



IT Energy & Carbon Aware Computing Programme

João Fernandes (IT)

Visita CERN: AGRAPS FEUPLink – 25 de Maio 2024



IT Department

Outline

-  Background
-  The HL-LHC & Global Challenge
-  Strategy & Roadmap
-  Oportunidades para Portugal

La science au service de la paix

Le CERN a été fondé en 1954 avec 12 États membres européens



23 États membres

Allemagne, Autriche, Belgique, Bulgarie, Danemark, Espagne, Finlande, France, Grèce, Hongrie, Israël, Italie, Norvège, Pays-Bas, Pologne, **Portugal**, République tchèque, Roumanie, Royaume-Uni, Serbie, Slovaquie, Suède et Suisse.

3 États membres associés en phase préalable à l'adhésion

Chypre, Estonie, Slovaquie

7 États membres associés

Croatie, Inde, Lettonie, Lituanie, Pakistan, Türkiye, Ukraine

6 Observateurs

États-Unis, Japon, Russie (statut suspendu), Union européenne, JINR (statut suspendu), UNESCO

Le budget annuel du CERN s'élève à 1 200 MCHF

Au 31 décembre 2022

Employés :
2 658 titulaires, **900** boursiers

Associés :
11 860 utilisateurs, **1 516** autres

Plus de 50 accords de coopération avec des États et territoires non-membres

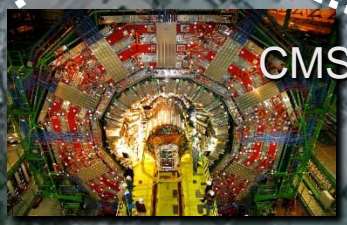
Afrique du Sud, Albanie, Algérie, Arabie Saoudite, Argentine, Arménie, Australie, Azerbaïdjan, Bangladesh, Bélarus, Bolivie, Bosnie-Herzégovine, Brésil, Canada, Chili, Colombie, Costa Rica, Égypte, Émirats Arabes Unis, Équateur, Géorgie, Honduras, Iran, Islande, Jordanie, Kazakhstan, Liban, Macédoine du Nord, Malte, Maroc, Mexique, Mongolie, Monténégro, Népal, Nouvelle Zélande, Palestine, Paraguay, Pérou, Philippines, Qatar, République de Corée, République populaire de Chine, Sri-Lanka, Thaïlande, Tunisie, Vietnam.

LHC @CERN



CERN

CMS



CMS

1 PB/sec
> 2000 disks/sec

ALICE



ALICE



ATLAS

ATLAS

LHCb



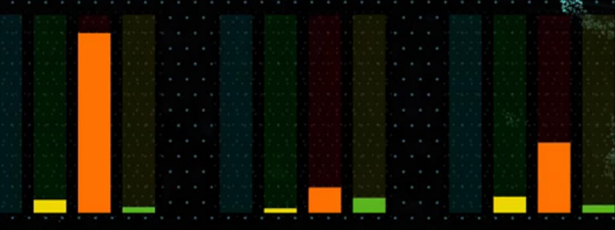
LHCb

LAST DATA UPDATE

9.7 MB Downloaded Wednesday, 11 September 2019 14:05:12
Last transfer was on : Monday, 29 July 2019 08:00:00

LOADING
100 %

VOLUME TRANSFERS VOLUME FILES VOLUME DATA



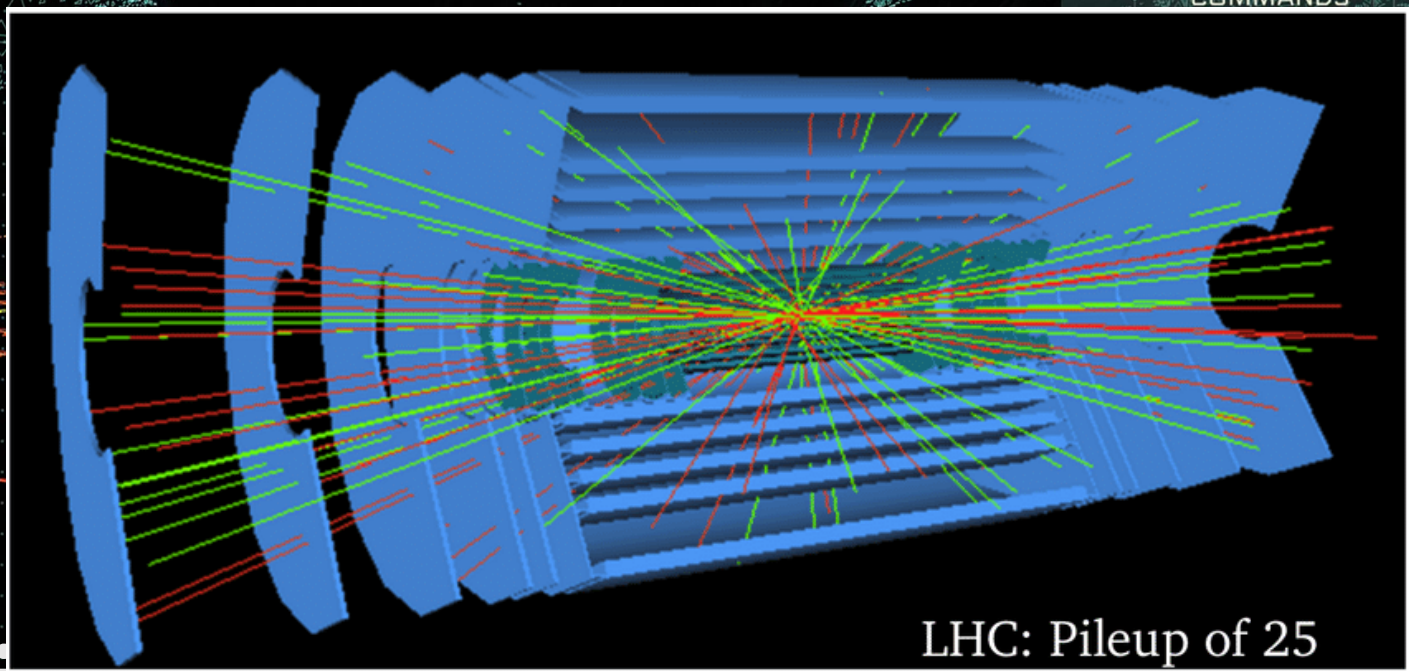
DATA TRANSFER CONSOLE

405847605 From UFlorida-HPC To UMissHEP Monday, 29 July 2019 04:04:50
0 From UCSOT2 To INFN-T1 Monday, 29 July 2019 04:05:40
0 From Vanderbilt To Nebraska Monday, 29 July 2019 04:06:08
165672773 From IN2P3-CC To INFN-BARI Monday, 29 July 2019 04:07:31
4938009 From FLHIP_T2 To CERN-PRDD Monday, 29 July 2019 04:08:20
76581123.5 From INFN-T1 To GLOW Monday, 29 July 2019 04:08:36
132252923.125 From INDIACMS-T1FR To pic Monday, 29 July 2019 04:08:43
1827625179.6667 From CERN-PRDD To KR-KNU-T3 Monday, 29 July 2019 04:09:29
1874048 From MIT_CMS To FLHIP_T2 Monday, 29 July 2019 04:09:54
502081950 From INFN-T1 To CIT_CMS_T2 Monday, 29 July 2019 04:10:11
264120 From CERN-PRDD To SWF Monday, 29 July 2019 04:11:04
0 From UNI-SOUTHGRID-BALRP To GLOW Monday, 29 July 2019 04:12:05
165839772 From INFN-T1 To JINR-T1 Monday, 29 July 2019 04:12:10
1276779676.33333 From CSCS-LCG2 To INFN-LNL-2 Monday, 29 July 2019 04:12:10
2905786389 From SPRACE To JINR-T1 Monday, 29 July 2019 04:12:20
0 From INFN-LNL-2 To CSCS-LCG2 Monday, 29 July 2019 04:12:25
22443295.895568 From IN2P3-CC To praguecg2 Monday, 29 July 2019 04:13:03
168198.208651667 From Uni-SOUTHGRID-IOX-HEP To CERN-PRDD Monday, 29 July 2019 04:13:11
0 From Belgri-ULC To CIT_CMS_T2 Monday, 29 July 2019 04:14:30
0 From Vanderbilt To UCSOT2 Monday, 29 July 2019 04:14:57
33666768.3792114 From RU-Protvino-IHER To CERN-PRDD Monday, 29 July 2019 04:15:10
169449714 From CSCS-LCG2 To RU-Protvino-IHER Monday, 29 July 2019 04:15:45

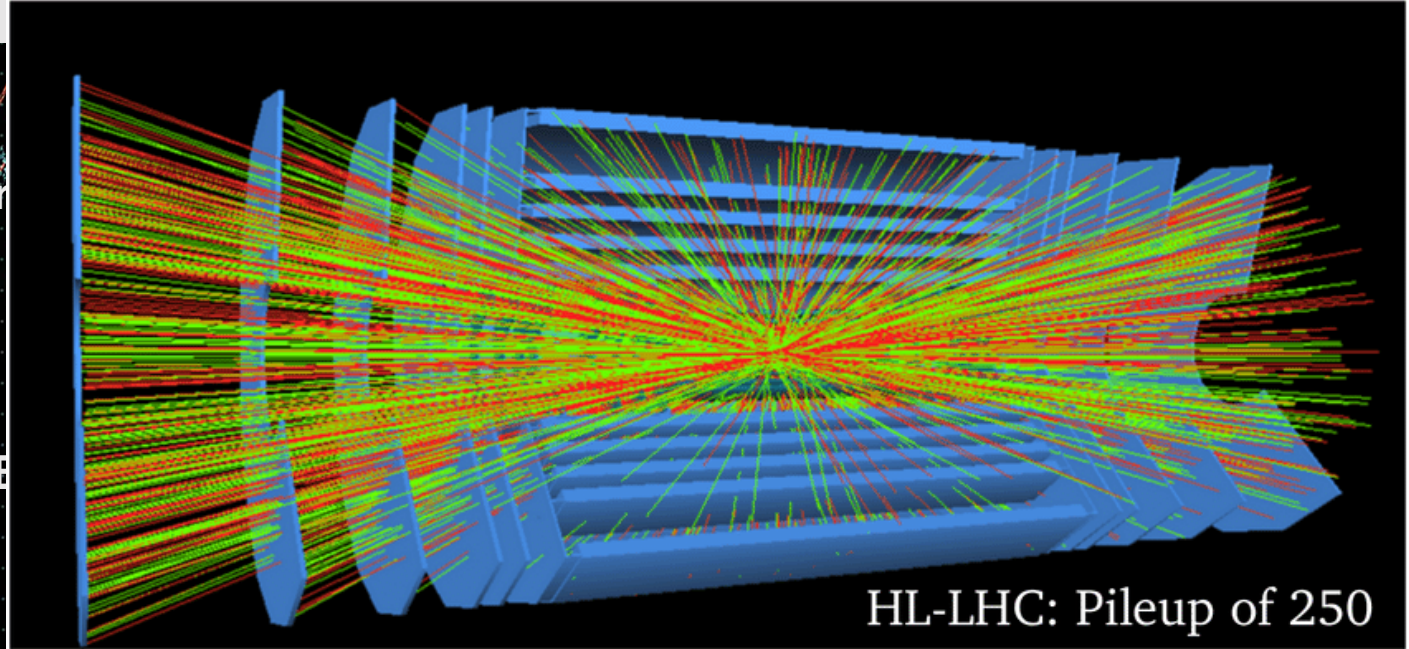
The World's Computing

About 1 million pr

>1000 Petabytes of CE



LHC: Pileup of 25



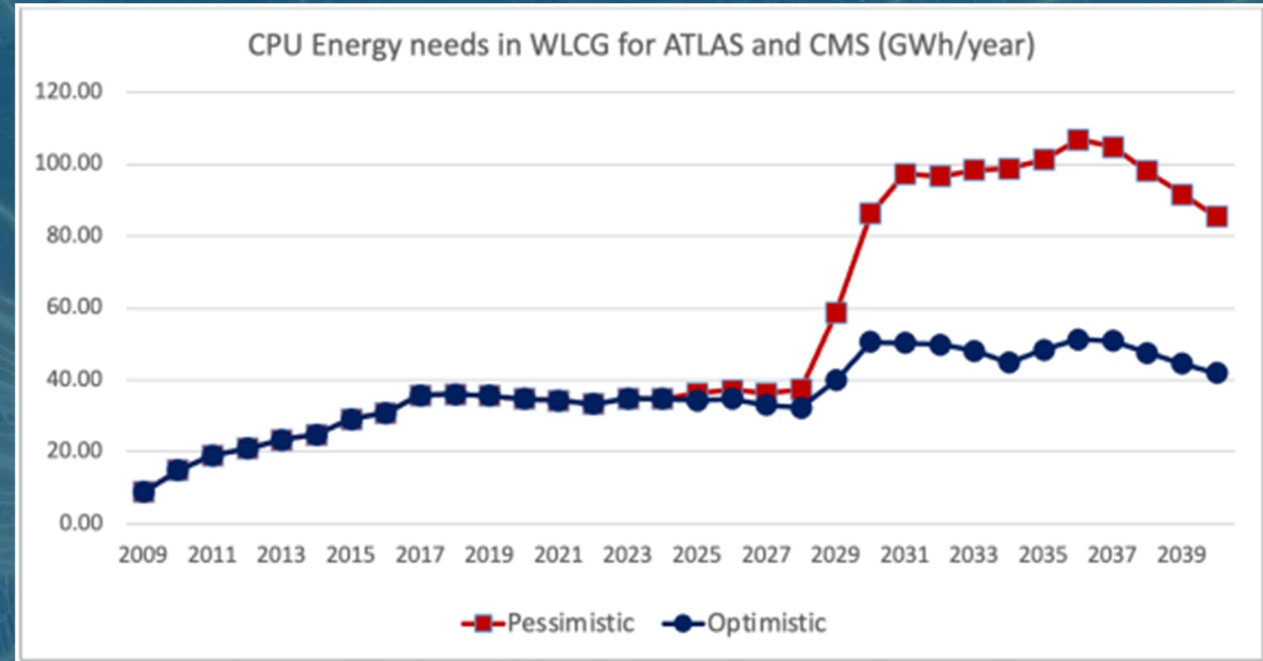
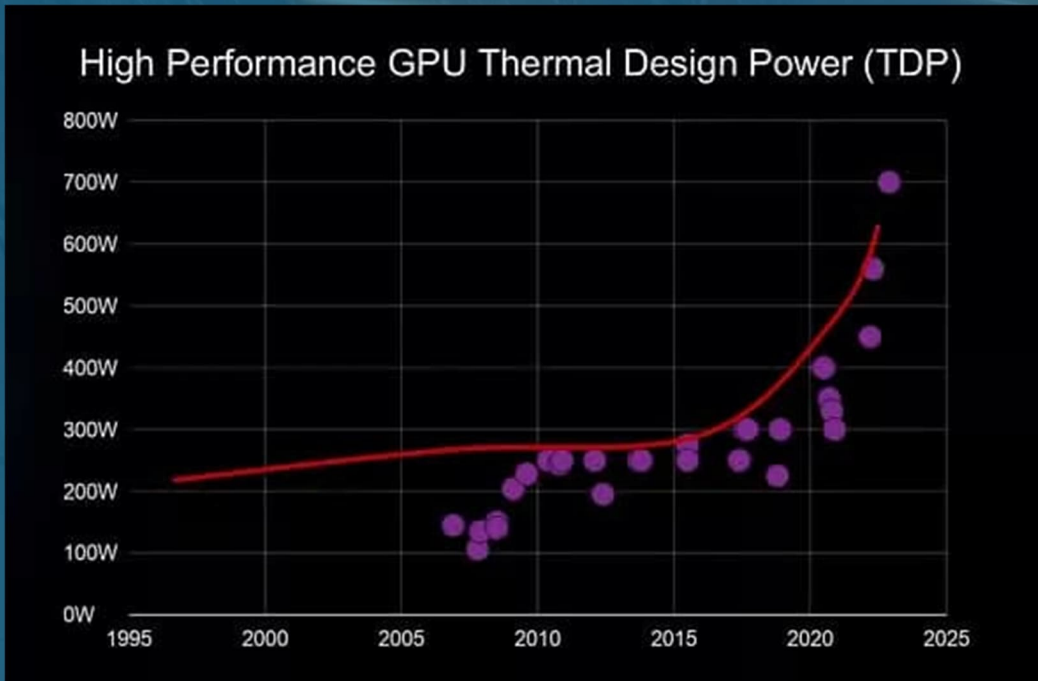
HL-LHC: Pileup of 250

The HL-LHC Energy Footprint

HEP in the Run4 scenario of the High Luminosity LHC

More complex events and more collisions

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



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

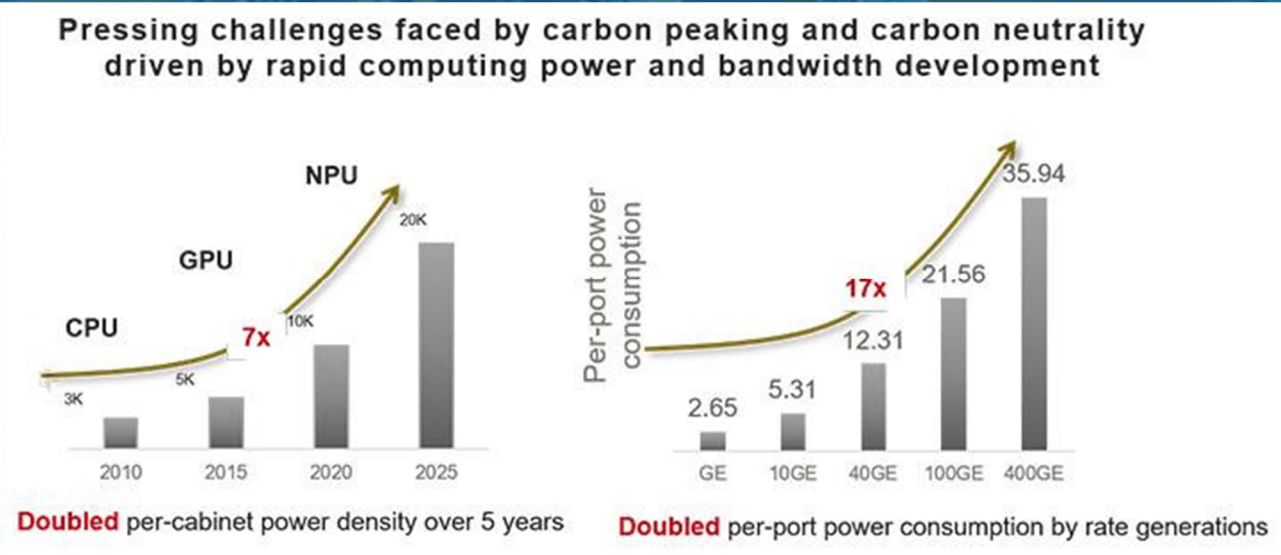
ATLAS and CMS: **30-50%** of their algorithms to use GPU or similar acceleration-based architectures **before 2030**

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 comfortable belief “increase of performance is carbon-neutral” progressively **disrupted.**

The screenshot shows the IEA 50 website interface. At the top, there is a search bar with the text 'Search everything' and a dropdown menu set to 'Energy system'. Below the navigation bar, the main heading reads 'Tracking Clean Energy Progress 2023' with a subtitle 'Assessing critical energy technologies for global clean energy transitions'. There are two tabs: 'Overview' (selected) and 'Methodology'. Under the 'Overview' tab, there is a section titled 'About this report' which states: 'The IEA's Tracking Clean Energy Progress (TCEP) assesses recent developments for over 50 components of the energy system that are critical for clean energy transitions. The components assessed include sectors, subsectors, technologies, infrastructure and cross-cutting strategies.'



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”

Only carbon? No, also water...

The Observer
Computing

AI's craving for data is matched only by a runaway thirst for water and energy

As Google and Microsoft prepared their Bard and Bing large language models, both had major spikes in water use - increases of 20% and 34%, respectively, in one year, according to the companies' environmental reports."

Google's data centers used 355 million gallons of The Dalles' water last year, 29% of the city's total water consumption.

Steam rises above the cooling towers in The Dalles data center in Oregon. These plumes of water vapor create a mist at dusk. Google photo

The Opportunity

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

Must approach the problem **across multiple domains:**

Facilities, H/W, S/W, Workload deployment

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)**

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.



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



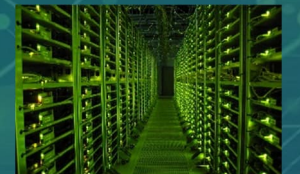
Promote **sustainable computing and green software** patterns in the existing educational programmes such as the CERN School of Computing.



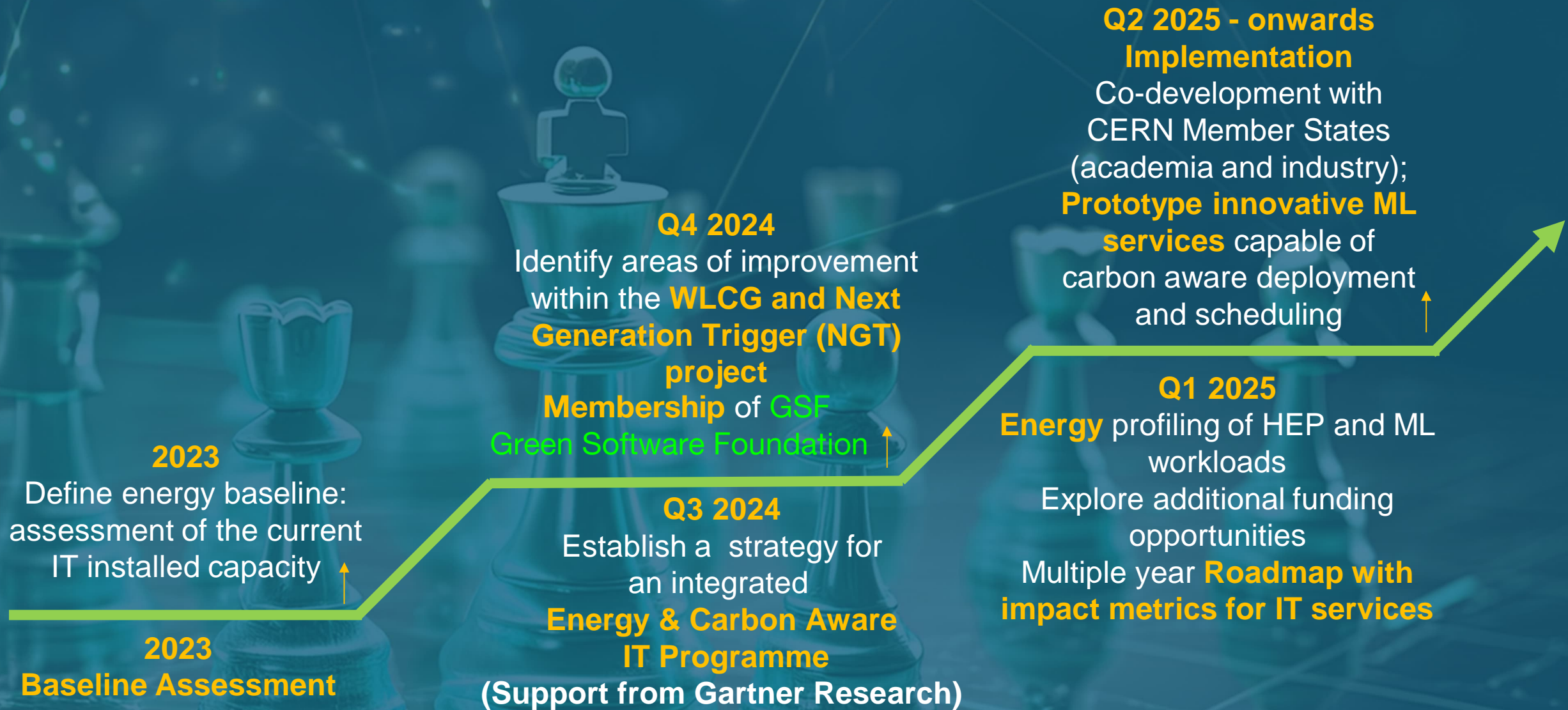
Green Procurement: mainly on-premises but also gradually leveraging the public cloud, developing strategies for **low carbon intensity deployments**.



CERN Data Centres: **increasingly carbon-neutral with improved design, heat recuperation, green procurement**. Further develop strategies to increase low carbon energy consumption and continuous improvement of infrastructure lifecycle



Strategy and Roadmap



Oportunidades para Portugal



Contactos iniciados através do ILO para explorar oportunidades

- Directamente com empresas portuguesas
- Através de estágios do AICEP



Possibilidades de colaboração CERN-IST ao abrigo do Framework Agreement atual

- O mesmo modelo poderá ser extendido a outras instituições em Portugal caso haja interesse

Obrigado!

Questions?

```
Project
├── blog
│   ├── next
│   ├── components
│   ├── context
│   ├── documentation
│   ├── graphql
│   ├── hooks
│   ├── lib
│   ├── node_modules library root
│   └── pages
│       ├── admin
│       ├── api
│       │   ├── _app.tsx
│       │   ├── _document.tsx
│       │   ├── about.tsx
│       │   └── index.tsx
│       ├── public
│       ├── tests
│       └── utils
│           ├── theme.ts
│           ├── babelrc
│           ├── env.example
│           ├── env.local
│           ├── eslintrc.js
│           ├── .gitignore
│           ├── next-env.d.ts
│           ├── package.json
│           ├── README.md
│           ├── tsconfig.json
│           └── yarn.lock
├── External Libraries
└── Scratches and Concepts
```

```
1 | import type { AppProps } from 'next/app'; 8.23 kB (gzip: 3.33 kB)
2 |
3 | import type { AppProps } from 'next/app'; 5.11 kB (gzip: 2.16 kB)
4 | import { ApolloProvider } from '@apollo/client'; 123.67 kB (gzip: 33.78 kB)
5 | import { ThemeProvider } from '@material-ui/core/styles'; 2.45 kB (gzip: 1.15 kB)
6 | import CssBaseline from '@material-ui/core/CssBaseline'; 61.61 kB (gzip: 20.02 kB)
7 | import { Container } from '@material-ui/core'; 63.32 kB (gzip: 20.38 kB)
8 | import { useApollo } from '../graphql/client';
9 |
10 | import { LightTheme, darkTheme } from '../utils/theme';
11 | import useLocalStorage from '../hooks/useLocalStorage';
12 |
13 | import NavBar from '../components/NavBar';
14 |
15 | export default function App({ Component, pageProps }: AppProps) {
16 |   const [currentTheme, setCurrentTheme] = useLocalStorage({ key: 'theme-value', initialValue: 'light' });
17 |   const apolloClient = useApollo(pageProps.initialApolloState);
18 |
19 |   useEffect(() => {
20 |     const jssStyles = document.querySelector(selectors: '#jss-server-side');
21 |     if (jssStyles) {
22 |       jssStyles.parentElement.removeChild(jssStyles);
23 |     }
24 |   }, []);
25 |
26 |   return (
27 |     <>
28 |     <Head>
29 |     <title>ECU-DEV</title>
30 |     <meta name="viewport" content="minimum-scale=1, initial-scale=1, width=device-width" />
31 |     </Head>
32 |     <Component {...pageProps} />
33 |     </>
34 |   );
35 | }
```