



GreenDIGIT

GreenDIGIT Tools for Environmental Sustainability in Digital Research Infrastructures: Assessment Methodology & Metrics Publication System

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SC4RC Interactive Session

May 4, 2026



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Agenda

- **GreenDIGIT Project Overview**
- **Environmental Impact Assessment Methodology**
 - Methodology overview
 - Live demo
 - Audience participation
- **Environmental Impact Metric Publication System (EIMPS)**
 - Use cases & Architecture
 - Demo and Applicability to European Research Infrastructures
- **Wrap-up & Open Discussion**



Acknowledgement:
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<https://www.menti.com/al3gkhbpd29y>



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GreenDIGIT Project (2024-2027)- Objectives

HORIZON-INFRA-2023-TECH-01-01:

New technologies and solutions for reducing the environmental and climate footprint of RIs

- **O1: Assess status and trends** of low-impact computing within 4 DIGIT RIs (EGI, SLICES, SoBigData, EBRAINS) and in the broader digital service provider community of ESFRIs, to produce **recommendations and roadmaps** for providers during and beyond the project.
- **O2: Provide reference architecture and design principles**, as well as an actionable model for RIs about environmental impact assessment and monitoring, reflecting on the **whole RI lifecycle** and including the digital infrastructure components and their interaction with the broader environment.
- **O3: Develop and validate new and innovative technologies, methods, and tools** for digital service providers within European Research Infrastructures through which they can reduce their energy consumptions and overall environmental impact.
- **O4: Develop and provide for researchers technical tools** that assist them in the design, execution and sharing of environmental impact aware digital applications with reproducibility, Open Science and FAIR data management considerations.
- **O5: Educate and support digital service providers and researchers** in the RI communities about good practices on environmental impact-conscious lifecycle management and operation of infrastructures



CESNET,
CSIC-IFCA,
SZTAKI,
CNRS



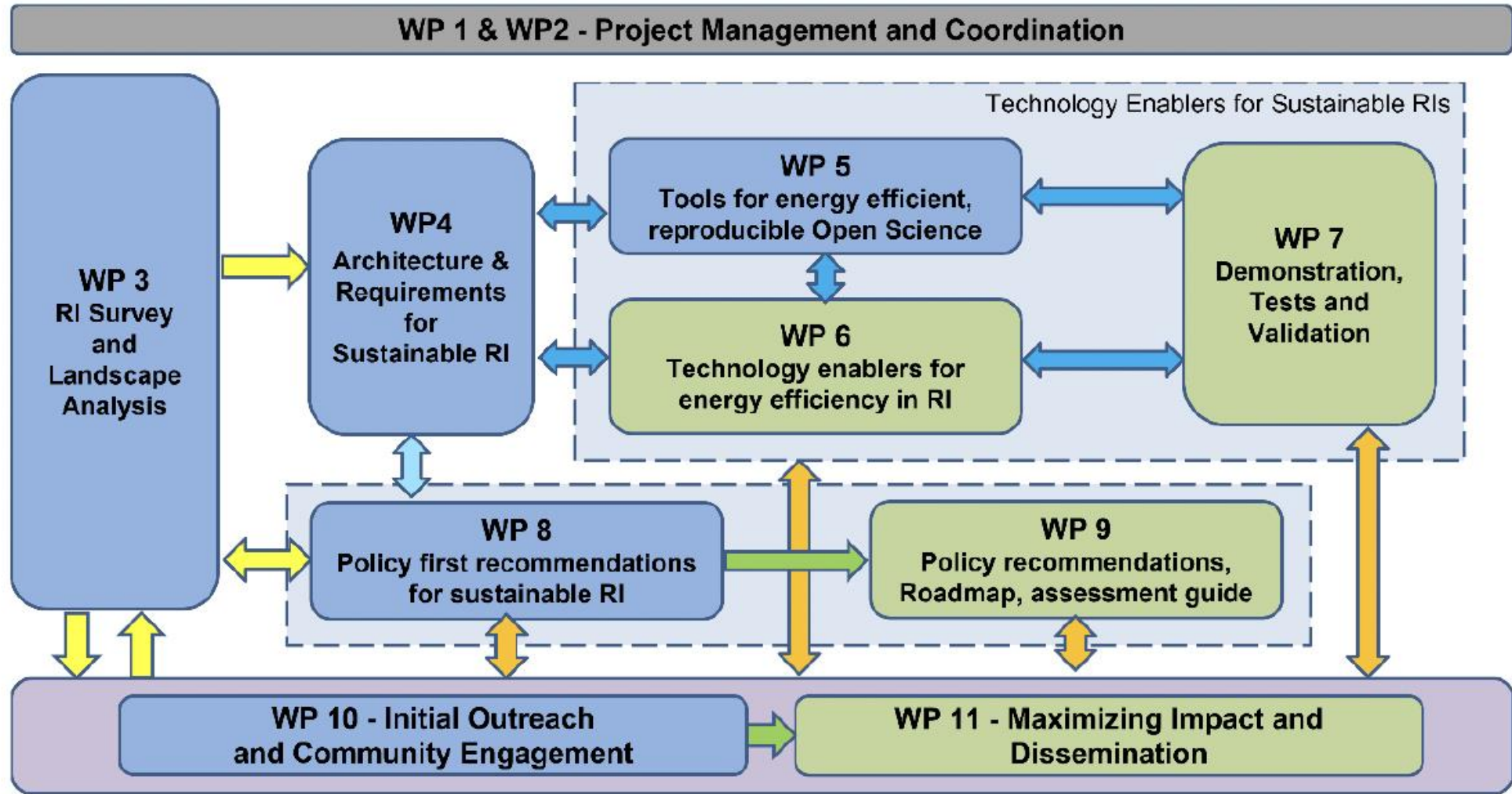
UvA (NL) -
Coordinator



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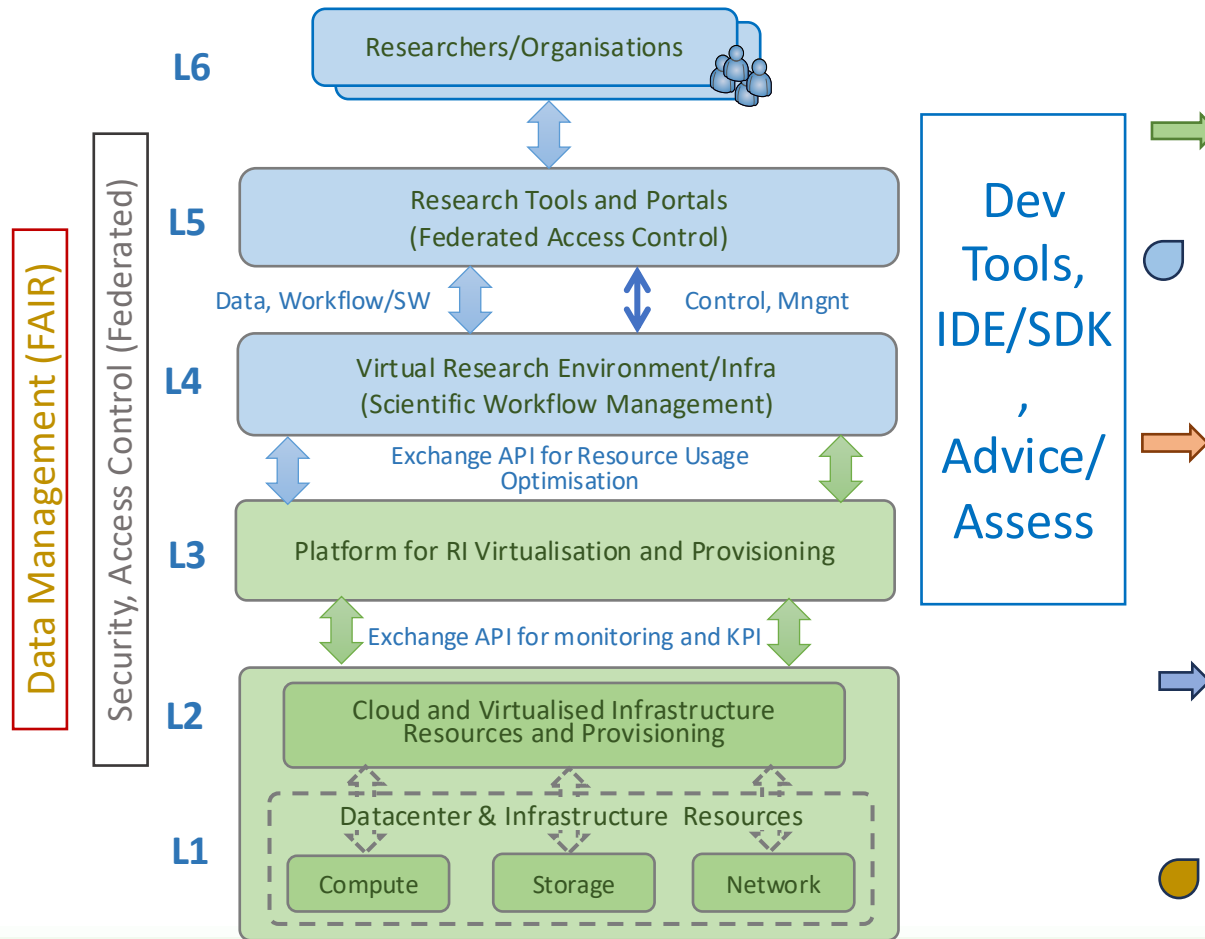


Work Package Overview and Status





RI Sustainability by Design



Pillar 1 – Layered and Modular Architecture for Sustainable Digital Infrastructure

- Functional components, Layers, API, Requirements

Pillar 2 - Software and Scientific Applications Architecture Design Patterns for Energy Efficiency and Environmental Impact Reduction

- Green aware API including necessary energy, performance, and environment information

Pillar 3 - Lifecycle-Oriented Sustainability Management of Research Infrastructures and Scientific Applications

- RI lifecycle stages (concept, design, development, deployment, operation, decommissioning) and scientific workflow and research data

Pillar 4 – Common Information Models for Sustainability Metrics and Monitoring Interoperability

- Including **Requirements, KPI, Metrics** + FAIR properties for Sustainability

Pillar 5 - Sustainable Data Management and Energy-Efficient Storage Systems

- Distributed storage tiering and access optimisation





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Environmental Impact Assessment Methodology for Digital RIs



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Environmental Impact Assessment Methodology

- Developed in the GreenDIGIT project to **assess environmental impact of digital Research Infrastructures (RIs)** in the **ICT** sector.
- Environmental impact assessment of **A)** impacts & capability levels, **B)** identifying & prioritising actions, **C)** monitoring impact: **Climate Change (CO₂), Energy, Waste, Water.**
- **Practical steps** to assess impact magnitude and support strategic planning for sustainability actions.



*GreenDIGIT Deliverable D3.2 Environmental Impact Assessment
Methodology & Guidelines for RIs: <https://zenodo.org/records/19488358>*



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6-Step Methodology

1.

Identification of
scope and impacts

2.

Assessment of
impacts and
capability level

3.

Identification of
actions

4.

Determination of
priority levels

5.

Formalising the
action plan

6.

Monitoring and
reporting



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Step 1: Identification of Scope & Target Capability Level

- Energy Efficiency & Decarbonisation
- Environmental Monitoring and Impact
- Pollution, Waste, and Circularity
- Water and Ecosystems
- Lifecycle Integration
- Governance and Compliance
- Stakeholder Engagement and Awareness



in the **Self-Assessment Questionnaire (SAQ)**



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Step 2: Assessment of Impacts & Current Capability Level

- **Inventory of RI Components** for data gathering
- **Self-Assessment Score** for current capability: **1-3**
- Matched automatically with **an improvement priority**

Capability level	Description
Level 1: Ad-hoc / Initial	Awareness is minimal and practices are largely unstructured.
Level 2: Developing / Partial	Some measures exist, but they are inconsistent or not formalised.
Level 3: Established / Assured	The RI is confident that the topic is systematically addressed with well-defined practices.



Step 3: Identification of Actions

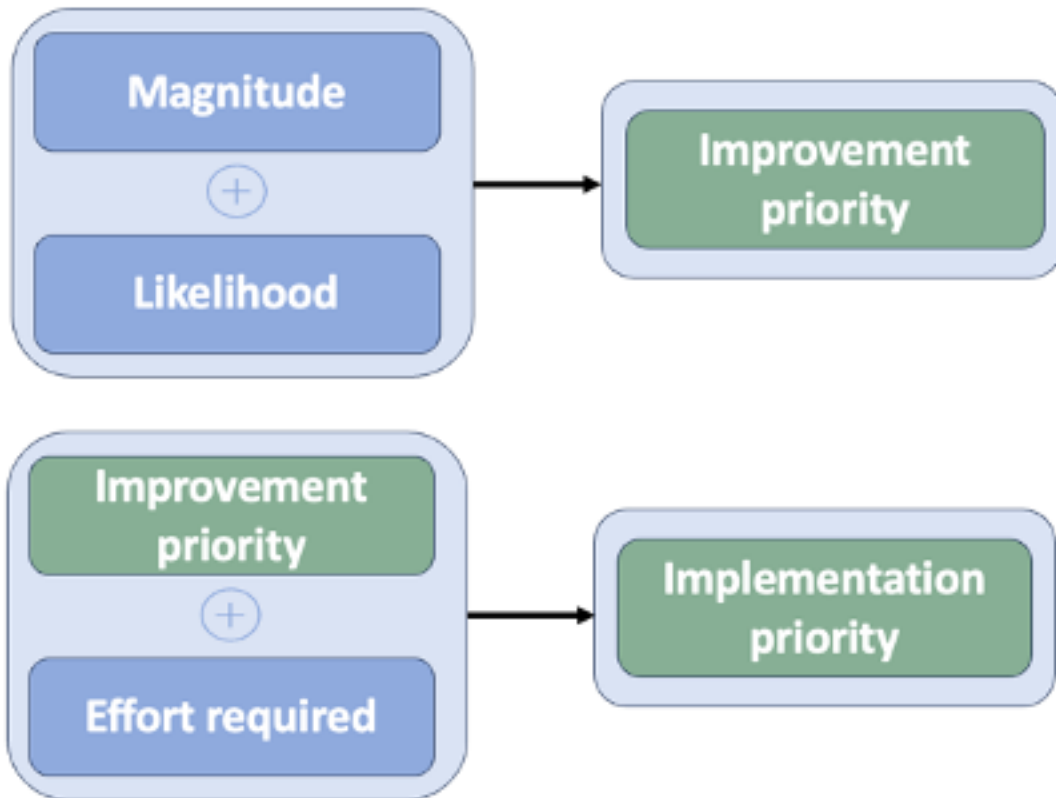
in the **Self-Assessment Questionnaire (SAQ)**



Capability Level	Description	Recommended Action
1	The RI does not use or track renewable energy usage.	Assess the current energy mix and identify opportunities to procure or transition to renewable energy sources. Start collecting data and documentation to verify sources (e.g. supplier declarations, energy certificates).
2	Some energy comes from renewable sources, but tracking is limited or informal.	Increase the share of renewable energy through updates contracts or on-site generation. Implement processes for regular verification and reporting (e.g. through Guarantees of Origin, utility audits).
3	A high proportion of energy is sources from renewables, verified through formal documentation or contracts.	No action needed. Continue monitoring and ensure transparency in reporting renewable energy sourcing and verification.



Step 4: Determination of Priority Levels



Matrix for improvement priority level determination

		Likelihood		
		High	Medium	Low
Magnitude	High	high	high	medium
	Medium	high	medium	low
	Low	medium	low	low

Matrix for implementation priority level determination

		Effort Required		
		High	Medium	Low
Improvement priority	High	planned	urgent	immediate
	Medium	low	planned	urgent
	Low	no action needed	low	planned



Step 5: Formalising the Action Plan

Step 6: Monitoring & Reporting

Implementation priority level	Definition of action
Immediate	Top priority, quick win or urgent fix – act now.
Urgent	Needs addressing soon – schedule in near term.
Planned	Include in standard planning – not urgent but necessary.
Low	Can be postponed or handled when convenient.
No action needed	Either already sufficient or not impactful enough.



Leader & deadline for each action prioritised as **planned, urgent or immediate**



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Self-Assessment Questionnaire (SAQ)



GreenDIGIT Deliverable D8.1 Self-Assessment Questionnaire:

<https://zenodo.org/records/17210726>



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SAQ

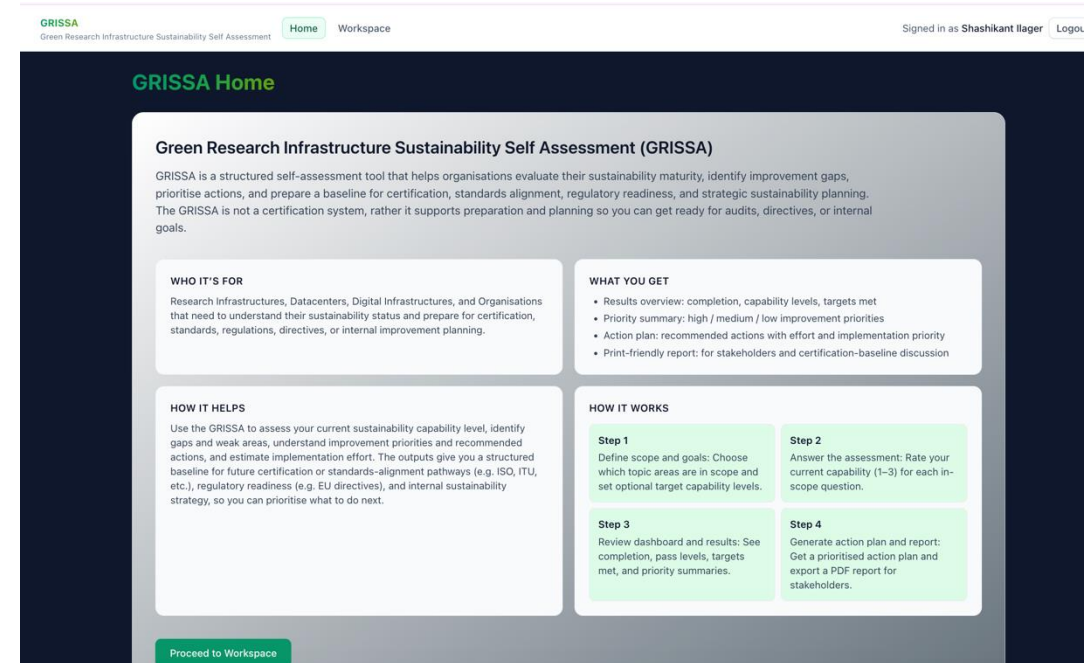
Scope and Goals	In Scope?	Target Capability level?
Governance and Compliance		
G1: Alignment with relevant EU regulations (CSRD, ESRS, EED, ESPR, WEEE, LCA, ISO14040, ISO14044)	No	Select....
G2: Existence of a formal environmental sustainability strategy	No	Select....
G3: Defined roles and responsibilities for sustainability	No	Select....
G4: Inclusion of sustainability in internal policies or quality systems	No	Select....
G5: Inclusion of sustainability in procurement or supplier management	No	Select....
Stakeholder Engagement and Awareness		
S1: Sustainability awareness/training for staff	No	Select....
S2: Involvement of stakeholders in environmental planning	No	Select....
S3: Transparent communication of environmental performance	No	Select....
Energy Efficiency and Decarbonisation		
E1: Adoption of renewable energy sources	Yes	Select....
E2: AI-driven workload or energy optimisation	Yes	Select....
E3: Waste heat recovery or reuse strategies	Yes	Select....
E4: Power Usage Effectiveness (PUE) tracking and optimisation	Yes	Select....
E5: Carbon Use Effectiveness (CUE) tracking and reduction	Yes	Select....
E6: Flexible energy usage or smart grid responsiveness	Yes	Select....
Environmental Monitoring and Impact		
M1: Measurement of environmental KPIs (GHG, energy, water, waste)	Yes	Select....
M2: Use of environmental metrics in planning and reporting	Yes	Select....
M3: Lifecycle-based environmental impact assessment (based on LCA methodology)	Yes	Select....
M4: Use of WUE (Water Usage Effectiveness) or similar water metrics	Yes	Select....
M5: Implementation of monitoring tools/platforms	Yes	Select....
Pollution, Waste, and Circularity		
P1: Reduction of operational waste (incl. e-waste)	Yes	Select....
P2: End-of-life management for equipment	Yes	Select....
P3: Circular IT practices (reuse, remanufacturing, modularity)	Yes	Select....
P4: Pollution control (air, water, soil)	Yes	Select....
P5: Use of low-impact or non-toxic materials	Yes	Select....
Water and Ecosystems		
W1: Water usage monitoring and reduction strategies	Yes	Select....
W2: Impact on local ecosystems or biodiversity	Yes	Select....
W3: Rainwater harvesting, reuse, or runoff management	Yes	Select....
W4: Water-based cooling systems and water efficiency strategies	Yes	Select....
Lifecycle Integration		
L1: Sustainability embedded in the design phase	Yes	Select....
L2: Consideration of sustainability during implementation	Yes	Select....
L3: Operational sustainability practices	Yes	Select....
L4: Decommissioning/termination phase planning	Yes	Select....



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SAQ Demo: Web Tool

- Role-based access control
- Dedicated workspace navigation
- Assessment versioning
- Actionable dashboard and reports



Please scan to
access the tool



Note: This is a beta version. We are extending the SAQ tool to support the **creation of certification baselines**. We welcome your feedback and input as we continue to develop it.



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Environmental Impact Metric Publication System (EIMPS)



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Environmental Metric Collection in Federated, and Heterogeneous RIs

How many of you have attempted to develop **green-aware scheduling** or **resource management algorithms** and encountered obstacles due to the lack of reliable, ***federated*** metric infrastructure?

But why?

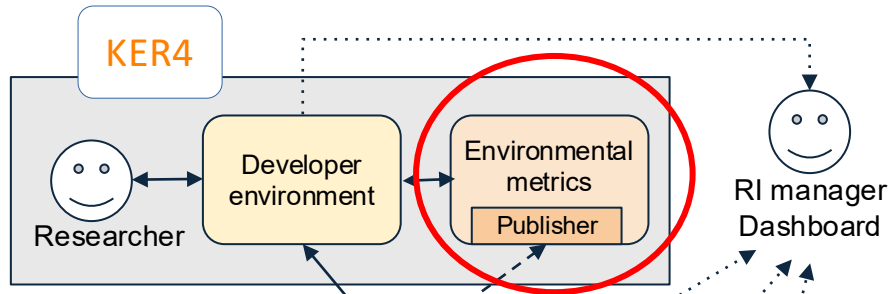
- Fragmented telemetry
- Heterogeneous resources and software stacks
- Diverse monitoring tools inside each RI
- No common namespace or understanding between RIs
-People/system don't want to share
-



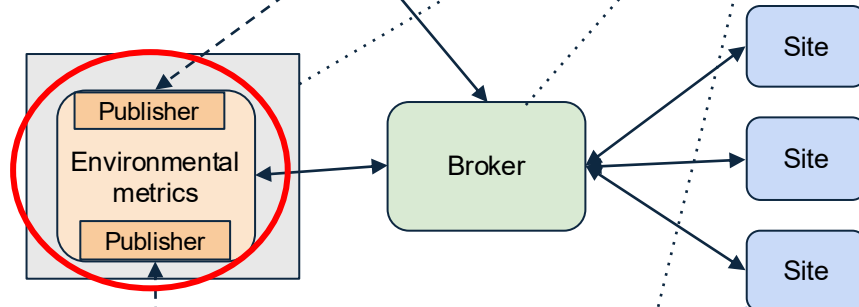


SW Tools for Environmental Sustainability

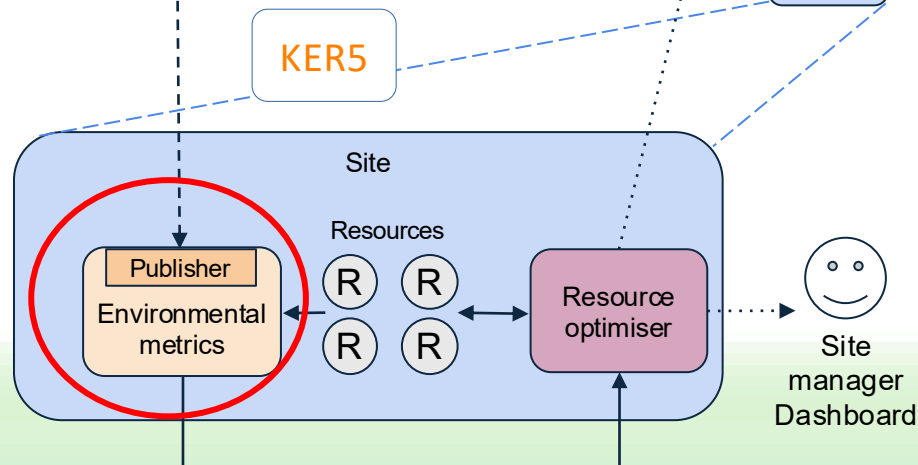
Level 1:
Experiment



Level 2:
Infrastructure



Level 3:
Site



Level 1: Developer Tools for Energy-Efficient Software Design- Optimised code; prevent re-execution of already conducted experiments

Level 2: Energy-Efficiency Aware Schedulers- Reshuffle jobs based on site carbon intensity and efficiency

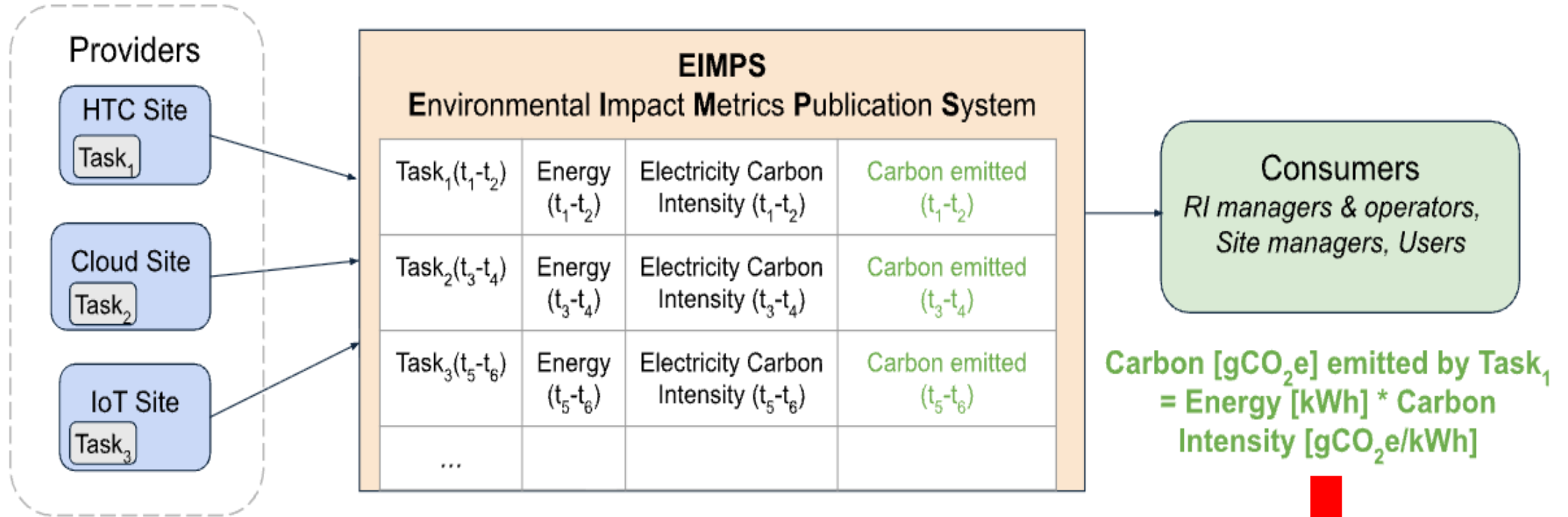
Level 3: Energy-Efficiency Aware Resource Manager- Delay execution based on electricity cost, regulations, and carbon intensity; dynamically turn resources on/off

Metrics Infrastructure- Gather relevant environmental sustainability metrics (**federated**) and serve them to decision-making systems (schedulers, frameworks, VREs)





GreenDIGIT Metric Publication System

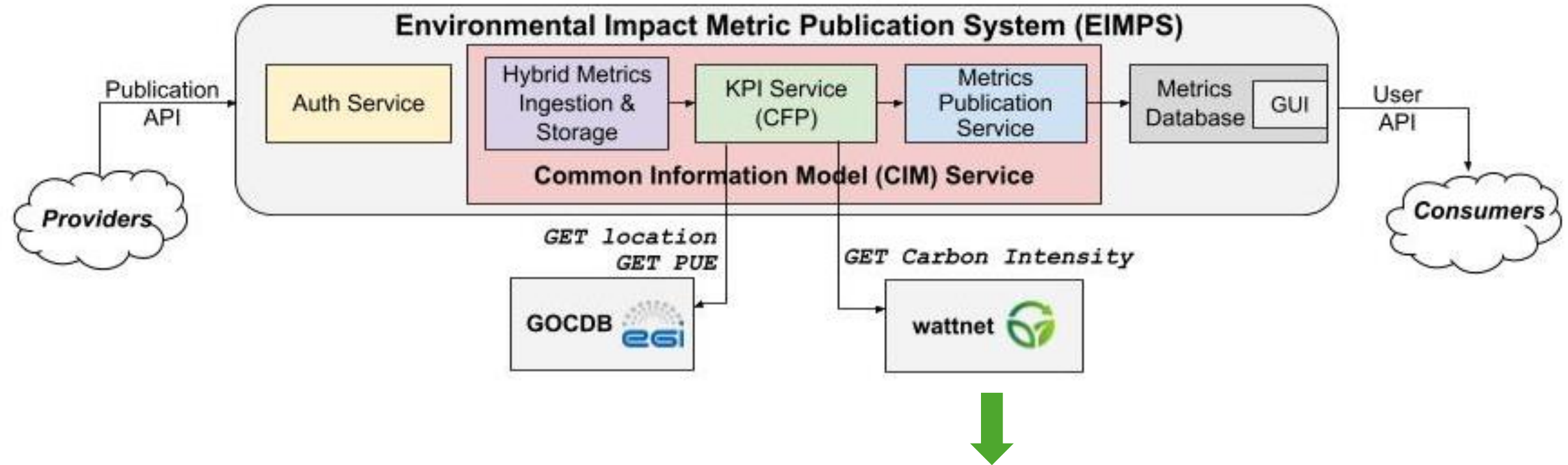


WIP to include scope 3/embodied carbon metrics for RI's IT equipment (reporting)





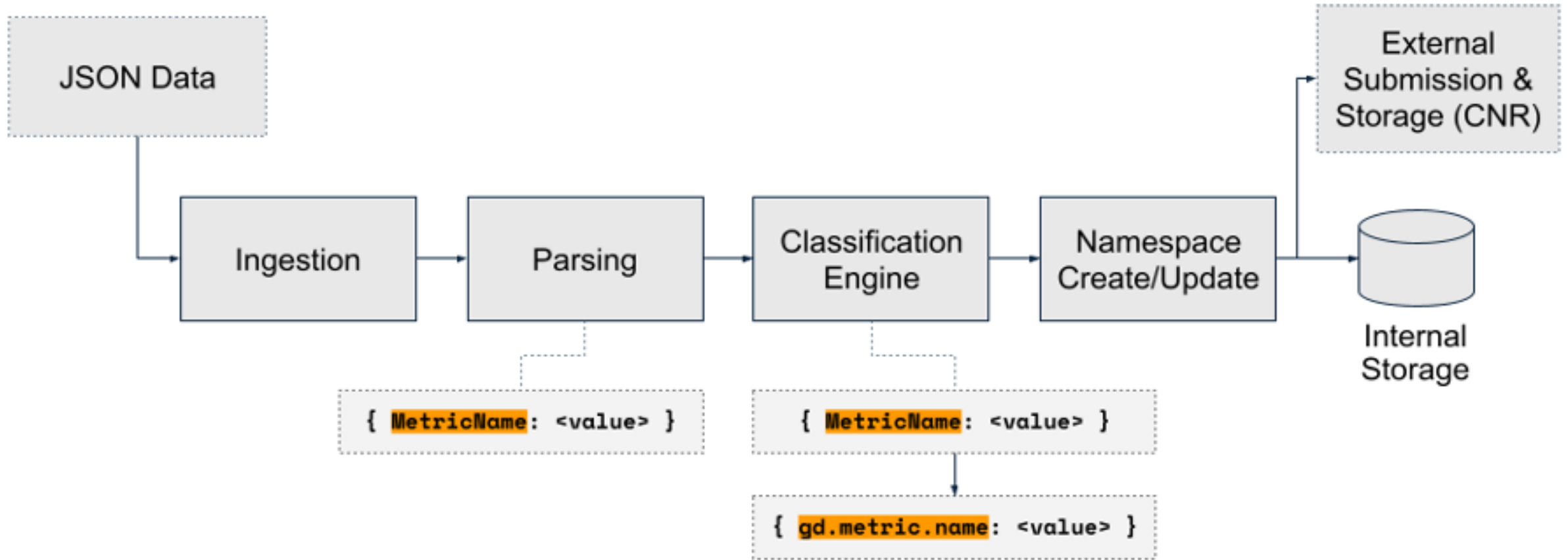
EIMPS overview



To find more about it, attend the talk by our CSIC-IFCA team:
Contributed Talks: (Track A) Thursday @11:30.



Common Information Model (CIM) Pipeline





Example of converted metrics

Raw metrics (DIRAC)

```
{
  "JobID": 213217892,
  "Status": "Done",
  "Owner": "esantos",
  "Site": "EGI.PRAGUE.cz",
  "StartExecTime": "2025-09-24 23:45:16",
  "EndExecTime": "2025-09-25 14:00:37",
  "Energy(kwh)": 0.2258672685,
  "LoadAverage": 75.6103448275862,
  "NormCPUTime(s)": "785476.013",
  "TotalCPUTime(s)": "48787....",
  "PUE": 1.5,
  ...
}
```

CIM Standard

```
{
  "metadata": {
    "site_name": "EGI.PRAGUE.cz.exec-grid-001",
    "datacenter": "EGI.PRAGUE.cz",
    "timestamp": "2025-09-25T14:00:37Z",
    "window": {
      "start": "2025-09-24T23:45:16Z",
      "end": "2025-09-25T14:00:37Z"
    },
    "tags": {"site_type": "grid", "execunitfinished": true,...}
  },
  "metrics": {
    "gd.energy.consumption.total": 225.8672685,
    "gd.performance.load.average": 75.6103448275862,
    "gd.performance.cpu.time.normalized": 785476.013,
    "gd.performance.cpu.time.total": 48787...,
    "gd.energy.ency.pue": 1.5,
    "gd.environment.emissions.ci": 24.0,
    "gd.environment.emissions.cfp": 5.4208144444
  }
}
```

CNR-SQL

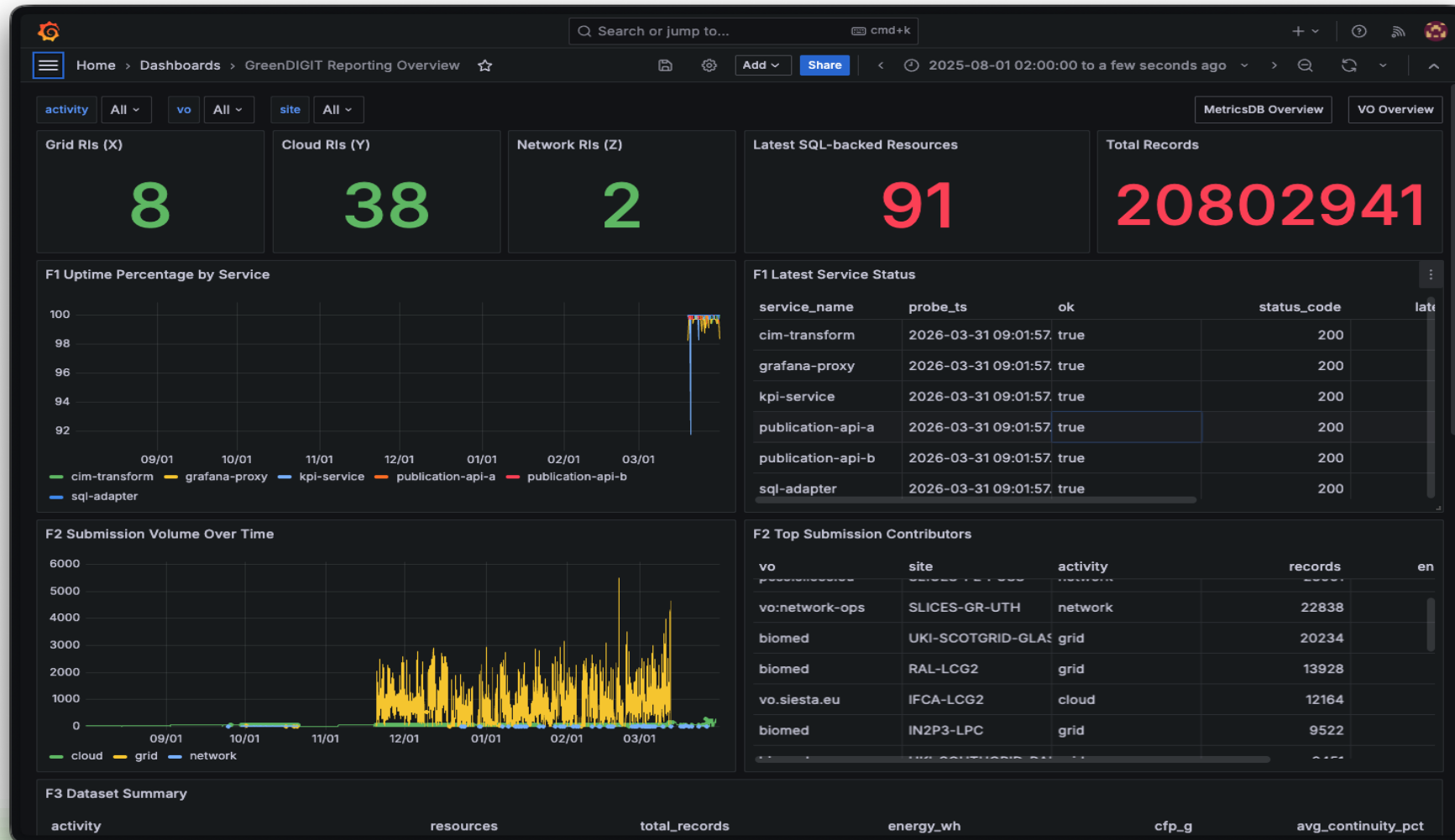
```
{
  "sites": { "site_type": "grid" },
  "fact_site_event": {
    "site": "EGI.PRAGUE.cz",
    "event_start_timestamp": "2025-09-24...",
    "event_end_timestamp": "2025-09-25...",
    "recorded_at": "2025-09-25T14:00:39Z",
    "pue": 1.5,
    "CI_g": 24.0, "CFP_g": 5.42...,
    "energy_wh": 225.8673, ...
  },
  "detail_grid": {
    "execunitid": "213217892",
    "wallclocktime_s": 51302,
    "normcputime_s": 785476,
    "totalcputime_s": 48787 ...
  },
}
```





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Dashboard overview



Acknowledgement:
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Reporting at a Glance

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All figures reflect data collected since EIMPS entered production, up to 31 March 2026

10

**Research
Infrastructures**

actively reporting

3

**GreenDIGIT
Consortium**

EGI · SLICES · SoBigData

7

**ESFRI Roadmap
External**

independently reporting

8.2M+

**EUR Records
Collected**

across all RIs

9 Countries
across Europe

3 Types
HTC · Cloud · Network

Oct 2025
first metrics reported



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Demo

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GreenDIGIT WP6 CIM API

Login to generate token

Email

Password



Get Token

Login to Dashboard

The token is only valid for 1 day. You must regenerate in order to access.

If you have problems logging in, please contact:
goncalo.ferreira@student.uva.nl

This work is funded from the European Union's Horizon Europe research and innovation programme through the [GreenDIGIT project](#), under the grant agreement No. 101131207.





Search or jump to... cmd+k

Home > Dashboards > GreenDIGIT I... Share

2025-08-01 02:00:00 to a few seconds ago

activity All vo All site All MetricsDB Overview VO Overview

Impact Trend: Energy (Wh)

Impact Trend: Carbon Footprint (gCO2e)

Aggregation by VO (Energy Wh)

Aggregation by Site Type (Carbon gCO2e)

Top Contributors: Sites by Energy

Impact Summary Table

vo	site	site_type	records	energy_wh	cfp_g
enmr.eu	NIKHEF-ELPROD	grid	2107474	2190539	1236511
enmr.eu	SARA_MATRIZ	grid	2715954	2190154	929147



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EIMPS

- The EIMPS will be open for access to European RIs (especially ESFRI roadmap RIs)
- If you are interested in integrating your RI/using EIMPS, connect with us
- Currently, this federated metric system is being catered to different purposes, including schedulers, resource allocation algorithms, brokering systems, and other stakeholders involved



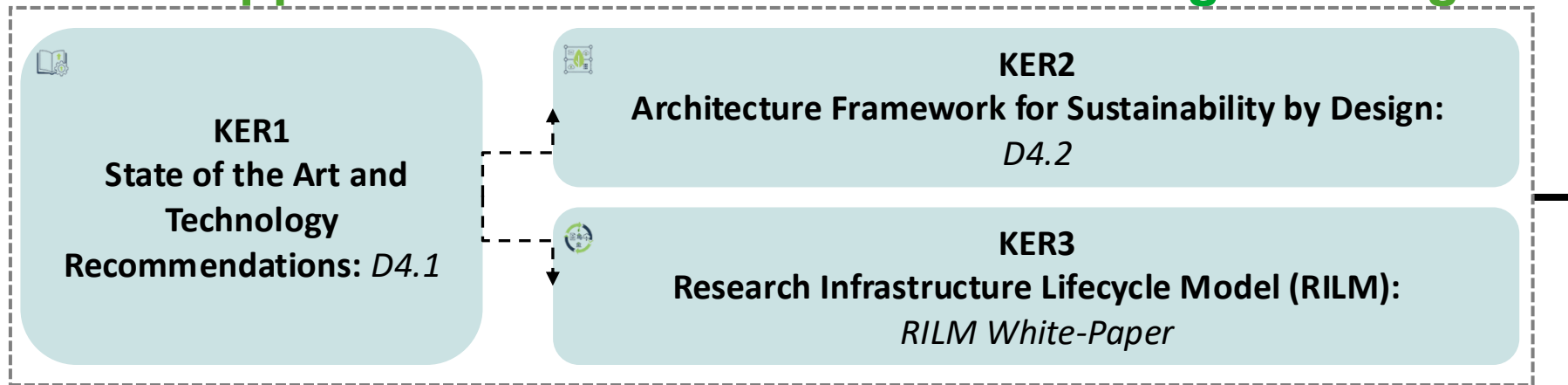
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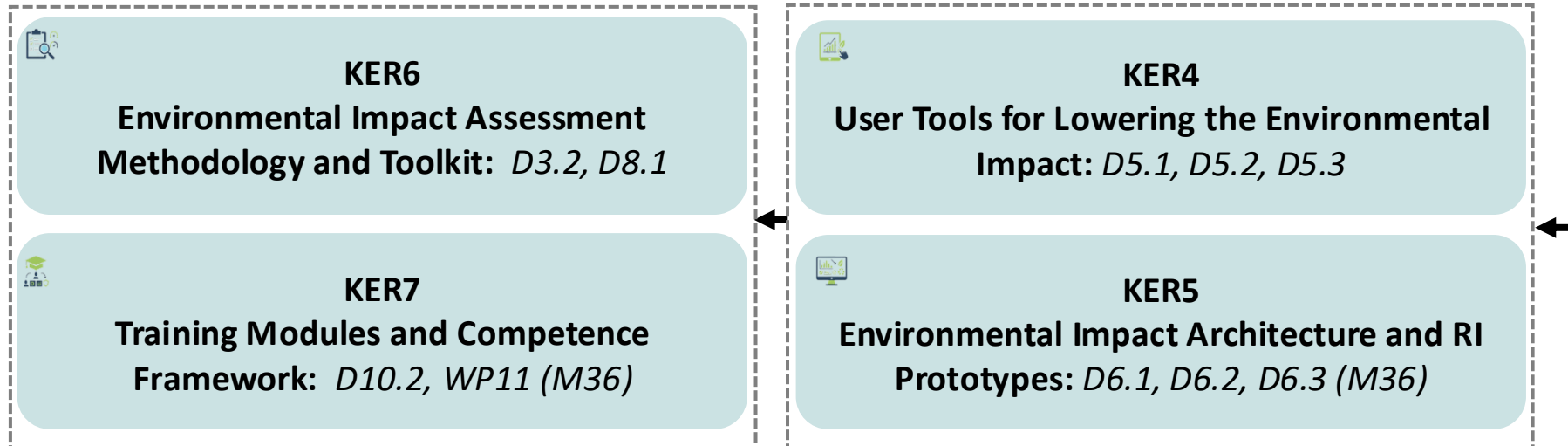
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Key Exploitable Results (KER)s

To be wrapped into a “Green Evolution Package ” to digital RIs



Foundations - “The What and How-to”



Evaluation & Dissemination - “Checking” and “Sharing” **Implementation & Tools - “The Doing”**



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Summary

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Important software tools:

- EcoJupyter: <https://github.com/g-uva/EcoJupyter>
- Wattnet: <https://wattnet.eu/>
- SAQ tool: <https://mc-a4.lab.uvalight.net/grissa/saq>
- GreenDIGIT CIM API: <https://greendigit-cim.sztaki.hu/gd-cim-api/v1/>
- GreenDIGIT KPI API: <https://greendigit-cim.sztaki.hu/gd-kpi-api/v1/docs>



About the Challenge

GreenDIGIT addresses the need to reduce the environmental impact of digital research infrastructures (RIs) through data-driven approaches for monitoring, analysing, and improving sustainability performance. As digital infrastructures account for a growing share of global greenhouse gas emissions, the project takes an infrastructure-level view that covers energy consumption, carbon footprint, and other sustainability-relevant dimensions across RI operations.

Within this context, the **Environmental Impact Metric Publication System (EIMPS)** serves as an enabling service for collecting and organising sustainability-related metrics from heterogeneous environments such as Grid, Cloud, and Network infrastructures.

This challenge focuses on **predictive modelling** over operational and sustainability-related time-series data, inviting participants to forecast near-future site-level workload and environmental impact signals - such as jobs, energy consumption, and carbon footprint - in a mature production-like infrastructure setting.

GreenDIGIT Hackathon: ECML-PKDD and SLICES summer school



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GreenDIGIT Partners: European ESFRI Digital Research Infrastructure

UvA (NL) - Coordinator

EGI
infrastructure
EGI Foundation
(NL)

CESNET (CZ)
CNRS (FR)
CSIC (ES)
SZTAKI (HU)

SLICES-RI
SU (FR)
UvA (NL)
TUM (DE)
UTH (GR)
PSNC (PL)
MI (CH)

SoBigData
CNIT (IT)
CNR (IT)
GSP (FR)

EBRAINS
EBRAINS
AISBL (BE)



slices RI



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