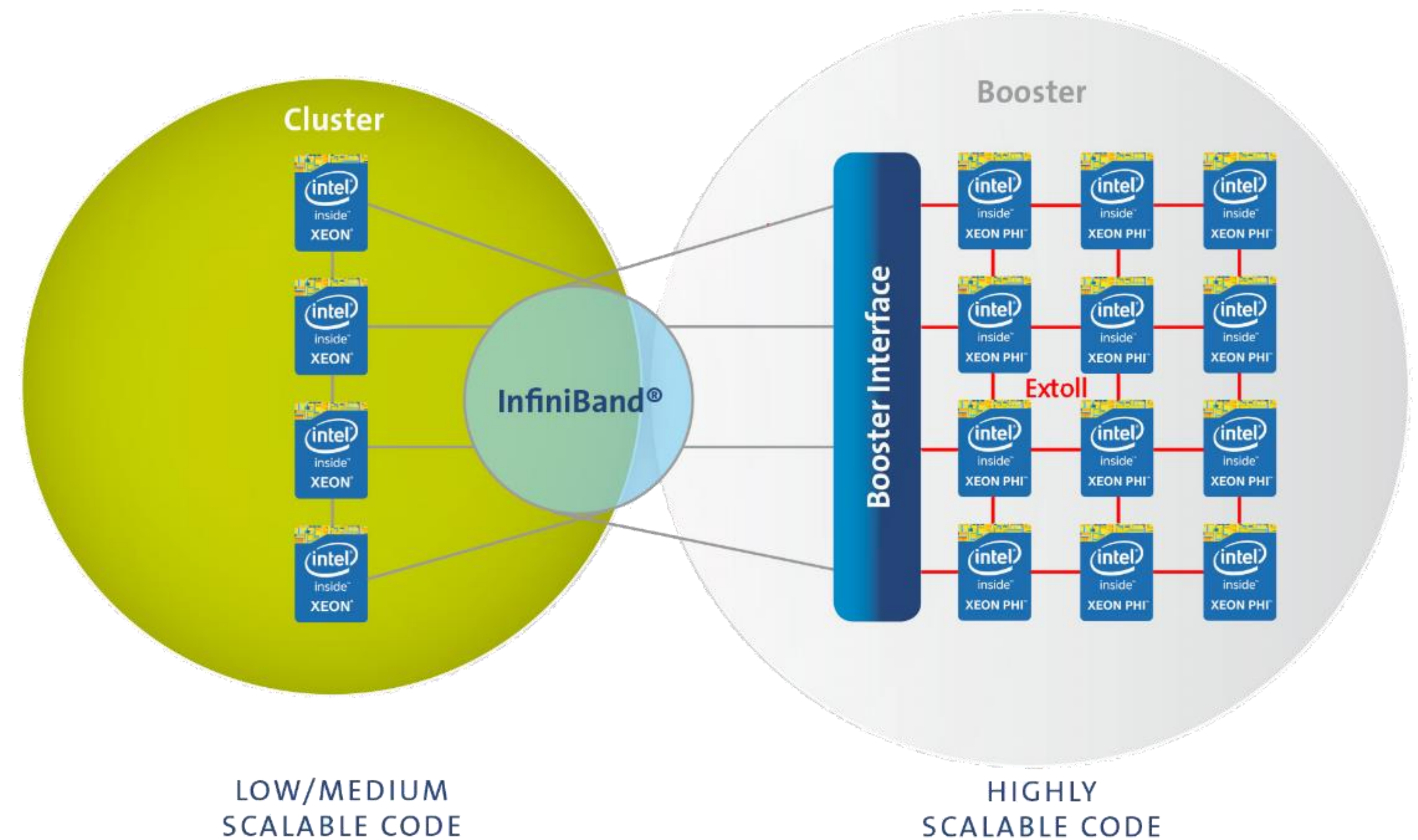


Goal: reduce the overall power consumption of HPC systems

- **Energy efficient Hardware:**
 - Flexible resource assignment → increase utilisation
 - Many-core processors provide more FLOPs / Watt
 - Avoids fans by direct water cooling
 - Explore immersion cooling (GreenICE Booster)
- **Energy aware Software:**
 - High resolution RAS plane
 - Infrastructure monitoring
- **Power saving Infrastructure:**
 - Direct water cooling enables higher inlet temperatures
 - Warm-water facilitates free cooling
 - Energy might be reused



Hardware: the Cluster-Booster architecture

- **Cluster:** 128 CPU nodes (Intel Xeon – Sandy Bridge)
- **Booster:** 384 many-core processors (Intel Xeon Phi – Knights Corner)
 - Exploit energy efficient many-core processors
- Less time and energy needed to run a mix of applications
 - Best suited hardware for every application part
 - Only requested resources are blocked
 - Dynamic allocation further increases system utilization

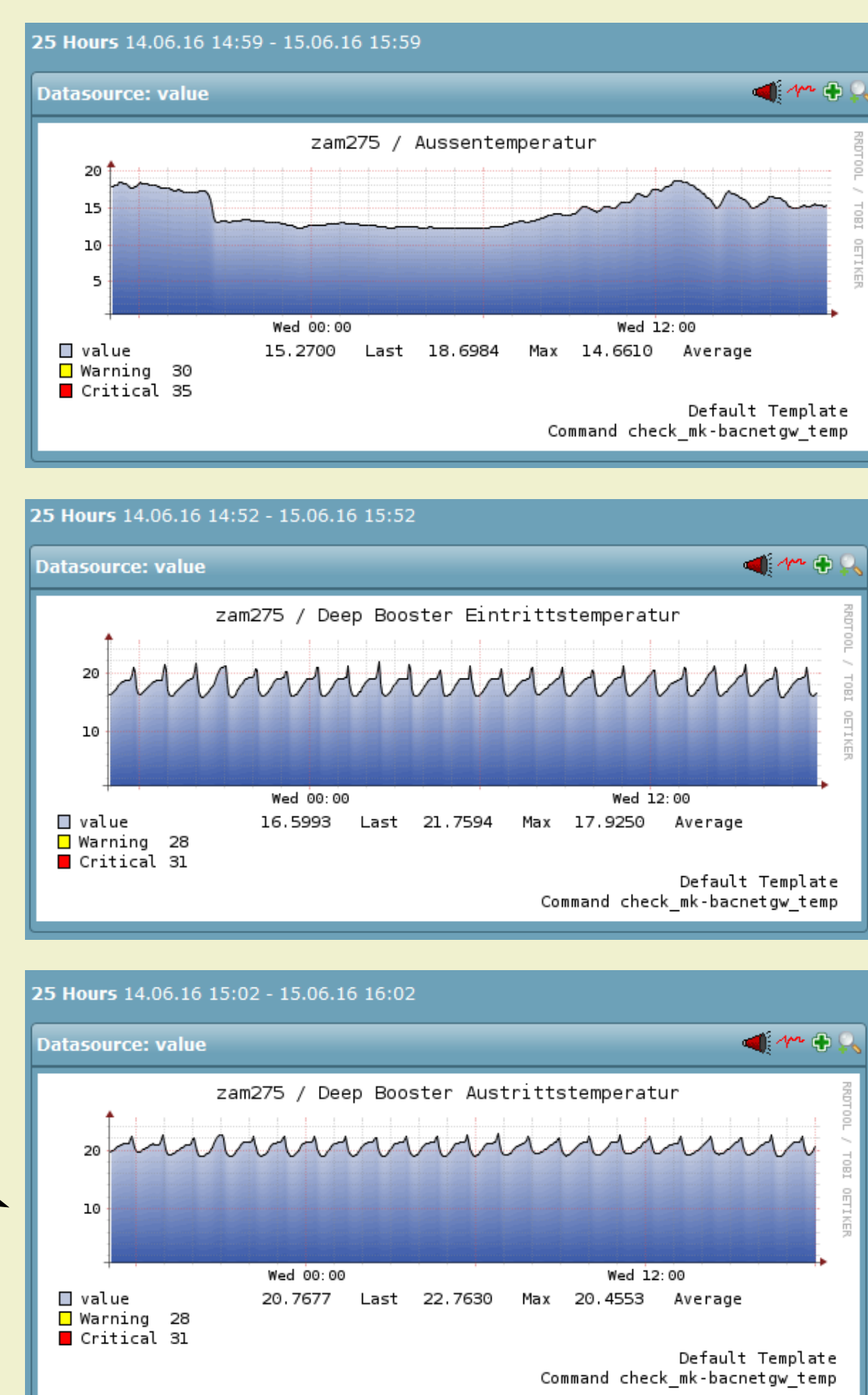
→ Higher Return Of Investment (ROI)

Software: the DEEP monitoring system

- Extensive set of sensors across the system
 - Individual components (processor, FPGA)
 - Board-level sensors managed via BMC
 - Chassis-level sensors (leakage, power supply)
 - RAS-plane orchestrates all data (Cassandra data base on BIC)
- Extensive infrastructure sensor and monitoring ("Check_MK")
 - Temperature, pressure, power, water quality (PH, conductivity)
 - Online readout, graphics, automatic E-mail reporting

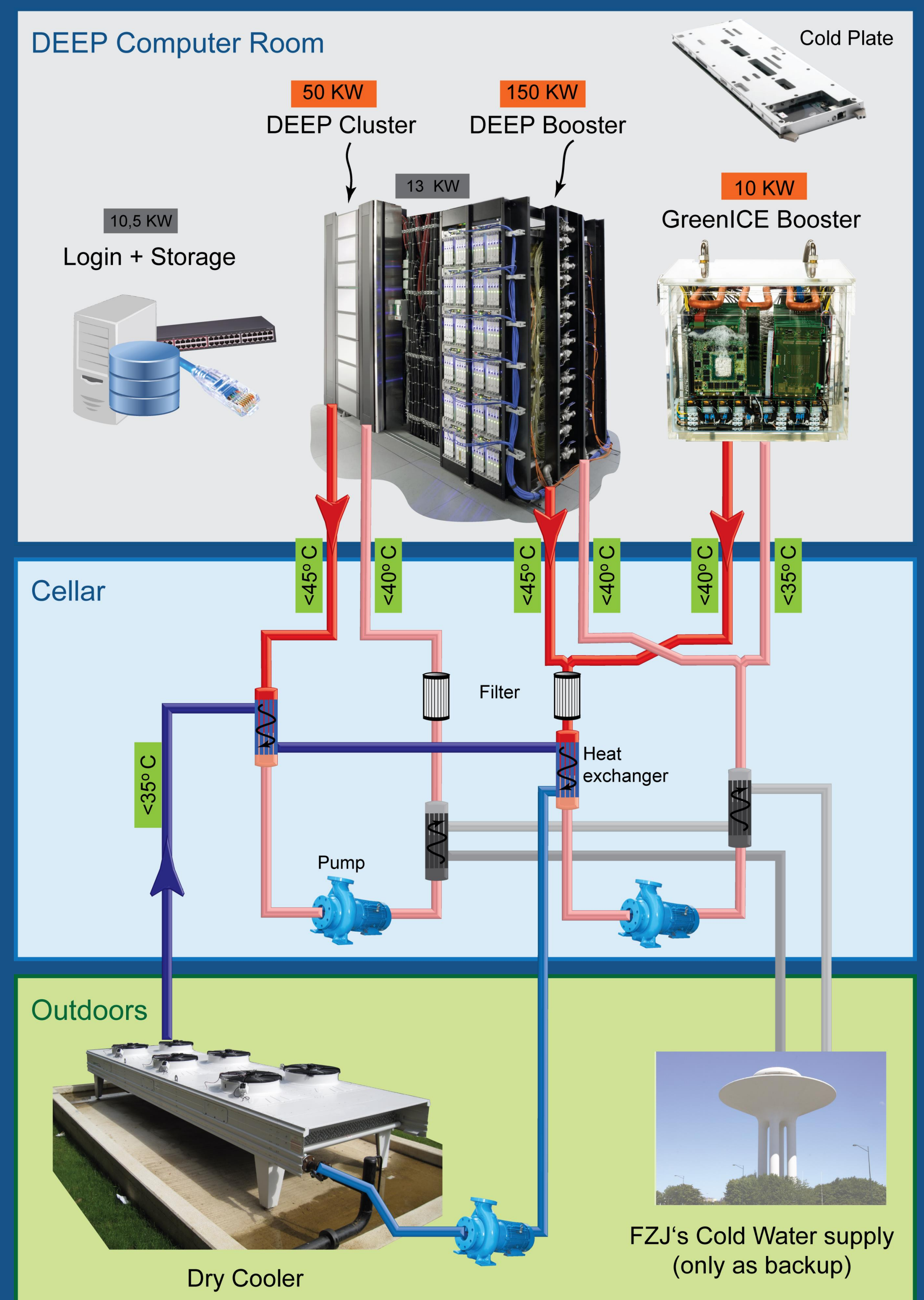
→ More Control

All services						
Service	Icons	Status Detail	App	Checked	Perf-O-Meter	
zam275		71 rows, summe1 (user) 17:48				
Check_MK		Agent version 1.2.0p15, execution time 25.0 s	2016-06-07 08:34:15	59 sec	25.0 s	
Check_MK_inventory		no unchecked services found	2016-04-29 11:48:13	2 hrs		
Check_MK_HW/SW Inventory		OK - found 2619 entries	2016-02-23 16:13:38	19 min		
Aussentemperatur		OK - OK, Temperatur: 15.4 °C	2015-12-17 06:32:19	59 sec		
CPU load		OK - 15min load 0.65	2015-12-17 06:32:19	59 sec	0.9	
CPU utilization		OK - user: 21.0%, system: 16.4%, wait: 0.0%, total: 37.5%	2015-12-17 06:32:19	59 sec	37%	
Deep Booster Aussentemperatur		OK - OK, Temperatur: 19.1 °C	2016-06-09 16:40:15	59 sec		
Deep Booster Druck sekundär		OK - OK, Druck: 4.1 bar	2016-02-18 12:30:30	59 sec		
Deep Booster Eintrittstemperatur		OK - OK, Temperatur: 16.1 °C	2015-12-17 06:32:19	59 sec		
Deep Booster Pumpe Steuerung		OK - OK, Rueckgabewert: 1.0	2015-12-17 06:32:19	59 sec		
Deep Booster Ruecklauftemperatur primär		OK - OK, Temperatur: 13.1 °C	2015-12-17 06:32:19	59 sec		
Deep Booster Ruecklauftemperatur sekundär		OK - OK, Temperatur: 19.0 °C	2016-06-09 16:40:15	59 sec		
Deep Booster Vorlauftemperatur primär		OK - OK, Temperatur: 6.2 °C	2015-12-17 06:32:19	59 sec		
Deep Booster Vorlauftemperatur sekundär		OK - OK, Temperatur: 18.7 °C	2016-06-09 16:40:15	59 sec		
Deep Cluster Austrittstemperatur		OK - OK, Temperatur: 20.9 °C	2015-12-17 06:32:19	59 sec		
Deep Cluster Druck sekundär		OK - OK, Druck: 2.9 bar	2016-02-18 12:30:30	59 sec		
Deep Cluster Eintrittstemperatur		OK - OK, Temperatur: 19.3 °C	2015-12-17 06:32:19	59 sec		
Deep Cluster Pumpe Steuerung		OK - OK, Durchflussleistung: 70.0 Prozent	2015-12-17 06:32:19	59 sec		
Deep Cluster Pumpe Steuerung		OK - OK, Rueckgabewert: 1.0	2016-03-24 13:42:49	59 sec		



Infrastructure: the DEEP cooling

- Warm water cooling
 - Inlet Temperature: <40 Celsius
 - Outlet Temperature: <45 Celsius
 - Free cooling all year round
 - Potential Energy re-use (e.g. floor heating)
- Less power consumption for cooling



Website: www.deep-project.eu