Increasing sustainability in the community of Research on Universe and Matter

Sustainable HEP 2026

A. Redelbach (FIAS, Frankfurt University), J. Bürger (ErUM-Data-Hub),
L. Di Bella (ErUM-Data-Hub, TU Dortmund University),
B. Fischer (ErUM-Data-Hub, RWTH Aachen University),
M. Horzela (Goettingen University), V. Kartik (DESY),
S. Krischer (RWTH Aachen University), T. Kuhr (LMU University Munich),
K. Schulz (DESY), K. Schwarz (DESY), D. Spiteri (DESY),
C. P. Walther (TU Dortmund University), A. Warkentin (ErUM-Data-Hub)

ERUM DATA HUB

Outline

- Goals defined in White Paper 2024
- Introducing ErUM action group
- Results / monitoring of goals
- Developments for teaching / outreach
- Conclusions and next steps

Chronological context of project

- In-person Workshop 2023 https://indico.desy.de/event/37480/
- Goals defined in White Paper 2024

https://doi.org/10.1140/epjs/s11734-024-01436-4

- Online discussions 2024
  - Short pitches https://indico.desy.de/event/44490/
  - Disussion evening https://indico.desy.de/event/45927/

- In-person Workshop 2025 on Sustainability and Ethics https://indico.desy.de/event/47133/
- Formation of **ErUM action group 2025**

- Workshop report reviewing progress on sustainability measures in 2026 https://arxiv.org/pdf/2602.24087

ErUM communities

ErUM - research on universe and matter including subcommunities:

- Astroparticle Physics (KAT)
- Elementary Particle Physics (KET)
- Accelerator Physics (KfB)
- Neutron Physics (KFN)
- Synchrotron radiation (KFS)
- Nuclear probes and ion beams (KFSI)
- Hadron and Nuclear Physics (KHuK)
- German Observatories (RDS)

Projects in Germany – international embedding

Goals defined in White Paper – short term

White paper: Resource-aware Research on Universe and Matter: Call-to-Action in Digital Transformation

- portfolio of measures to be taken, ordered in terms of effort and time
- **short time scale** - with little effort these measures can be implemented
- **medium time scale** of a few years
- **longer term** requiring further coordinated planning

On short time scale:

S1 Raise awareness of the climate challenge at all levels
S2 Disseminate knowledge of measures to address the challenge
S3 Monitor and report energy consumption at job level
S4 Consider carbon footprint for all investments and project plans
S5 Enhance awareness of the trade-off between research benefit and climate impact

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Goals defined in White Paper – medium term

M1 Make data FAIR to promote reuse.

M2 Reduce and compress data having the anticipated scientific value of the retained information and the resource requirements in mind.

M3 Optimize the choice of storing intermediate results against re-calculating them.

M4 Optimize job orchestration and scheduling in workflows.

M5 Use workflow management to make processing FAIR.

M6 Make software FAIR and reliable by following good software development practices and ensuring sustainable support.

M7 Design software for optimized energy consumption and provide tools to measure it.

M8 Continue research on potential of AI or other new technologies for efficient use of resources, but balance gain of research action against resource consumption of these developments.

M9 Monitor and report energy consumption at site and project level, provide information of the individual use per scientist/project/publication.

M10 Extend monitoring of resources beyond CO_2e (water, material etc.).

M11 Train scientists in good practices.

M12 Regularly review and update the CO_2e reduction plan.

M13 Strive to become a role model at all levels and help to establish sustainability in everyday life.

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Goals defined in White Paper – long term

L1 Adjust computing in space and time to the availability of renewable energy, e. g. computing centers close to off-shore wind parks with a job scheduling using only or mainly the surplus of renewable energy available at a given time.

L2 Develop software and middleware that can respond dynamically to the availability of renewable energy.

L3 Optimize power usage effectiveness.

L4 Re-use of produced heat.

L5 Adjust hardware lifetime considering emissions due to procurement and operation.

L6 Include the resources needed for continuous IT support into project planning

https://doi.org/10.1140/epjs/s11734-024-01436-4

ErUM Action group: goals

Triggered by workshop 2025

→ Formation of Action Group Sustainability in Digital Transformation

Main goals:

- Raising awareness within community
- Understanding our place in the bigger picture
- Creating and curating communication
- Broadening adoption of already well-known solutions
- Training material on sustainable computing

S3: Monitor and report energy consumption at job level

Monitoring and reporting of per job energy consumption is becoming more widespread at sites.

Example **DESY**: provides an estimate of CO_2 footprint of batch jobs to users

For the **VISPA cluster of the ErUM-Data groups** in Aachen: System informing users about the footprint of their jobs including indications when energy mix is most favorable for running jobs.

ATLAS experiment:

- Workflow management system PanDA equipped to collect estimates of footprint of all ATLAS jobs
- Estimate of footprint of user jobs, along with link to more information about calculations
- Actual footprint depends on site where job runs, the numbers reported to users based on averages over all sites

Estimated Carbon Footprint for the Task

Category	gCO2
Succeeded	0.06 gCO2
Failed	0 gCO2
Cancelled	0 gCO2
Total	**0.06 gCO2**

More details on estimation: https://panda-wms.readthedocs.io/en/latest/advanced/carbon_footprint.html

https://doi.org/10.1140/epjc/s10052-025-14976-3

M7: Design software for optimized energy consumption and provide tools to measure it

Efficient software that runs at scale can reduce emissions and make large-scale computing sustainable.

Several examples of software designed for optimized energy consumption, using **more efficient languages** and **data formats**.

Awkward-arrays: Contiguous in memory, sizeable chunks of events are processed in parallel instead of performing event-by-event calculations https://doi.org/10.1051/epjconf/202024505023

RNtuple format in ROOT implements thread-safety and provides significant efficiency gains over previous TTree format.

Tools to measure resource consumptions exist, but application is not yet as widespread as other software quality control methods, such as testing.

M7: Design software for optimized energy consumption and provide tools to measure it

Practical approach: only **focus on commonly-used software components**, maximizing the benefit of measuring consumption and improving efficiency.

In medium term, **educating scientists** to minimize resource usage can have a knock-on effect on large-scale energy consumption.

On the longest time scale, getting **energy certifications of software programs** will ensure that energy consumption gets attention in the project planning phase and reduces significantly the carbon footprint.

Research Software Quality Toolkit (RSQKit): developed alongside European Research Infrastructures for Open Science provides a community-contributed collection of expert-verified tasks, tools, and training https://everse.software/RSQKit/improving_environmental_sustainability

Developments for cross-domain **Green DiSC certification model**
https://www.software.ac.uk/GreenDiSChttps://www.software.ac.uk/GreenDiSC

Results/monitoring: Long term Adjust computing according to availability of renewable energy

Adjust computing in space and time according to availability of renewable energy

Computing centers close to off-shore wind parks with a job scheduling using mainly renewable energy available at given times.

Very difficult to reach goal - idea of a new center close to off-shore has not yet gained much support.

First approach towards **green job scheduling** by just launched ErUM-Data project **SUSFECIT** aiming at including the availability of green energy in an automated job scheduling system.

https://commons.wikimedia.org/wiki/File:WW17-133_(33128552163).jpg

https://susfecit.erumdatahub.de/

SUSFECIT
Sustainable Federated Compute Infrastructures

Teaching / outreach: Podcasts

Plan to produce multiple podcast episodes offering different perspectives and discussions on sustainability in the ErUM-Data-Community.

Already **published a first episode**, featuring impressions from politics, economy and science on AI and sustainability

https://open.spotify.com/episode/56fHzTRlflEw9FWY4yVXHm

Societal, economical and ecological dimensions of sustainability from ErUM perspective to be discussed

Covering topics like AI, large scientific infrastructures and future endeavors in the community.

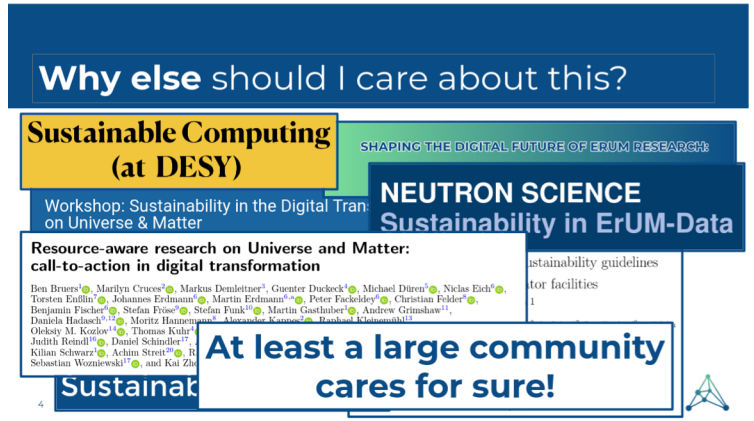
Teaching / outreach: Slide deck

Starting point through our slide deck "Where to Start?“ targeting following aspects:

- Helping to **motivate** why research groups should care about sustainability
- Providing a **basis for discussions** on sustainability in a working group
- Offering easy starting points to contribute with small steps
- First version of slide deck has recently been used

  → available as a downloadable resource

  → Offer to **present it in interested working groups**



Summary / get in contact

- **Cross-disciplinary goals** have been followed up by ErUM action group Sustainability in Digital Transformation
- Progress on goals at different time-scales
- **Multi-step framework** for integrating sustainability into research practices developed
- Perspective: Broadening the use cases towards more global efforts in sustainability

→ Reach out to us!

sustainability@erumdatahub.de

www.erumdatahub.de/en/