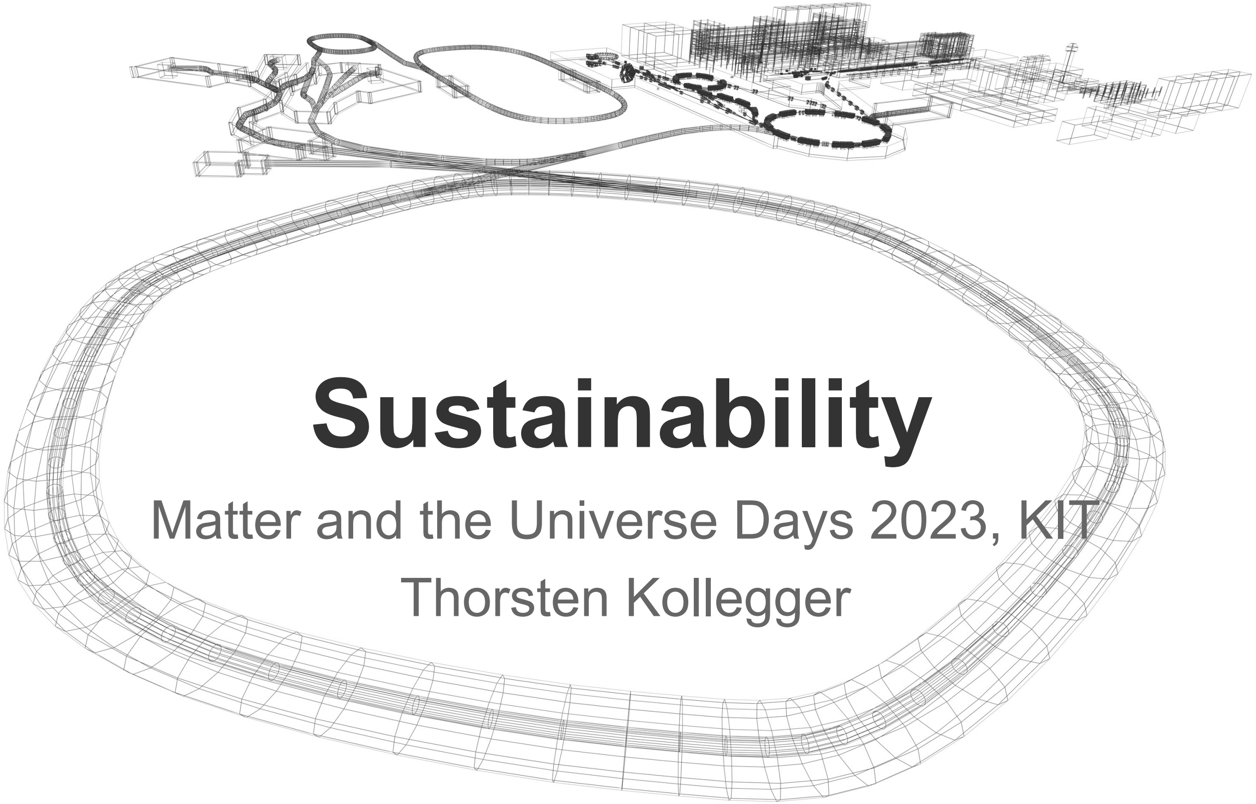


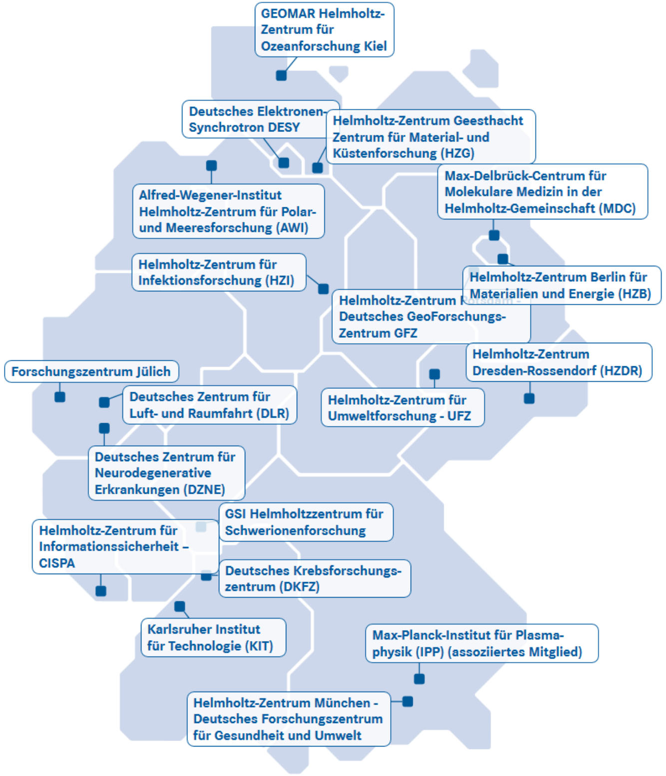
Sustainability

Matter and the Universe Days 2023, KIT

Thorsten Kollegger

Sustainability in (RF Matter) Scientific Computing

Scientific Computing in the Research Field Matter



Scientific Software Development
at all centers and programs

- Topic DMA in Matter and Technology
- collaboration with other research fields, Helmholtz Inkubator platforms

Sizeable scientific computing systems at
all research field matter centers
to support research activities

- ”Classical” scientific compute systems (HPC,…)
- Systems coupled to large scale (accelerator) infrastructures (DESY/XFEL, GSI/FAIR, HZB)
- Systems integrated into international federations, e.g. KIT, DESY, GSI in WLCG

Sustainability

Computing is sustainable, isn't it?

There are a few things to consider

- Your scientific code is executed on the scientific compute systems mentioned before
- The components of these systems need to be **manufactured**
- These systems require **electric energy** to operate and transform this into heat
- These systems need **data centers** with sophisticated **cooling** infrastructure

Sustainability


Frankfurter Allgemeine
ZEITUNG FAZ.NET

STROMVERBRAUCH

Data-Center hängen Airport ab

VON THORSTEN WINTER, FRANKFURT - AKTUALISIERT AM 14.12.2016 - 11:04

Frankfurts Rechenzentren verbrauchen inzwischen mehr Strom als der Flughafen. Und die Betreiber erhöhen stetig ihre Kapazitäten.

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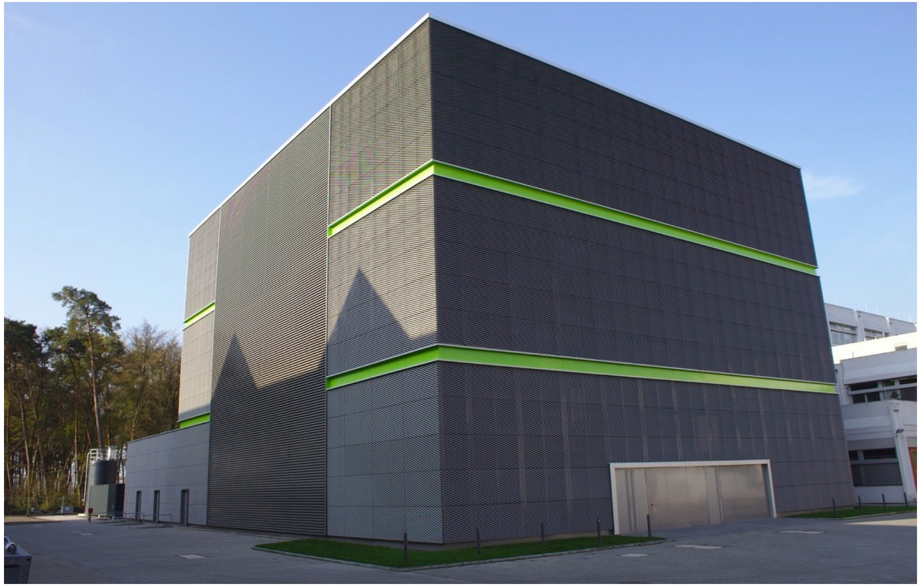
Data Center



GSI Green IT Cube

- 12 MW data center built to handle the FAIR/GSI computing needs
- Innovative cooling concept

BLAUER ENGEL
DAS UMWELTZEICHEN
www.blauer-engel.de/uz161

Environmentally friendly: Power Usage Effectiveness ~1.07
(cf. average data center in 2018: <PUE>~1.58)

Data Center Life Cycle

Components and resources in the data center life cycle stages:

- **Manufacturing**: IT (server, data storage and network devices), uninterruptible power supply (UPS) and batteries
- **Distribution**: IT, UPS and batteries
- **Use**: energy, refrigerant and water consumption of the data center
- **Disposal**: IT, UPS and batteries

Quantifying the impact

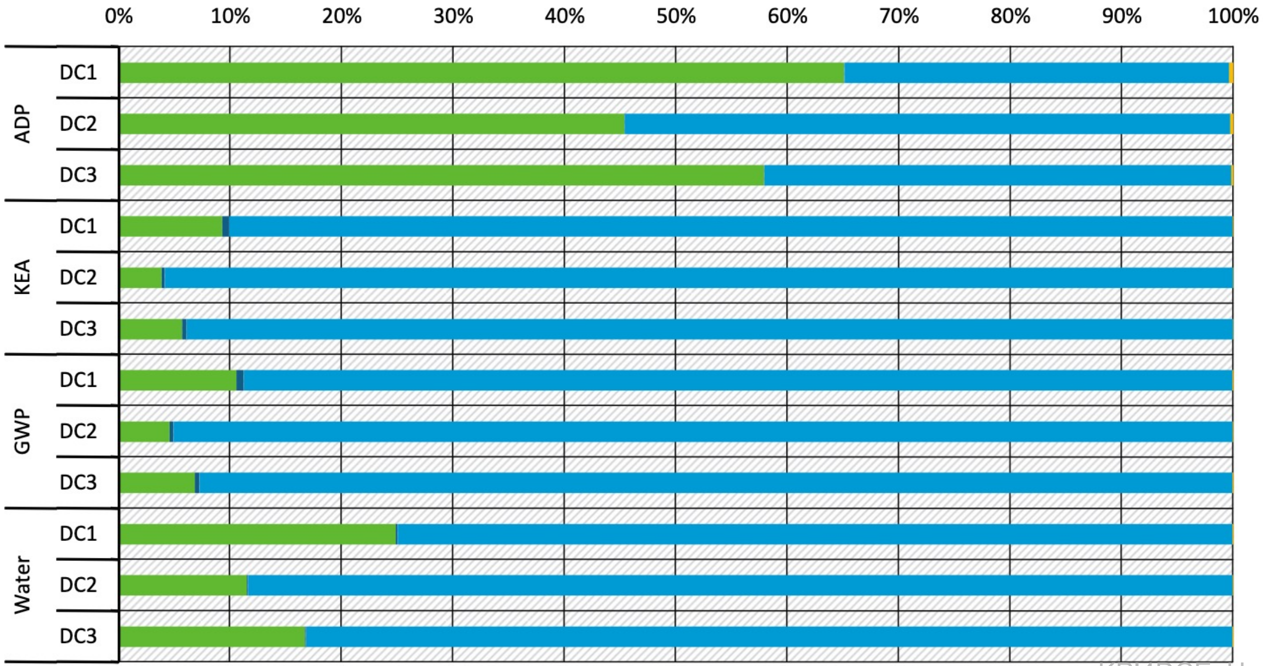
Key Performance Indicators (KPI) to **quantify data center performance**

- Most widely used defined in EN 50600 and ISO 30134:
  Power Usage Effectiveness (PUE), Renewable Energy Factor (REF),
  IT Equipment Energy Efficiency for Servers ($ITEE_{SV}$),
  IT Equipment Utilization for Servers ($ITEU_{SV}$).

Indicators for **natural resource consumption**

- Abiotic resources depletion potential (ADP)
- Cumulative energy expenditure (KEA)
- Global warming potential (GWP)
- Water consumption (Water)

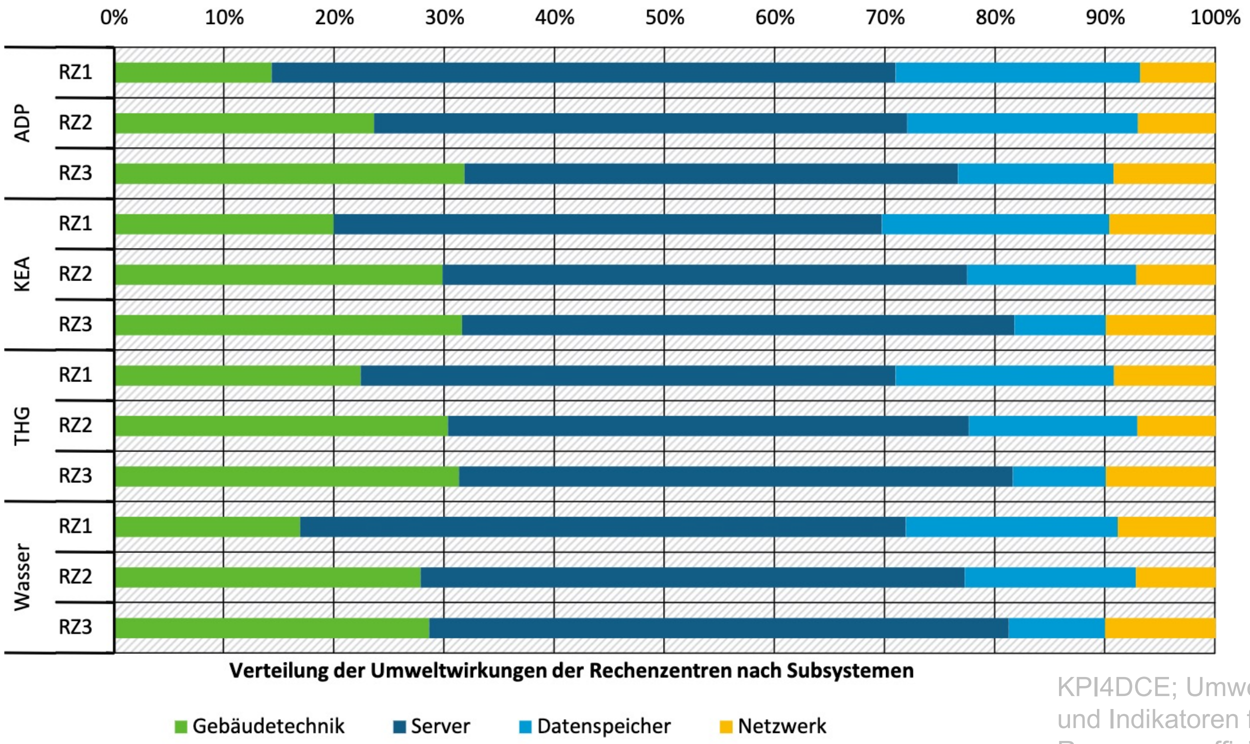
Environmental Impact



Relative distribution of the environmental impacts of the data centers by life cycle stages

KPI4DCE; Umweltbundesamt: “Kennzahlen und Indikatoren für die Beurteilung der Ressourceneffizienz von Rechenzentren und Prüfung der praktischen Anwendbarkeit”

Environmental Impact

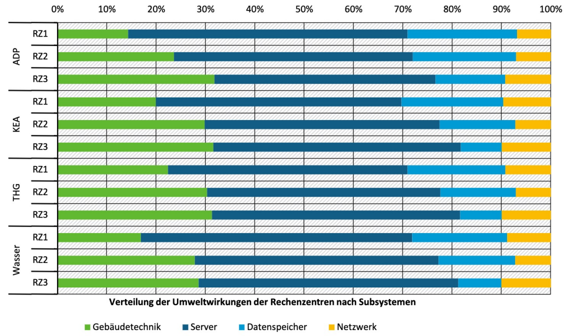


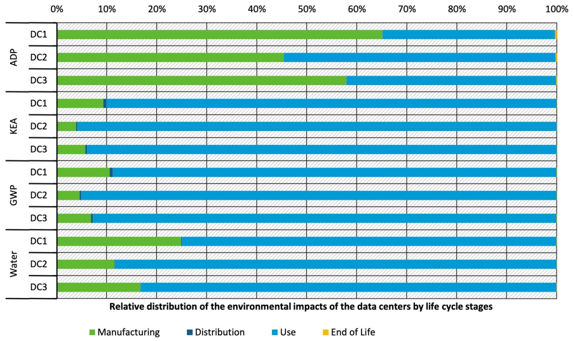
KPI4DCE; Umweltbundesamt: “Kennzahlen und Indikatoren für die Beurteilung der Ressourceneffizienz von Rechenzentren und Prüfung der praktischen Anwendbarkeit”

Environmental Impact

Take away messages for environmental impact

- 20% in Data Center Technology,
  80% in Compute Systems themselves
- Usage and Manufacturing are the two main life cycles stages with dominant impact; Distribution and Disposal can be neglected





Environmental Impact

Functional Areas affecting the environmental impact

1. Application performance
2. System operation
3. System design
4. System components
5. Data Center infrastructure

Environmental Impact

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Areas strongly correlated

Environmental Impact

Functional Areas affecting the environmental impact

1. Application performance
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Areas strongly correlated

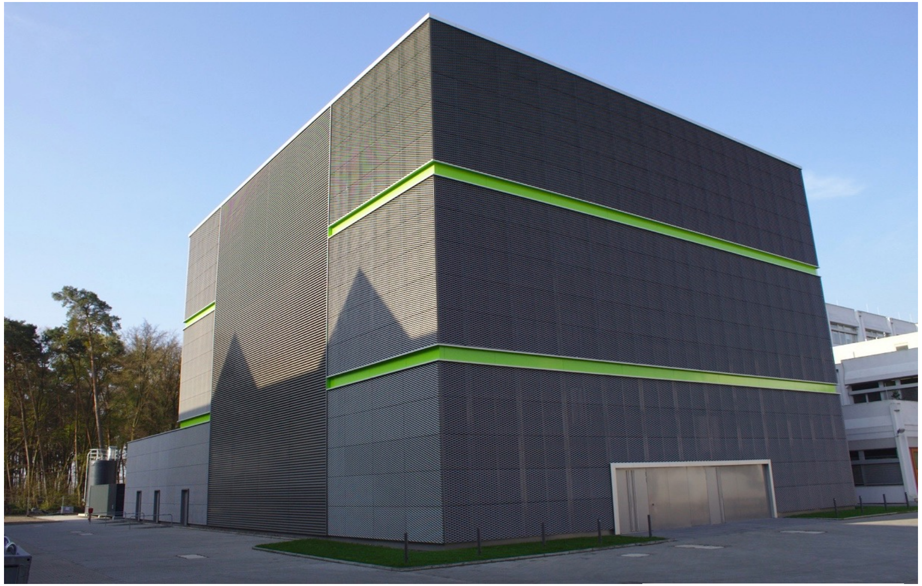
Unique opportuity in research field matter: control of (nearly) all functional areas
Unique chance to optimize

Data Center Optimization

GSI Green Cube as example

- Optimized PUE, not much room to improve
- Certified operation in all life cycle steps ("Blauer Engel")
- 100% renewable energy

What else can be done?



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Data Center Optimization

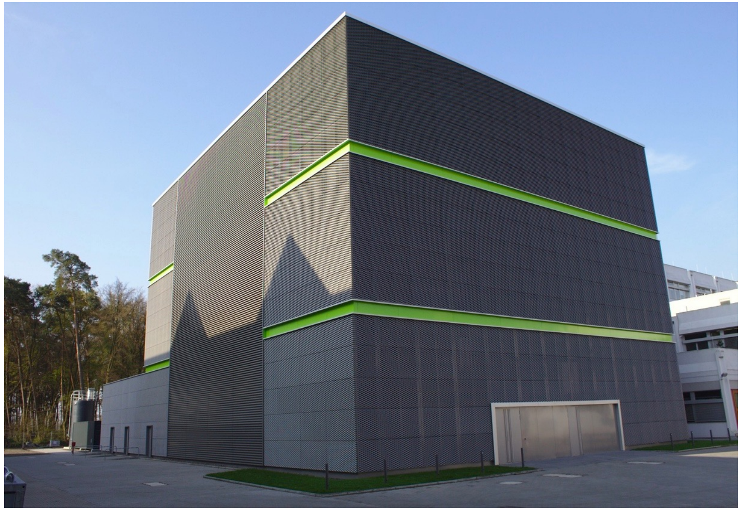
GSI Green Cube as example

- PUE optimized => cooling system optimized

However: there is still a 12MW
24/7 heat load from the servers!

How can this be reused?

- GSI: heating of office buildings
- Research projects:
  heat storage and increased temperatures (pumping, direct liquid cooling) for higher efficiency and better coupling into local/district heating systems,



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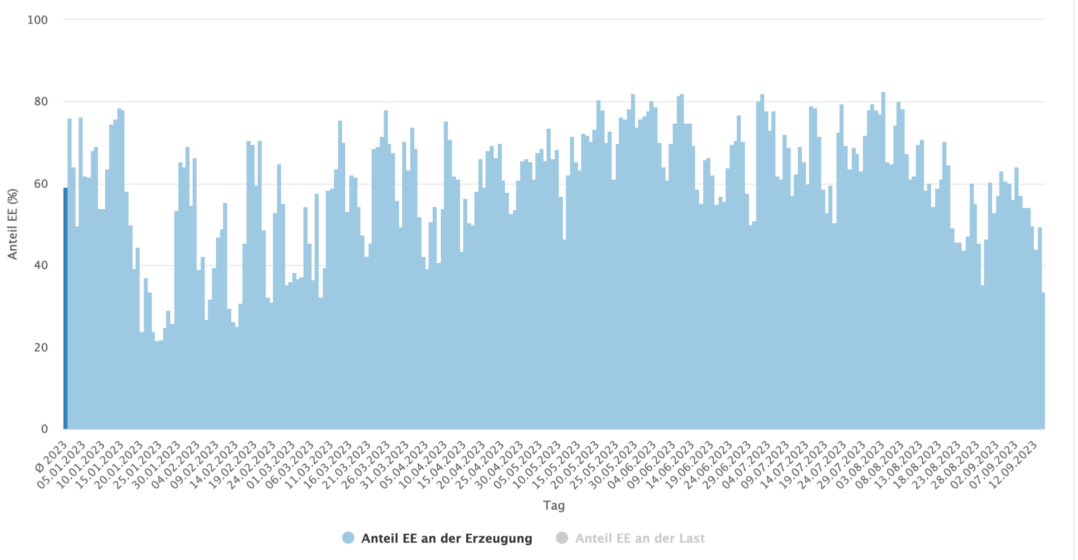
Optimization

GSI Green Cube as example

- 100% renewable energy

However: renewable energy is not always available

Research projects:
Optimized workload scheduling, Energy Storage to balance e.g. day/night differences



Optimization

Sustainability in (RF Matter) Scientific Computing

FAIR Digital Open Lab

close collaboration with industry, startups, research