• Acknowledgments
• What is this technology?
• Demonstration Goals
• Setup
• Turning Data into Information
• Conclusions
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What is it?

Direct Liquid Cooling

Asetek RackCDU D2C™ Liquid Cooling

Direct Cooling of CPU and Memory

CPU Cooling Concept

Modulating Valve
Facility Side

Liquid to Liquid Heat Exchanger

Asetek RackCDU™

Server Rack

Flexible Tubes to Each Server

Integrated Pump and Cold Plate

Asetek RackCDU™ D2C™ “System” (servers and basic computer rack not included)
Demonstration Goals

Estimate Energy Savings of This Technology Compared to A Base Case

**Direct Cooling Case**
- Asetek Cooled Cisco Servers
- electrical power
- power meter
- kW (electrical)
- remaining heat goes inside the data center
- Btu meter
- Btu/hr.
- heat removed by direct cooling system
- kW (heat)
- calculate fraction cooled by direct cooling
- Romonet Simulation Software

**Base Case**
- Air Cooled Cisco Servers
- electrical power
- power meter
- kW (electrical)
- remaining heat goes inside the data center
- kW (heat)
- Romonet Simulation Software

Goal: Key Variables

Goal: Determine Fraction of Server Heat Captured for a Broad Range of Conditions

• Supplied Water Temperature
  15°C - 45°C (59°F - 113°F)

• Water Flow Rate (Return Water Temperature)
  ~0.5-4.9gpm = ~17°C-~50°C (62°F – 122°F)

• IT Heat Level
  ~100 w/server (idle) → ~440 w/server (max. power)
Setup

38 Asetek Cooled Cisco Servers

Lytron CDU Not Part of Asetek Product

Asetek CDU

Back of Rack with 38 Cisco Servers
Setup (cont.)

Supply Water Temp. Control

Metering: Btu, Electrical Power

Lytron CDU

Power Meter

Btu Meter
Setup (data collection)

Asetek CDU (Water to Water Heat Exchanger)

Building Chilled Water Loop

Water to Water CDU

Btu Meter

T₁, T₂, Flowrate, Btu

Data Collection Joulex Software Database

IPMI kW kW kW (per outlet)

Elect. Panel

ServerTech PDUs

Air-Cooled Servers

Server

Server

Server

Server

Server

Server

Server

Server

Server

Server
Collected Data (sample)
Asetek Cooling - 100% Server Load
(~430 watts/server, ~28°C Inlet)

15C Water Supply
20C Water Supply
35C Water Supply
40C Water Supply
45C Water Supply

Percent of Server Power Water Cooled
Rack CDU Return Water Temp. (C)

Asetek Cooling - ~50% Server Load
(~270 watts/server, ~28°C Inlet)

20C Water Supply
25C Water Supply
30C Water Supply
40C Water Supply
45C Water Supply

Percent of Server Power Water Cooled
Rack CDU Return Water Temp. (C)

Asetek Cooling - Idle Server Load
(117 watts/server, ~28°C Inlet)

15C Water Supply
20C Water Supply
30C Water Supply
40C Water Supply

Percent of Server Power Water Cooled
Rack CDU Return Water Temp. (C)
Data Center Models

Base Case

Chiller Only Case

Cooling Tower Case

Dry Cooler Case

2MW IT Load, N+20% Fixed Speed CRAHs (id. sel.), N+1 Water Cooled Chillers, N+1 Counter-Flow Cooling Towers, N+1 UPS, 2N Step-Down PDUs
Modeling Results: pPUE for Full IT Load

Annual Energy Consumption by Asetek Infrastructure Support Type
Server Load = 100% (climate: San Jose CA)

- Total Energy Consumption

- Annual Energy Consumption (kWh/yr)

- Supply Water Temp.
- Asetek Support Type
- Aux. Cooling Type
- pPUE

- Base Case: 1.45
- 40C Dry Cooler: 1.29
- 30C Cooling Tower: 1.28
- 30C Dry Cooler: 1.28
- 20C Cooling Tower Chiller Boost: 1.25
- 20C Dry Cooler Chiller Boost: 1.26
- 20C Chiller: 1.35

- Fraction Cooled Reduction from Base Case
- Elect Loss
- Asetek Liquid Cooling
- HVAC
- IT Load

- Return Water Temp. Add 10C (All)

preliminary results
Modeling Results: pPUE Estimates for 50% IT Load

Annual Energy Consumption by Asetek Infrastructure Support Type
Server Load = 50% (climate San Jose CA)

- Site Total Energy Consumption
- Annual Energy Consumption (kWh/yr)
- Supply Water Temp.
- Asetek Support Type
- Aux. Cooling Type
- pPUE

- Base Case: 1.52
- 40C Dry Cooler: 1.39
- 30C Cooling Tower: 1.38
- 30C Dry Cooler: 1.37
- 20C Cooling Tower Chiller Boost: 1.36
- 20C Dry Cooler Chiller Boost: 1.36
- 20C Chiller: 1.43

- Fraction Cooled Reduction from Base Case
- Elect. Loss
- Asetek Liquid Cooling
- HVAC
- IT Load
- Return Water Temp. + 10C (All)

Preliminary results
Modeling Results: pPUE Estimates for Idle IT Load

Annual Energy Consumption by Asetek Infrastructure Support Type
Server Load = Idle (climate: San Jose CA)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Annual Energy Consumption (kWh/yr)</th>
<th>pPUE</th>
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<tbody>
<tr>
<td>Base Case</td>
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<tr>
<td>20°C Cooling Tower</td>
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<td>Chiller Boost</td>
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<tr>
<td>20°C Chiller</td>
<td>5,000,000</td>
<td>1.58</td>
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<tr>
<td>Chiller</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fraction Cooled Reduction from Base Case:
- Elect Loss: .42 (9%)
- Asetek Liquid Cooling: .42 (9.5%)
- HVAC: .42 (9%)
- IT Load: .42 (9%)
- Return Water Temp. Add 10°C (All): .42 (9%)

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Conclusions

• This direct cooling technology should provide a significant reduction (~16-21%) in total data center energy consumed if implemented as modeled for an IT load of 50%.

• Using colder water when economically available reduces the total energy consumed for the climate modeled (San Jose CA) in our study. Other climates will provide different results.

• Significant site-level energy savings should be possible using this technology even though it does not capture 100% of the server waste heat.
Backup Slide

Measured Air Cooled Server Power vs. Air Inlet Temperature

Air Cooled Servers (IP39, IP40) Power vs. Inlet Air Temperature

Front Panel Air Inlet Temperature (°C)
Air Cooled Server Power Adjustment vs. Front Panel Air Inlet Temperature

Server Power Increase vs. Front Panel Temp
Calculated from Schneider Electric White Paper 138 D. Moss, J. Bean

Percent Server Power Increase as a Function of Front Panel Server Air Inlet Temperature Compared to a Front Panel Inlet Temperature of 22.2C (72F)

$y = 0.000661x^2 + 0.004231x$

$R^2 = 1.000000$