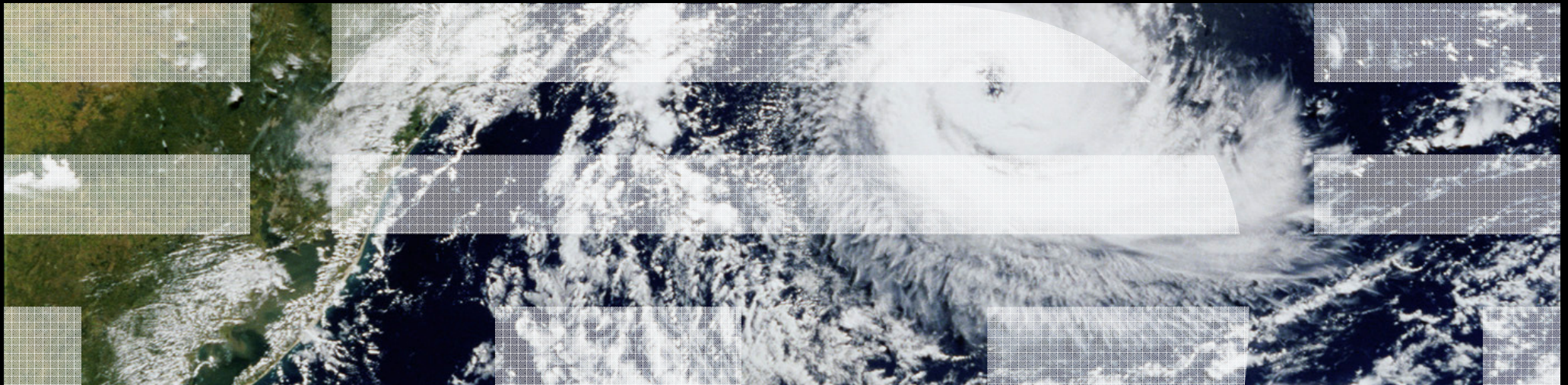
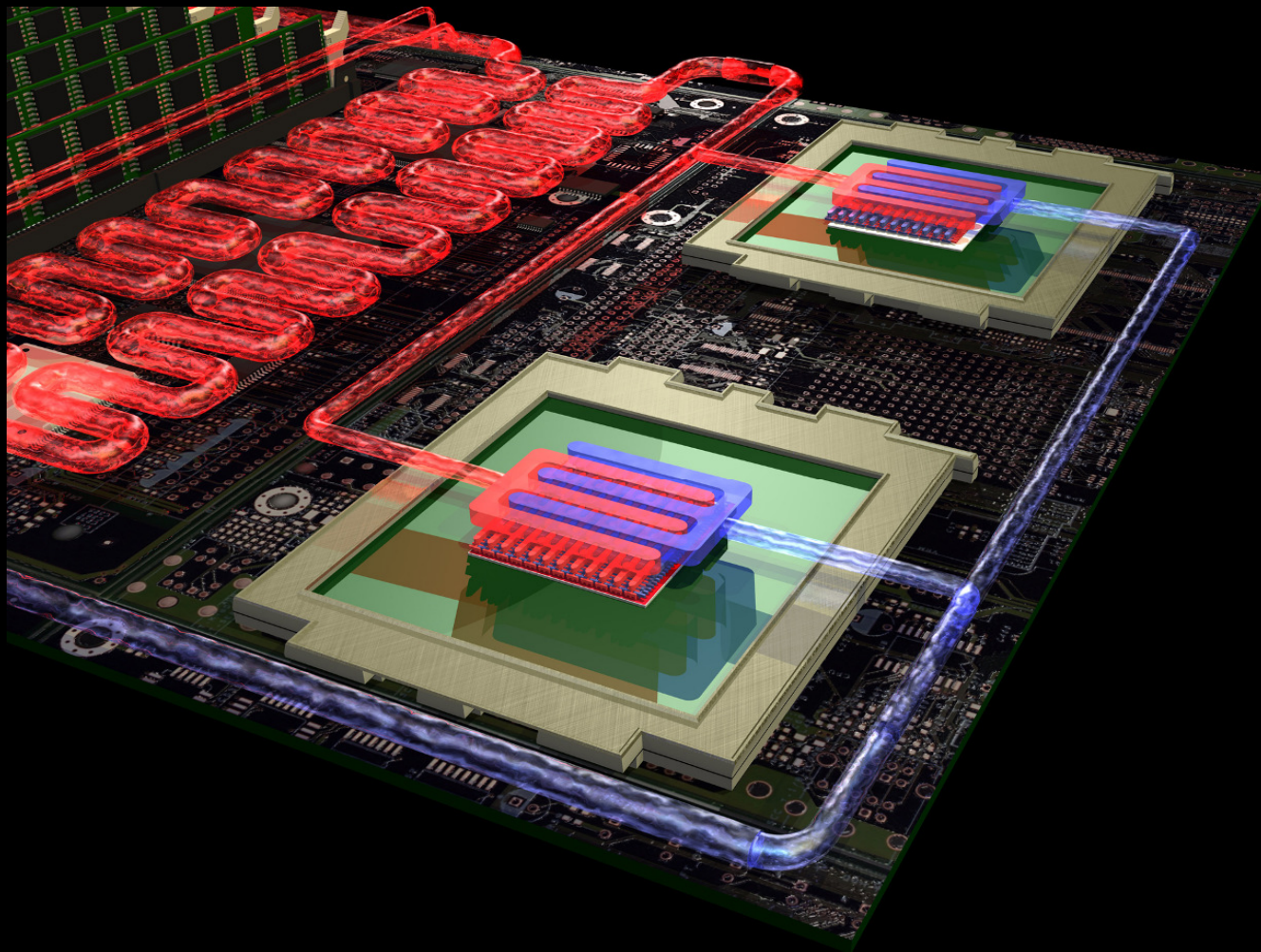


IBM Research – Entwicklungstendenzen im Rechenzentrums-Umfeld

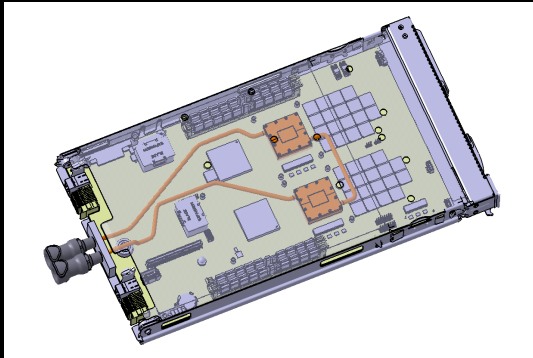
Marc Mühlhoff, 17. Oktober 2011



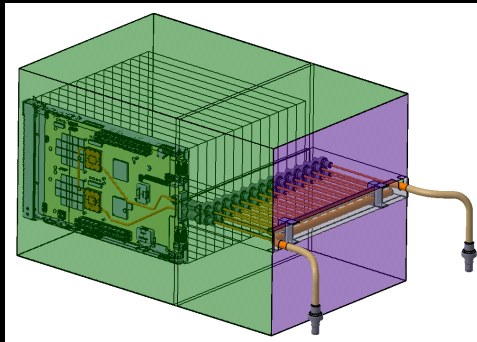
Water – Hot Water – Reuse – 3D-Chip



Aquasar Pilot Project

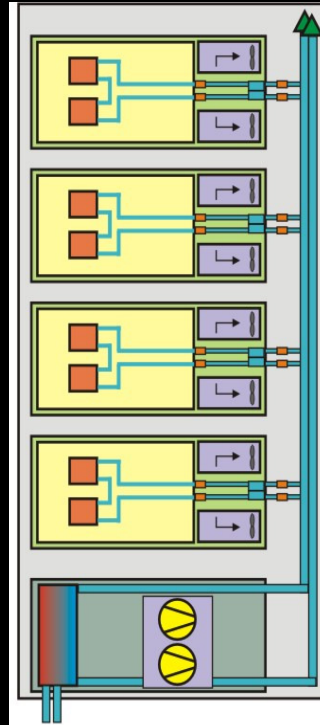


1. 1. QS/HS22 Blades with fluid-loop



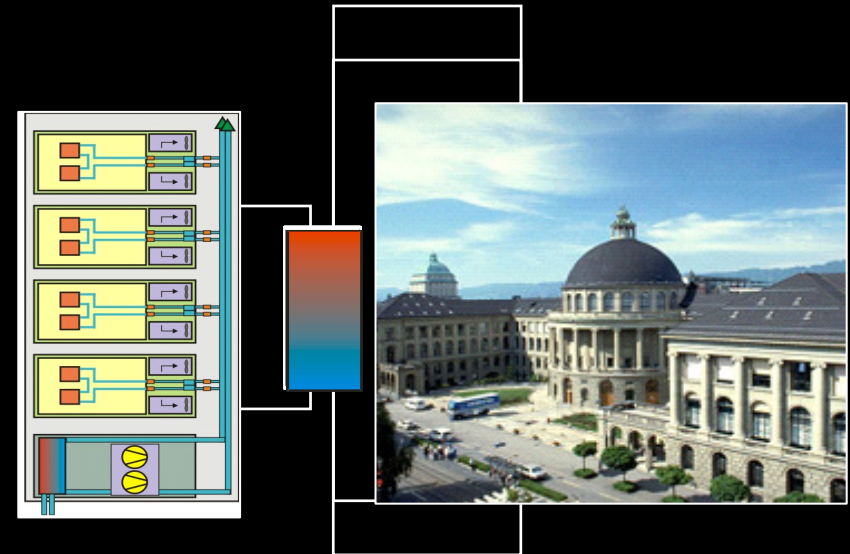
2. 2. Fullypopulated BladeCenter® servers with manifold

System uses a mixed population of 11QS22 IBM PowerXCell 8i and 3 H22 Intel Nehalem Blades per Blade Center® server.



3. 3. Populated Rack with Blade Center® servers and pumps

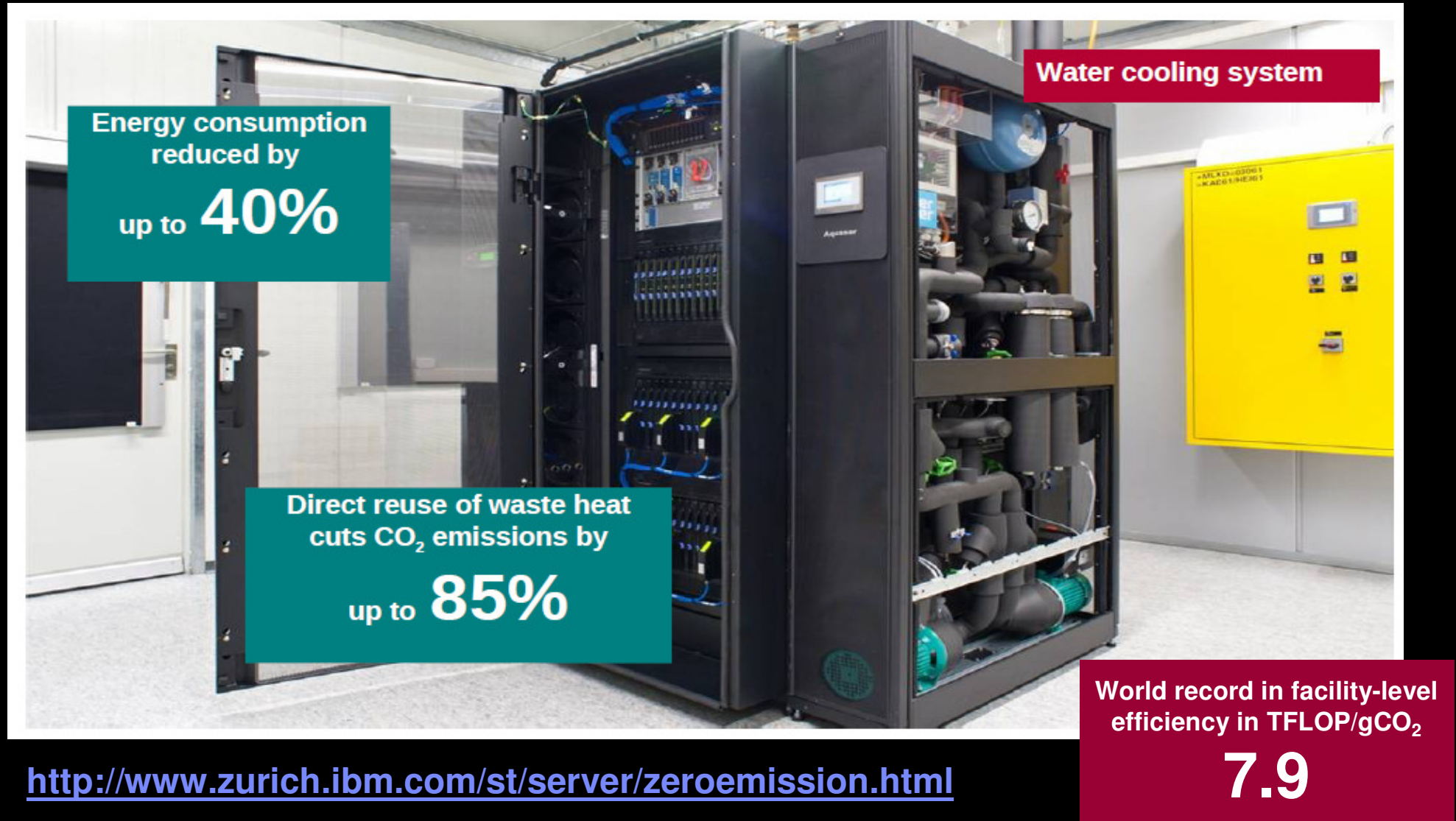
	Thermal conductivity [W/(m*K)]	Volumetric heat capacity [kJ/(m³*K)]
Air	0.0245	1.27
H ₂ O	0.6	4176



4. 4. Connection to heat distribution system of ETH for 50-60°C hot water

Two Blade Center® servers are liquid cooled and one is air cooled for reference. The rack also holds communication equipment and a storage server. The closed cooling loop holds 10 liters of water, the coolant flow is 30 liters per minute.

Hot Water-cooled IBM Blade Center Cluster *Aquasar* at ETH Zürich



**Energy consumption
reduced by
up to **40%****

Water cooling system

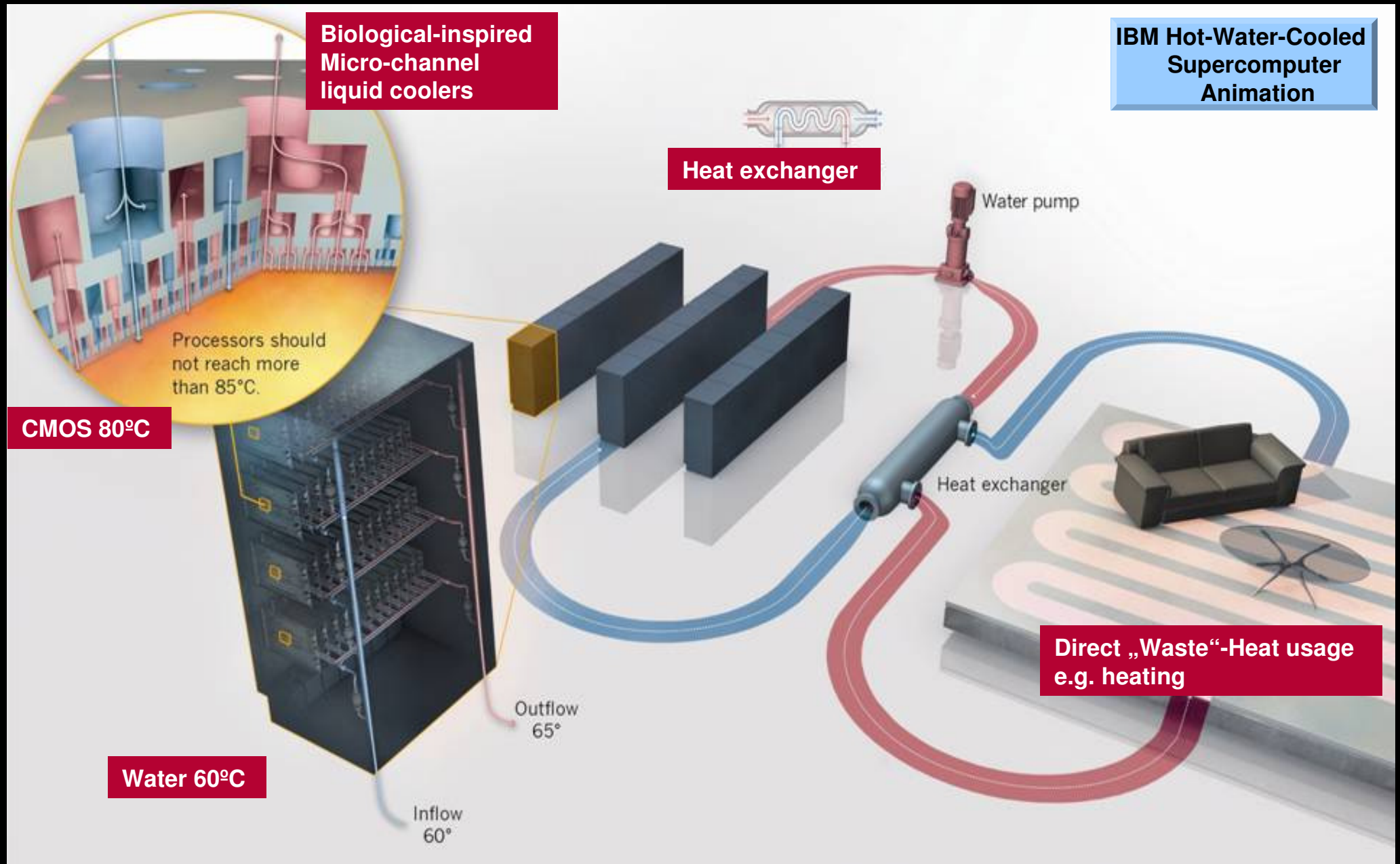
**Direct reuse of waste heat
cuts CO₂ emissions by
up to **85%****

**World record in facility-level
efficiency in TFLOP/gCO₂**

7.9

<http://www.zurich.ibm.com/st/server/zeroemission.html>

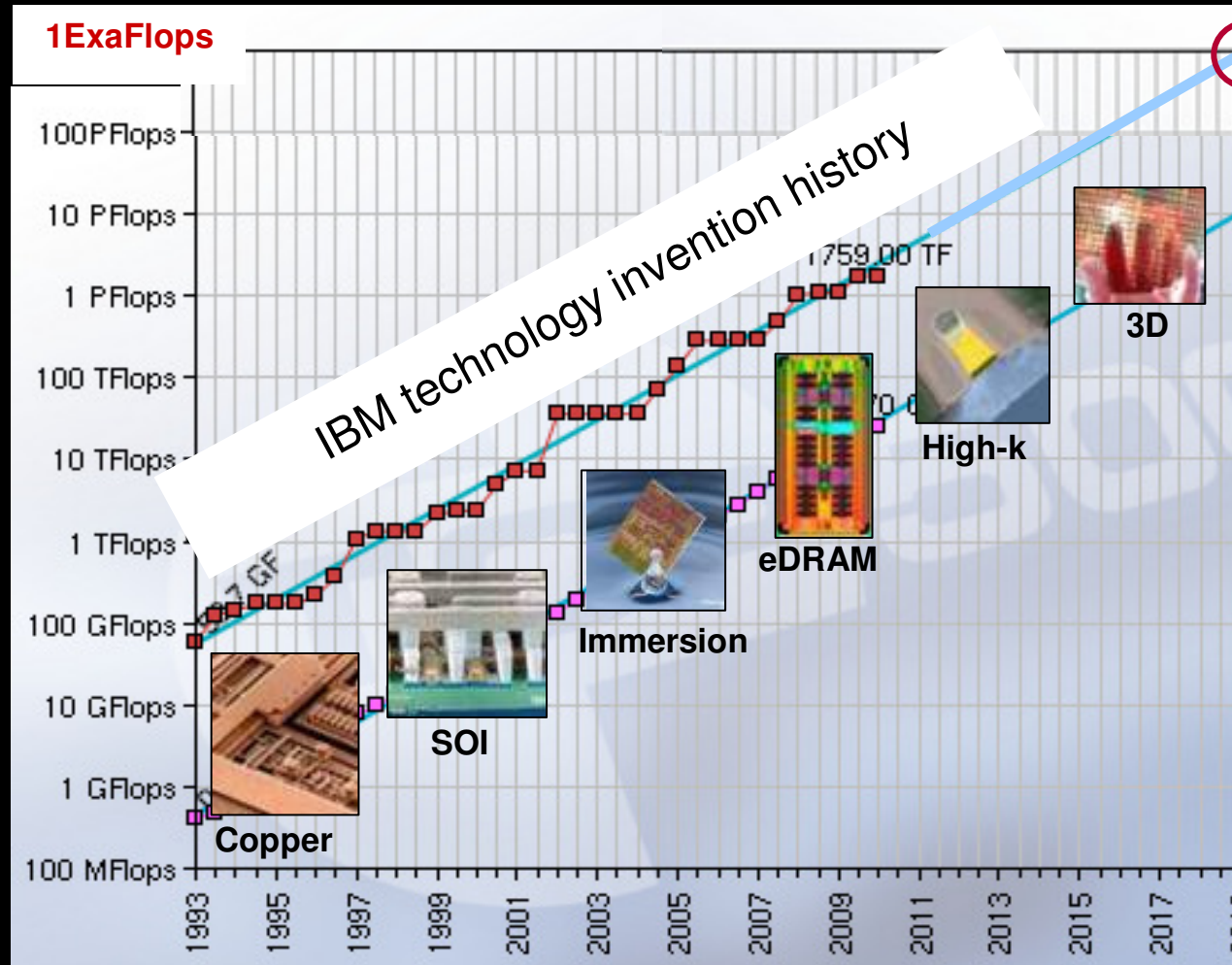
Cooling with hot water: towards a zero-emission datacenter



On the Roadmap: 3D-chip stacks

3D-integration as enabler for exascale computing

Number one super-computer performance



Performance history of super computers and forecast

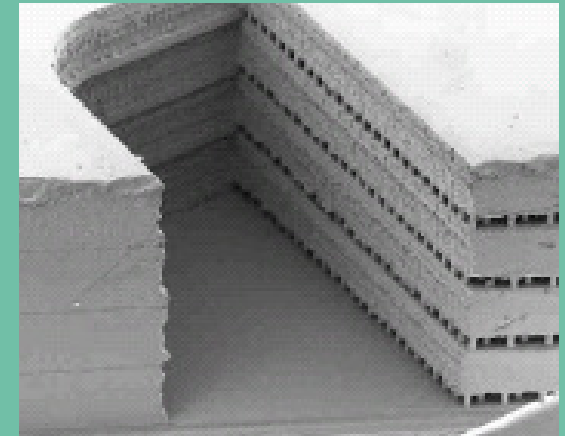
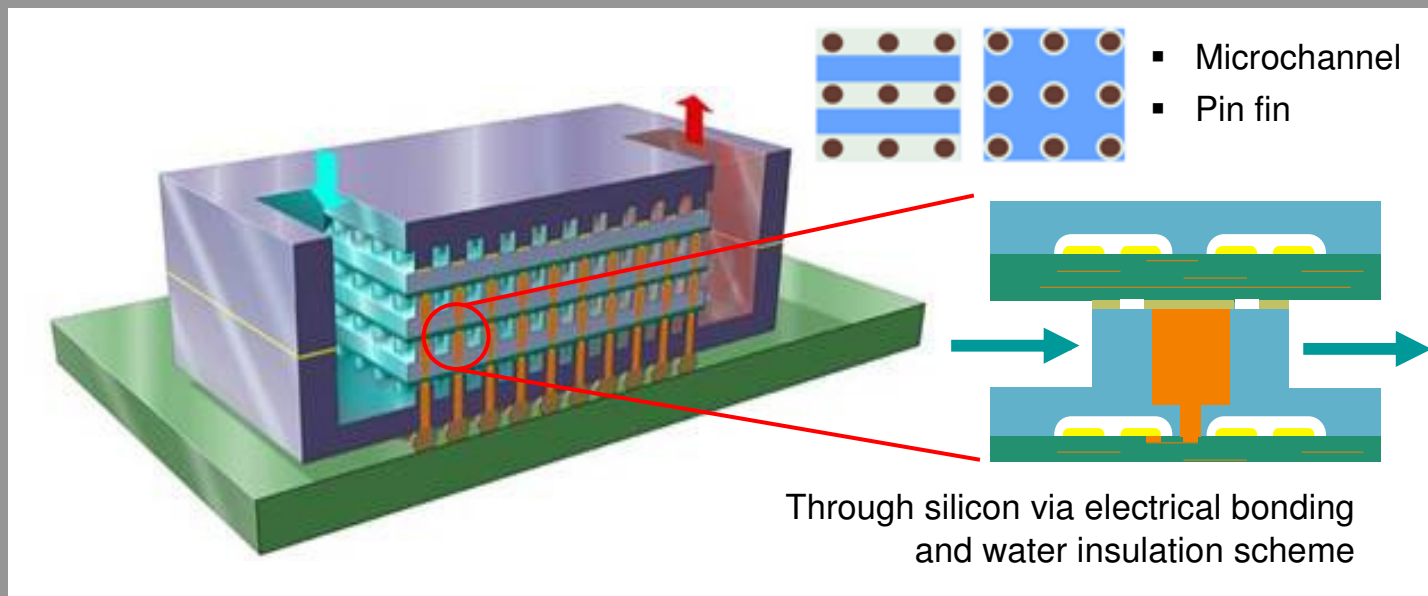
By 2025:
3D-chip stacks with
interlayer cooling

1 ExaFLOP/s =
 10^{18}
or
10.000.000.000.000.000.000
floating point operations per second
or
roughly **300** times
the computing power of today's
fastest computer

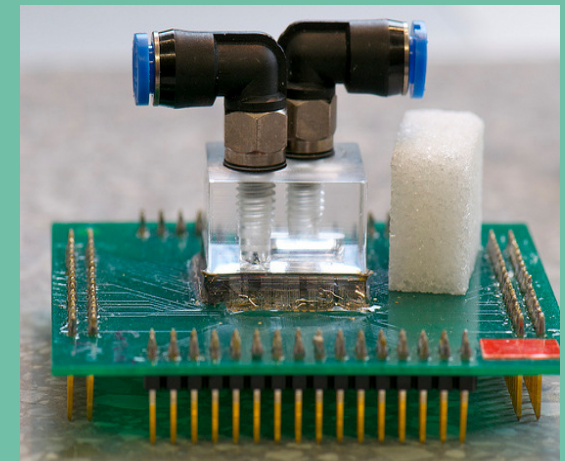
3D-chips cooled with interlayer liquid cooling

- 3D integration requires (scalable) **interlayer liquid cooling**
- Challenge: isolate electrical interconnects from liquid
- A large fraction of energy in computers is spent for data transport
- **Shrinking computers saves energy**

A look inside a 3D-chip stack



cross-section through fluid port
and cavities



Test vehicle with fluid manifold and
connection

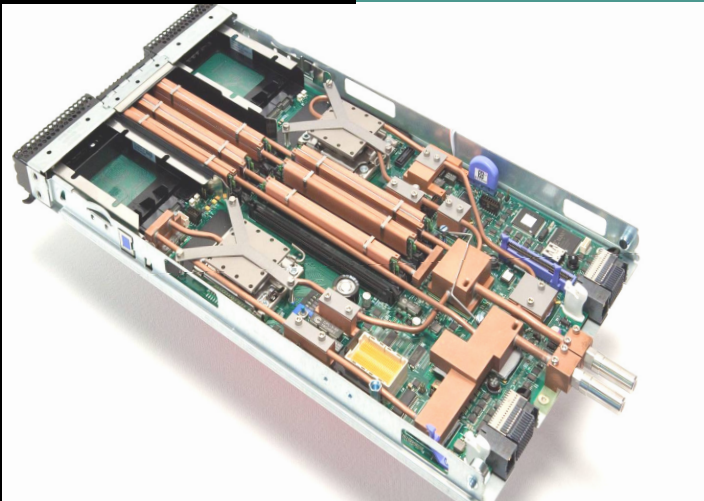
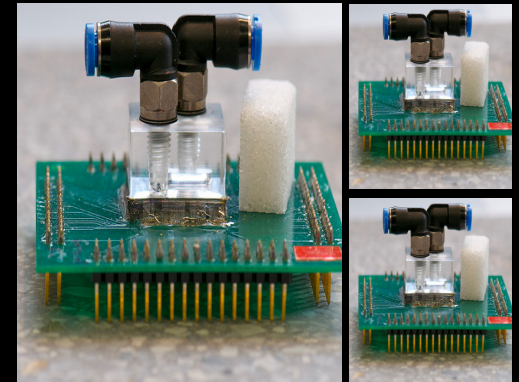
On the cube road

Paradigm Changes

- Energy will cost more than servers
- Coolers are million fold larger than transistors

Moore's Law goes 3D

- Single layer scaling slows down
- Stacking of layers allows extension of Moore's law
- Approaching functional density of human brain



Future computers look different

- Liquid cooling and heat re-use, e.g. Aquasar
- Interlayer liquid cooled 3D chip stacks
- Smarter energy by bionic designs

Energy aspects are key

- Cooling – power delivery – photonics
- Shrink a rack to a “sugar cube”: 50x efficiency

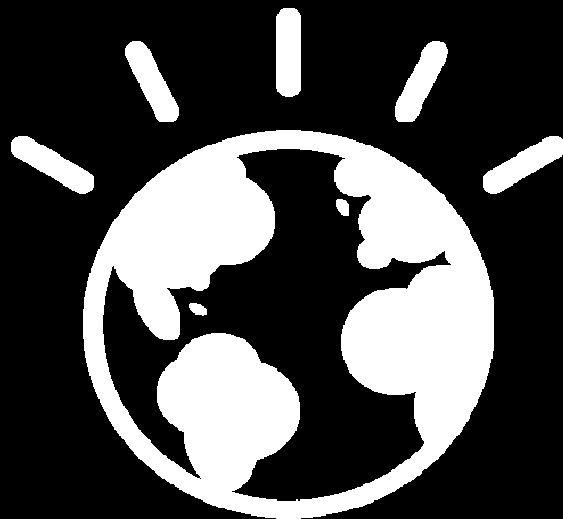
Kernpunkte beim Design eines Rechenzentrums

Zusammenfassung

- Steigende Verfügbarkeitsanforderungen
 - Wartung und Austauschbarkeit technischer Anlagen im laufenden Betrieb
- RZ-Infrastruktur (Kälte/USV/Elektro) muss der IT anpassbar sein
 - Trend von luft- zu wassergekühlten Systemen
 - Modulare und skalierbare technische Anlagen und Systeme
- Potentiale zur Erhöhung der Energieeffizienz müssen in der RZ-Planung bereits berücksichtigt werden
 - Gesamtheitliche und gewerkeübergreifende RZ-Planung und –Realisierung

Es gibt nicht **DIE** Lösung - Jedes **RZ-Konzept** ist abhängig von individuellen Randbedingungen, Parametern und den sich stets ändernden technologischen Erneuerungen!

Vielen Dank!



Marc Mühlhoff



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