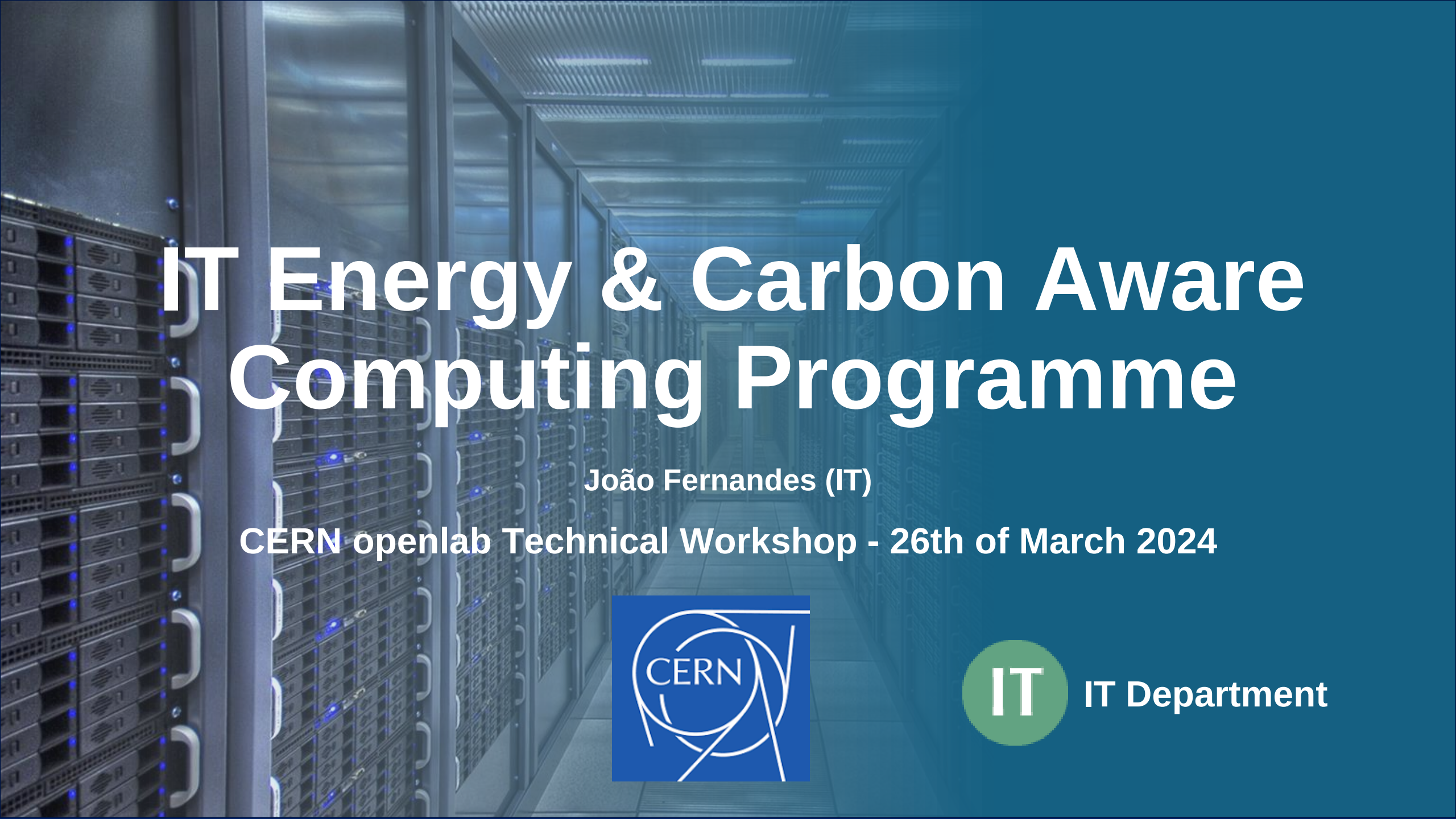

CERN



IT Energy & Carbon Aware Computing Programme

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CERN openlab Technical Workshop - 26th of March 2024

IT Department

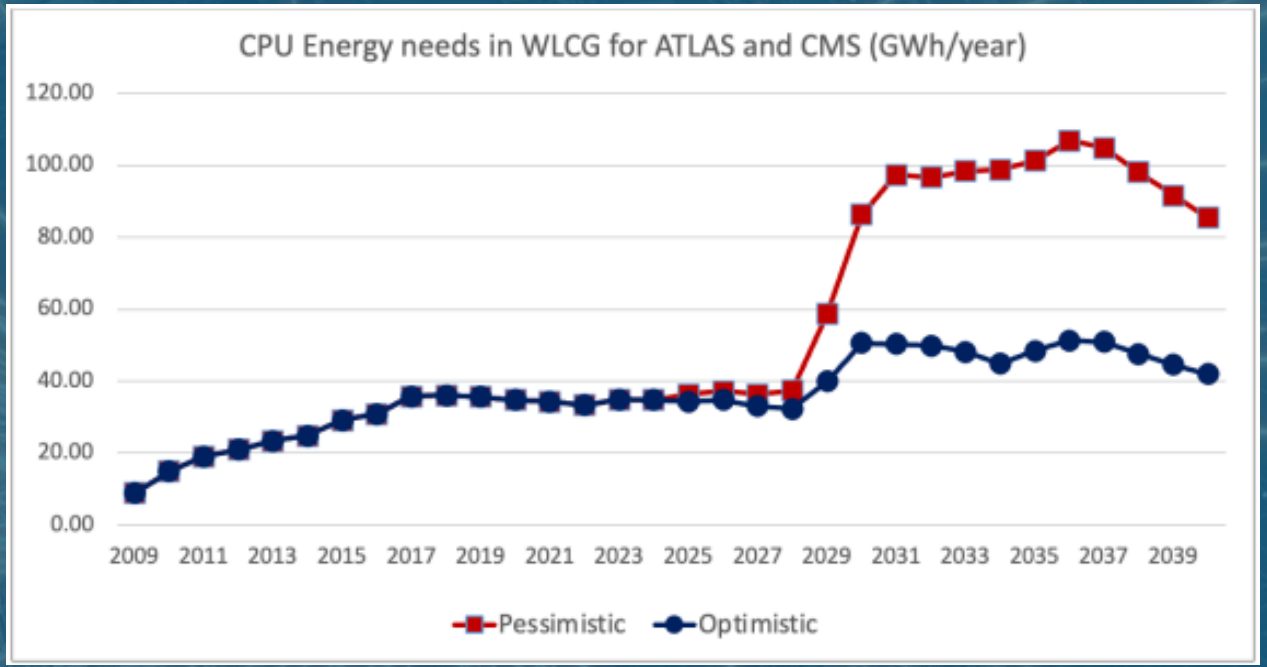
Outline

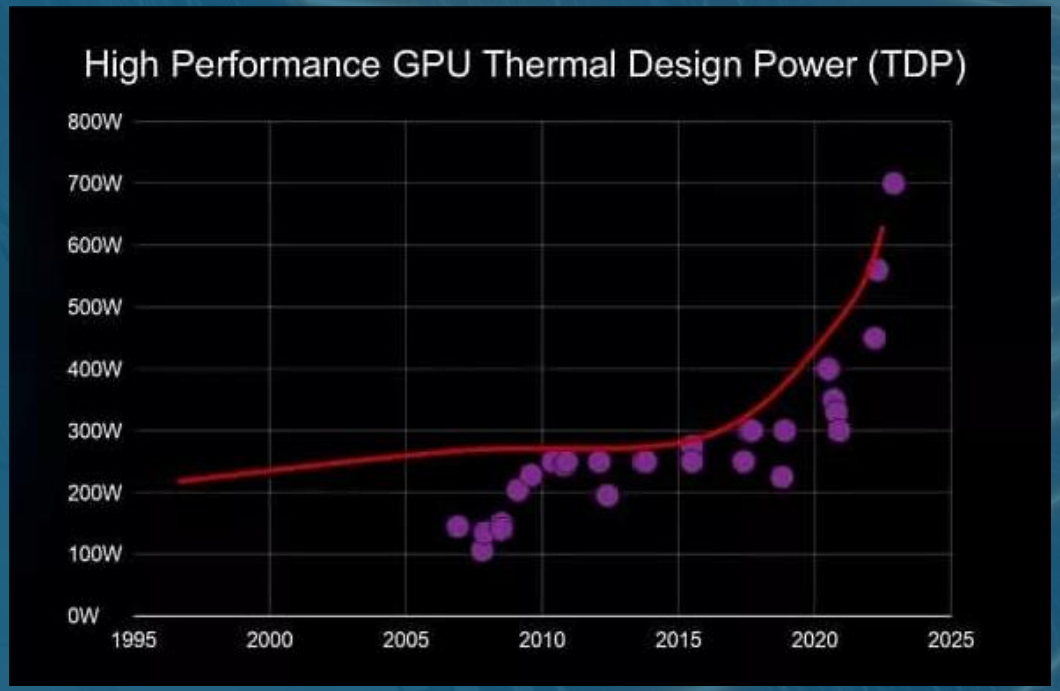
- The HL-LHC and the global challenge
- The Opportunity
- Strategy & Roadmap
- Expected Impacts

The HL-LHC Energy Footprint

HEP in the Run4 scenario of the High Luminosity LHC
- Luminosity increased by a factor of 10
- More complex events and more collisions

Consequence: **Exascale (Computing, Data) challenge**





Resource intensive technology such as **Machine Learning** increasingly consolidated in HEP workflows

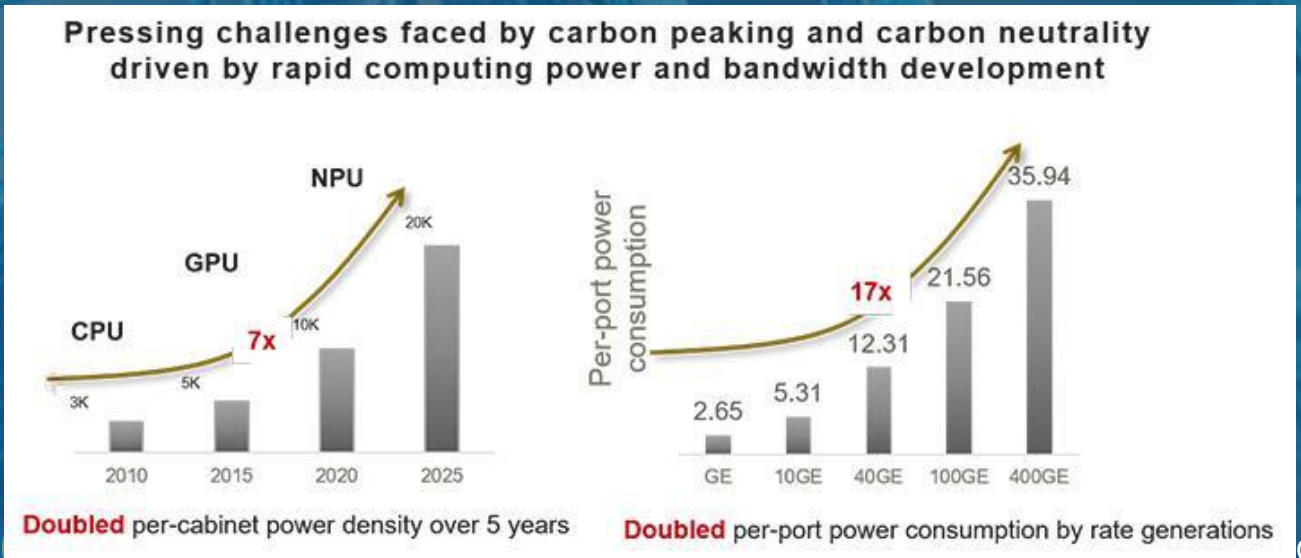
ATLAS and CMS: **30-50%** of their algorithms to use GPU or similar acceleration-based architectures **before 2030**

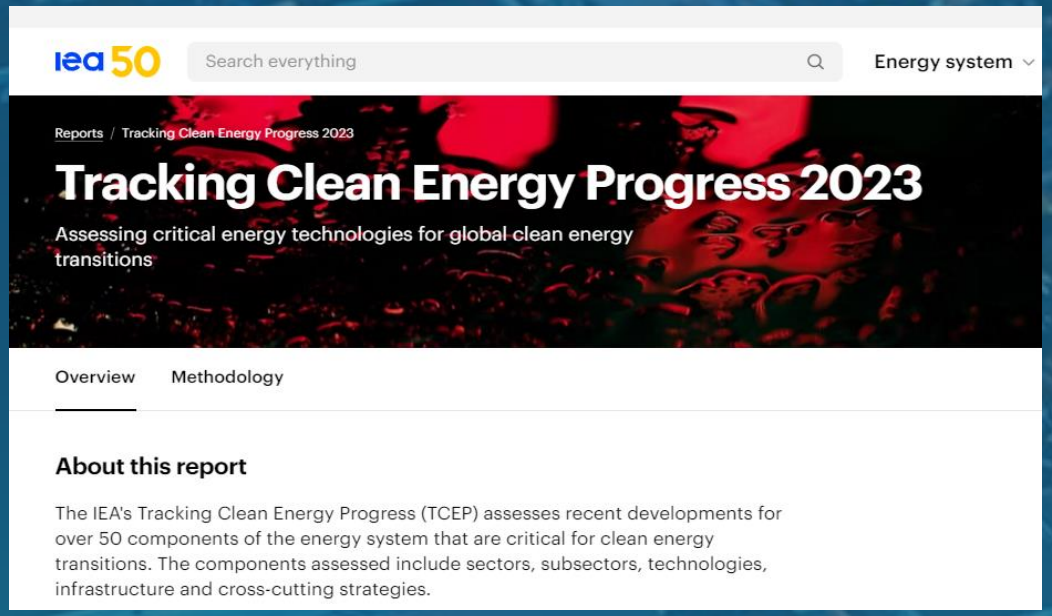
The Global Challenge

IEA "Tracking Clean Energy Progress 2023" report: "*rapid improvements in **energy efficiency** have helped limit energy demand growth [...]. However, to get on track with the Net Zero Scenario, emissions must **drop by half by 2030**.*"

The price to pay for increasing computing performance? Money but also... **increasing Energy consumption and Carbon emissions**

The comfortable belief "*increase of performance is carbon-neutral*" progressively **disrupted.**





Gartner predictions:
Sustainable computing is one of the top 3 global trends in computing technology;

"*By 2028, more than 70% of enterprises will alter their data center strategy due to their limited energy supply, up from less than 5% in 2023*"

The Opportunity

Innovative technology is paradoxical…computing is increasingly resource hungry; at the same time, **progressively identified as key to help reduce emissions.**

CERN Data Centres increasingly carbon-neutral with improved design, heat recuperation, green procurement.
But **software must also be considered; e.g. detector simulation very resource intensive; must analyse efficiency of main workloads**
Storage: exabyte (10^{18} bytes) HL-LHC regime. HDD vs SDD: must tackle **Scope 3 (embodied CO2)**

Must approach the problem **across multiple domains**:
H/W, S/W, Workload deployment

Experience can be shared within the WLCG.
Energy efficiency of increasing importance to the approximately 40 countries where **WLCG sites are located**.
CERN has a societal responsibility.

IT Energy & Carbon Aware Computing Programme

Initial Lines of Action

Carbon aware HEP data processing: energy benchmarking of HEP simulation software applications (e.g. MadGraph and AdePT) as a model to expand to other HEP applications.

Sustainable AI: Assessment of the environmental impact of IT ML services to include energy-efficiency aspects by design (models training and reuse, communication patterns, data formats).

Promote sustainable computing and green software patterns in the existing educational programmes such as the CERN School of Computing.

Green Procurement: mainly on-premises but also gradually leveraging the public cloud, developing strategies for low carbon intensity deployments.

CERN Data Centres: further develop strategies to increase low carbon energy consumption and continuous improvement of infrastructure lifecycle

CERN Data Centers Energy

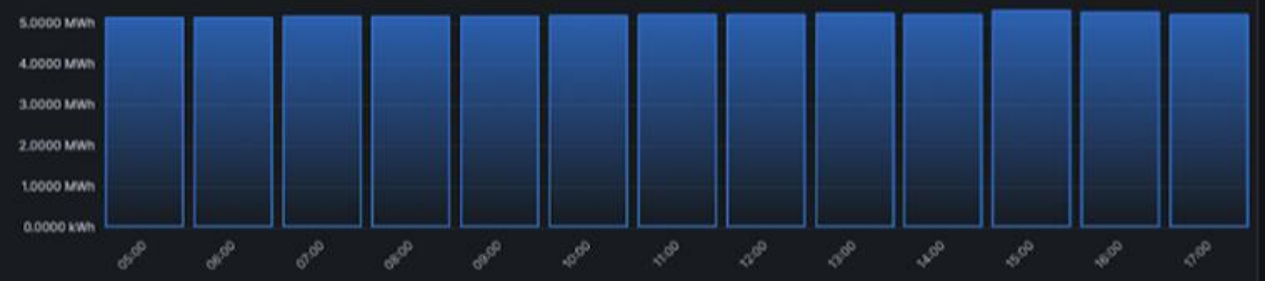
urly Energy

5.23 MWh

Hourly CO2

0.0710 t/h

ergy



Hourly CO2

CERN Data Centers Power

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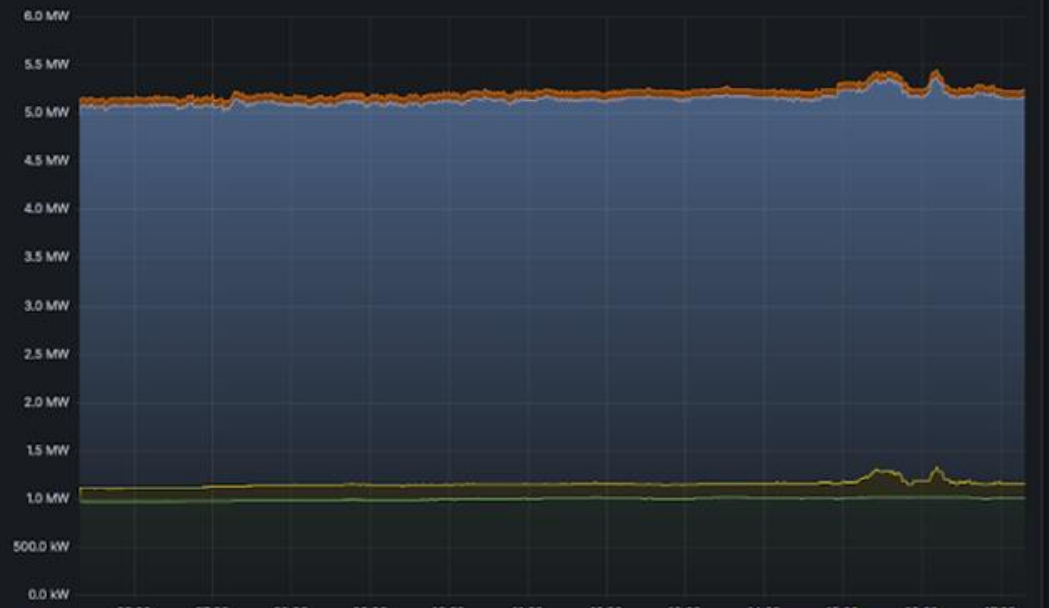

Name	Mean	Last *	Max	Min
6045	998.3 kW	1.0 MW	1.0 MW	984.0 kW
775	156.0 kW	150.5 kW	317.1 kW	0.0 kW
513	4.0 MW	4.0 MW	4.1 MW	3.9 MW
773	78.1 kW	77.9 kW	78.8 kW	77.8 kW

773
77.9 kW

6045
1.0 MW

775
150.9 kW

513
4.0 MW

Total
5.2 MW

Eco2Mix

Name	Mean	Last *	Max	Min
Nuclear	3.5 MW	3.9 MW	3.9 MW	0.0 kW
Hydro	621.2 kW	716.2 kW	786.6 kW	0.0 kW
Wind	718.1 kW	349.2 kW	854.7 kW	0.0 kW
Solar	167.2 kW	69.7 kW	344.6 kW	0.0 kW
Fossil	187.1 kW	181.4 kW	201.5 kW	0.0 kW
Bio	0.0 kW	0.0 kW	0.0 kW	0.0 kW

Bio
0.00%

Fossil
3.46%

Hydro
13.66%

Nuclear
74.86%

Solar
1.33%

Wind
6.66%

Strategy and Roadmap

2023
Define energy baseline: assessment of the current IT installed capacity

2023
Baseline Assessment

Q4 2024
Identify areas of improvement within the **WLCG and Next Generation Trigger (NGT) project**
Membership of GSF Green Software Foundation

Q3 2024
Establish a strategy for an integrated **Energy & Carbon Aware IT Programme**

Q2 2025 - onwards
Implementation
Co-development with CERN Member States (academia and industry); **Prototype innovative ML services** capable of carbon aware deployment and scheduling

Q1 2025
Energy profiling of HEP and ML workloads
Explore additional funding opportunities
Multiple year **Roadmap with impact metrics for IT services**

Expected Impact

- Establish an **integrated IT strategy** to reduce carbon footprint, potentially leading to gradual **cost savings** of the overall IT technical delivery
- **Increase the capabilities** of IT in offering responsible services including **sustainable AI**; Make long-term contributions by establishing a set of best practices for the HEP AI community.
- Gradually introduce a carbon-aware computing architecture for IT service delivery, favoring an energy-effective model, including **green software** development.
- **Promote a set of guidelines** for the LHC community on optimizing HEP software and workflows in terms of energy consumption.
- **Engage with the community, exchange lessons and establish** a carbon-awareness **critical mass**, amplifying the impact of the Organization's contribution to the societal progress as an **international partner for sustainable technology.**

Thank You!

Questions?