

SUSFECIT



Sustainable Federated Compute Infrastructures

Markus Schumacher

on behalf of but not blessed by the SUSFECIT Research Network
(Aachen University, Bonn University, CERN, DESY, Freiburg University,
Göttingen University, KIT, Siegen University, Wuppertal University, Öko-Institut e.V.)

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The Consortium

Partners



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Marc Schumann
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Erik Bründermann
Achim Streit
Kathrin Valerius



Christian Gutt



Christian Zeitnitz

The Basic Idea of SUSFECIT

Sloppy: „Perform calculations when and where sun is shining or wind is blowing“



➤ A bit more precise:

Adapt the amount of calculations and energy consumption to the temporal and local availability of renewable energies (RE) to be used in compute centres e.g. exploit that compute jobs are “easily” dispatchable in time and space

➤ Means of adaption:

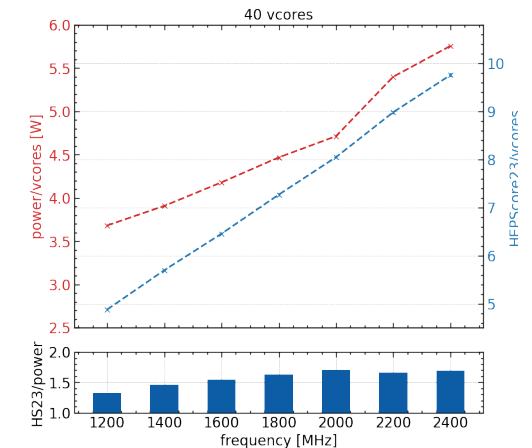
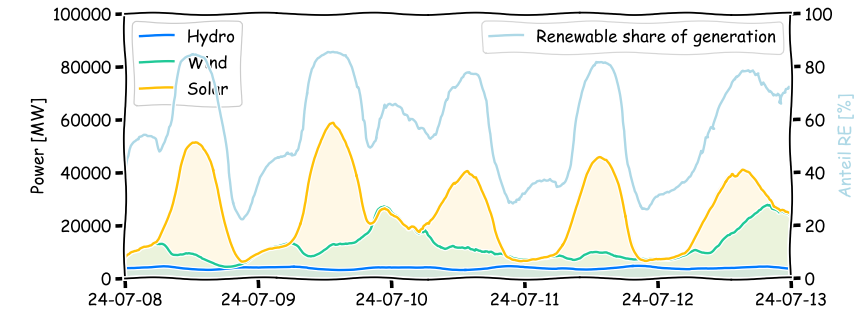
- shut down (parts) of cluster
- reduce clock frequency of CPUs (GPUs)
- transfer jobs to sites where enough RE is available

➤ Requirements on hardware:

- overprovisioning of resources to compensate for volatility of RE and dark doldrums
- include energy storage (in/close-by compute centres) in concept to compensate for volatility of RE and dark doldrum

➤ Requirements on strategy of operation/ software ecosystems:

- Forecast of available RE with good temporal and local resolution (and requested compute time)
- Orchestration of jobs in time and on compound of sites according to available RE and compute demands (incl. check pointing for transfer of jobs between sites)
- Accounting of elapsed time, consumed energy, produced CO₂ footprint (incl. LCA), used water, ...

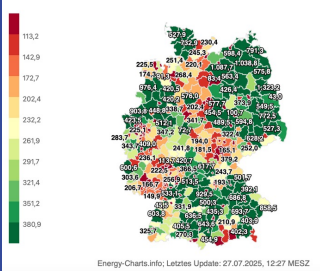


The „House“ of SUSFECIT and its Research Areas (RAs)

Development of overall strategy
Links btw. three ecosystems

RA1 Forecasting

Installierte Solarleistung in Deutschland in 2025
Werte in MWp – Gesamtsumme: 108.352 MWp



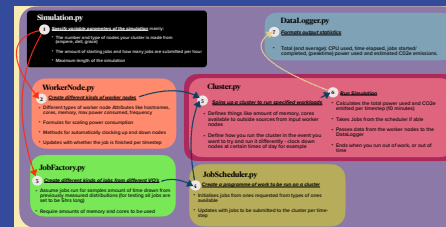
RA2 Orchestration



RA3 Accounting



RA4 Digital twin for simulation and optimization of interlinked ecosystems above



RA5 Development and deployment of tutorials, creation of awareness and education of scientists (all, ~ 0.5 FTE)

Goals:

- Increase the environmentally sustainable use and operation of federated compute resources.
- Raise awareness of the impact of scientific computing on the CO₂ footprint
- Train talented early career scientists in cutting-edge technologies

Dissemination:

- First developed and deployed for ATLAS, CMS and ET
- Later:
 - KATRIN, XENONnT, LXZD (neutrino and astro-particle physics)
 - Experiments at PETRA-III, EU-XFL, ESRF (synchrotron radiation physics)
- Perhaps: Further use cases identified

Links to PUNCH4NFDI, EGI, WLCG via partners and associated partners

Associated partners will act as critical reviewers, alpha-users and multipliers

RA1 Forecasting and RA2 Orchestration

RA1 Forecasting (lead & coordinated by Bonn, P. Bechtle; partners: AC, DESY, Öko; ~ 1 FTE)

- - forecasting of available RE (and price) with good temporal and spatial resolution
- - estimation of required overprovisioning of resources (and local energy storage)
- - optimization to minimal environmental impact incl. LCA of machines and infrastructure, ...

Development of ecosystem to connect and evaluate available public data bases and its interfaces to COBalD/TARDIS, AUDITOR, Digital Twin

RA2 Orchestration (lead & coordinated by KIT, M. Giffels; BN, DESY, GÖ, FR; ~ 3.5 FTE)

- Adaption of jobs distribution to availability of RE
- Include concepts and tools to shut down or throttle clock frequency of parts of cluster
- Implementation of dynamic resource limit in COBalD/TARDIS
- Development and Implementation of checkpoint-restore for compute jobs

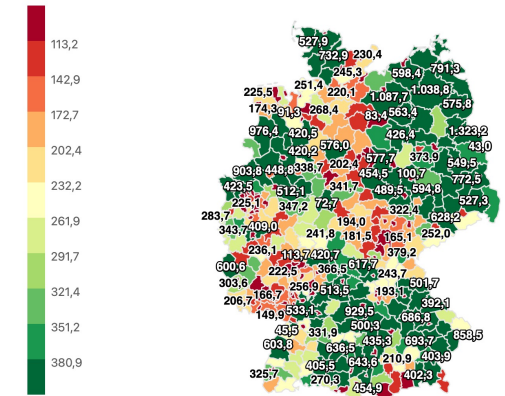
Advancement of ecosystem COBalD/TARDIS and its interfaces to Forecasting, AUDITOR, Digital Twin



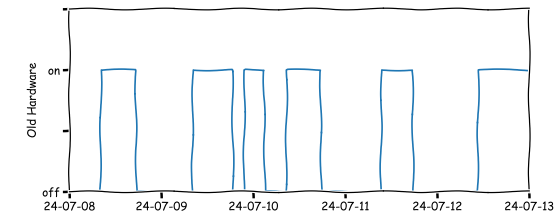
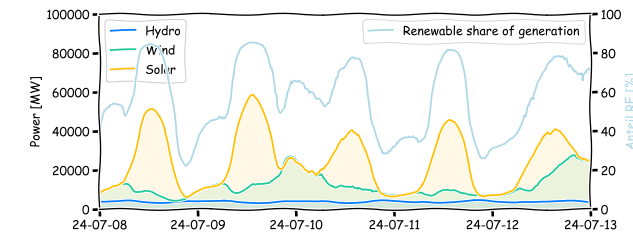
Operation of Breathing Sun Clusters at several sites and evaluation of performance
(limit on number of floating nodes, turn around time for smooth operation, ...)

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Energy-Charts.info; Letztes Update: 27.07.2025, 12:27 MESZ



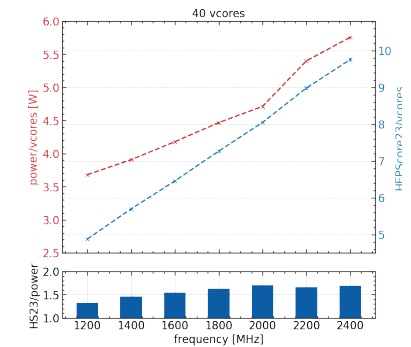
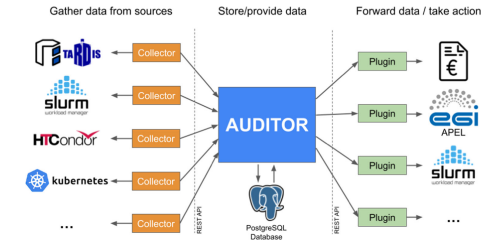
RA3 Accounting and RA4 Digital Twin

RA3 Accounting (lead and coordinated by Freiburg, M. Böhler; partners KIT, Öko-Institut; ~2 FTE)

→ full accounting of environmental impact of scientific computing

- New plugin to determine energy consumption and CO₂ footprint for compute jobs
- Extension for time dependent clock rate, GPUs, ...
- Extension to include storage, data transfer, network footprint
- Include new KPI and models from Öko-Institut in accounting pipeline
- Include water usage, embedded CO₂, depletion of abiotic resources

Advancement of ecosystem AUDIOTR COBaID/TARDIS and its interfaces to Forecasting, COBaID/TARDIS and Digital Twin



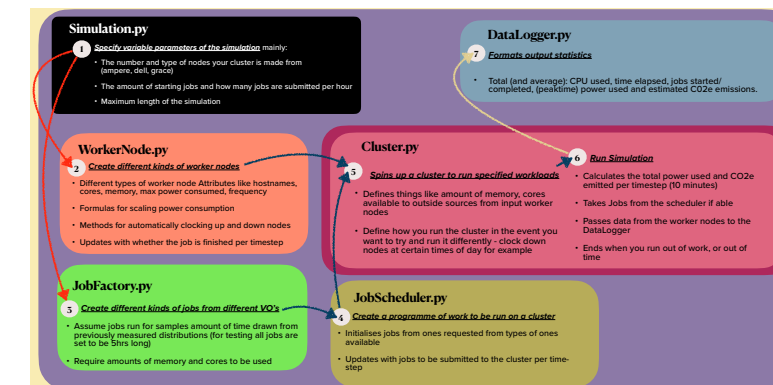
RA4 Digital Twin (lead and coordinated by DESY, D. Spiteri; partner BN; ~1 FTE)

Extend simulation proto type for single site DESY to

- Geographical distributed, federated IT infrastructure with job and data transfer
- Clock rate trotting, breathing sun/wind clusters
- Realistic job mixes including check pointing

Advancement of simulation framework and implementation fo feedback loops

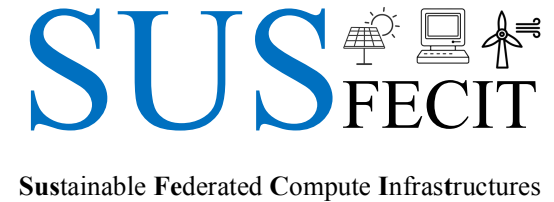
And interfaces to Forecasting, COBaID/TARDIS and AUDITOR



Conclusions (repetition for your reading pleasure only)

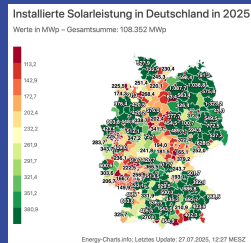
- 2024: electricity consumption of compute centres in D 20 billion kWh in 2024 (4% of total), 7.3 t CO₂ footprint
- Next 5 years: energy consumption expected to double $\leftrightarrow$ goal of CO₂ neutrality in D in 2045

→ Advance environmental sustainability of scientific computing in SUFECIT project



Development of overall strategy
Links btw. three ecosystems

RA1
Forecasting



RA2
Orchestration



RA3
Accounting



RA4 Digital twin



Goals:

- increase the environmentally sustainable use and operation of federated compute infrastructures
- raise awareness of the impact of scientific computing on CO₂ footprint from ErUM communities
- train talented early career scientists in cutting-edge technologies

Hope:

- SUSFECIT will provide tools to help reach this goal and dissemination to ErUM communities and beyond will be successful

Backup

RA5 Education & dissemination, role of associated partners,

Thorough documentation, development of tutorials and conduction of educational workshops in order to foster new use cases and to disseminate the developed concepts and ecosystems to a wider audience
Workshops shall be advertised and organized in cooperation with the ErUM-Data Hub.

Feedback by and roll out to WLCG via S. Campana (WLCG project leader)

Connection link, alpha-users and multipliers in respective community:

KAT community via K. Valerius (KIT) and M. Schumann (Freiburg)

KFS community via C. Gutt (Siegen) and KFB community via E. Bründermann (KIT)

Heads of the HPC centres at Freiburg (D. von Suchodoletz) and at the SCC at KIT (A. Streit)
provide feedback from a computer science and resource provider point of view

Links to other BMFTR-funded research networks such as “Federated storage FUSE”, to PUNCH4NFDI, EGI ...
via individuals from (associated) partner institutes, who are active members (of boards) in this initiatives

The ErUM-Data Hub kindly agreed that it will provide support for dissemination of developed concepts and technologies and for conducting workshops and tutorials to train scientists in all ErUM communities.