Moderating the Environmental Impact of Digital Infrastructures

Experiences and Plans from CESGA and the ENSURE Project

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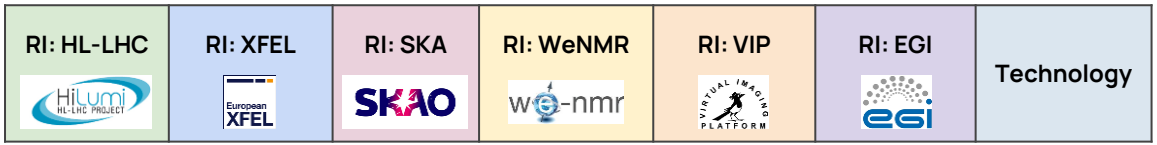
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Outline

- ENSURE project
  - Scope and technical approach
- Precursor project - GreenDIGIT
  - Management framework
  - Energy-aware workload distribution with DIRAC
- CESGA in ENSURE

ENSURE Project

- **EN**vironmentally **SU**stainable digital services and practices for **RE**search infrastructures
- HORIZON-INFRA-2025-01-TECH-01 Consortium
  - 20 partners, 36 months
    - 1 Sep 2026 - 31 Aug 2029
  - ESFRI Landmarks
    - **HL-LHC, European XFEL, SKA**
  - Life-Science communities
    - **WeNMR, VIP**
  - Pan-European digital infra provider
    - **EGI**
  - Research & Technology centres



ENSURE Project (2026-2029) - Objectives

Overarching objective

Develop and validate a comprehensive set of **tools, reference datasets, and technologies**, including a management and certification programme, that enables **Research Infrastructures** to measure, model, monitor and moderate the **environmental impact of their digital activities**.

Specific objectives

1 Establish an **environmental impact management framework with a certification programme** for digital activities of Research Infrastructures.

2 Provide an infrastructure for **gathering and visualising environmental metrics** for digital RI services and applications.

3 **Extend an application workload manager** with environmental impact-aware features, and use it to moderate the energy demand of digital RIs.

Technologies

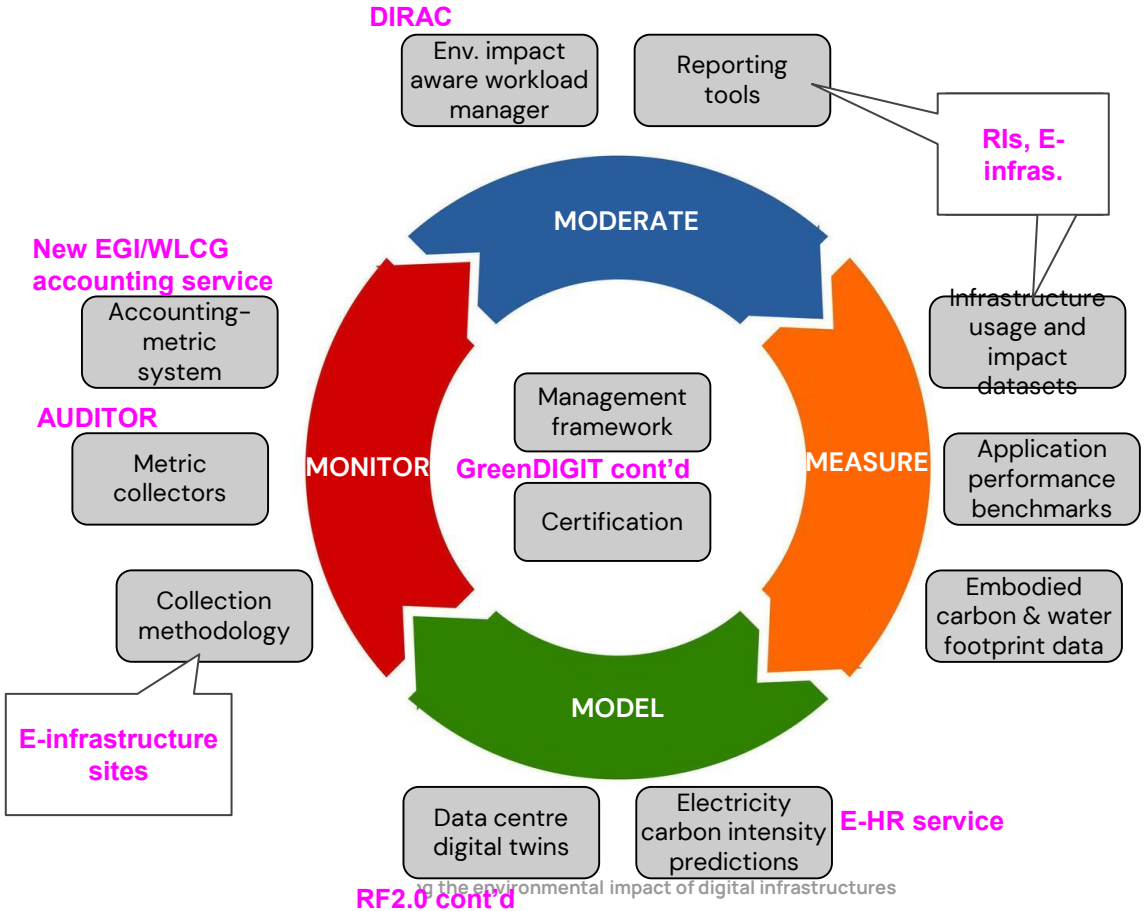
4 **Validate** the management-certification framework, the metrics infrastructure and the workload manager **across the largest digital RIs of the ESFRI community**.

Validation

5 Deliver a digital service environmental impact-lowering **programme for RIs**.

Uptake

The ENSURE 4M cycle



Validation, training and uptake programme

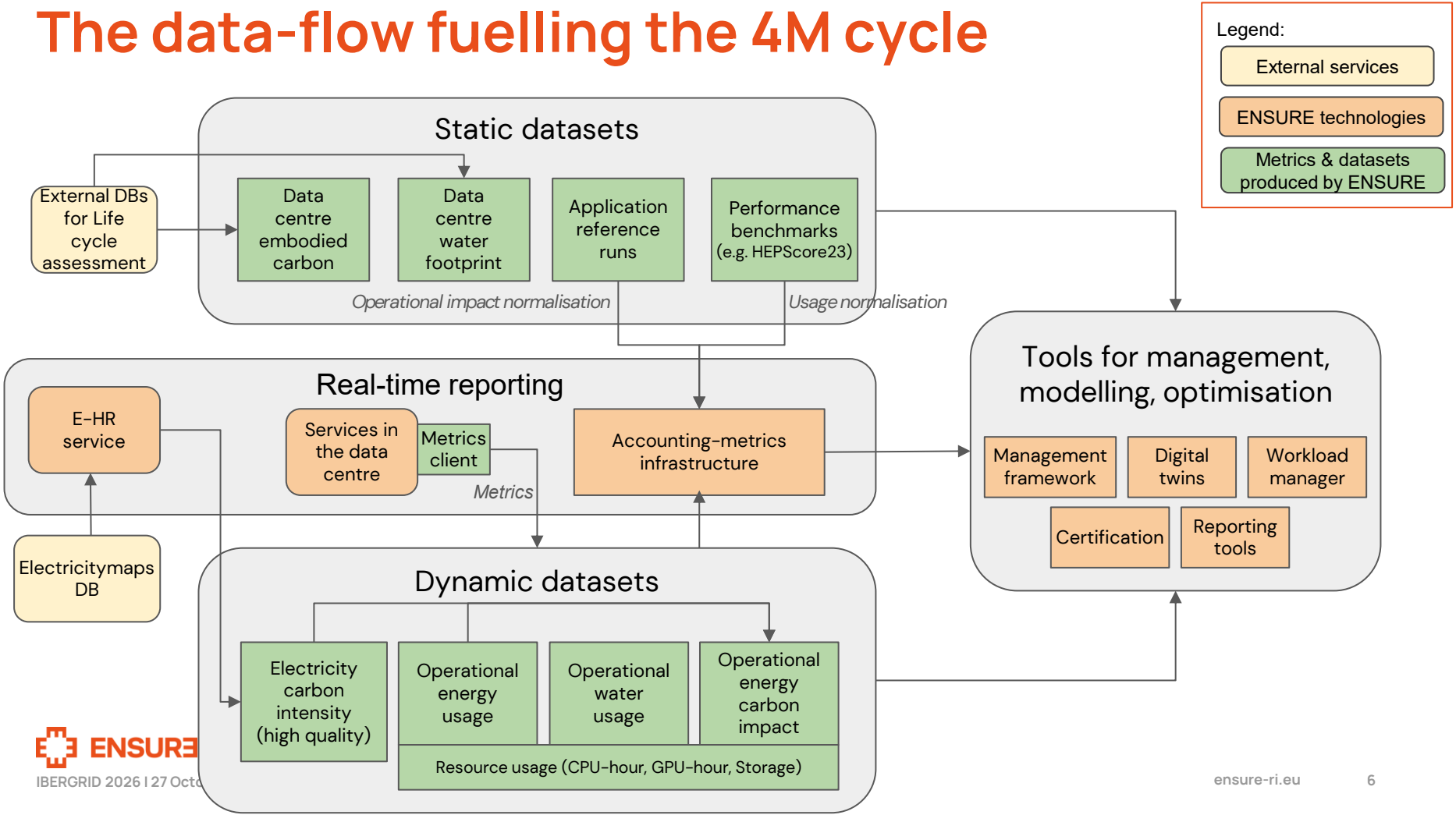
ENSURE RIs

HiLumi HL-LHC PROJECT · European XFEL · SKAO · we-nmr · VIRTUAL IMAGING PLATFORM · EGI

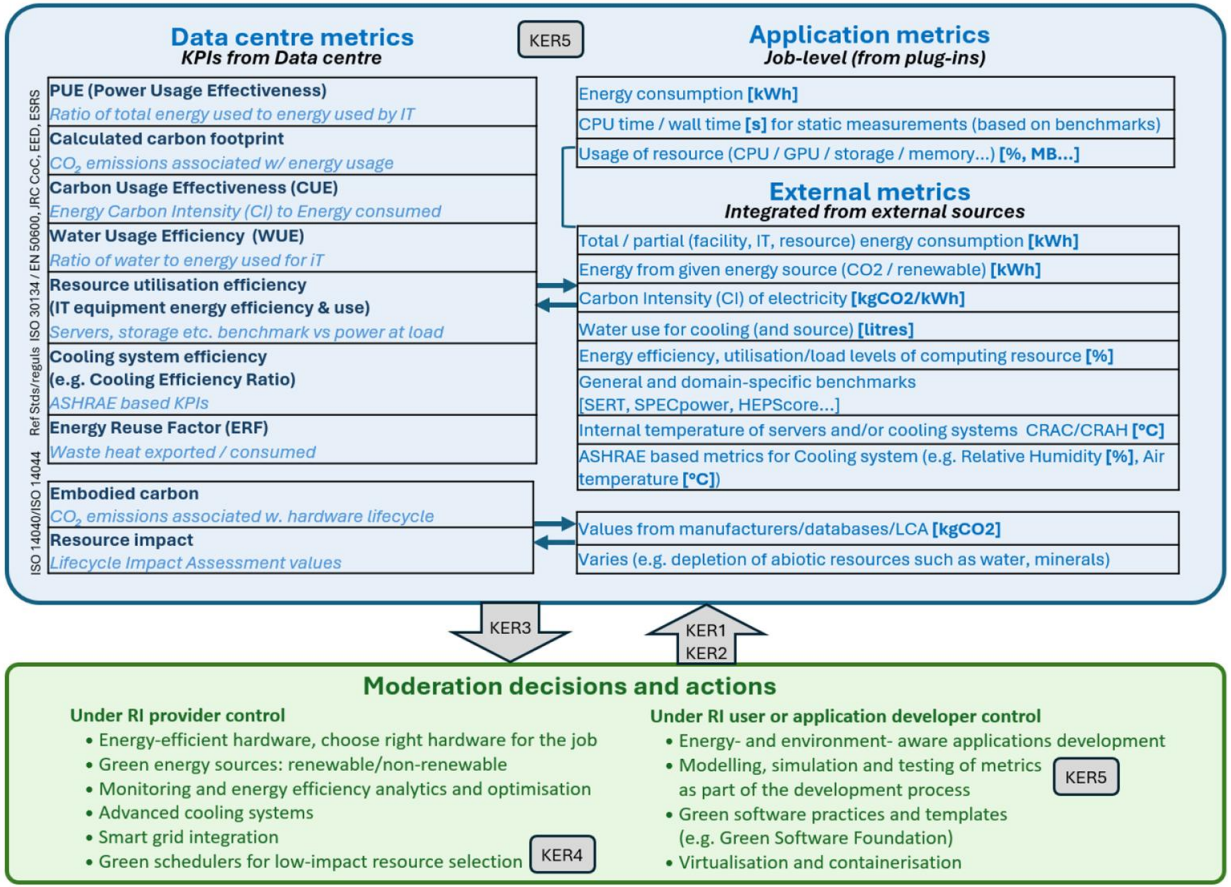
External RIs and communities

ESCAPE · panosc · EOSC · ENVRI community · EOSC-Life · ESFRI

The data-flow fuelling the 4M cycle



Metrics flowing in the 4M cycle



GreenDIGIT Project (2024-2027)

greendigit-project.eu

- Main outcomes from GreenDIGIT that ENSURE builds on
  - Management framework
  - Energy-aware workload distribution with DIRAC

GreenDIGIT Management Framework

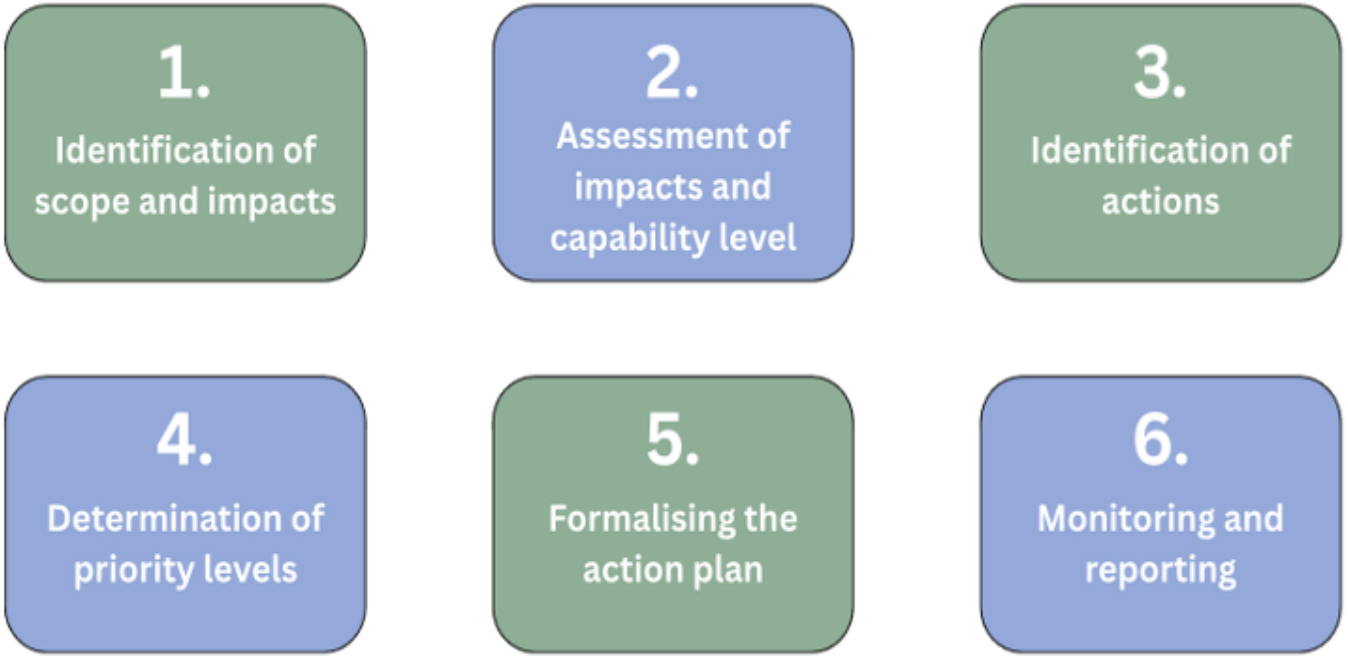
- **Environmental impact assessment framework** developed in GreenDIGIT to help RIs evaluate their current environmental sustainability & form an action plan for improvements. ***ISO 14040 (LCA), ITU-T L.L.1410***
- **Impact categories:** Climate Change (CO_2), Energy, Waste, Water.
- **Practical steps** to **A)** assess target & current capability levels, **B)** identify & prioritise actions, **C)** monitor impact.
- **Assessment parameters**: impact magnitude, likelihood, and effort required to support strategic planning.



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

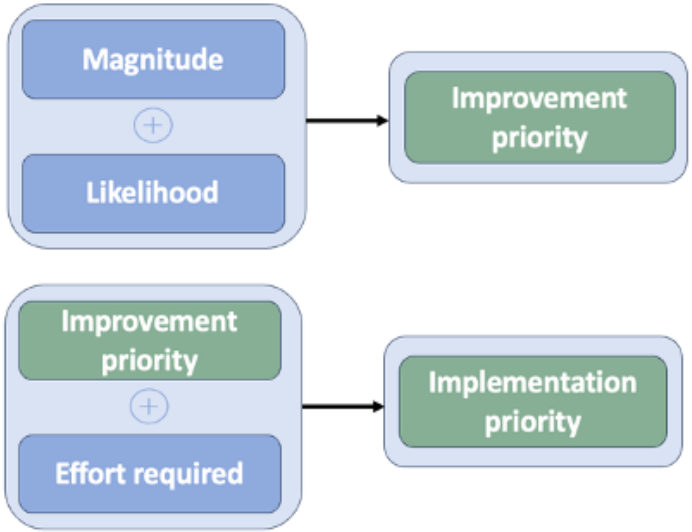
GreenDIGIT Management Framework

Based on 6-step methodology



GreenDIGIT Management Framework

Determination of priority levels



Improvement and implementation priority assessment parameters

Matrix for improvement priority level determination

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

Matrix for implementation priority level determination

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

Self-Assessment Questionnaire (SAQ)

- **SAQ** developed in GreenDIGIT by EGI
- **Web Tool (GRISSA)** developed in GreenDIGIT by UvA: https://mc-a4.lab.uvalight.net/grissa/saq

→ Developed as a joint service to implement methodology steps in practice

GreenDIGIT D8.1 Self-Assessment Questionnaire: https://zenodo.org/records/17210726

GreenDIGIT Management Framework

Certification Baseline

- GRISSA is the current web tool that makes the framework usable and testable

7 Themes	32 Scope Items	33 Questions	1–3 Target Levels

- The tool translates the baseline into a repeatable assessment process

Scope & Goals → Questionnaire → Results (scoring, status, feedback) → Action Plan → Review / Improvement

- Certification maturity model levels

Level 1	**Established**	Basic policies, responsibilities, and baseline monitoring exist.
Level 2	**Managed**	Practices are implemented, measured, reviewed, and improved.
Level 3	**Optimised**	Lifecycle sustainability embedded in decisions and supported by evidence.

Energy-aware workload distribution with DIRAC

How to Moderate: DIRAC → GreenDIRAC

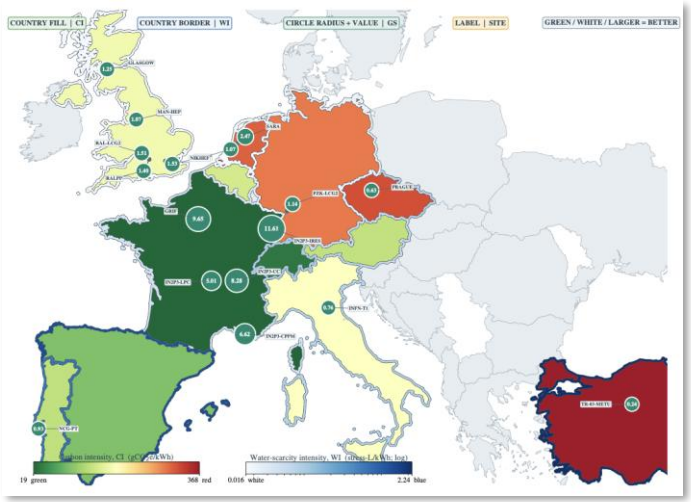
Moderate turns insight into action: steering where and when workloads run to cut environmental impact.

- A continuous loop: closes the 4M cycle using real-time results from Measure, Model and Monitor.

Example: DIRAC → GreenDIRAC

- DIRAC: the interware behind LHCb, Belle II, JUNO, CTAO and several grid infrastructures (EGI, GridPP). Its pilot-job architecture reserves compute resources against job requirements and site properties.
- GreenDIRAC (built in GreenDIGIT, to be extended by ENSURE) adds environmental impact as a scheduling criterion - ranking sites by Carbon intensity and PUE, reporting CO2/energy per payload.

Ranking and selecting resources



- **DIRAC WMS** based on the **pilot job** architecture
  - Allows flexible computing resource reservation taking into account user job requirements and resource properties and capabilities

- GreenDIRAC extension
  - Prioritizing sites for the pilot placing
  - Monitoring the job execution environments and parameters
    - Evaluating and reporting consumed **energy** and produced **CO2** for each payload

- Site characterization using
  - ***wattnet.eu*** service data for CI, WI, etc
  - Site PUE and hardware parameters

$$\text{GreenScore} = \frac{\text{CEE}}{\text{CI} \times \text{PUE}}$$

where CEE is Compute Energy Efficiency

CESGA in ENSURE
Efficiency measured and managed since 2011

Average PUE

1.71 → **1.49**

2011 2021

Overhead energy per unit of IT energy cut from 0.71 to 0.49 (about 30% less), mainly through cooling optimised for a facility load above 300 kW

ISO 50001 certified

Energy management system and a dedicated energy-efficiency policy

Continuous PUE monitoring

Facility energy tracked over time, not estimated once

Accounting heritage

CESGA operated the EGI Accounting Portal for many years: hands-on experience with usage accounting at European scale

A new data centre designed for sustainability

Under construction to host FinisTerrae-IV, with energy efficiency and sustainability as core design requirements, not retrofits



New facility

Power, cooling, fire protection and security designed together for efficiency



FinisTerrae-IV

Next flagship supercomputer, about 20 PFLOPS peak (estimated), replacing FinisTerrae-III



Long-term storage

Planned ~100 PB tape and ~25 PB disk/flash for archive and backup

CESGA's contributions to ENSURE

Research and technology data-centre partner in the data-centre and metrics work packages

Impact management framework

Help develop and refine the Environmental Impact Management Framework

Life-cycle data

Integrate life-cycle assessment (LCA) datasets

Digital-twin hosting

Provide computing to host data-centre digital twins for external RIs

Energy and water vs workload

As a water-cooled site, validate methods with STFC and TÜBİTAK

Accounting metrics

Deploy the AUDITOR client to feed real operational data into ENSURE accounting

Operational experience

Share lessons from 15 years of efficiency management

A real production site to validate ENSURE tools

Validation environment

FinisTerrae-III

Now: current production system

FinisTerrae-IV

In the new data centre, once operational

Two generations of system for testing ENSURE tools in production



Science use case: ANERIS

CESGA supports the ANERIS marine-science community, giving ENSURE a real scientific workload to test sustainability tools at scale

ENSURE

Thank You For Your Time! Questions?

ensure-ri.eu

/company/ensure-eu-project

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