10 Things We Know to Be True

A Behind the Scenes Look at Google Data Center Financial and Operational Efficiencies

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History

2005: Container

2006: Purpose built

2007: Modular at scale

2008/2009: PUE and best practices

2010: Renewable energy

2011: Certifications
Where the Internet lives

Take a look inside Google's high-tech data centers.
1. Focus on the user and all else will follow
2. It's best to do one thing really, really well
3. You can be serious without a suit
4. The need for information crosses all borders
5. You don't need to be at your desk to need an answer
6. Fast is better than slow
7. Great, just isn't good enough
8. There is always more information out there
9. You can make money without doing evil
10. Democracy on the web works
Focus on the user and everything else will follow.
Global Scale

- 30 trillion unique URLs on the web, 30x more than 2008
- 100 billion search queries a month processed (or more than 3 billion a day)
- 425 million active Gmail users
- 5 million business using Google Apps

...after offsetting our footprint

0 Carbon Emissions
It's best to do one thing really, really well.
• Time to market
• Pre-position
• Scale with demand
• Beautiful on the inside
• Built for function
• Industrial plants
• Modular
• Scalable
• Cost effective
You can be serious without a suit.
Owned and operated.

- Corporate culture
- On-site benefits
- Sense of ownership
- Better-faster-cheaper
- Empower employees
- Key learning: Reward innovations
• Cost effective
• Key learning: The simple things do matter
The need for information crosses all borders.
- At Google scale
- Cloud infrastructure: Day 1
- Control the stack
• Carbon neutral
• Efficiency best practices
• Sustainability strategy
You don’t need to be at your desk to need an answer.
• Maximize server space
• Scalable
• Key learning: Work with what you have
Fast is better than slow.
• Economies of scale
• Decentralized plant
• Manufactured off-site

Reduced lead times and cost.
• Massively modular
• Central plant
• Cost effective
Flexible infrastructure.

- Accommodate new technology
- Evaluate all components
- Integrated approach
Great, isn’t good enough.
- Flexibility
- TCO based decisions
- Efficiency
The right cooling for the right location.

- Air side cooling
- Geography makes a difference
- One size doesn’t fit all

- Know your constraints
- Think out-of-the box
- Sustainability
There is always more information out there.

Deep Dive:
Technical Iteration
Google Data Center: Traditional Cooling
Google Data Center: Heat Removal Options

Is moving water more cost effective than moving air?

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<th>Temp (°C)</th>
<th>Air Specific Heat (J/kg K)</th>
<th>Air Thermal Conductivity (W/mK)</th>
<th>Water Specific Heat (J/kg K)</th>
<th>Water Thermal Conductivity (W/mK)</th>
<th>Cp ratio (Water/Air)</th>
<th>k ratio (Water/Air)</th>
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1. Heat capacity and thermal conductivity of H2O are respectively ~4x and 24x greater than those of air.
2. Initial data indicates that moving water is more efficient for server floor heat removal.
Are pumps more efficient than fans for server floor heat removal?

Applicable fan peak (static) efficiency is near 60%, while applicable pump is closer to 70% efficient

• Dissipating a 10MW IT load
  • ~160hp (120kW) using H2O pumps
  • ~620hp (465kW) using fans…~3.85x more energy!
Google Data Center – Patented Cooling
Waterside economization
You can make money without doing evil.

Water sources
Reclaimed water.
Industrial canal water.
Sea water.
Storm water.
No water (or at least very little).
Democracy on the web works...
Parting thoughts
Data Center Landscape

Number of Server/Storage Units

Typical PUE*

- Single: >2.5
- Rack/Computer Room: 2.0
- Midsize DC: 1.6
- Enterprise DC: 1.4
- Large DC: 1.1

Server information source: Forecast Analysis: Data Centers, Worldwide, 2010-2016, 2Q12 Update, Gartner Inc.

*PUE Google analysis
Financial and Operational Efficiency

- Holistic sustainability strategy?
- What’s is your data center efficiency strategy?
- What’s your data center financial strategy?
Thank you.