Reduced and Alternative Energy for Cloud and Telephony Applications

James Hughes, Fellow

Cloud Computing

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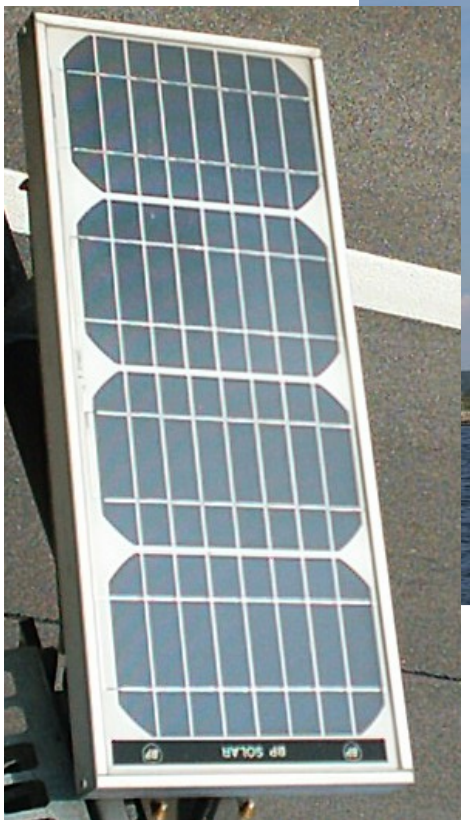
Agenda

- Energy usage in a Telco
  - Trends and direction
- Energy usage in data centers
  - Total Energy
  - Server Energy
  - Consolidation
  - Saving energy by selecting data center location
    - Latency issues
- Promising research areas
  - FAWN
  - Ceph
- What about data center recycling

Green Radio Scenarios

Two Market Profiles:

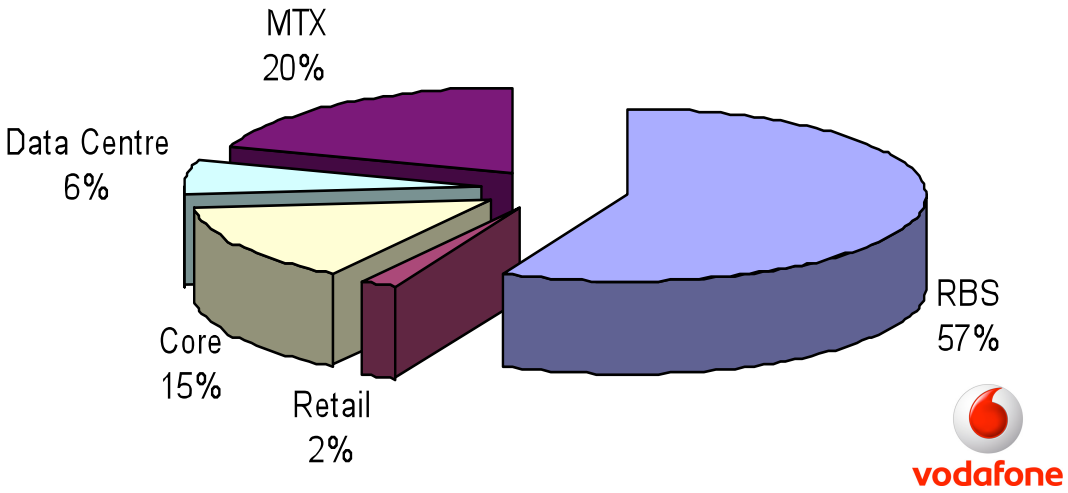
- **Developed World**
  - **Developed Infrastructure**
  - **Saturated Markets**
  - **Quality of Service Key Issue**
  - **Drive is to Reduce Costs**
- **Emerging Markets**
  - **Less Established Infrastructure**
  - **Rapidly Expanding Markets**
  - **Large Geographical Areas**
  - **Often no mains power supply**
    - **power consumption a major issue**

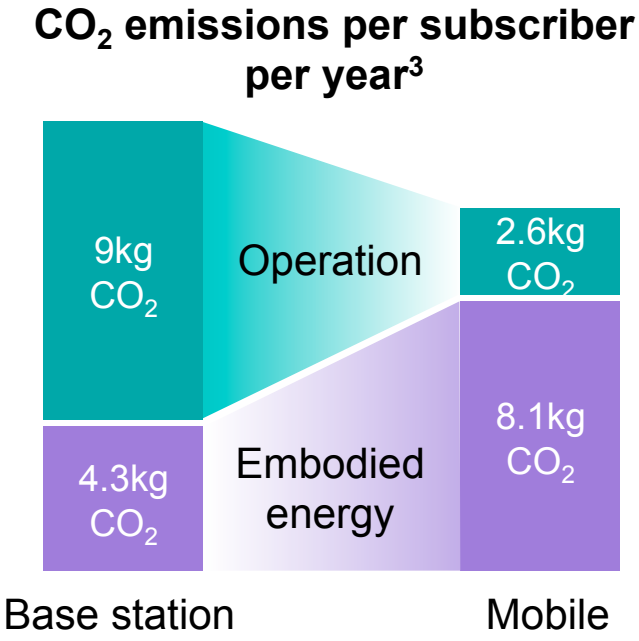


Peter Grant, Green Radio – The Case for More Efficient Cellular Base Stations, May 2009, University of Edinburgh

Energy Cost per Subscriber

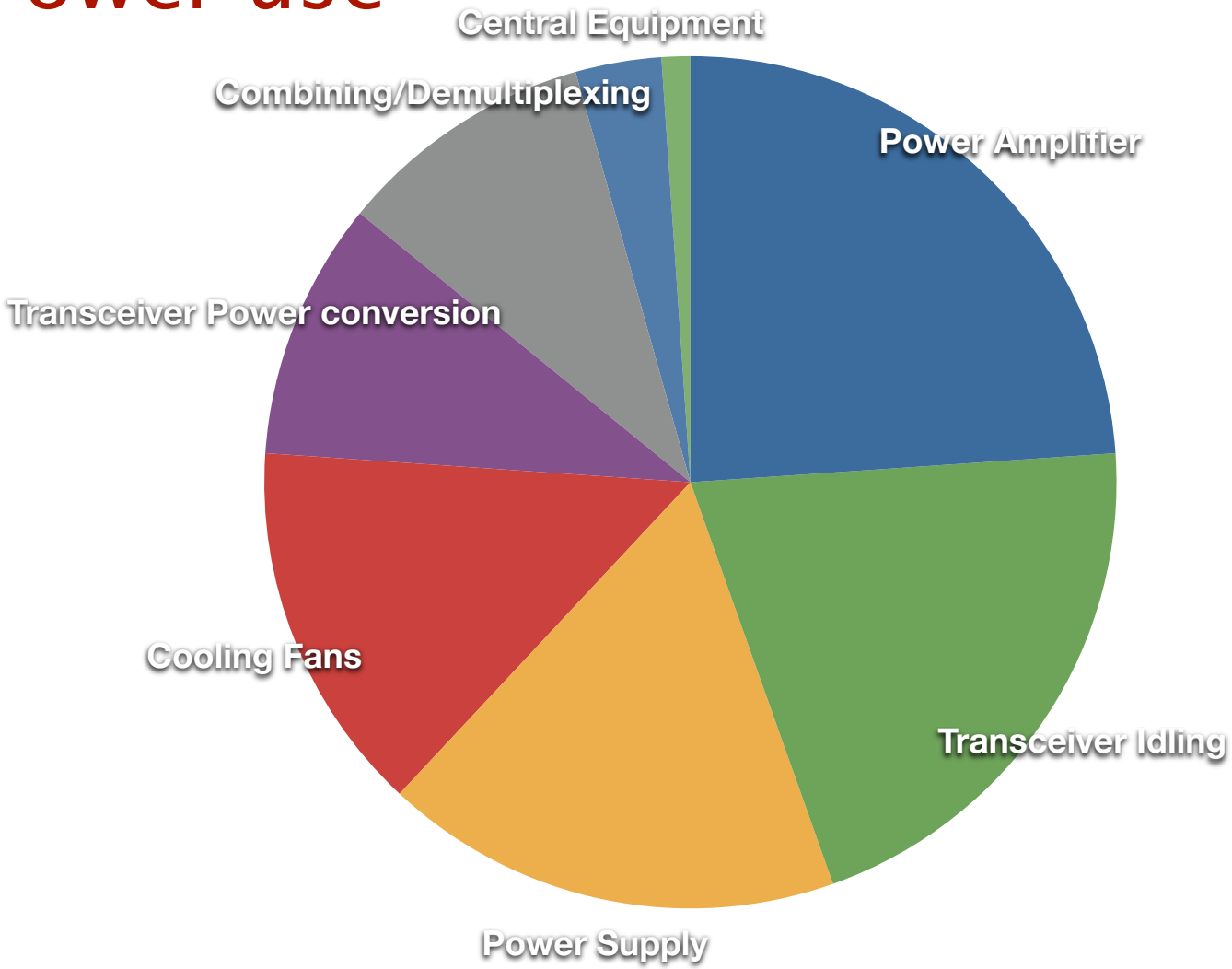
- **Operation vs Embodied**
- **Data Center a small part**
- **Room for improvement**





Tomas Edler, Green Base Stations – How to Minimize CO2 Emission in Operator Networks, Ericsson, Bath Base Station Conference 2008

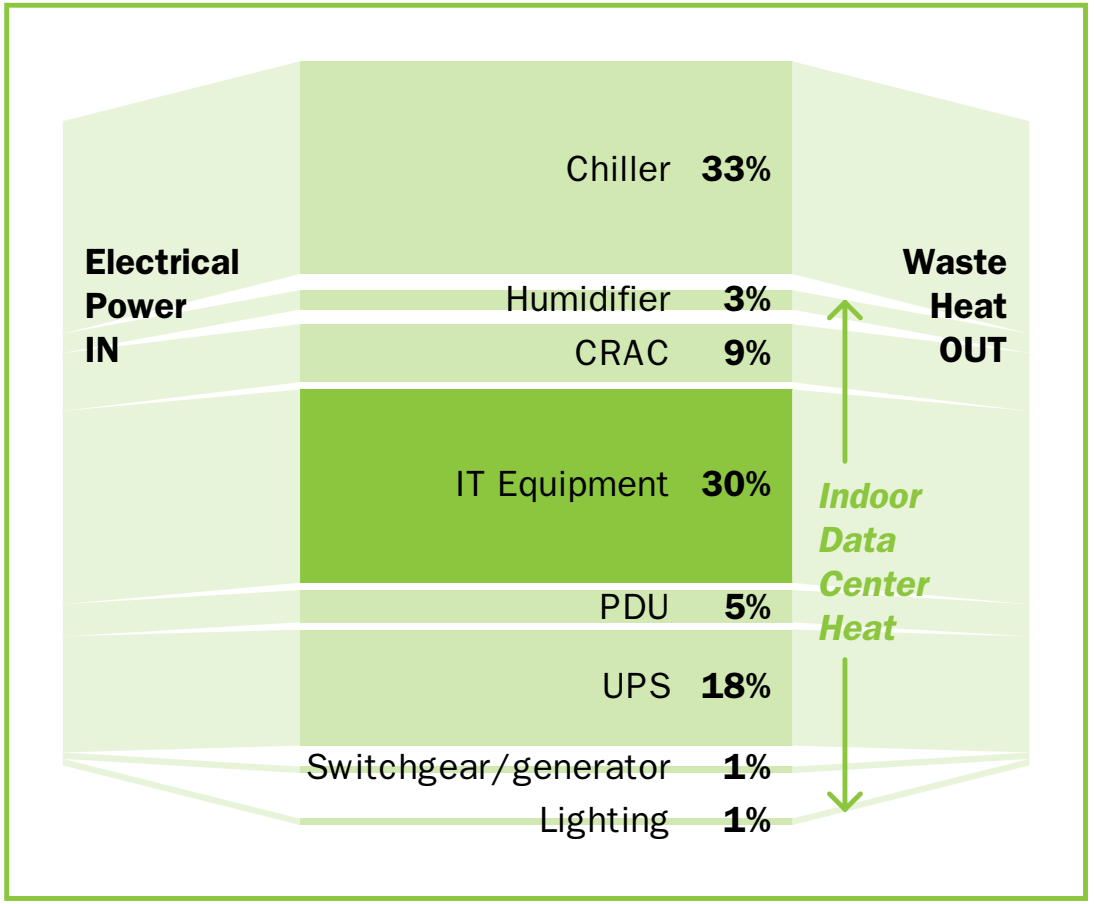
Base Station Power use



Tomas Edler, Green Base Stations – How to Minimize CO2 Emission in Operator Networks, Ericsson, Bath Base Station Conference 2008

Where does the data center power go?

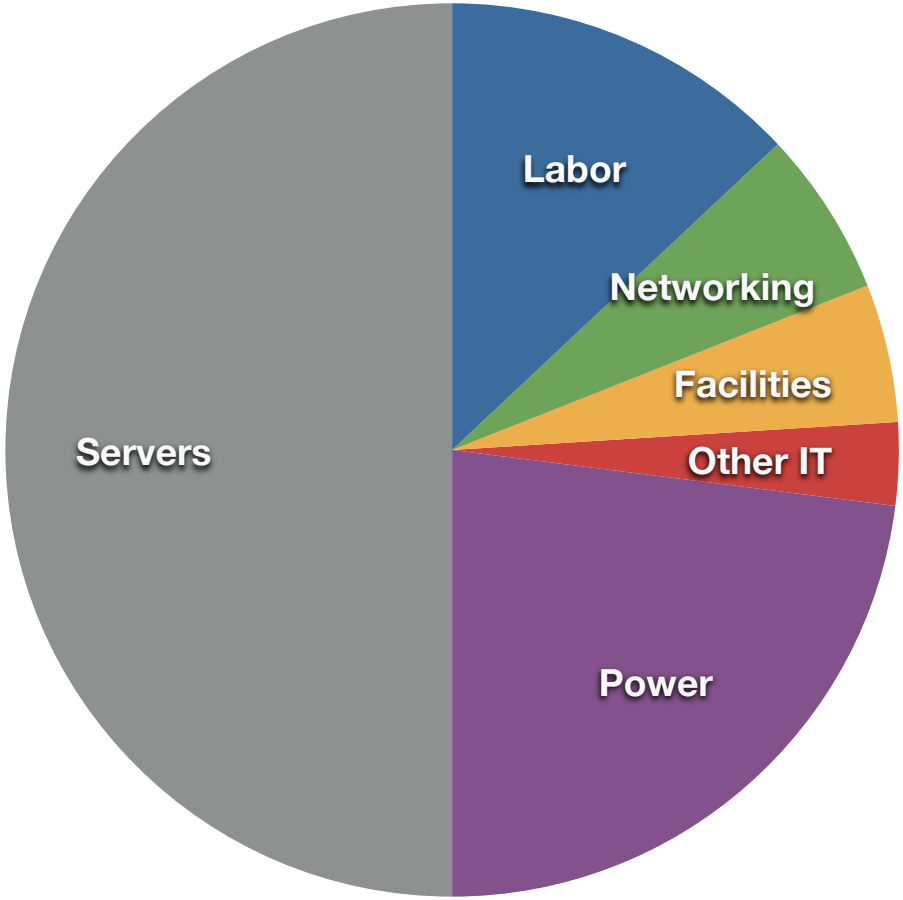
- **Energy losses in the U.S. T&D system are ~7.2%**
- **1w server savings is a 3.3w overall savings**
- **Ambient cooling**
- **UPS**



http://climatetechnology.gov/library/2003/tech-options/tech-options-1-3-2.pdf
http://doe.thegreengrid.org/files/temp/E12A2B5D-B0E1-CA1A-97C1553AF4A01249/Green_Grid_Guidelines_WP.pdf

Economic arguments

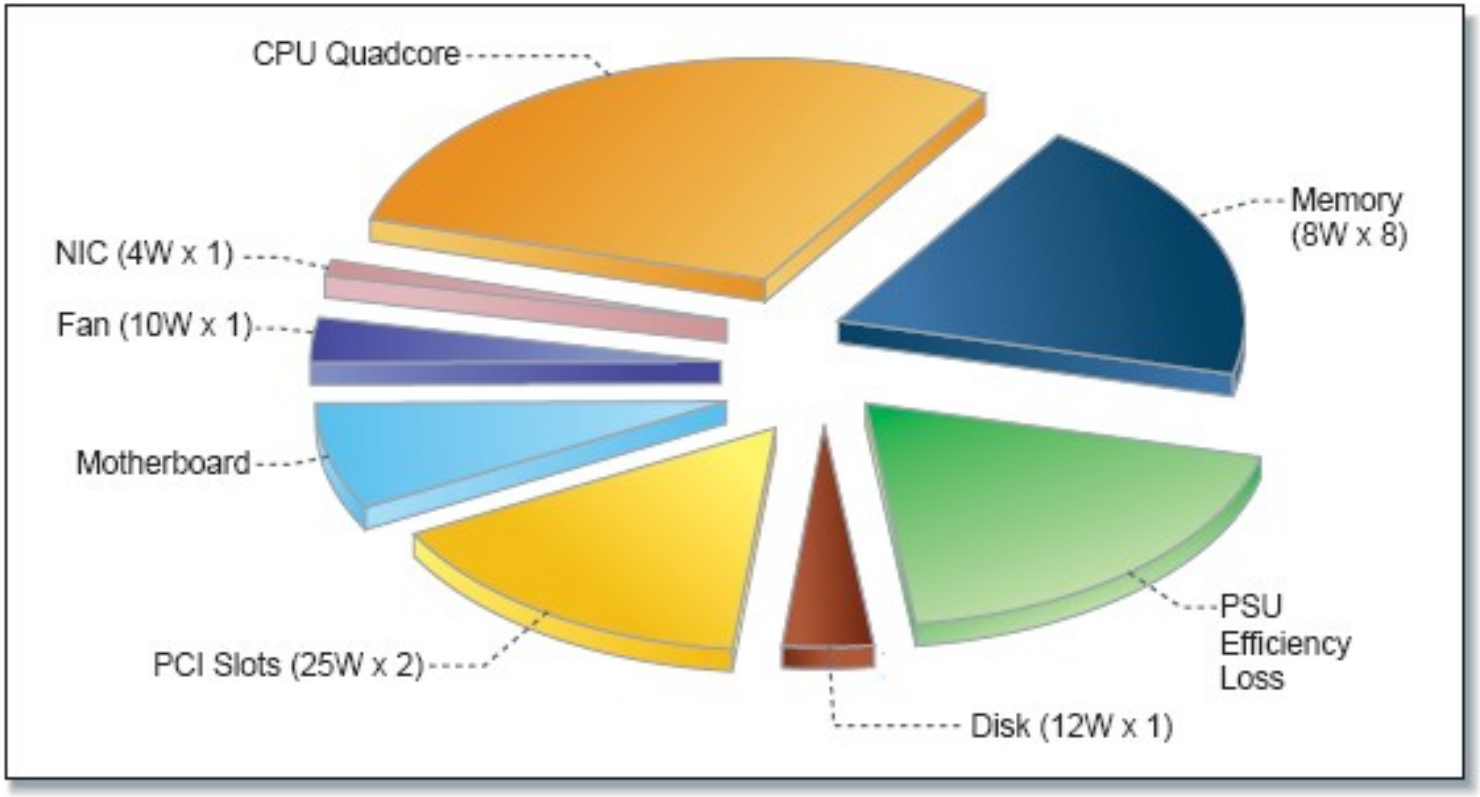
- **Servers and Power are 70% of data center TCO**



Data Center 3 Year TCO

http://scap.nist.gov/events/2009/itsac/presentations/day2/Day2_Cloud_Blakley.pdf

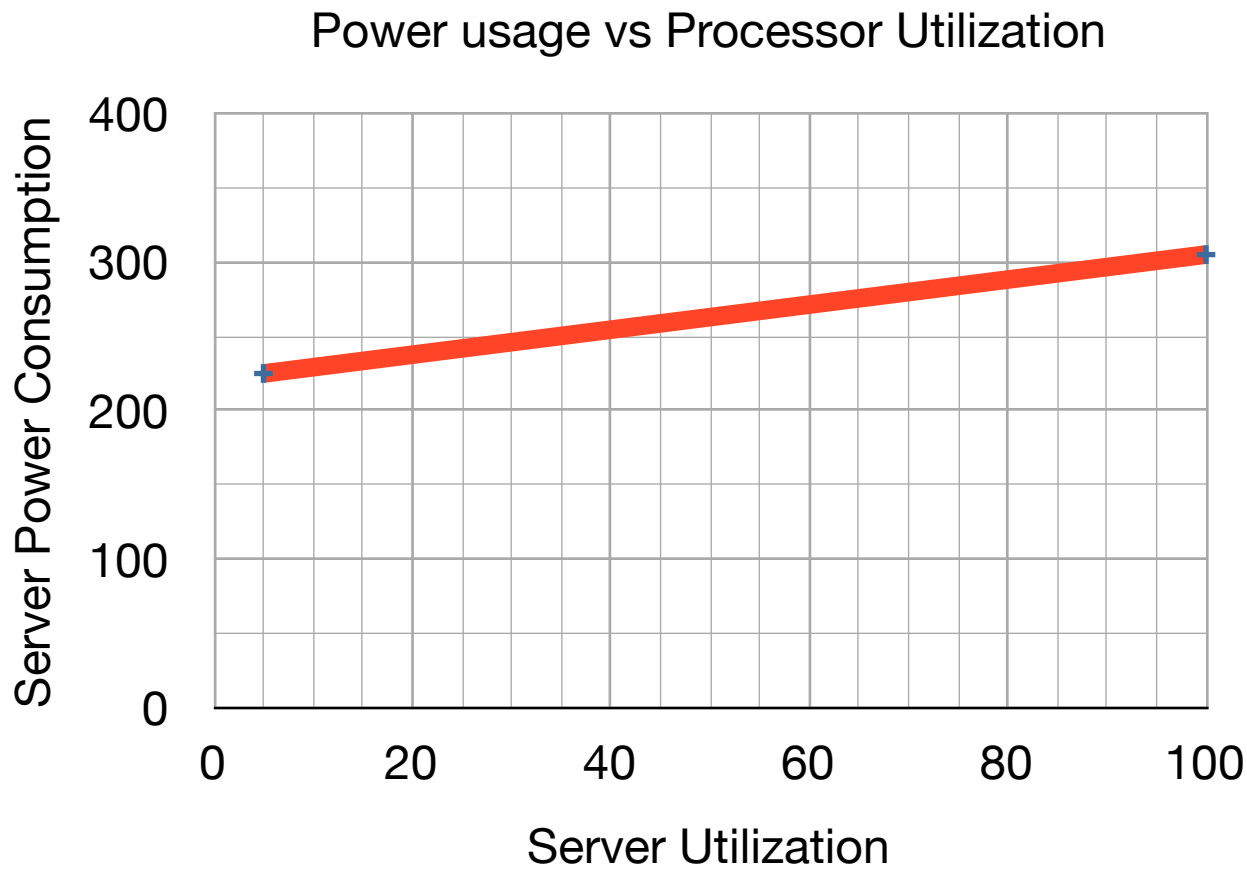
Breakdown of Server Power Consumption



Server Power Consumption (Source: Intel Labs, 2008)

The Argument for Server Consolidation

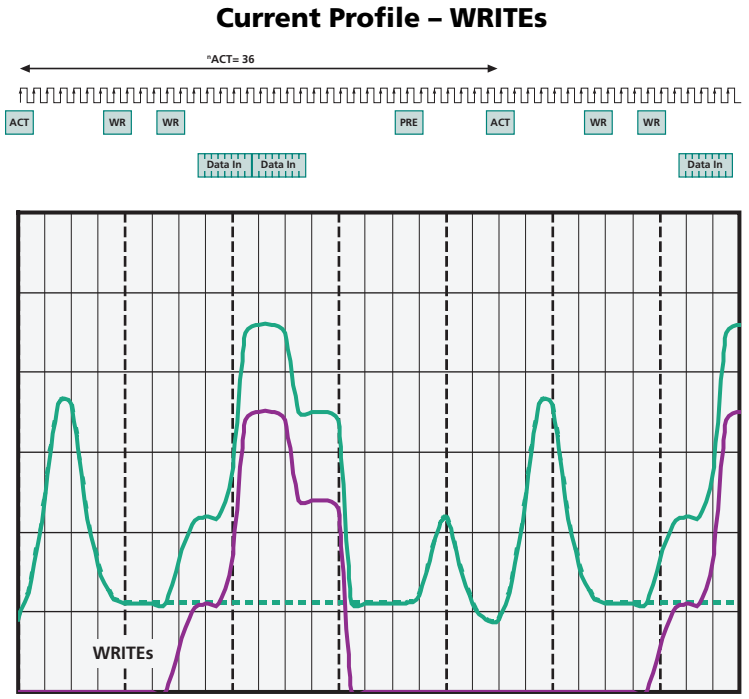
- **Average server is 10% utilized**
- **Consolidation increases utilization**

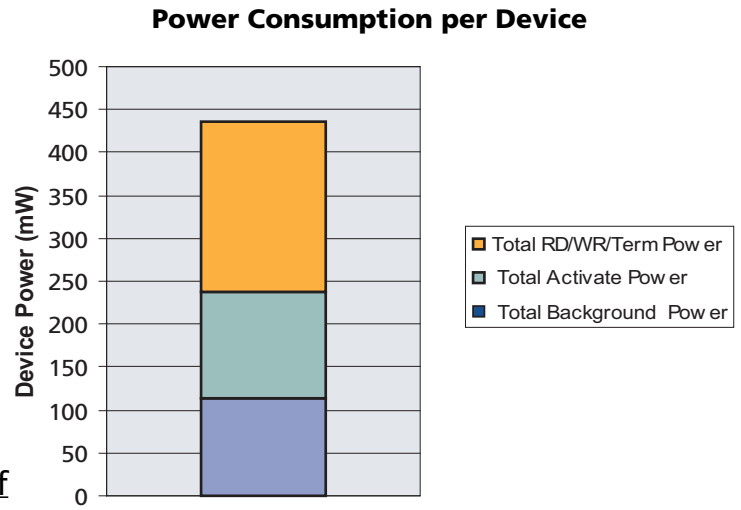


CPU Utilization and Power Consumption (Source: Blackburn 2008)

RAM Power

- Energy based mostly on access
- 25% static power utilization
- RAM Dedup
  - Reduce static power utilization
  - Embodied Energy

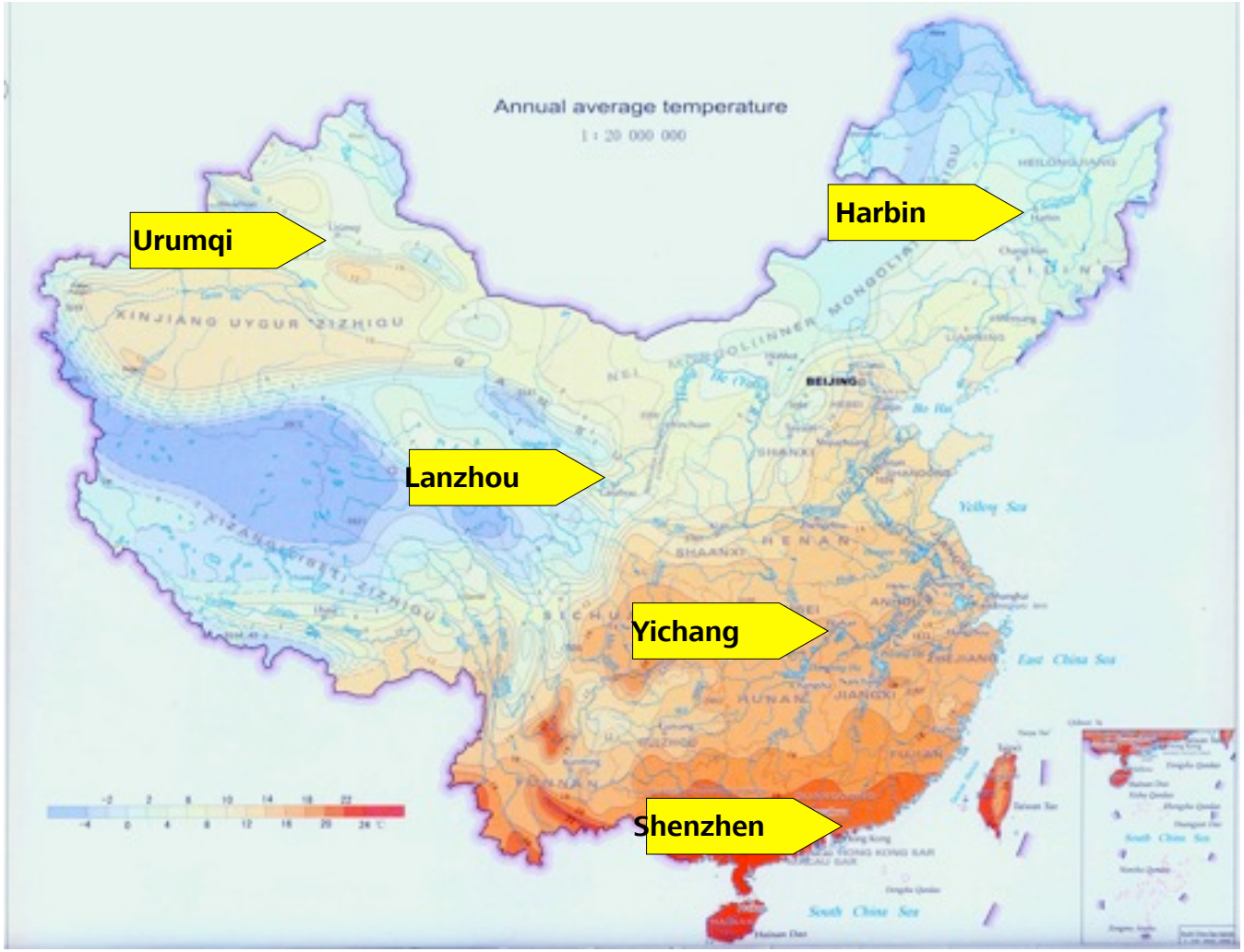




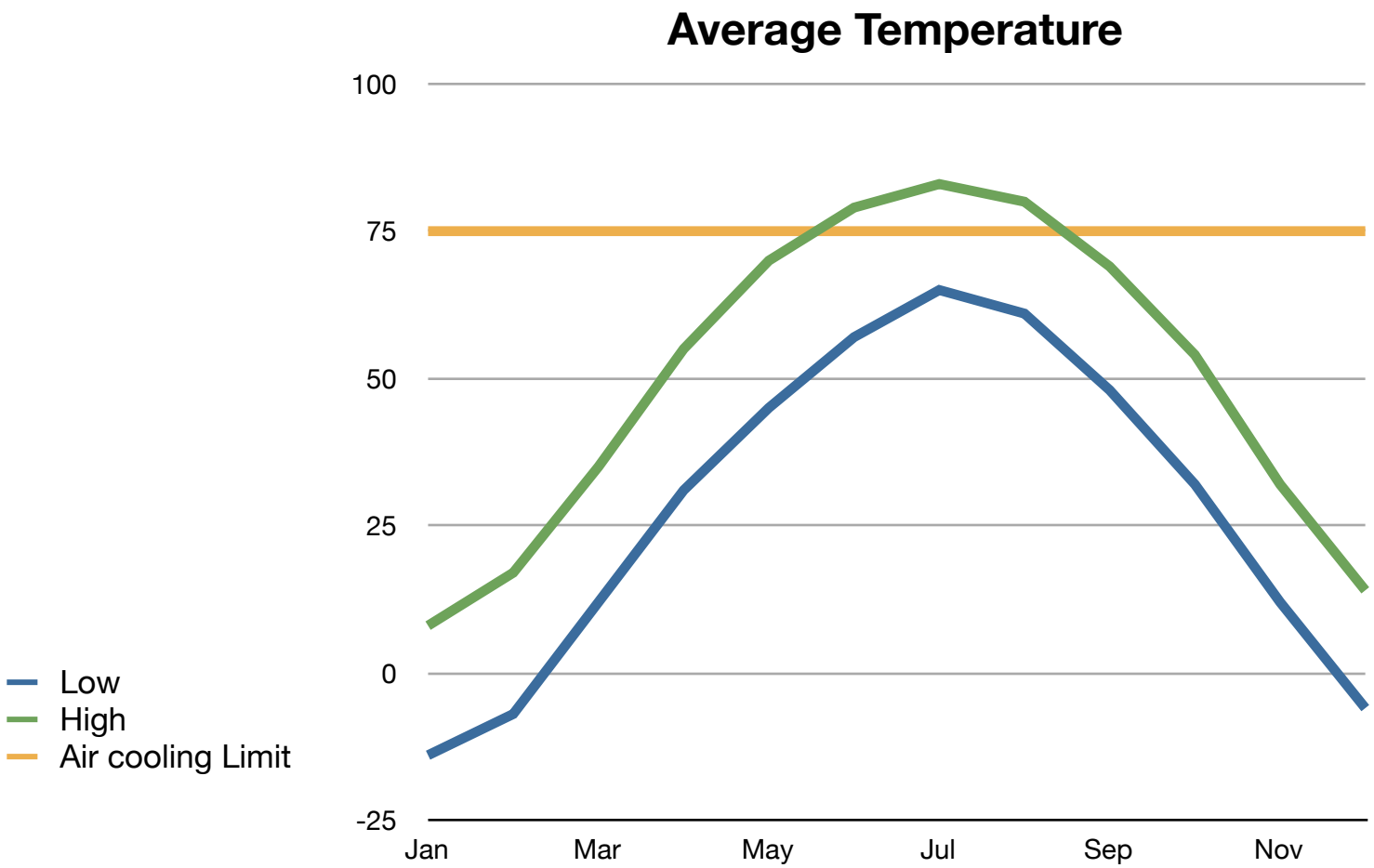
http://download.micron.com/pdf/technotes/ddr3/TN41_01DDR3%20Power.pdf

Data center location matters

- On how many days is cooling necessary in each city?
  - Assume air cooling
- Cost of electricity?
- Latency?
- Network Capacity?



Ambient Cooling, Harbin, China



http://www.travelchinaguide.com/climate/harbin.htm

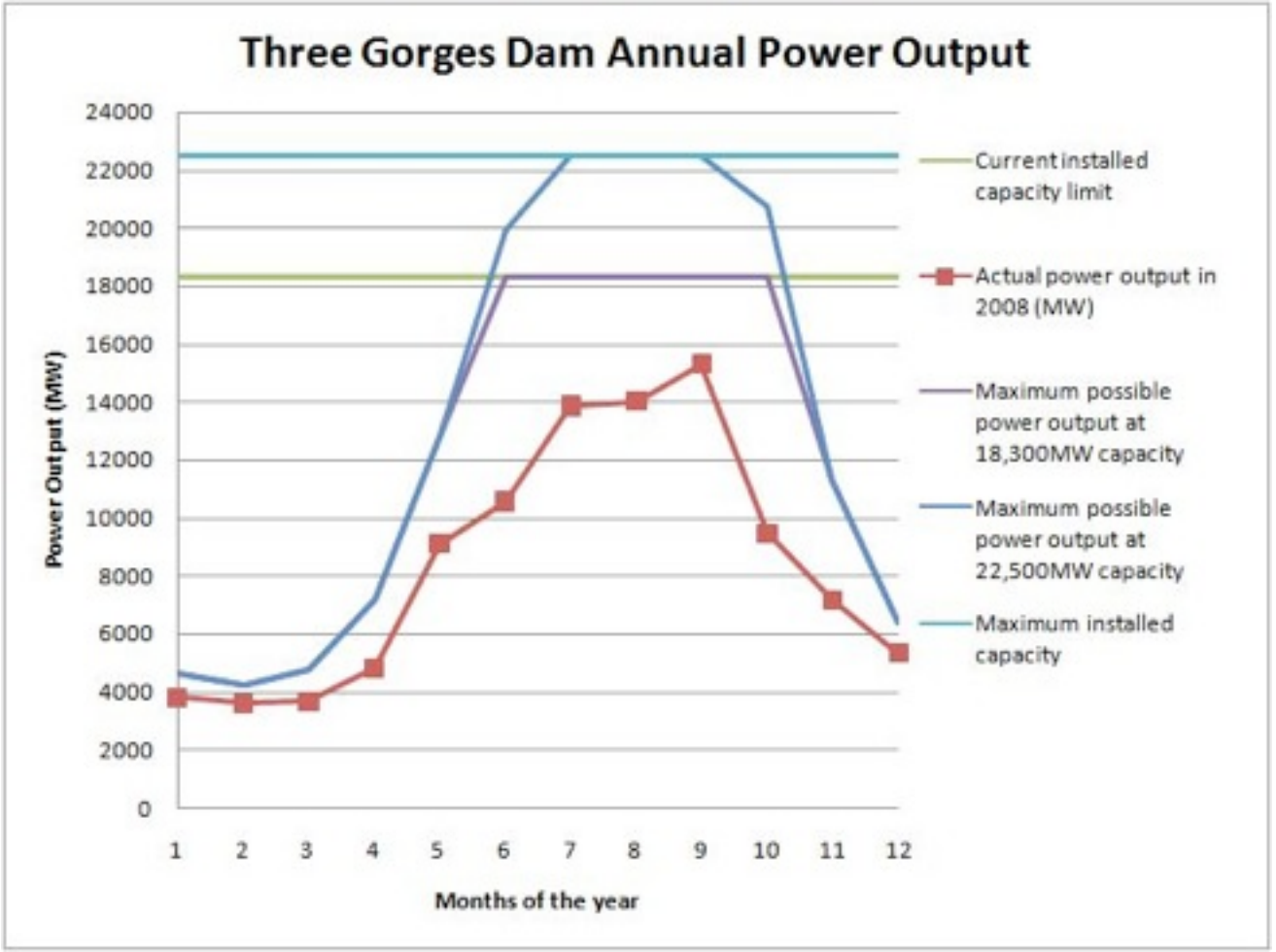
Eliminating Transmission loss

- **Colocate data centers with electricity generation**
- **Dams have water to cool data centers**

http://en.wikipedia.org/wiki/Three_Gorges_Dam

Hydroelectric power

- **Not Constant**



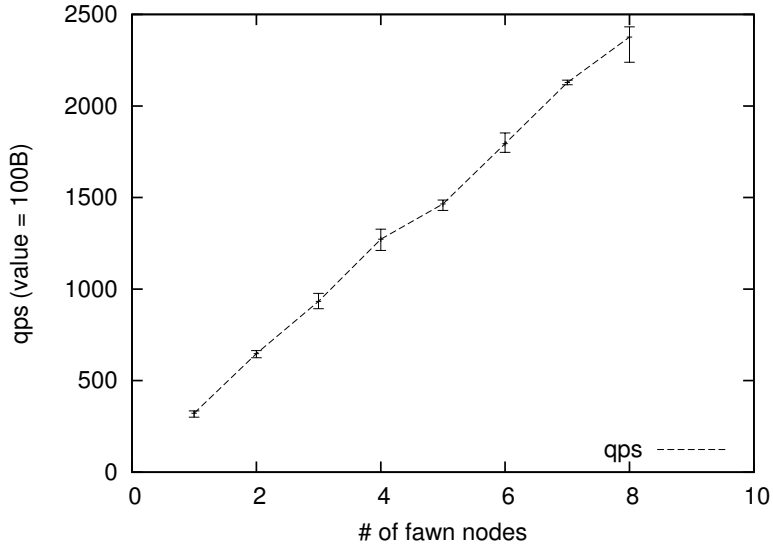
http://en.wikipedia.org/wiki/Three_Gorges_Dam

Improvements in Networking

- **2,250 miles**
  - **24ms optical latency**
  - **130ms measured (San Francisco to Chicago)**
- **5x improvement with AON**

Fast Array of Wimpy Nodes

- Scales linearly
- Using small processors
- High performance
- Energy efficiency
  - 75x of a “Server”
- Can Fawn nodes scale to 1000s?
- Can the cost of Flash be competitive to disk?
  - When?

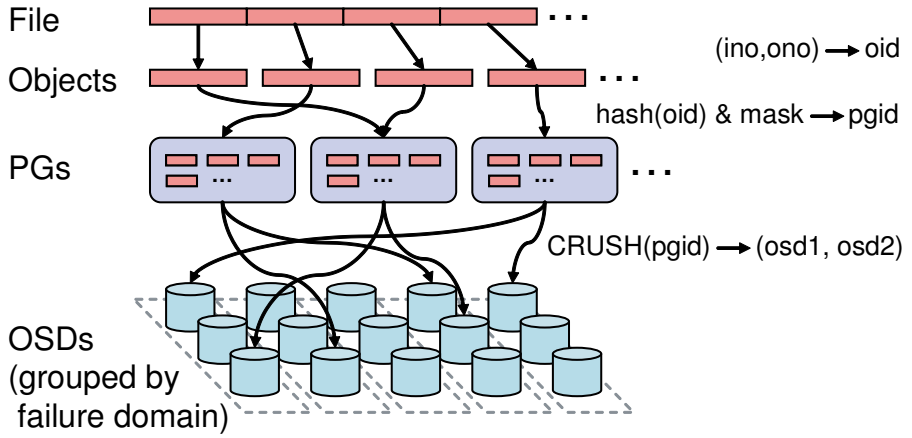


System	QPS	Watts	Queries/Joule
Alix	704	6	117
Soekris (1)	334	3.75	89
Soekris (8)	2431	30	81
Desktop+SSD	2728	80	34
Gumstix	50	2	25
Macbook Pro	53	29	1.8
Desktop	160	87	1.8
Server	600	400*	1.2

http://www.cs.cmu.edu/~dga/papers/fawn-pdl-tr-08-108.pdf

Ceph: A Scalable, High-Performance Distributed File System

- **Problem?**
  - **12 x 1TB disk server from Dell**
    - **~$8000**
  - **12 x 1TB disk sells for ~$1000**
  - **750W**
- **Can this be reduced?**
  - **Ceph uses a $100 ARM server per 2 x 1TB disks**
  - **Does it scale?**
  - **Can the centralized metadata server be eliminated?**
  - **Reliability at scale?**
  - **180W?**



http://www.ssrc.ucsc.edu/Papers/weil-osdi06.pdf

Recycling

- Average server / storage system has a 3 year life
  - Companies like Amazon replace racks at the 3 year mark
- How do we reduce the embodied CO_2?
  - Can we recover value from the waste?
- Does “Fail in place” make a difference?
- “DESIGN FOR DISASSEMBLY TO RECOVER EMBODIED ENERGY”
  - Buildings

http://eprints.qut.edu.au/2846/1/Crowther-PLEA1999.PDF

Innovation over time

- **Moore's law is not cause but effect**
  - **Doubling every 2 years is 41%/yr**
  - **Feature size improvement of 19%/yr**
    - **Continuous process improvement**
- **Green IT will be similar**
  - **Many improvements can be made**
  - **No single fundamental roadblock**
- **Energy use (by itself) has no value**
  - **Increases in efficiency lowers cost and increases competitiveness**
- **In a commodity market, can lower cost indicate more green?**
  - **If government force manufacturers to pay recycling fee?**

Conclusion

- Energy usage in a Wireless Telco focuses on base stations
- Energy usage in data centers has much room for improvement
  - Location
    - Cooling, low transmission loss, UPS
  - Latency
- Server Energy
  - Consolidation
    - Necessary but not sufficient
  - Can more/smaller processors be an answer?
    - Now that we know how to horizontally scale?
- The future for energy savings is bright

Thank You

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