Lenovo HPC Solution
Cooling Technology
How to measure Power Efficiency

• **PUE**
  
  \[ \text{PUE} = \frac{\text{Total Facility Power}}{\text{IT Equipment Power}} \]
  
  - **Power usage effectiveness (PUE)** is a measure of how efficiently a computer data center uses its power;
  - PUE is the ratio of total power used by a computer facility to the power delivered to computing equipment.
  - Ideal value is 1.0
  - It does not take into account how IT power can be optimised

• **ERE**
  
  \[ \text{ERE} = \frac{\text{Total Facility Power} - \text{Treuse}}{\text{IT Equipment Power}} \]
  
  - **Energy Reuse Effectiveness** measures how efficient a data center reuses the power dissipated by the computer
  - ERE is the ratio of total amount of power used by a computer facility to the power delivered to computing equipment.
  - An ideal ERE is 0.0. If no reuse, ERE = PUE
Lenovo Choice of Cooling

**Air Cooled**
- Standard air flow with internal fans
- Fits in any datacenter
- Maximum flexibility
- Brodest choice of configurable options supported
- Supports Native Expansion nodes (Storage NeX, PCI NeX)

<table>
<thead>
<tr>
<th>PUE</th>
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**Indirect Water Cooled**
- Air cool, supplemented with RDHX door on rack
- Uses chilled water with economizer (18°C water)
- Enables extremely tight rack placement

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<th>PUE</th>
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**Direct Water Cooled**
- Direct water cooling without fans
- Higher performance per watt
- Free cooling (inlet up to 50°C water)
- Energy re-use
- Densest footprint and high TDP SKU
- Ideal for geos with high electricity costs and new data centers

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<tr>
<th>PUE</th>
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Choose for broadest choice of customizable options
Choose for compromise between flexibility and energy efficiency
Choose for highest performance and energy efficiency
Next Generation Liquid Cooling

• Enable high performance / power processors – 165W - 205W+ CPUs
• Enable high performance memory with direct water cooling (3D Cross Point)
• Support wide inlet water range 10°C – 50°C
• Target > 95% heat recovery (Air 5°C - 40°C; Water 10°C – 50°C)
• Direct warm water cooled almost all system components
• Provide Rack (Chassis & Manifold) insulation
• Investigate solutions for water cooled power supplies
Improved Water Cooling Architecture for Purley

Improvements for 90% heat to water recovery

• Focus on maximizing efficiency for high (50°C) inlet water temperatures

• Direct water cooling of processors, memory, voltage regulation devices and IO devices (Network and Disk)

• Water circuit traverses all critical components to optimize cooling.
NeXtScale improvements for 95% heat capture

- Existing node water loop and quick disconnects
- New technology for capturing heat radiated from small components
- New water cooled storage devices, and transceivers
- New sealed full wide tray
- New Liquid Cool PSU
- One PSU per full wide tray
- New Liquid Cool PSU Manifold
- Existing chassis WCT manifold
Power consumption, Junction Temperature and Cooling

- Example: HPL scores across a range of temperatures:
  - 12 sample processors running on NeXtScale System WCT

- HPL scores remain mostly flat for junction temperatures in the range that water cooling operates.

- The HPL scores drop significantly when junction temperature is in range that air cooling operates.

- Conclusion: Water Cooling enables the highest performance possible for each processor SKU at any water inlet temperature under 45°C

* Vinod Kamath
DWC reduces Processor Temperature on Xeon 2697v4

Conclusion: Direct Water Cooling lowers processor power consumption by about 5% and allows higher processor frequency.

NXT with 2 socket 2697v4, 128 GB 2400 MHz DIMM Inlet Water temperature is 28°C.
Air and DWC performance DC power on Xeon 2697v4

<table>
<thead>
<tr>
<th>Turbo On</th>
<th>Air-cooled</th>
<th>Water-cooled</th>
<th>Performance delta</th>
<th>Power delta</th>
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Conclusion:
With Turbo OFF, Direct Water Cooling reduces power by 5%
With Turbo ON, it increases performance by 3% and still reduces power by 1%

DC energy is measured through aem DC energy accumulator.
2 X 3 petaflops SuperMUC systems at LRZ Phase 1 & Phase 2

**Phase 1**

- Fastest computer in Europe on TOP500, June 2012
  - 9324 nodes with 2 Intel Sandy Bridge EP CPUs
  - HPL = 2.9 petaflop/s
  - InfiniBand FDR10 interconnect
  - Large File Space for multiple purpose
    - 10 Petabyte File Space based on IBM GPFS with 200 GB/s I/O bandwidth
- Innovative technology for energy effective computing
  - Hot Water Cooling (45°C)
  - Energy Aware Scheduling
- Most energy efficient high-end HPC system
  - PUE 1.1
  - Total power consumption over 5 years to be reduced by ~ 37% from 27.6 M€ to 17.4 M€

**Phase 2**

- Acceptance completed
  - 3096 nx360 M5 compute nodes
    Haswell EP CPUs
  - HPL = 2.8 petaflop/s
  - Direct Hot Water Cooled, Energy Aware Scheduling
  - InfiniBand FDR14
  - GPFS, 10 x GSS26, 7.5 PB capacity, 100 GB/s I/O bandwidth
CooLMUC-2

- Lenovo NeXtScale Water Cool Technology (WCT) system
  - Water inlet temperatures 50 °C
  - All season chiller-less cooling
  - 384 compute nodes
  - 466 teraflop/s peak performance

Energy Reuse Effectiveness (ERE) measures how efficient a data center reuses the power dissipated by the computer

ERE = \frac{\text{Total Facility Power} - \text{Treasure}}{\text{IT Equipment Power}}

- SorTech Absorption Chillers
  - based on zeolite coated metal fiber heat exchangers
  - a factor 3 higher than current chillers based on silica gel
  - COP = 60%
  - Total electricity reduced by ~60%
Re-Use of Waste Heat

Leibniz Supercomputing Centre
Thank you