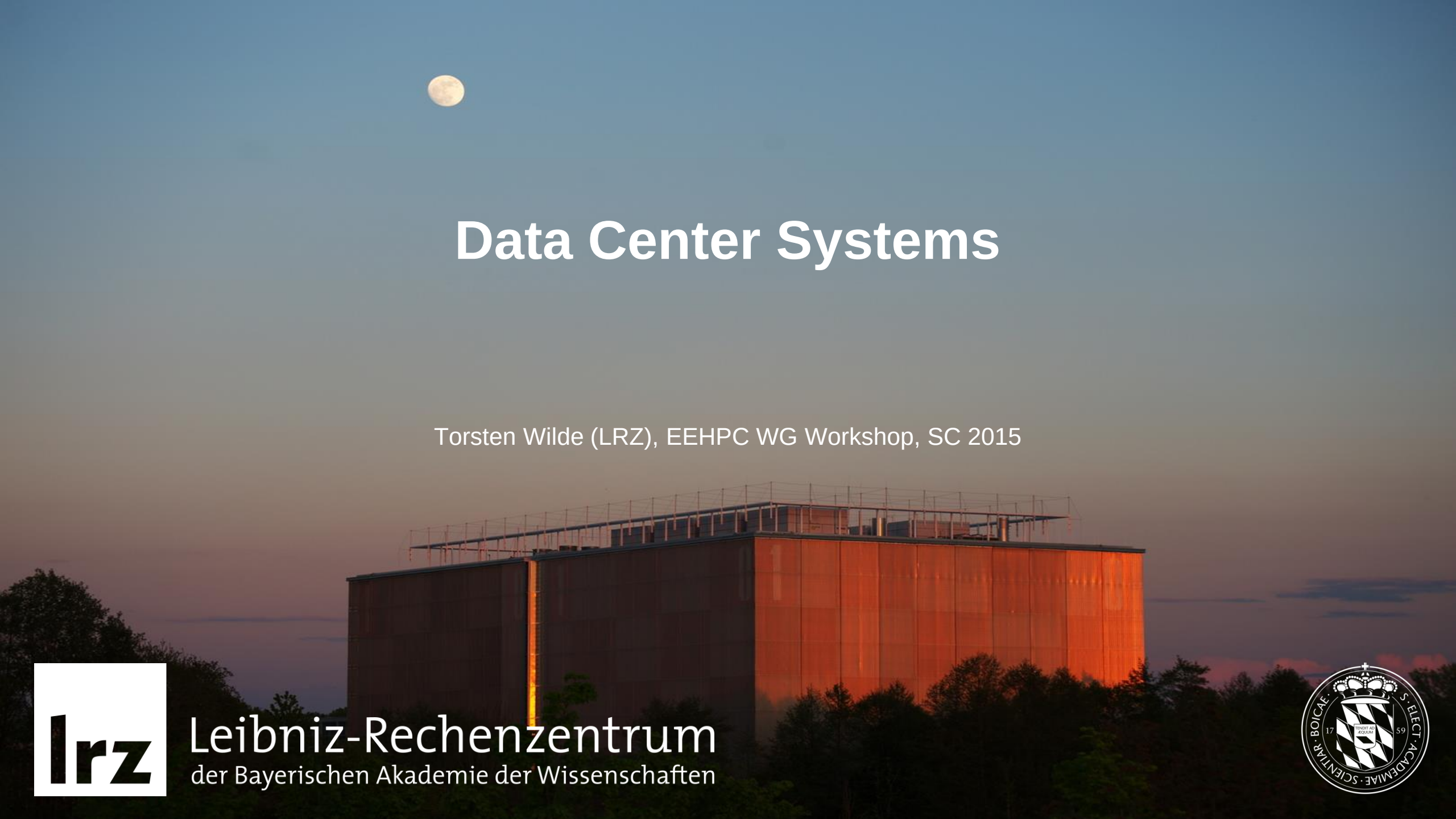
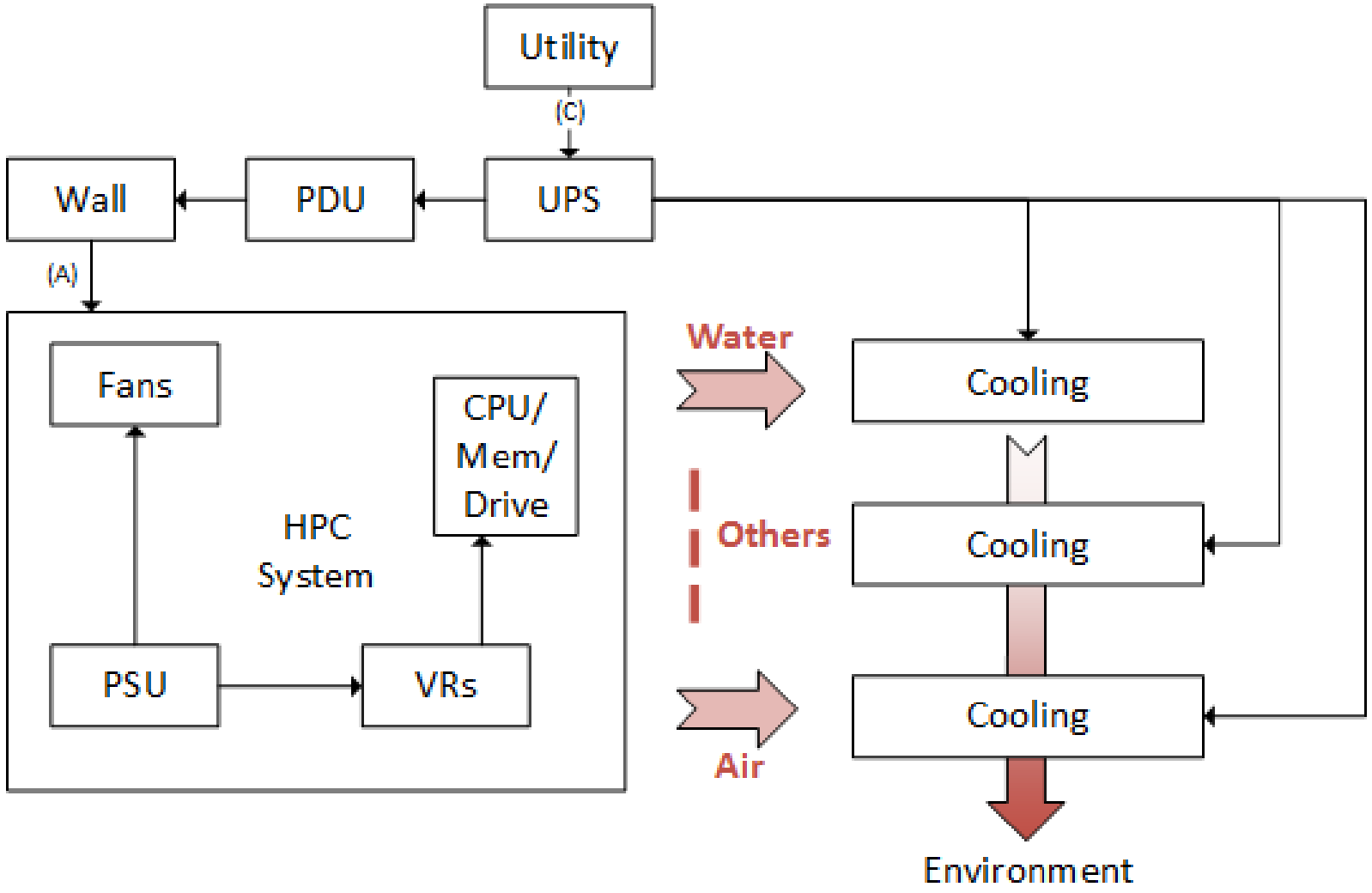
# Data Center Systems

Torsten Wilde (LRZ), EEHPC WG Workshop, SC 2015

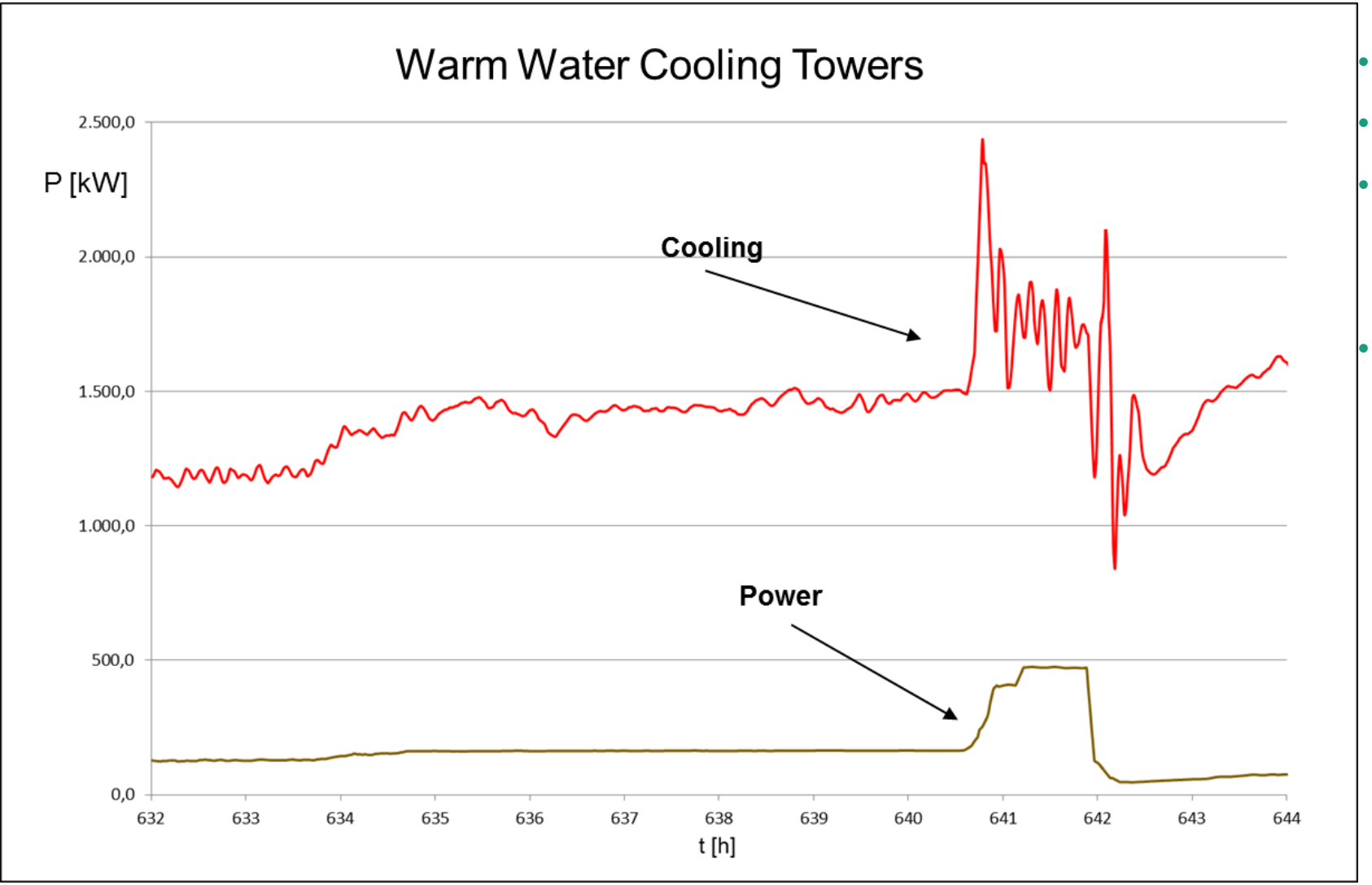


lrz
Leibniz-Rechenzentrum
der Bayerischen Akademie der Wissenschaften

# Data Center Infrastructure in a Nutshell



# Operations Control: Test of ΔTinlet(NSR) = -20 K
## Response of Warm Water (Chiller-less) Cooling Infrastructure




- Chiller less cooling (4 towers 2MW each)
- No additional cooling needed
- IT power consumption did not change but not part of command and control loop
- 4 separate optimized cooling circuits -> need one control for all 4, need to integrate IT

Setting target temperature for NSR from 40°C (104°F) to 20°C (68°F) doubles the cooling system power consumption (Outside < 10°C (50°F) )

# Multitude of Devices

- Cooling infrastructure devices:
  - Regulated and unregulated pumps
  - Heat exchangers
  - Cooling towers
  - CRAC
  - Chillers
  - 1- and 3-way valves
  - Resistors, regulators, and pipes
  - Special devices (adsorption chiller)
  - Etc.
- Power devices:
  - Meters
  - Transformers
  - UPS systems
  - Etc.

# Data Center Infrastructure Sensor API's

- M-Bus (Meter-Bus) protocol specifically for power and gas meters, European standard
- Modbus (serial communication protocol)
- BACnet (BACnet MSTP, BACnet/IP, and BACnet/Ethernet) international standard
- OPC (Open Platforms Communication)
- LONWorks (Local Operating Network) by Echelon Corporation
- N2Open by JCI
- Etc.

# Systems and Sampling-Rates

- Building Management/Automation Systems
  - JCI (Johnson Controls) – Building Automation System [LRZ]
    - 2297 values
  - WinCC (SIMENS) - Power Infrastructure Monitoring [LRZ]
    - 189 values (not counting IT systems PDUs)
  - Delta Controls Inc. - Building Management System [NREL]
    - 211 sensors
  - Power Meters [NREL]
    - 296 values (not counting IT systems PDUs)
  - Etc.
- Sampling Rates (determined by operational requirements)
  - JCI: 1min averages
  - WinCC: 5min, 15min averages (measurements are converted to archive values)
  - Delta Controls Inc.:  varying sampling rate, 10min, 15min averages for storage

# Infrastructure Control vs. Archival and Data Analysis

- Control
  - Automatic [LRZ]
  - Dispatcher (SCADA - Supervisory Control and Data Acquisition) [NREL]
- Data collected by building automation system can be inaccurate for monitoring and system analysis
  - Changes of +-X are ignored (not recorded) since value is used for control decision
  - Sensor readout frequency limited by connectivity. Same value is recorded for in-between timestamps.
- Gaps in data not considered critical
- Data quality and accuracy questionable

# New Generation of HPC Data Centers Use a Mix of Different Cooling Technologies

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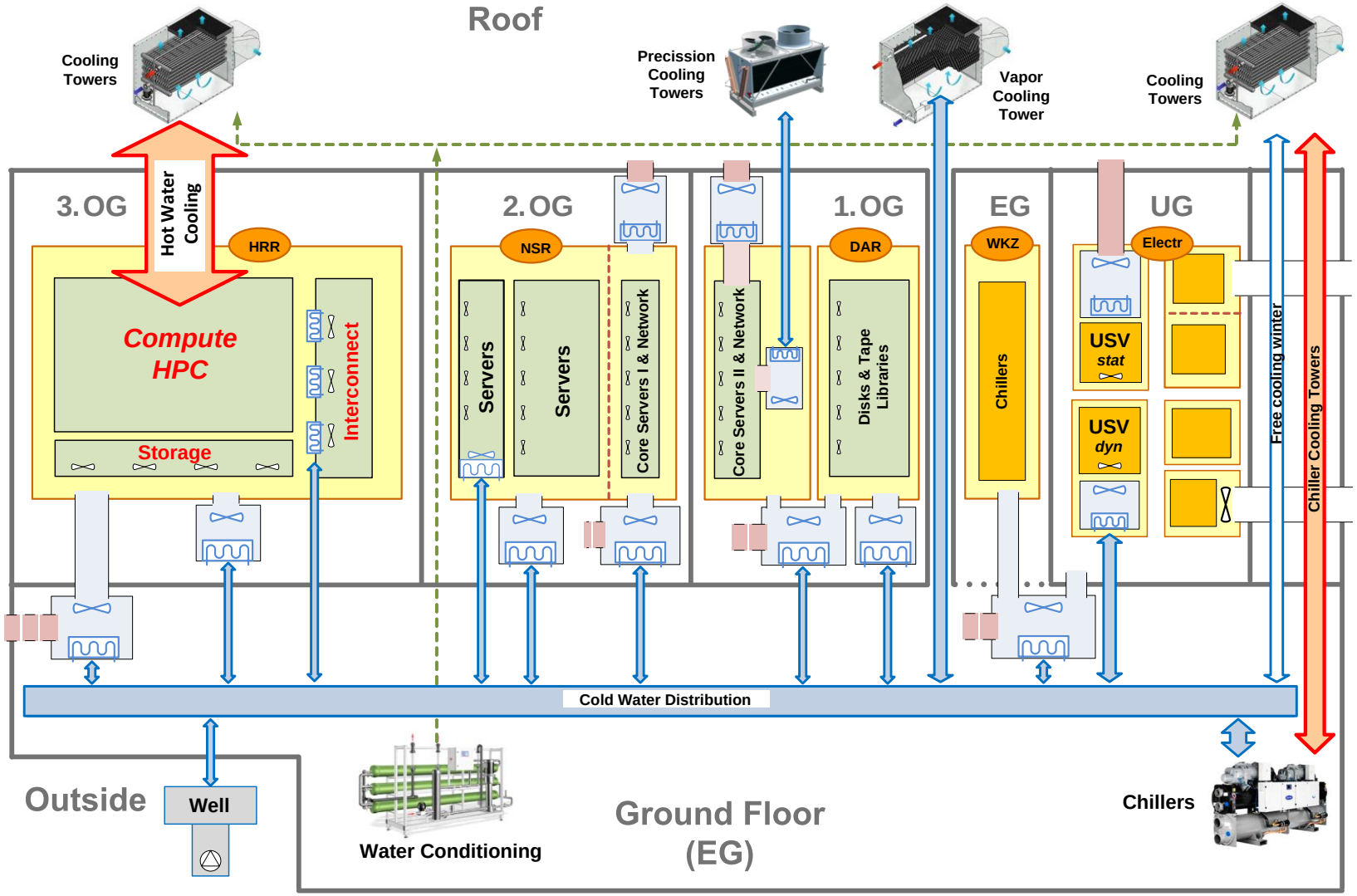


## Cooling capacity LRZ (new construction):

- Vapor cooling: 2MW
- Well water: 600kW
- Chillers: 3.2MW
- Evaporative cooling towers: 8MW



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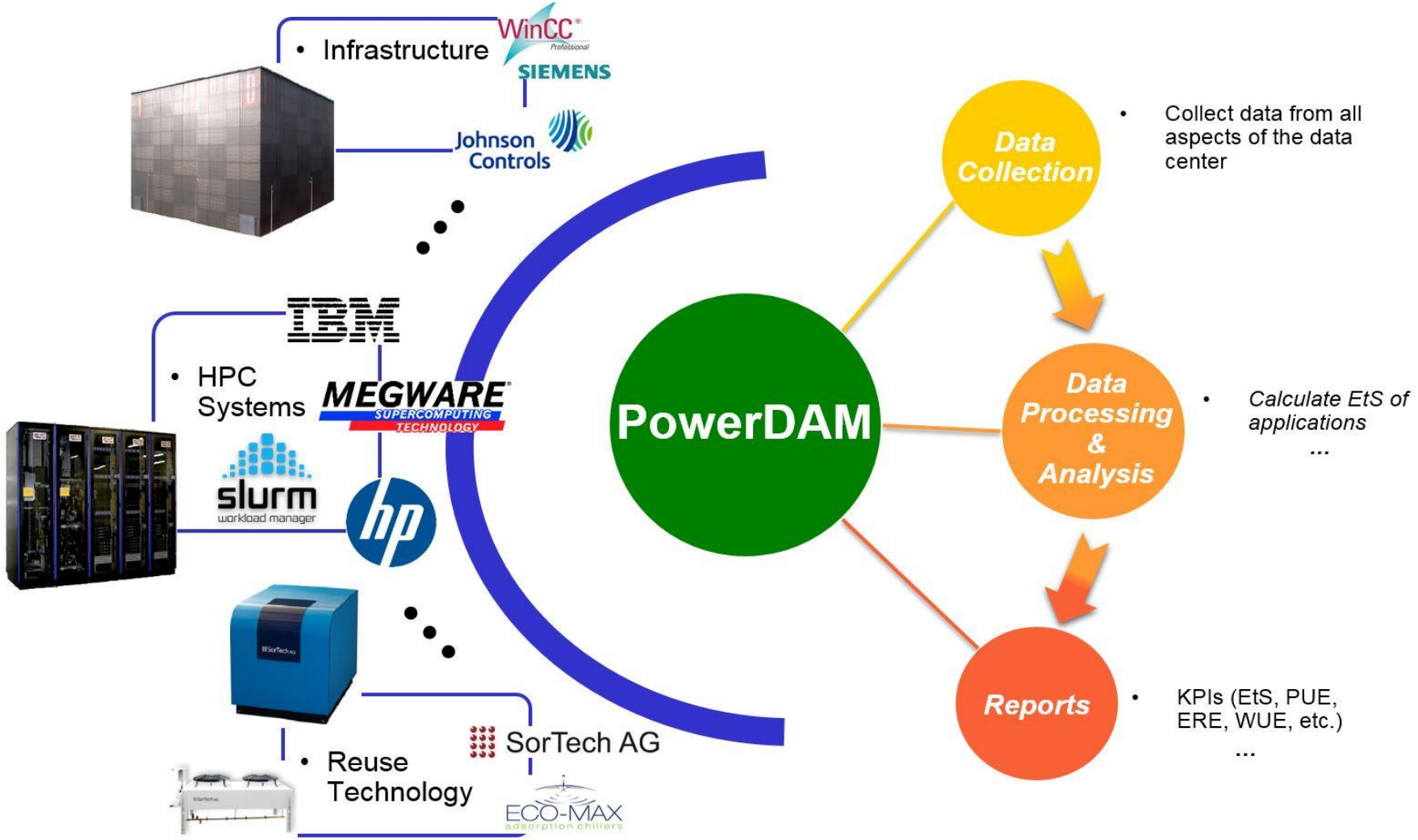
# Data Center Data Consolidation at LRZ




*Hayk Shoukourian, Torsten Wilde, Axel Auweter, Arndt Bode: "Monitoring Power Data: A first step towards a unified energy efficiency evaluation toolset for HPC data centers" published in Environmental Modelling & Software (Thematic issue on Modelling and evaluating the sustainability of smart solutions), Volume 56, June 2014, Pages 13–26; DOI: http://dx.doi.org/10.1016/j.envsoft.2013.11.011*

# Fun With Sensor Names

Leibniz Rechenzentrum
Garching

Musterbezeichnungen

**Festlegung Datenpunkt Adresse ( Adress-Beispiel 1 ):**
**Bei Lüftungs / Heizung / Kälte Anlage:**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | E | G | R | L | T | 0 | 1 | F | _ | Z | U | T | _ | M | W | 0 | 1 | REGRLT01F_ZUT_MW01 |
| R | E | G | R | L | T | 0 | 1 | F | _ | A | B | T | _ | M | W | 0 | 1 | REGRLT01F_ABT_MW01 |
| R | E | G | R | L | T | 0 | 1 | F | _ | Z | U | F | _ | M | W | 0 | 1 | REGRLT01F_ZUF_MW01 |
| R | E | G | R | L | T | 0 | 1 | F | _ | A | U | T | _ | M | W | 0 | 1 | REGRLT01F_AUT_MW01 |
| R | E | G | H | Z | G | 0 | 1 | F | _ | V | L | T | _ | M | W | 0 | 1 | REGHZG01F_VLT_MW01 |
| R | E | G | H | Z | G | 0 | 1 | F | _ | V | L | D | _ | M | W | 0 | 1 | REGHZG01F_VLD_MW01 |
| R | E | G | R | L | T | 0 | 1 | V | E | Z | U | F | U | S | B | 0 | 1 | REGRLT01VEZUFUSB01 |
| R | E | G | R | L | T | 0 | 1 | V | E | Z | U | F | U | B | M | 0 | 1 | REGRLT01VEZUFUBM01 |
| R | E | G | R | L | T | 0 | 1 | V | E | Z | U | F | U | S | M | 0 | 1 | REGRLT01VEZUFUSM01 |
| R | E | G | R | L | T | 0 | 1 | V | E | Z | U | R | P | W | M | 0 | 1 | REGRLT01VEZURPWM01 |
| R | E | G | R | L | T | 0 | 1 | V | E | Z | U | L | W | S | M | 0 | 1 | REGRLT01VEZULWSM01 |
| R | E | G | H | Z | G | 0 | 1 | K | M | V | L | D | M | S | M | 0 | 1 | REGHZG01KMVLDMSM01 |
| R | E | G | H | Z | G | 0 | 1 | K | M | V | L | D | X | S | M | 0 | 1 | REGHZG01KMVLDXSM01 |
| R | E | G | H | Z | G | 0 | 1 | V | _ | _ | _ | D | D | M | W | 0 | 1 | REGHZG01V__DDMW01 |
| R | E | G | R | L | T | 0 | 2 | K | L | A | U | _ | _ | S | T | 0 | 1 | REGRLT02KLAU__ST01 |
| R | E | G | R | L | T | 0 | 2 | K | L | A | U | _ | _ | R | M | 0 | 1 | REGRLT02KLAU__RM01 |
| R | E | G | R | L | T | 0 | 2 | K | L | F | O | _ | _ | R | M | 0 | 1 | REGRLT02KLFO__RM01 |
| R | E | G | R | L | T | 0 | 2 | K | L | M | I | _ | _ | R | M | 0 | 1 | REGRLT02KLMI__RM01 |

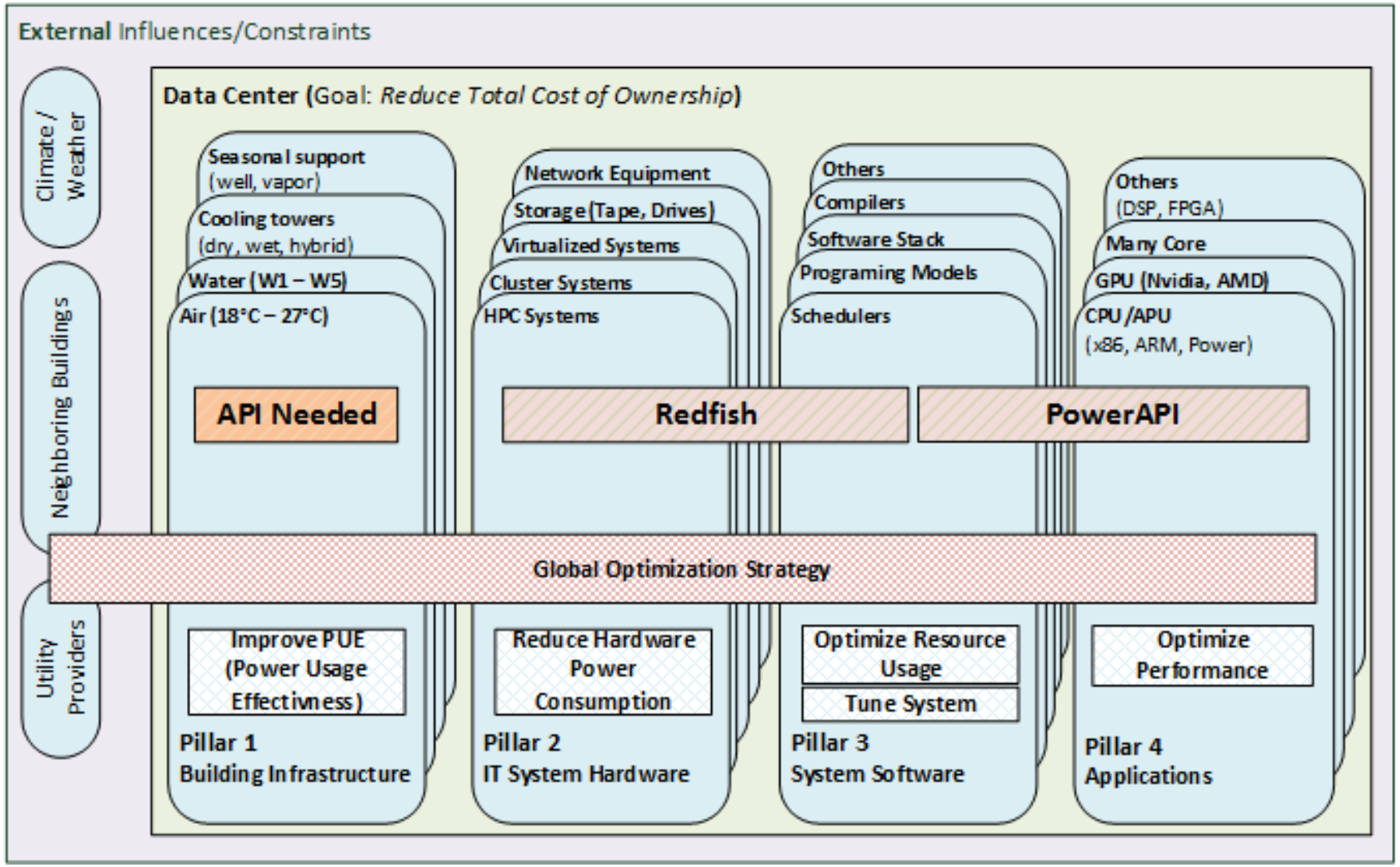
| | |
|---|---|
| Stelle 1: | Gebäude (R/I/H) |
| Stelle 2+3: | Geschoß |
| Stelle 4+5+6: | Anlagenart |
| Stelle 7+8: | Anlagennummer 2-stellig |
| Stelle 9+10: | Gerät |
| Stelle 11+12: | Gerätestandort |
| Stelle 13+14: | Funktionsart (Fühlertyp) |
| Stelle 15+16: | Datenpunktart |
| Stelle 17+18: | Zähler |

## PowerDAM API:

$$RootResource(.Resource) * _SensorType = Value; Timestamp$$

- **jci.IUGSS41.EZ04_MW__PE_power**
  - IUGSS_41EZ__PEMW04
  - @JCSQL:NAE054-01:NAE054-01/N2 Trunk1. NAE054-MIG136.IUGSS_41EZ__PEMW04.Present Value
- **WinCC:**
  - Names relate to individual circuit names without any regard to possible structure
  - Use of German Umlaute

# Summary




Open Access 4 Pillar Framework Paper: http://www.springerlink.com/openurl.asp?genre=article&id=doi:10.1007/s00450-013-0244-6

- Need to understand each pillar
- Optimize and measure (KPIs) for each
- Need global approach for optimal results
  - includes utility provider
  - define operating points
  - keep infrastructure efficiency constant over the whole operating range
  - measure and assess

# Acknowledgment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