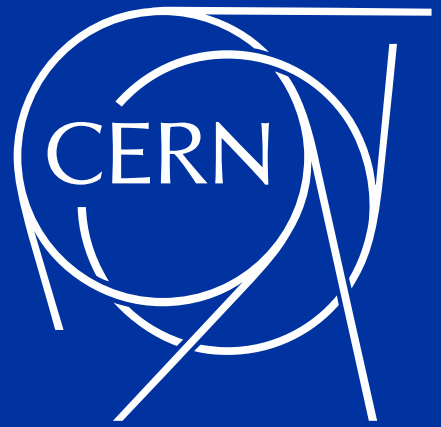


CERN’s strategy for an environmentally responsible research

Sonja Kleiner – On behalf of CERN

Annual Meeting of the Swiss Physical Society – September 2024 – ETH Zürich

About CERN

The largest particle physics laboratory in the world

Our goal is to understand the most fundamental particles and laws of the universe

Founded in 1954

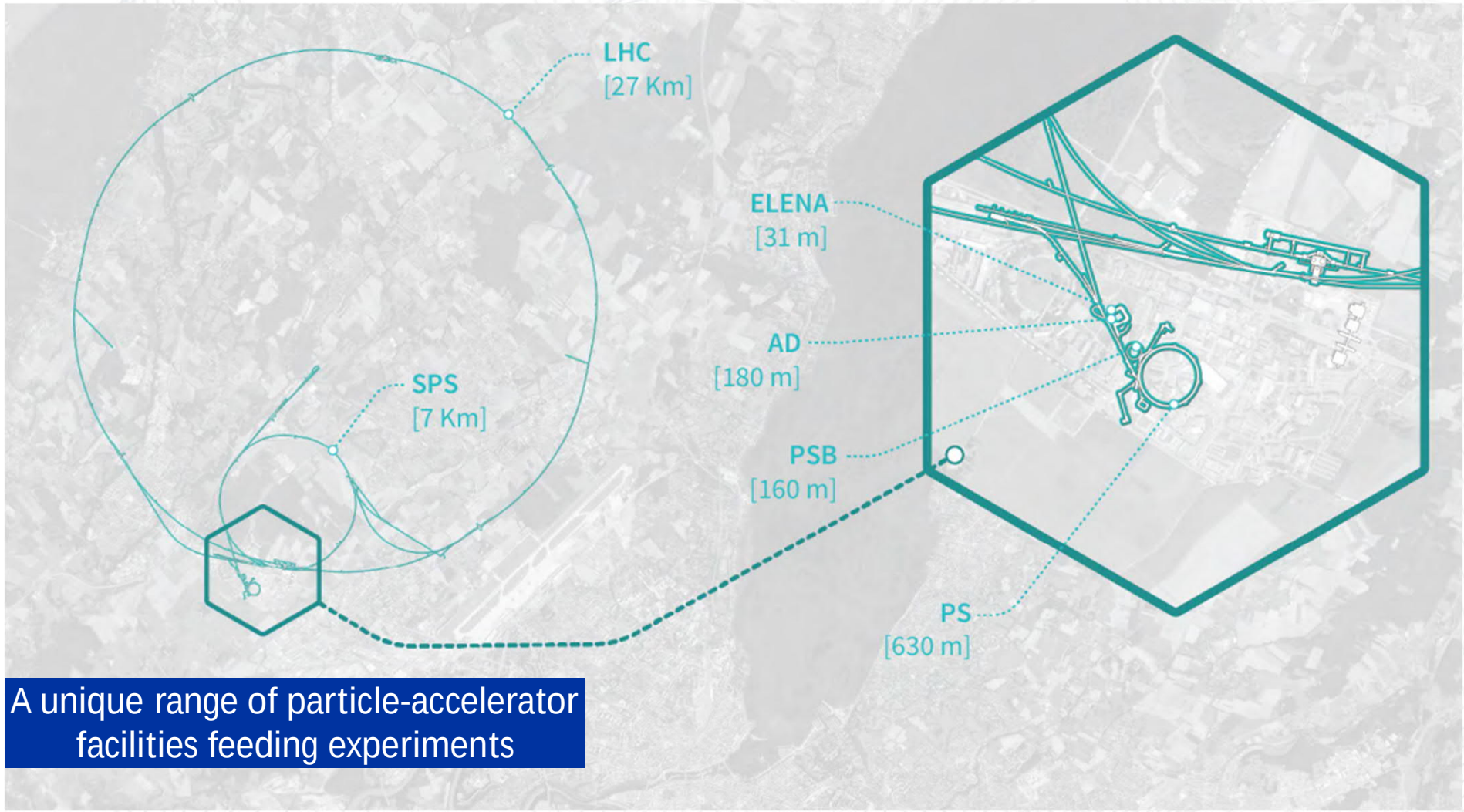
Run by 24 Member States

Employs about 3500 people

More than 12’000 Users

More than 250’000 visitors/y

About CERN



A unique range of particle-accelerator facilities feeding experiments

70 km of tunnels

80 underground caverns

1000 km of technical galleries & trenches

About 691 buildings

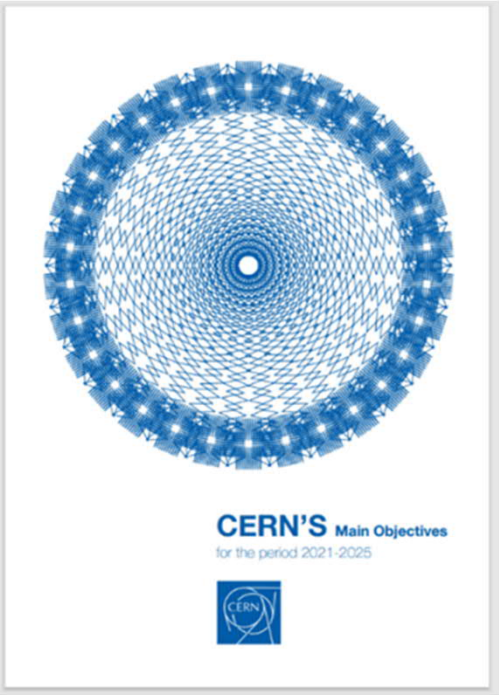
About CERN

Four pillars underpin CERN's mission

Our mission is to:

- perform world-class research in fundamental physics.
- provide a unique range of particle accelerator facilities that enable research at the forefront of human knowledge, in an environmentally responsible and sustainable way.
- unite people from all over the world to push the frontiers of science and technology, for the benefit of all.
- train new generations of physicists, engineers and technicians, and engage all citizens in research and in the values of science.

Current strategy for environment and sustainability



<u>Three main lines of actions (2021-2025):</u>

- ❑ Minimise the Laboratory's impact on the environment
- ❑ Pursue actions and technologies aiming at energy savings and reuse
- ❑ Identify and develop CERN's technologies that may contribute to mitigating the impact of society on the environment

Environment and sustainability are crucial aspects of projects and activities in the High Energy Physics field.
Any future project should have minimal environmental footprint.

CERN & United Nations SDGs

SUSTAINABLE DEVELOPMENT GOALS

SDG 3 - HEALTH
CERN helps to develop technologies that contribute to better healthcare for all, such as medical imaging and hadron therapy.

SDG 4 - EDUCATION
Education is one of CERN's core missions. We offer high quality programmes that inspire thousands of students, teachers and young researchers each year.

SDG 5 - GENDER
Diversity is a core value for CERN. Our diversity policy aims at leveraging the added value that comes from bringing together people of different nationalities, genders, professions and ages.

SDG 7 - ENERGY
CERN develops strategies for minimise the increase of energy consumed by the installations, increase energy efficiency and implement energy recovery.

SDG 9 - INNOVATION
CERN inventions are brought to industry through knowledge transfer, to have a positive impact on society and innovation.

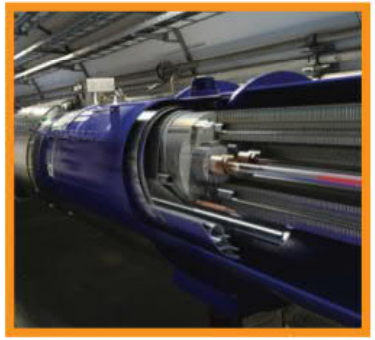
SDG 16 & 17 - INTERNATIONAL COOPERATION
CERN is a successful model for international collaboration. CERN gathers researchers from all over the world, contributing to human knowledge and peace, for the benefit of all.

THERAPY
Accelerators provide particle beams for more targeted cancer treatment.

BEAMLINE FOR SCHOOLS COMPETITION
Students from the two winning teams spend a week at CERN to carry out their experiment using a CERN accelerator.

25 BY 25 DIVERSITY & INCLUSION INITIATIVE
First ever targets-based strategy to boost the nationality and gender diversity within the Staff and Fellows population.

HEATING LOCAL HOUSING
Heat recovered from CERN's accelerator cooling systems to heat a new residential area in the town of Ferney-Voltaire, benefiting up to 8000 people.



A MAGNET IN THE LHC TUNNEL
Exploring the universe requires new technologies and ingenious engineering to build the machines that explore physics at a new frontier.

SESAME
This new synchrotron light source in Jordan started operation in 2017. It is a unique collaboration between eight Middle East members, modelled on CERN's governance structure.

CERN High priority environmental objectives – Horizon 2025

ENERGY

The laboratory is committed to limiting rises in electricity consumption to 5% up to the end of Run 3 (baseline 2018) – Target max 1314 GWh/y

EMISSIONS

CERN's objective is to reduce direct CO_2e emissions by 28% by the end of Run 3 (baseline 2018) – Target max 138 300 tCO_2e

WATER AND EFFLUENTS

The laboratory is committed to keeping the increase in its water consumption to 5% up to the end of Run 3 (baseline 2018) – Target max 3651 ML

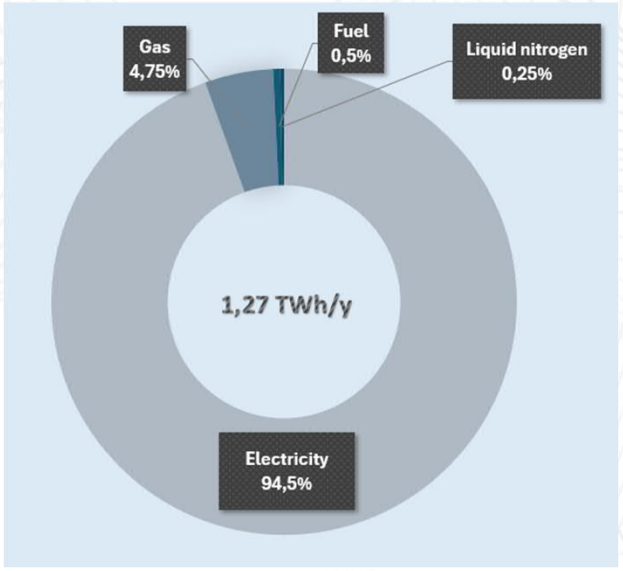
No showstopper to achieving these objectives by the first year of the next long shutdown (LS3) 2026 - 2028

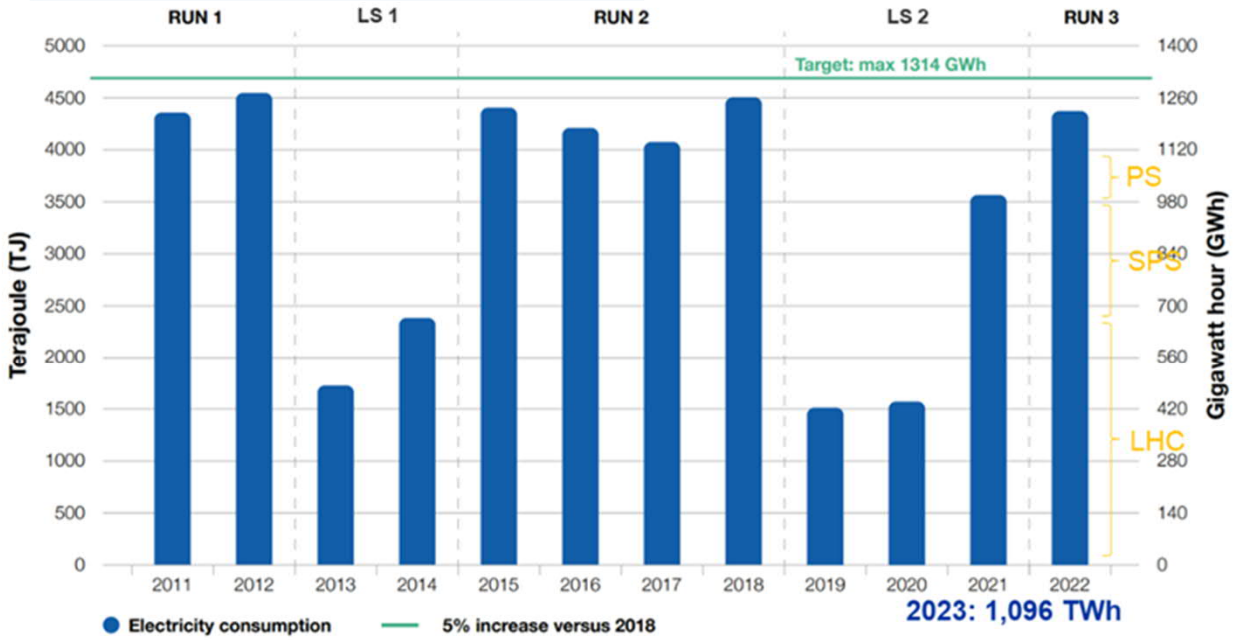
Three public facing Environment Reports published, following the Global Reporting Initiative (GRI) Standards – available here

Energy

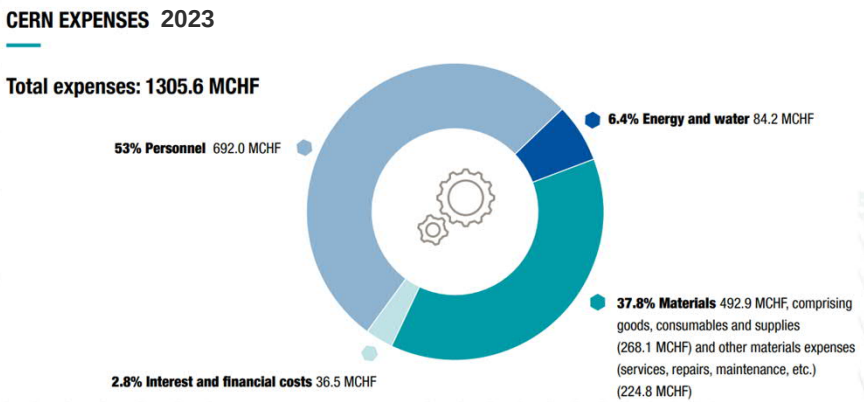
CERN's Annual Energy Consumption

- 4 sources of energy: electricity-gas-fuel-liquid nitrogen, for a total averaged energy consumption of about 1.27 TWh/y during run periods
- Electricity consumption monitored by 320 measuring devices – data handled thanks to the WebEnergy tool, developed internally, for forecasting and reporting
- Energy procurement represents about 6% of CERN's annual budget when the accelerators are running





CERN'S ELECTRICITY CONSUMPTION 2011–2022
Run periods refer to the years in which the accelerators are in operation, with occasional technical stops as and when necessary. Outside these periods, the accelerator complex enters 'long shutdowns' for essential maintenance and consolidation.

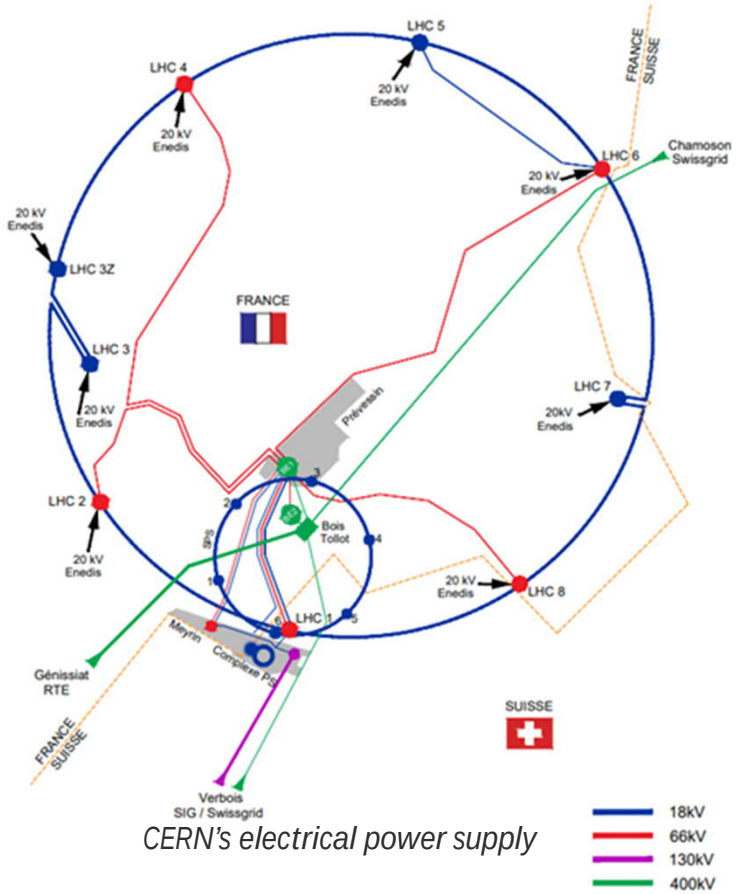


Energy

CERN's Electrical Power Supply

- Under normal circumstances, electricity is entirely procured from France where the energy grid mix is higher than 90% low-carbon
- 3870 m^2 of solar panels integrated in CERN's iconic new building inaugurated in October 2023 – Science Gateway. Electricity production of about 500 MWh/y

- With respect to renewable energy, CERN's objective at Horizon 2030 is to cover its total electricity needs by 10% renewable (PV) Power Purchase Agreements (PPAs), fully covering the electricity needs of the CERN Campus infrastructures, including CERN Data Centres – Agreements currently in preparation



CERN's electrical power supply

Energy

CERN is awarded the ISO 50001 energy certification

8 FEBRUARY, 2023

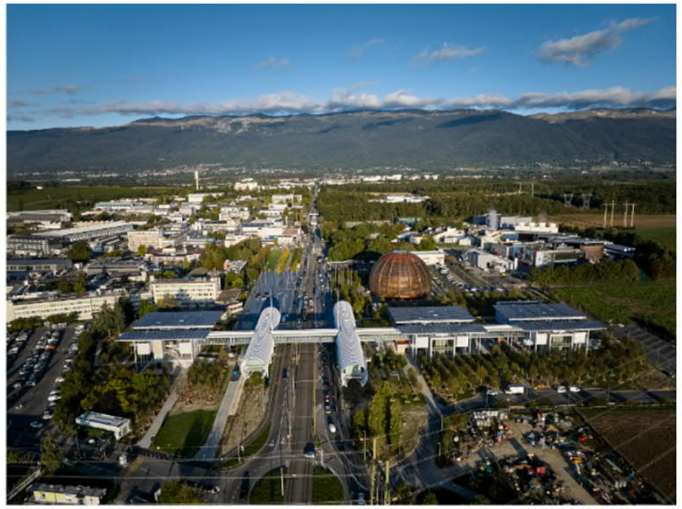
The CERN Meyrin site in 2020 (Image: CERN)

As part of CERN's commitment to responsible energy management, the Organization began the ISO 50001 certification process in 2022. The certification was officially awarded on 2 February 2023 for a period of three years, i.e. until 1 February 2026.

Managing energy responsibly: CERN passes ISO 50001 audit

CERN is one of the first scientific laboratories to have obtained ISO 50001 certification for energy management. Following our first surveillance audit, find out how we can all play a role in improving energy management

14 MAY, 2024 | By HSE unit



The CERN Meyrin site. Continual improvement of energy management is one of the key pillars of the Organization's strategy to minimise its impact on the environment. (Image: CERN)

CERN Energy Policy

CERN, an intergovernmental organization for fundamental research in particle physics, defines and implements an Energy Policy. This policy covers all the energy sources needed for its activities and installations, whether they are based in France or in Switzerland. The policy is periodically reviewed.

1. Objectives

In line with the CERN Safety Policy, the Energy Policy is designed to continuously improve the Organization's energy performance and minimise the impact of its activities on the environment. Its specific goals are to:

- keep the energy required for its activities to a minimum,
- improve energy efficiency, and
- recover waste energy.

2. Means

The Organization makes the necessary means available, in particular funding and personnel, needed to meet its Energy Policy objectives.

In particular, the Organization:

- implements structured, efficient and sustainable measures to ensure the continuous improvement of its energy performance,
- ensures that the Energy Policy objectives are integrated into the design of its sites and facilities and taken into account in the definition and execution of its activities,
- establishes appropriate internal regulations, keeps them up to date and monitors compliance with them,
- communicates proactively with all persons participating in its activities or present on its site, as well with as the Host States and the public,
- collaborates with the Host States.

Energy

Keeping energy required for CERN's activities to a minimum

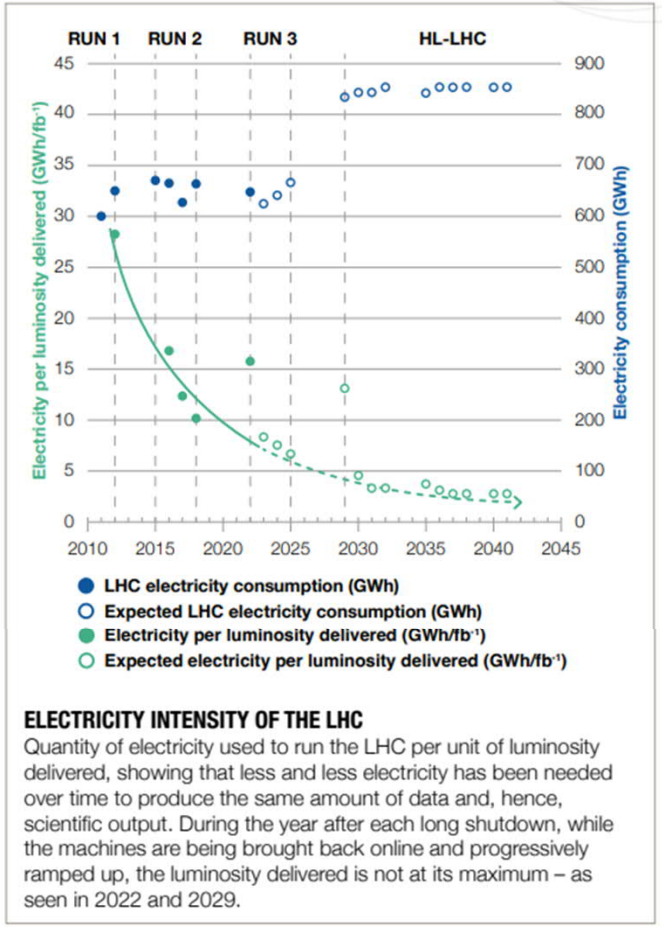
- Limiting the energy consumption of CERN's accelerator complex has always been a priority for the Organization (e.g extensive usage of superconductivity for LHC)
- Total energy savings in place since 2010 of about 100 GWh, mainly thanks to facilities upgrades (PS East Area new magnets and power converters), changes in operation modes (SPS magnets powering, eco-mode for cryoplants), large building consolidation (HVAC, electricity & envelope)
- Additional energy saving measures over the years 2022 & 2023 in response to the energy crisis – reduced accelerator schedule – reduced gas consumption (later heating and reduced temperature)
- Planned savings at Horizon 2030 of about 100 GWh, out of which about 25-30 GWh of gas linked to heat recovery projects decided in 2022

Energy

Improving energy efficiency

- CERN aims to increase the energy efficiency of the LHC in terms of luminosity delivered per unit of energy consumed – other KPI's defined for the PS and SPS complex – The energy performance of the accelerators is closely followed-up
- New targets for CERN Data Centres – the new Data Centre on the Prévessin site (F) has a PUE target of 1.1 – recently inaugurated (ramp-up to 12 MW over the next 10 years) – to be compared with the Data Centre on the Meyrin site (CH) built in the 70th with an Annual PUE of 1.5 (4 MW – 35 GWh/y)
- Procurement guidelines evaluating energy performance over the planned or expected operating lifetime when procuring equipment, products and services

  → Criteria (sum of all items covered by one invitation to tender): power consumption > 500 kW or annual energy consumption > 5 GWh

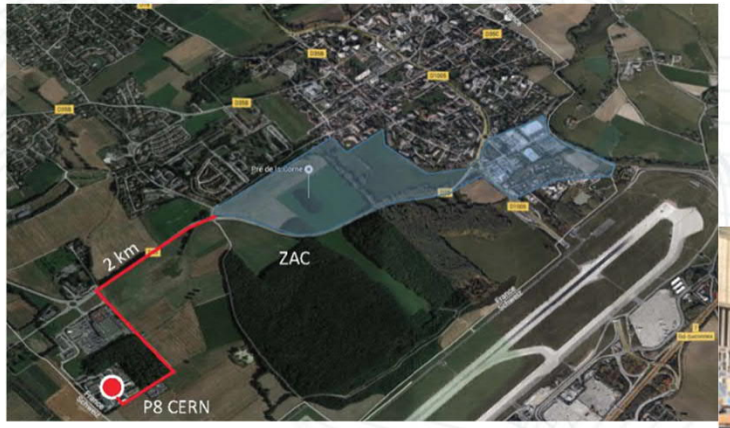


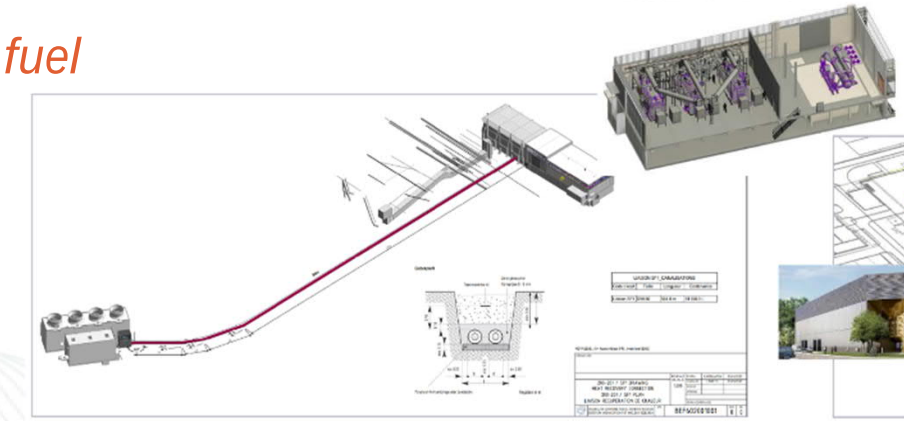
ELECTRICITY INTENSITY OF THE LHC
Quantity of electricity used to run the LHC per unit of luminosity delivered, showing that less and less electricity has been needed over time to produce the same amount of data and, hence, scientific output. During the year after each long shutdown, while the machines are being brought back online and progressively ramped up, the luminosity delivered is not at its maximum – as seen in 2022 and 2029.

Energy

Recover waste energy – ongoing projects

- One project for heating new housing in a surrounding municipality (~ 8000 people) – 20 GWh/y recovered waste heat from LHC PA8 cooling tower units
- Two projects for heating CERN main sites – recovered waste heat from cooling tower units (LHC PA1,) and from the new Prévessin Data Centre – expected reduction of the gas consumption of about 25-30 GWh/y as of 2027
  - *An outstanding step for CERN to depart from fossil fuel*



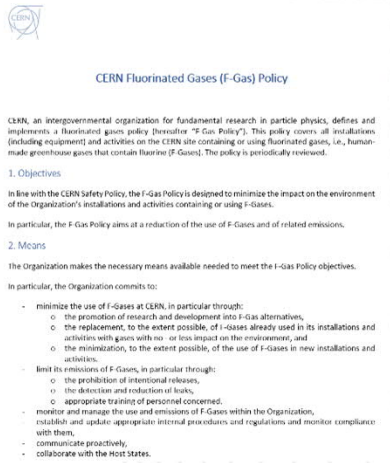


Heating plant – Meyrin site (CH)

Heating plant – Prévessin site (F)

Emissions

- CERN's greenhouse gas emissions reported according to the Greenhouse Gas Protocol
- Direct emissions/scope 1 mainly linked to LHC experiments and the use of fluorinated gases – CERN F-Gas Policy recently approved
- Indirect emissions/scope 2 linked to the supply of electricity – CERN Energy Policy published in 2022
- Indirect emissions/scope 3 mainly resulting from procurement (92%) – CERN Environmentally Responsible Procurement Policy effective since 2024 + Guidelines for duty travel published early 2024



CERN Fluorinated Gases (F-Gas) Policy

CERN, an intergovernmental organization for fundamental research in particle physics, defines and implements a fluorinated gases policy (hereafter "F-Gas Policy"). This policy covers all installations (including equipment) and activities on the CERN site containing or using fluorinated gases, i.e., human-made greenhouse gases that contain fluorine (F-Gases). The policy is periodically reviewed.

1. Objectives

In line with the CERN Safety Policy, the F-Gas Policy is designed to minimize the impact on the environment of the Organization's installations and activities containing or using F-Gases.

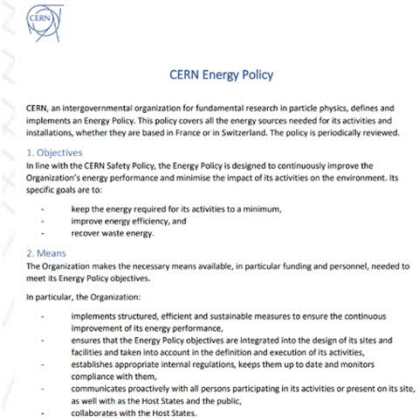
In particular, the F-Gas Policy aims at a reduction of the use of F-Gases and of related emissions.

2. Means

The Organization makes the necessary means available needed to meet the F-Gas Policy objectives.

In particular, the Organization commits to:

- minimize the use of F-Gases at CERN, in particular through:
  - the promotion of research and development into F-Gas alternatives,
  - the replacement, to the extent possible, of F-Gases already used in its installations and activities with gases with no - or less impact on the environment, and
  - the minimization, to the extent possible, of the use of F-Gases in new installations and activities.
- limit its emissions of F-Gases, in particular through:
  - the prohibition of intentional releases,
  - the detection and reduction of leaks,
  - appropriate training of personnel concerned.
- monitor and manage the use and emissions of F-Gases within the Organization, establish and update appropriate internal procedures and regulations and monitor compliance with them,
- communicate proactively,
- collaborate with the Host States.



CERN Energy Policy

CERN, an intergovernmental organization for fundamental research in particle physics, defines and implements an Energy Policy. This policy covers all the energy sources needed for its activities and installations, whether they are based in France or in Switzerland. The policy is periodically reviewed.

1. Objectives

In line with the CERN Safety Policy, the Energy Policy is designed to continuously improve the Organization's energy performance and minimise the impact of its activities on the environment. Its specific goals are to:

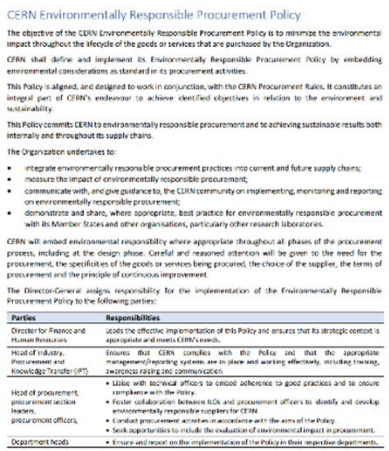
- keep the energy required for its activities to a minimum,
- improve energy efficiency, and
- recover waste energy.

2. Means

The Organization makes the necessary means available, in particular funding and personnel, needed to meet its Energy Policy objectives.

In particular, the Organization:

- implements structured, efficient and sustainable measures to ensure the continuous improvement of its energy performance,
- ensures that the Energy Policy objectives are integrated into the design of its sites and facilities and taken into account in the definition and execution of its activities,
- establishes appropriate internal regulations, keeps them up to date and monitors compliance with them,
- communicates proactively with all persons participating in its activities or present on its site, as well with as the Host States and the public,
- collaborates with the Host States.



CERN Environmentally Responsible Procurement Policy

The objective of the CERN Environmentally Responsible Procurement Policy is to minimize the environmental impact throughout the lifecycle of the goods or services that are purchased by the Organization.

CERN shall define and implement its Environmentally Responsible Procurement Policy by embedding environmental considerations as standard in its procurement activities.

This Policy is aligned, and designed to work in conjunction, with the CERN Procurement Rules. It constitutes an integral part of CERN's endeavour to achieve identified objectives in relation to the environment and sustainability.

This Policy commits CERN to environmentally responsible procurement and to achieving sustainable results both internally and throughout its supply chains.

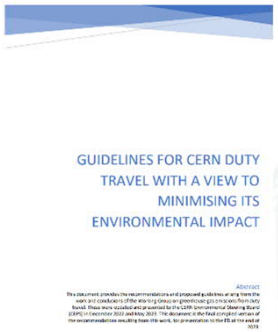
The Organization undertakes to:

- integrate environmentally responsible procurement practices into current and future supply chains;
- measure the impact of environmentally responsible procurement;
- communicate with, and give guidance to, the CERN community on implementing, monitoring and reporting on environmentally responsible procurement;
- demonstrate and share, where appropriate, best practice for environmentally responsible procurement with its Member States and other organisations, particularly other research laboratories.

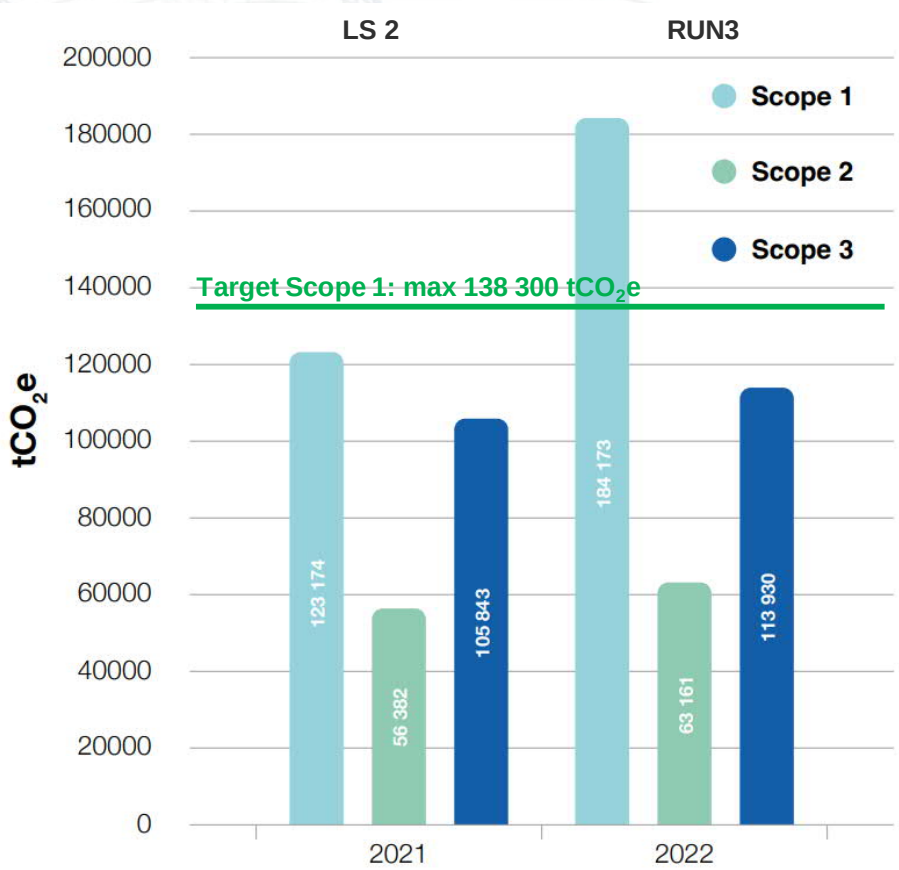
CERN will embed environmental responsibility where appropriate throughout all phases of the procurement process, including at the design phase. Careful and reasoned attention will be given to the need for the procurement, the specificities of the goods or services being procured, the choice of the supplier, the terms of procurement and the principle of continuous improvement.

The Director-General assigns responsibility for the implementation of the Environmentally Responsible Procurement Policy to the following parties:

Parties	Responsibilities
Director for Finance and Human Resources	Leads the effective implementation of this Policy and ensures that its strategic content is appropriate and meets CERN's needs.
Head of Industry, Procurement and Knowledge Transfer (IPT)	Ensures that CERN complies with the Policy and that the appropriate management/reporting systems are in place and working effectively, including training, awareness raising and communication.
Head of procurement, procurement section leaders, procurement officers;	• Liaise with technical officers to ensure adherence to good practices and to ensure compliance with the Policy. • Foster collaboration between TOs and procurement officers to identify and develop environmentally responsible suppliers for CERN. • Conduct procurement activities in accordance with the aims of the Policy. • Seek opportunities to include the evaluation of environmental impact in procurement.
Department heads	• Ensure and report on the implementation of the Policy in their respective departments.

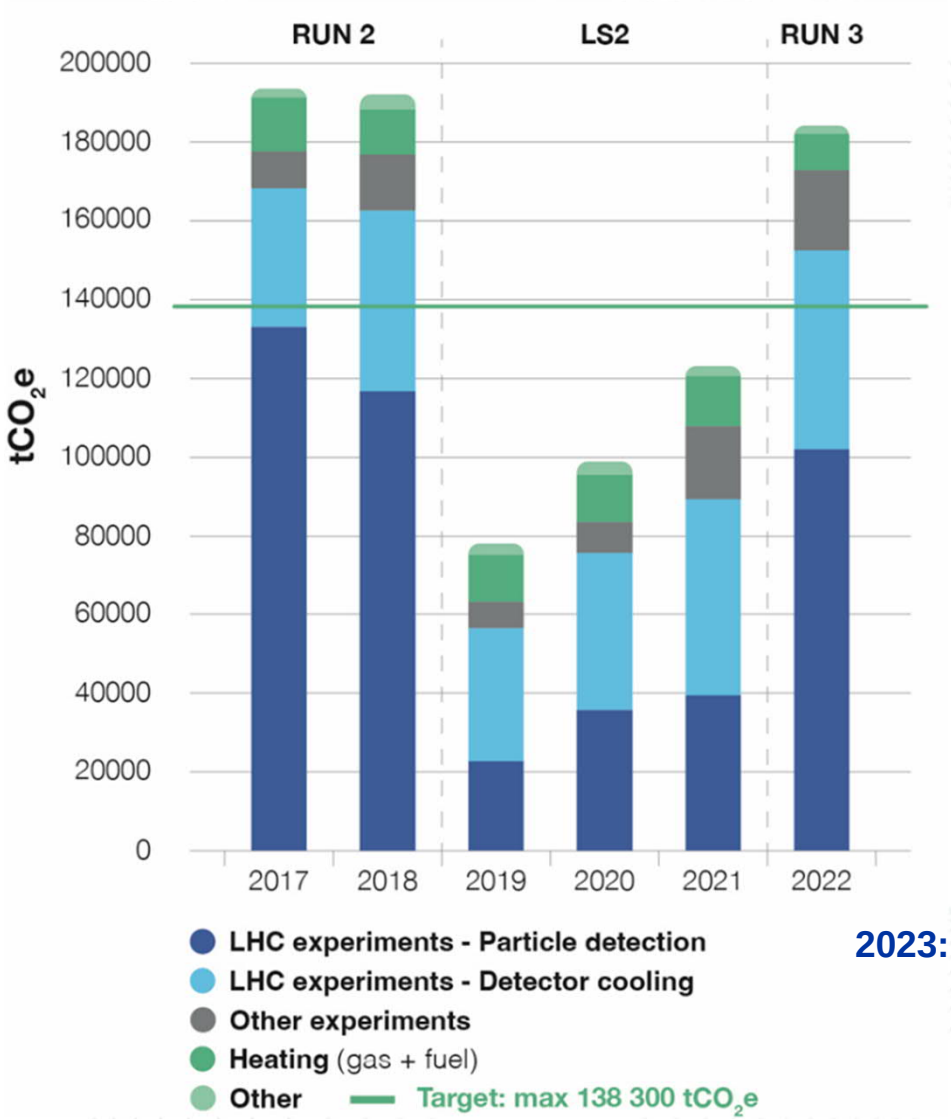


GUIDELINES FOR CERN DUTY TRAVEL WITH A VIEW TO MINIMISING ITS ENVIRONMENTAL IMPACT



CERN'S TOTAL SCOPE 1, 2 AND 3 EMISSIONS 2021–2022

Emissions



2023: 170'000 tCO_2e

Scope 1 – direct emissions

Detector cooling
Reduction potential for RUN4 vs 2018
of ~ 40'000 tCO_2e

Particle detection
Reduction potential for RUN4 vs 2018
of more than 13'000 tCO_2e

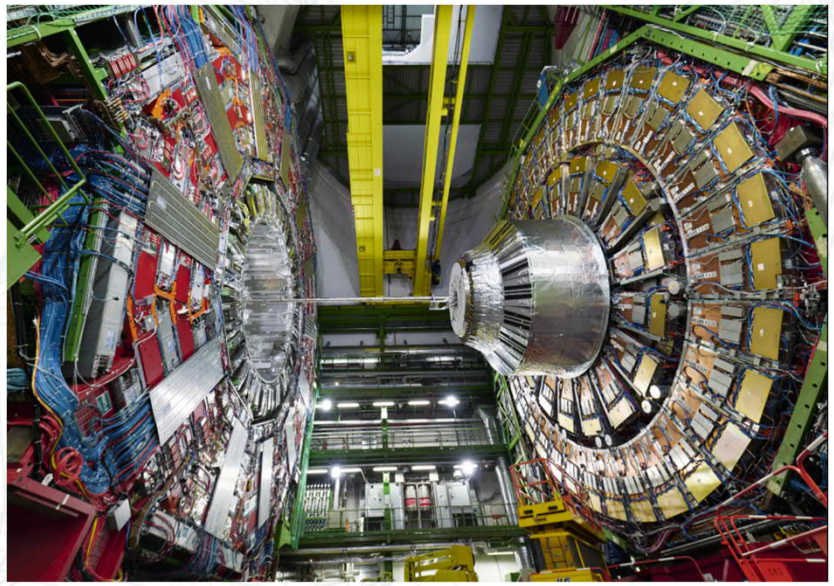
- Main source of scope 1 emissions linked to F-gases used for detector cooling (mostly PFCs such as C_6F_{14} and C_3F_8) and for particle detection (mostly HFCs such as HFC-134a)

Emissions

Scope 1 – direct emissions

- Within LHC experiments - 3 pillar R&D strategy to minimize emissions of fluorinated gases: recirculation and optimisation, gas recovery and the search for more environmentally friendly alternatives
- ATLAS and CMS: continued investment in R&D to reduce detector leaks and prepare for a transition from Perfluorocarbons (PFCs) to CO_2 cooling
- Since beginning of August 2023, ATLAS operates the RPC detectors with a new gas mixture – lowering CO_2e emissions from the RPC detectors

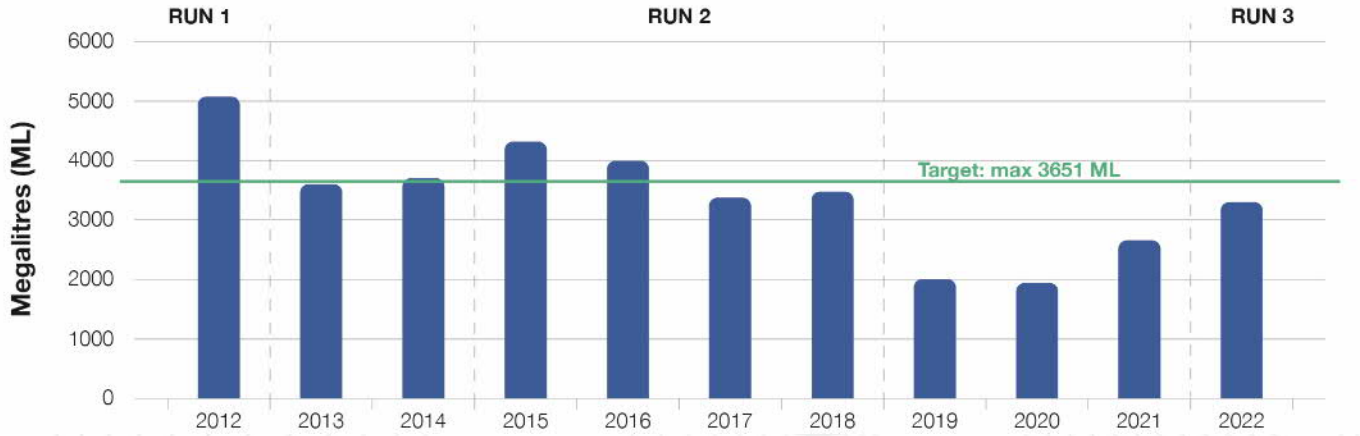
Final LS2 upgrade work to the ATLAS detector before cavern closure



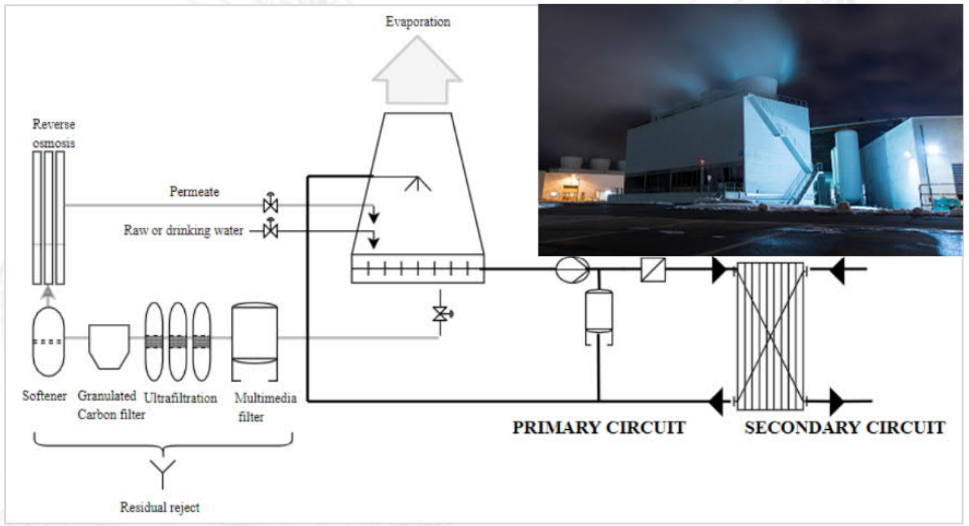
CMS during the final stages of LS2

Water and effluents

- CERN strives to minimise its water consumption through continuous consolidation and improvement of its cooling and sanitation infrastructures - Since 2000, water consumption has decreased by some 80%, from 15’000 megalitres to 3’234 megalitres in 2022
- Ambitious project for reducing the current impact linked to the blowdown of the LHC & SPS cooling tower circuits (released into a local stream: about -90% of effluent water volume and pollutants load from 2027/2028)



2023: 3000 ML



Future cooling water recycling plant under study

Horizon 2030

ENERGY

While the number of collisions will be multiplied by a factor of 5 to 7.5 during RUN4 (2029-2032) with respect to the nominal LHC design, CERN commits to limiting its electricity consumption to 1.5 TWh/y, which equates to an increase of 11%

EMISSIONS

Direct CO_2e emissions are linked to CERN's core operations. CERN's objective is to reduce them by 50% vs baseline 2018

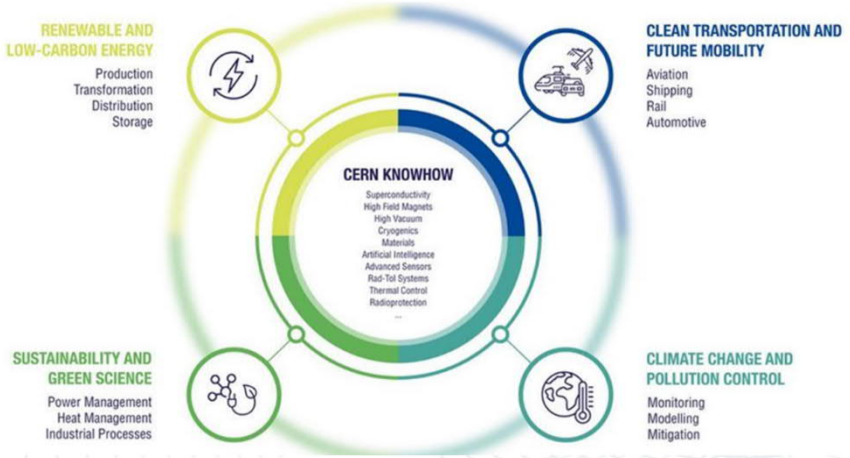
WATER AND EFFLUENTS

Despite a growing demand for cooling water, CERN will strive to keep the water consumption below 3600 ML

3 high priority objectives out of 9

Knowledge and technology for the environment - Highlights

- Several success stories over the last eight years in which CERN's technologies and know-how resulted in diverse environmental applications
- Environment – integrated in 2021 in the application fields of CERN technologies and know-how
- Focus on four main sectors with high impact potential and for which strong synergies with CERN's technical domains of expertise have been identified



Applying accelerators to environmental challenges with ARIES

Horizon 2020 project ARIES aims to improve the performance, availability and sustainability of particle accelerators, transferring its benefits and applications to science and society.

Read more

BAQ: A Startup to tackle radon gas

BAQ, a startup using CERN technologies, tackles radon in buildings.

Read more

Camstech: Electrochemical Sensors for Water Pollution Measurement

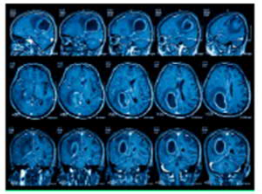
The start-up Camstech Ltd joined the STFC-CERN Business Incubation Centre in 2016.

Read more

FOSS4 Irrigation: how can high-energy physics help with water shortage?

Since 2016, CERN is part of a research project to develop a system for optimised irrigation, based on technologies developed for high-energy physics.

Read more



From LHC Magnets to High-Field MRI and Efficient Power Grids

The ever-increasing magnetic fields required to achieve the desired energies in colliders like the LHC and in the Future Circular Collider, are the main drivers for developing superconducting cable technology. Two technology synergies are emerging: high-field Magnetic Resonance Imaging (MRI) and "smart" superconducting grids.

Read more

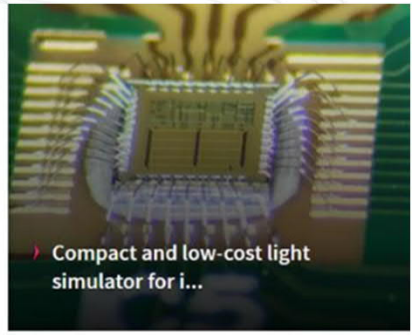
PlanetWatch

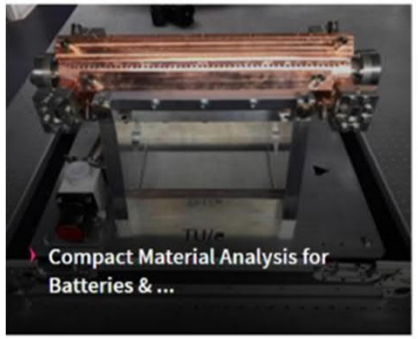
PlanetWatch, a CERN spin-off, aims to provide a solution to generate, validate, analyse and record air quality data. Their environmental sensor uses the CERN technology C2MON.

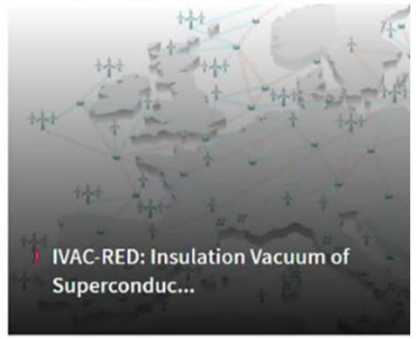
Read more

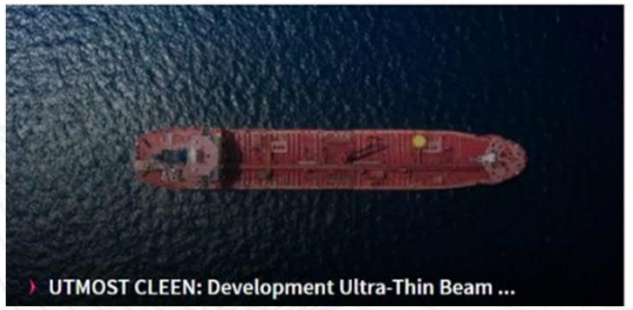
Knowledge and technology for the environment - Highlights

- 2022: CERN Innovation Programme on Environmental Applications (CIPEA) endorsed by CERN Management









Knowledge and technology for the environment - Highlights

- Others

Partnership with ABB

CERN to partner with industry on innovation to reduce environmental impact of large-scale facilities

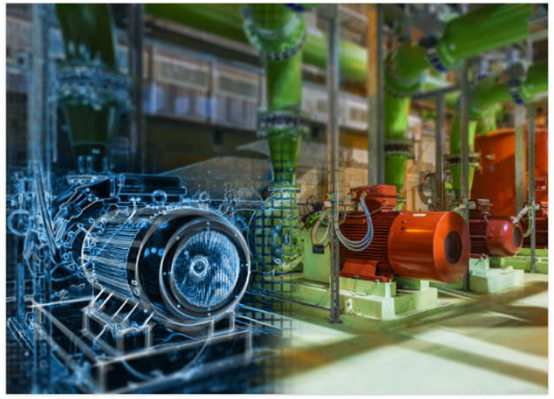
In its commitment to minimising its environmental impact and developing technologies that can help society towards a better planet, CERN has formed an innovation partnership with ABB, with the aim of reducing the Laboratory's energy consumption

Environment | 14 June, 2022

ABB and CERN identify 17.4% energy-saving opportunity in the Laboratory's cooling and ventilation motors

Through a strategic research partnership focused on CERN's cooling and ventilation systems, energy efficiency audits have helped to identify a savings potential of 17.4% across a total of 800 motors

28 FEBRUARY, 2024 | By CERN Knowledge Transfer group



CERN and ABB Motion, a global company specialised in digitally enabled motor and drive solutions to support a low-carbon future for industry, infrastructure and transportation, started collaborating in 2022 to reduce the energy consumption of CERN's cooling and ventilation systems. (Image: CERN)

Collaboration agreement with Airbus

CERN and Airbus partnership on future clean aviation

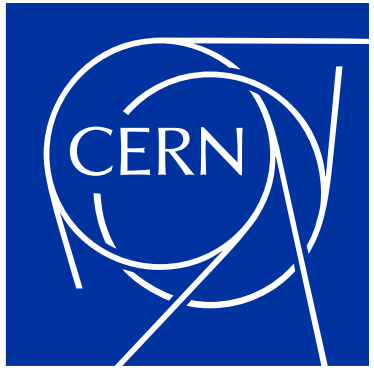
CERN and Airbus UpNext sign a collaboration agreement to assess the use of superconducting technologies for future low-emission aeroplanes.

AerospaceEnvironment | 01 December, 2022

Key Takeaways

Environment and sustainability constitute a focus area for CERN now and in the future

- Our responsibility is to demonstrate that any future research infrastructure is designed such as to minimise its impact on the environment. Anticipation is key, but not always possible due to the overall lifetime of our accelerators (e.g. for LHC, about 5 decades between design and operation). During operation, monitoring changes in rules/regulations/practices is essential for amendments
- The next long shutdown (LS3 – 3 years from 2026 on) is a key milestone to conclude essential projects (e.g. GHG emissions) in CERN's efforts to minimise its impact on the environment
- Horizon 2030 environmental objectives were recently approved. A set of projects and the corresponding budget has been integrated in CERN's Medium-Term Plan and was approved by the CERN Council in June this year
- A revised strategy beyond 2030 will be driven also by expectations of CERN Member States, Host States and by the needs of the HEP community


CERN