noworolski, Streetline Networks

What can we expect for region loads: Forecast for Enterprise and Mid-tier Data Centers



For Council's 6th power plan, forecast was for between 350-700 MWa growth for large data centers.

If efficiency is not incorporated in the data centers, loads can go significantly higher. Potentially as large as the past Aluminum industry in the region with loads in excess ~2500 MWa. Or over half the current industrial sales.

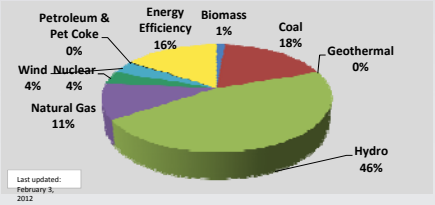
During development of the Seventh Power Plan we will be updating these forecast.

Preliminary indications suggest higher loads than 6th plan.

What Powers Data Centers?

Facebook has built solar array next to its new data center in Prineville, Oregon

- Conventional Grid Electric Utility
- Small amounts from other sources
  - On site solar & wind
  - Off site renewable purchases
  - Combined Heat & Power
  - Waste heat recovery
  - Backup Generators
  - Battery



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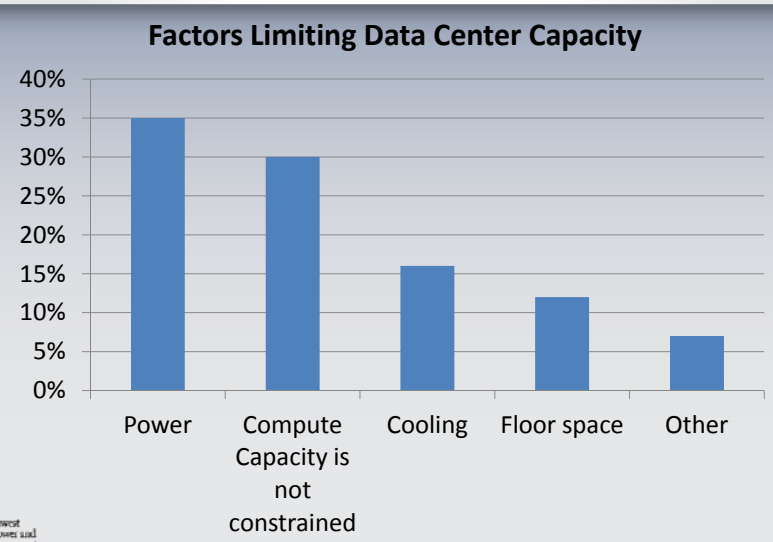
Running out of power in a major concern for the data center managers



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What About Energy Efficiency?

- High awareness of energy use & cost in IT industry
  - Large data centers pay the bill
  - The Green Grid: An IT industry consortium focused on resource efficiency (175 members)
  - IT equipment manufacturers engaged
- Little awareness in smaller embedded data centers
- Utility Programs address both large and small data centers
- USDOE initiatives
- Federal efficiency standards for some equipment
- Energy Star specifications for some IT equipment

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IT Sector Efficiency Potential in the Sixth Power Plan

- No potential in large data center facilities
  - Large facilities have built-in EE incentives
  - In 2009 no utility programs for large facilities
  - Put efficiency improvements in forecast
  - Likely change assumption for Seventh Plan
- Significant potential in small facilities
  - Server rooms & closets in embedded in commercial buildings
  - Server virtualization (88 average megawatts)
  - Likely expand measures list in Seventh Plan

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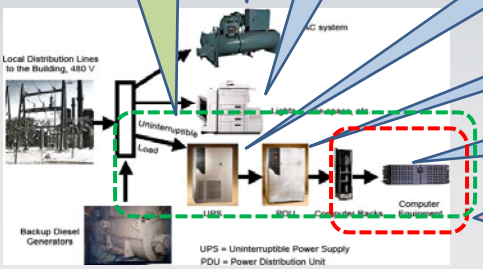
Where is the EE Potential in Facilities?



- •Efficient HVAC Equipment
- •Efficient AC to DC conversion
- •Efficient Lighting
- •Efficient Uninterruptible Power Supply
- •Efficient Power Distribution Equipment
- **•Efficient servers & switches**
- **•Server load management & optimization**
- •Air flow management and cooling strategies in server rooms

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Efficiency Opportunities: Design

Integrate form & function

- Equipment selection, reliability, sizing
- Cooling choices: Direct liquid cooling, ambient air cooling, chillers, avoid need for cooling
- Air flow management
- Power supply, distribution & conversion design

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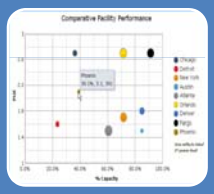
Efficiency Opportunities: Operations

Optimization strategies



- Tuning air-flow, cooling & humidity systems
- Server optimization, utilization, management
- Network speed switching to reduce transmission energy
- Benchmarking & metrics (PUE, DCiE, ERER, RCI, RTI)

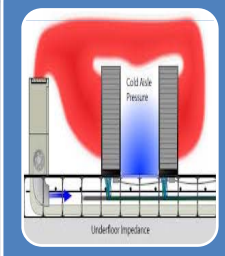
Efficiency Opportunities: Servers & Storage

Efficient Servers

- Internal cooling & processors
- Throttle down during idle
- E-Star Servers ~30% savings
- Consolidating IT system redundancies
- Virtualization
- Efficient Storage; thin provisioning

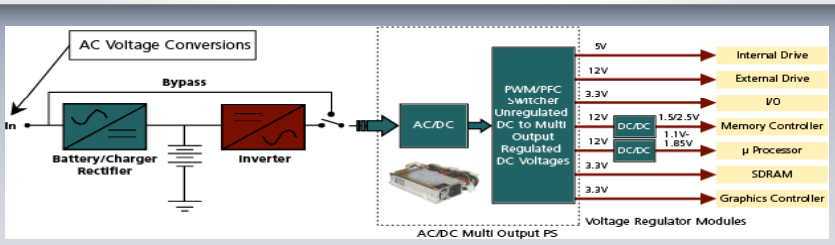
Efficiency Opportunities: Cooling & Ventilation

Cooling & Ventilation Systems



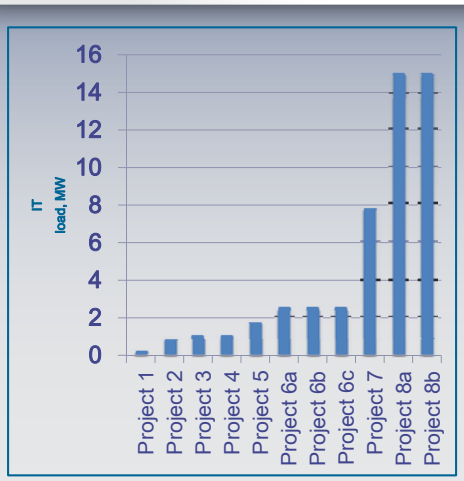
- Air Flow Management
  - Hot & cold aisle separation
  - Supply & return configuration
  - Volume & rate control
- Controls
- Temperature set points & humidity control
- Chilling systems
  - Evaporative, ambient, thermal storage, direct liquid cooling

Efficiency Opportunities: Power Conversion



- Supply at 480 volt AC
  - Server processors at 3-12 volt DC
  - Many voltages in between
  - Minimize conversion losses
  - Improve part-load performance
- UPS & PDU systems can be also be optimized

Some Examples of Utility Program Savings



Handful of projects from ETO

New Construction

- Finding about 10% savings over baseline
- Most common:
  - High efficiency HVAC
  - High efficiency UPS

•It does not take many projects to generate savings. Energy Trust of Oregon estimates an annual load reduction of 30 million kWh per year from 5 projects.

•Savings coming from small, localized, mid-tier and enterprise data centers.

Existing facilities

- Decommissioning outdated equipment
- Virtualization consolidate/run servers at higher capacity factor
- Measuring and reporting on performance on the IT and facility side

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Decommissioning inefficient servers is a good first step

- According to industry estimates, around 20 percent of servers in data centers today are obsolete, outdated or unused. Decommissioning one rack unit (1U) of servers can result in a:
- Savings of $500 per year in energy costs,
- An additional $500 in operating system licenses
- And $1,500 in hardware maintenance costs.

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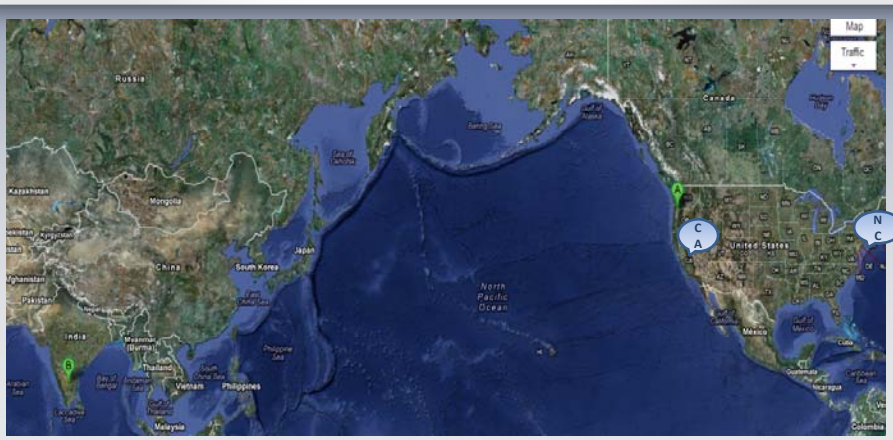
Another opportunity for efficiency is to "Follow the Moon"



Increasingly data centers need greater level of reliability and security for their services. Replication of systems can occur across servers in a same location or across the world. Following-the-moon allows for reduced cooling energy requirement.

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Data Center and Efficiency

- Data Centers infustructure enables displacement of less efficient economic activities.
- Data Center efficiency is increasingly becoming the top concern for IT and facility managers.
- About 60% of the data center mangers indicated that they have already analyzed efficiency or are currently analyzing efficiency in their facilities.

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Grid Support Services

- Microgrid applications
  - Backup generation and local integration of renewables
  - Automated decoupling
- Ancillary Services
  - Increase and decrease load for balancing
  - Move load based on grid congestion
- Data centers can be extremely flexible loads given sufficient incentive

In summary

- Connected load for data centers is in the hundreds of MWs in the PNW and growing fast
- Data Centers are enabling the economy and society to increase their efficiency
- Technology and industry structure change rapidly
- Forecasting data center loads has high uncertainty
- Unknowable future presents significant risks & opportunities for the electric utility industry
- Many sources of low-cost efficiency measures
- Mixed motivation to pursue efficiency
- Efficient facilities will reduce utility uncertainty
- Partnerships between data center operators, designers, trade associations and utilities could provide valuable synergies
- Council needs help from utilities and IT industry to keep up to speed on this fast growing sector

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