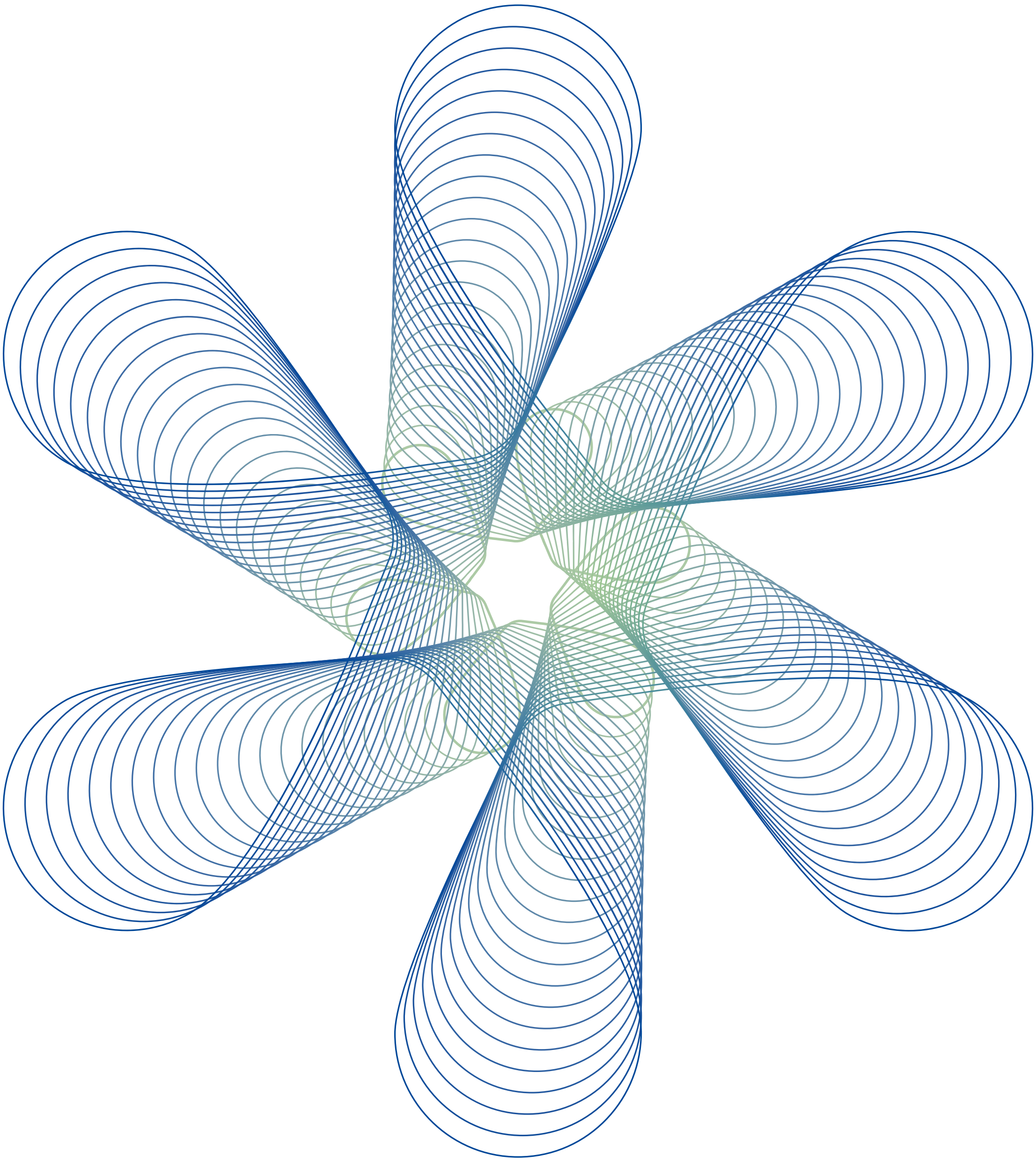


Environment Report

2023–2024

CONTENTS




FOREWORD

By Fabiola Gianotti, CERN Director-General

The years 2023 and 2024 have been marked by extraordinary achievements in CERN's scientific programme and more generally across the full spectrum of the Organization's activities, with a particular focus on environmental responsibility.

As an example, in 2024 the Large Hadron Collider (LHC) delivered an integrated luminosity of 124 inverse femtobarns to the ATLAS and CMS experiments — a record-breaking performance that also highlighted the increasing efficiency of CERN's accelerator complex in terms of data delivered per unit of energy consumed. CERN also inaugurated a new data centre with a power usage effectiveness of 1.1, which is significantly better than the European average, and equipped with an efficient heat-recovery system.

This reporting period was also a time of reflection and celebration, as CERN marked 70 years of discoveries, breakthroughs and innovation. Events held throughout 2024 brought together our global community, international partners and world leaders to honour CERN's achievements and reaffirm our shared values of excellence, collaboration, diversity and inclusion, openness and care for people and the environment. As we move towards the final stretch of LHC Run 3 and prepare for the next chapter of our scientific programme—first and foremost the High-Luminosity LHC—environmental stewardship remains at the heart of our strategy.

Looking further ahead, in early 2024 the CERN Council conducted a mid-term review of the study assessing the feasibility of a possible Future Circular Collider, which is being undertaken following the recommendations of the 2020 update of the European Strategy for Particle Physics (ESPP). The study report details the concepts, strategies and actions required to respect the environment, in line with CERN's environmental objectives, while boosting new technologies with the potential to help society to protect the planet and developing territorial synergies such as energy reuse. Shortly afterwards, the Council set in motion the process to update the ESPP in 2026; as in the past, the updated Strategy is expected to place emphasis on actions to improve the sustainability of our field.

In February 2023, CERN was granted ISO 50001 certification, the benchmark international standard for energy management, in recognition of the Organization's achievements in this domain and of its commitment to continuous improvement. The following January, the Enlarged Directorate approved CERN's revised environmental objectives for 2030, which introduce further constraints in domains including electricity consumption, direct CO_2 emissions, water usage and waste.

CERN's environmental commitments extend far beyond 2030. Building on the tremendous innovation and ingenuity that underpin the successful construction and operation of some of the world's largest and most advanced scientific instruments, a future flagship project will be a model for environmentally aware, sustainable research. CERN will thus continue to demonstrate that we can and must push back the frontiers of knowledge and technology while protecting the world we all share.

Fabiola Gianotti, Director-General

Fabiola Gianotti

By Benoît Delille, Head of the HSE unit

Science should not just address global challenges but act locally. And that is what we do at CERN. The operation of complex infrastructures like CERN's accelerators and experiments presents unique challenges, and it is through the engagement of our entire community that we are able to meet them.

Over the past two years, CERN has continued to demonstrate how large-scale scientific research can be conducted with a conscious commitment to environmental responsibility and continuous improvement. The period 2023–2024 was characterised not only by the exceptional performance of the accelerators, experiments and computing, but also by important steps forward in our environmental and sustainability actions. Apart from a month-long stop in 2023 due to a technical issue, the accelerator complex was in full operation throughout this period at the LHC energy level of 13.6 TeV.

As the LHC broke new records in integrated luminosity, we maintained our focus on optimising resource use, enhancing energy efficiency and reducing our environmental footprint. In 2023-2024, CERN made significant progress toward its environmental objectives for the period up to the end of Run 3 in the priority domains of energy, emissions, water and waste. This reporting period was also significant in preparing for CERN's next strategic phases – the end of LHC Run 3, the technical stop and Long Shutdown 3, which pave the way to the High-Luminosity LHC – and the long-term vision towards a possible Future Circular Collider.

New and revised environmental objectives for 2030 were approved by the Enlarged Directorate in January 2024. While the collision rate during Run 4 (2030-2033) will be multiplied by approximately a factor of five with respect to the nominal LHC design, CERN has committed to limiting its electricity consumption to 1.5 TWh/year and to reducing the direct CO_2 emissions linked to its core operations by 50%. CERN has also pledged to reduce its gas consumption by 60% with respect to the 2018 figures and to keep its water consumption below 3 600 megalitres, despite a growing demand for cooling water. The newly endorsed 2030 environmental objectives also set clear priorities in domains including biodiversity, ionising radiation and noise.

The vision set out by the Director-General ten years ago for CERN to be a role model for environmentally responsible research has pushed our scientists, engineers and technicians to define ambitious yet realistic objectives. I am grateful to everyone at CERN who contributes daily to building a safer, more sustainable laboratory that balances scientific excellence with care for the environment.

Benoît Delille, Head of the Occupational Health and Safety and Environmental Protection Unit

ENERGY
1 290 GWh

CERN has committed to limiting rises in electricity consumption by the end of Run 3 to 5% compared to the baseline year 2018, while delivering significantly increased performance of its facilities. This corresponds to a maximum target consumption of 1 317 GWh. It has also committed to increasing energy reuse.

CERN consumed 1 096 GWh of electricity in 2023 and 1 290 GWh in 2024. It also consumed 43 GWh (154 TJ) of energy generated by fossil fuels in both reporting years.

WASTE
76% recycled

CERN's aim is to continuously increase its recycling rate for non-hazardous waste. This rate rose from 56% in 2018 to 76% in 2024.

In 2023 and 2024 respectively, CERN disposed of 3 625 tonnes and 3 419 tonnes of non-hazardous waste, and of 1 379 tonnes and 975 tonnes of hazardous waste (both conventional and radioactive).

IN BRIEF 2023–2024

The accelerator complex was in full operation throughout this period, following its restart in July 2022 with a view to reaching the new energy level of 13.6 TeV. Operating periods feature short shutdowns of several weeks at the end of each year for the purposes of essential maintenance. In 2024, a revised schedule for the operation and shutdown of the accelerator complex was approved, delaying the end of Run 3 and the start of the third Long Shutdown to mid-2026.

EMISSIONS
170 024 tCO_2e

CERN's objective is to reduce its direct emissions by 28% by the end of Run 3 compared to the baseline year 2018 (maximum target 138 300 tCO_2e).

In 2023 and 2024, respectively:

- Direct Scope 1 emissions amounted to 170 482 and 170 024 tonnes of CO_2 equivalent (tCO_2e);
- Indirect Scope 2 greenhouse gas emissions due to CERN's electricity consumption were 63 572 and 66 965 tCO_2e;
- Indirect Scope 3 emissions arising from business travel, personnel commuting, catering, waste treatment and water purification (excluding procurement) amounted to 10 091 and 11 553 tCO_2e. Those arising from procurement amounted to 100 512 and 102 730 tCO_2e.

WATER AND EFFLUENTS
2 895 ML

The Laboratory has committed to keeping the increase in its water consumption up to the end of Run 3 below 5% compared to the baseline year 2018, which corresponds to a target maximum consumption of 3 651 megalitres despite the growing demand for water cooling at the upgraded facilities.

CERN used 2 830 megalitres of water in 2023 and 2 895 megalitres of water in 2024.

BIODIVERSITY
50 hectares of areas of ecological interest

CERN's biodiversity action plan for 2021-2025 comprises a set of initiatives designed to preserve and enhance its natural environment. These objectives are founded on Host State regulations and best practices in the field of biodiversity. The inventory of fauna and flora completed in 2022 identified some 50 hectares of areas of ecological interest, to be classed as a priority for preservation in the event of planned works and projects.

HAZARDOUS SUBSTANCES
>100 m^3 of mineral oil removed

CERN's regulatory framework for hazardous substances addresses potential risks to soil and water and is continuously adapted in line with Host State regulations. These substances are subject to regular monitoring and reporting.

IONISING RADIATION
<0.01 mSv

The European annual dose limit for public exposure to artificial sources is 1 millisievert (mSv). CERN has committed to keeping its contribution to no more than 0.3 mSv per year. In 2024, the dose received by any member of the public living near the Laboratory was below 0.01 mSv.

PROCUREMENT AND MATERIALS

The Organization took an important step towards integrating sustainability into its procurement processes by adopting an Environmentally Responsible Procurement Policy along with an implementation strategy, both of which were approved by CERN's Enlarged Directorate in 2023. CERN's materials needs are driven by the demands of cutting-edge scientific research, technology and infrastructure, which require materials of exceptional quality with unique characteristics. This report features CERN's materials management practices for the first time.

NOISE
45 dBA at night

CERN has committed to restricting the level of noise at its site perimeters to 70 dBA during the day and 60 dBA at night. The average noise levels measured at CERN's site perimeters are typically 50 dBA during the day and 45 dBA at night. In addition, CERN continues to monitor the evolution of noise levels in residential areas next to its sites, keeping noise footprint maps and 3D noise models up to date.

KNOWLEDGE AND TECHNOLOGY FOR THE ENVIRONMENT
25 projects

The CERN Innovation Programme on Environmental Applications (CIPEA) was launched in 2022 as a call for ideas from the CERN community to stimulate innovation in environmental applications based on CERN's technologies, know-how and facilities. The programme was expanded during the reporting period to include projects defined in collaboration with external partners, mainly from industry, in the key areas identified in the 2022 strategy. The eight CERN community projects initially selected are generating the first results.

AT A GLANCE

GOALS FOR 2030

CERN's first environmental objectives for the period until the end of Run 3 were approved by the Enlarged Directorate in early 2020. While this report provides an update on progress with respect to these original objectives, it also presents the environmental objectives for 2030, which were approved by the CERN Enlarged Directorate in January 2024.

The objectives and commitments for the period until 2030 are summarised below:

ENERGY

CERN has committed to limiting its electricity consumption to 1.5 TWh/year, which equates to an increase of 14% compared to the target set for the end of Run 3, despite significantly increasing demand due to the expanding physics programme. Further, the Organization aims to cover 10% of its electricity needs by renewable energy sources by this point in time, thanks to power purchase agreements, and to reduce its gas consumption by 60% compared to 2018.

WATER AND EFFLUENTS

CERN's objective is to keep its annual water consumption below 3 600 megalitres despite the growing demand for cooling water, to reduce the zinc load in effluents to the *Nant d'Avril* river in Switzerland by 90% and to increase the water retention volume available on CERN sites.

EMISSIONS

CERN's objective for scope 1 emissions is to reduce the emission of greenhouse gases resulting from the Organization's activities by 50%.

With regard to energy-related emissions, CERN aims to keep its scope 1 and 2 emissions constant compared to 2018.

For scope 3 emissions, the objective for commuting is to reduce individual motorised transport to 50%; the objective for emissions from duty travel is a reduction of 30% compared to 2019; in the area of catering, the objective is to increase the offer of vegetarian/vegan meals to 50% of the total offer. Objectives for procurement are being developed in the framework of the environmentally responsible procurement project and will be presented in future reports.

WASTE

CERN has committed to maintaining the rate of recovery of its non-hazardous waste above 70% in terms of weight. With respect to the reference year 2022, the Organization aims to increase the total rate of reuse by 10% by 2030 and to reduce the campus "household waste" per person on site by 5% (all in terms of weight). For radioactive waste, the objective is to keep the amount of waste recycled from the clearance of former radioactive waste above 55 tonnes/year.

BIODIVERSITY

CERN's objective with respect to biodiversity is to conserve and enhance the Organization's natural, agricultural and forest areas, thereby fostering biodiversity in the identified ecosystems (shrublands, meadows, woodlands and wetlands) and reducing the presence of urban heat islands on the CERN sites.

NOISE

CERN's priority is to control and reduce the noise footprint resulting from the Organization's activities. Concretely, CERN intends to reduce noise hotspots (>40 dBA) in residential areas, carrying out systematic environmental noise impact assessments for new infrastructures and major consolidation work.

IONISING RADIATION

Despite an expanding scientific programme, CERN's objective is to keep its radiological environmental impact negligible by continually optimising its facilities and activities to ensure that the doses received by the public are kept below 0.02 mSv per year (for reference, the European annual dose limit for public exposure to artificial sources is 1 mSv).

HAZARDOUS SUBSTANCES

CERN's objective is to reduce the potential environmental impact of hazardous substances used for the Organization's activities. Concretely, the aim is to reduce the quantity of transformer oil present on CERN's sites by 120 m^3 (compared to the 2023 baseline of 1 784 m^3).

ABOUT CERN

CERN, the European Organization for Nuclear Research, was founded in 1954. As the world's leading laboratory for high-energy particle physics, its core mission is fundamental physics research, aiming to answer questions about the fundamental constituents of matters and the Universe's structure and evolution.

A LABORATORY FOR THE WORLD

CERN is an intergovernmental organisation whose headquarters are in Meyrin, in the Swiss canton of Geneva. CERN's various facilities span both its Host States, Switzerland and France, and feature two main campuses: the original site in Meyrin, which straddles the Swiss-French border, and another in Prévessin, France.

The collaborative spirit between nations, institutions and scientists drives CERN's research. With over 17 000 contributors worldwide representing more than 110 nationalities, CERN benefits from a diverse network of talent. These contributors include approximately 3 700 CERN employees working on the design, construction and operation of the research infrastructure, collaborating with a vast user community of over 12 400 scientists from institutions in more than 80 countries.

Aligned with the principles of open science, CERN ensures that its research and technology outcomes are publicly accessible to society worldwide.

CERN's work significantly contributes to several United Nations Sustainable Development Goals (SDGs), in particular those relating to good health and well-being (3), quality education (4), gender equality (5), affordable and clean energy (7), industry, innovation and infrastructure (9), peace, justice and strong institutions (16), and partnerships for the goals (17). The Organization actively contributes to their implementation and aligns its environmental impact reduction efforts with additional SDGs
(see GRI Content Index).

GOVERNANCE AND GLOBAL COLLABORATION

CERN's family grew in the reporting period, with Brazil joining as an Associate Member State in 2023 and Estonia as a Member State in 2024. At the end of 2024, the Organization has 24 Member States, ten Associate Member States and four Observers. Following decisions by the Council in 2022, the Organization's cooperation with the Russian Federation and the Republic of Belarus terminated upon the expiry of the International Cooperation Agreements (ICAs) with the two countries in 2024.

The CERN Council, as the Organization's highest authority, oversees the strategy pursued in scientific, technical, administrative and other matters. Each Member State has a single vote, with most decisions requiring a simple majority. The Council is supported by five subordinate bodies: the Scientific Policy Committee, the Finance Committee, the Audit Committee, the Tripartite Employment Conditions Forum and the Pension Fund Governing Board.

Appointed by the Council, usually for five years, the CERN Director-General manages the Organization and reports directly to the Council. The Director-General is assisted by a Directorate composed of members proposed by the Director-General and appointed by the Council. In addition, CERN has an Enlarged Directorate, which consists of all the Directors and Department Heads.

The Staff Association is the only statutory organ representing the entire personnel, notably at the Tripartite Employment Conditions Forum (TREF). Besides the Staff Association, TREF is composed of representatives of the Member States and the Management, and its role is to examine the conditions of pay and employment.

The Organization is prominent on the global research stage, collaborating with national and international institutions and represented on scientific bodies such as the International and European Committees for Future Accelerators (ICFA and ECFA). CERN is a member of the European Intergovernmental Research Organisation forum (EIROForum), which connects Europe's major scientific research institutions, allowing exchanges on environmental initiatives and various other topics through dedicated working groups. CERN also holds Observer status at the United Nations General Assembly, underscoring its commitment to global scientific cooperation.

ETHICS AND INTEGRITY

CERN's commitment to research, innovation, education and collaboration is built on strong ethical standards. The CERN Staff Rules and Regulations outline the responsibilities of the Organization and its personnel. CERN's Code of Conduct embodies the Organization's values, namely integrity, commitment, professionalism, creativity and diversity and applies to everyone on CERN's sites, ensuring a respectful and supportive working environment.

CERN is committed to engagement with its personnel, whether they are employed by the Organization or come to the Laboratory to carry out their research. To this end, several mechanisms for engagement, feedback, support and reconciliation are in place, notably through the Ombud, the Human Resources department, the Users Office and the Staff Association, and dedicated bodies are in place to address specific concerns.

UNIQUE INSTALLATIONS FOR UNIQUE RESEARCH

CERN's particle accelerators enable frontier research in particle physics. The Large Hardon Collider, or LHC, CERN's current flagship facility, is the world's largest and most powerful accelerator, colliding proton and heavy ion beams in several particle detectors for study by scientists. The LHC's capabilities will be further expanded with the High-Luminosity LHC (HL-LHC), which is expected to operate from 2030 to 2041 with the aim of increasing the beam collision rate (luminosity) and consequently boosting the amount of physics data that can be collected, allowing further measurements, observations and possibly discoveries to be made.

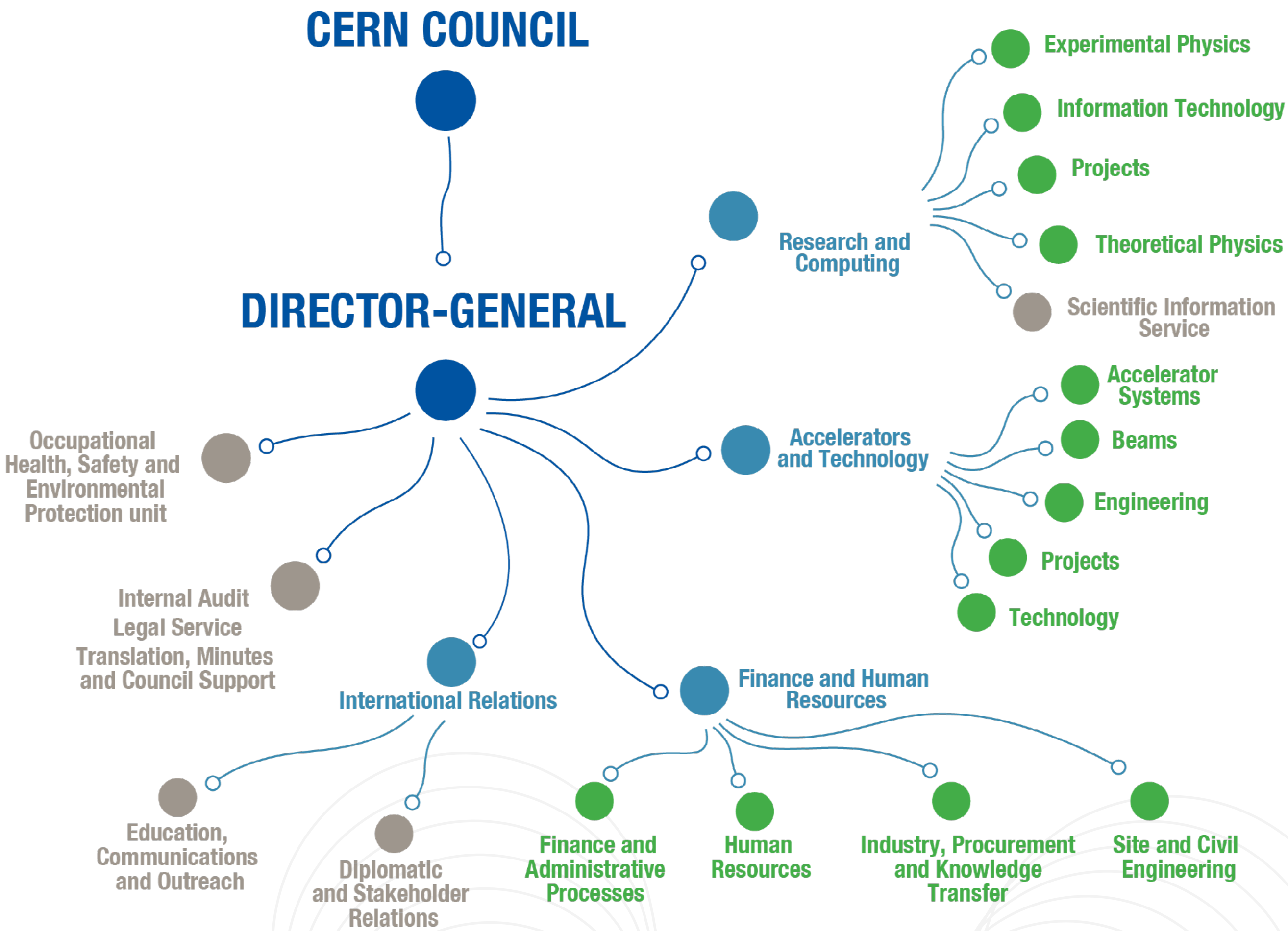
Planning for a successor to the HL-LHC is a priority for the Organization, along with R&D on various technologies in preparation for potential future facilities to extend CERN's research vision into the late 21st century. In 2021, responding to a recommendation from the 2020 update of the European Strategy for Particle Physics (ESPP) to "investigate the technical and financial feasibility of a future hadron collider at CERN with a centre-of-mass energy of at least 100 TeV and with an electron-positron Higgs and electroweak factory as a possible first stage", the CERN Council launched the Future Circular Collider Feasibility Study to examine the detailed implementation of such a venture. The mid-term review of this study, which evaluated the project's technological, geological, environmental, administrative, financial and territorial feasibility, was concluded in February 2024. The mid-term review generated positive conclusions, along with high expectations as to final results of the study, which are due to be released in 2025 as input for the ESPP update.

INSPIRING AND EDUCATING NEW GENERATIONS

Education is at the heart of CERN's mission, with its research and technology inspiring students and the public alike. The Laboratory has long been a popular destination, welcoming hundreds of thousands of visitors each year on guided tours. This reach expanded significantly with the opening of the CERN Science Gateway, a dedicated centre for education and outreach, inaugurated on 7 October 2023. By the end of 2024, it had welcomed over 450 000 visitors from more than 175 countries — a marked rise from the pre-opening annual average of around 150 000. Each year, several thousand students take part in CERN's training and graduate programmes, while many more engage with the Laboratory through a wide range of educational initiatives, from undergraduate internships to high-school competitions, primary school activities, and specialised training for high-school teachers.

ENGAGING WITH THE CERN COMMUNITY

CERN's Management is dedicated to environmentally responsible research practices and engages regularly with its personnel in order to foster the unique creative and innovative spirit that characterises the Organization for the benefit of the environment (see Knowledge and Technology for the Environment). Following a successful workshop in 2022 to inform the CERN community of the many actions and projects under way to address the Organization's environmental priorities and objectives, a Town Hall meeting was organised on CERN and the environment in November 2024 to provide an update and to introduce the new and expanded objectives for the period until 2030 (See Management Approach).



CERN's ORGANISATIONAL STRUCTURE IN 2023–2024
In blue, CERN sectors; in grey, CERN units and in green, CERN departments.

MANAGEMENT APPROACH

ENVIRONMENTAL STRATEGY AT CERN

CERN is deeply committed to environmental stewardship, which is integral to its operations and organisational goals. In alignment with the European Strategy for Particle Physics, which was last revised in 2020 and will be updated again in 2026, CERN adopts a systematic and unified approach to managing its environmental impact. The Strategy underscores the necessity for thorough examination and reduction of the environmental footprint of ongoing and future facilities.

CERN's environmental and sustainability strategy is founded on three primary principles: minimising the Laboratory's impact on the environment, minimising energy consumption while enhancing energy efficiency and reuse, and fostering the development of technologies that could contribute to mitigating the impact of society on the environment. The Occupational Health and Safety and Environmental Protection unit (HSE) acts as the principal authority on safety-related issues and monitors the implementation of the Organization's Safety policy, which integrates all health, safety and environmental aspects.

CERN adheres to the precautionary principle in all its environmental management efforts, taking proactive measures to avert significant environmental harm. This principle is universally applicable: in instances where available data does not allow a comprehensive risk assessment, precautionary actions are implemented without exception.

A STRUCTURED FRAMEWORK FOR ENVIRONMENTAL MANAGEMENT

CERN established the CERN Environmental Protection Steering board (CEPS) in 2017. CEPS is responsible for identifying and prioritising key environmental areas in alignment with CERN's strategy and proposing specific action plans. Environmental objectives are approved by the Enlarged Directorate, which comprises all Directors and Department Heads. Following approval, CEPS oversees the execution of these objectives, which are periodically reviewed to address evolving priorities.

CERN's Energy Management Panel (EMP), created in 2015 and comprising all the main energy consumers and stakeholders, complements these efforts by focusing on energy consumption reduction, efficiency improvements and energy reuse initiatives. The EMP was further strengthened in 2023 by the creation of the enlarged EMP, which specifically oversees the provisions of the ISO 50001 certification obtained by CERN on 2 February 2023. As the main internationally recognised energy management standard, ISO 50001 sets out processes to continuously improve energy performance. CERN follows these processes by setting up, monitoring and further developing an energy management system that is aligned with its energy policy and relevant legislation (see Energy).

Further, with a view to fostering the sustainability of its operations and future projects, the Sustainable Accelerator Panel (SAP) was set up in 2023 to liaise with future accelerator initiatives and develop full lifecycle sustainability as a key consideration in any project's inception phase. The SAP also serves to identify accelerator technologies with the potential to reduce the environmental impact of future accelerators and collaborates with key partners, acting as a forum and focal point for exchange and discussion.

CERN's environmental management approach includes an array of dedicated tools developed by the Organization, all of which support CERN's commitment to environmental compliance and monitoring (See Environmental Compliance and Management of Hazardous Substances).

COLLABORATION WITH THE HOST STATES

As CERN operates on both French and Swiss territory, it collaborates closely with its two Host States, adopting regulations that are aligned with those of France and Switzerland. In cases where CERN has no specific regulation, national laws and regulations apply on a territorial basis.

In 2007, CERN formalised its collaboration with the Canton of Geneva and the Prefecture of Ain through a tripartite committee on non-radiological environmental matters (*Comité Tripartite pour l'Environnement* – CTE). This committee holds regular meetings to coordinate environmental issues. Additionally, in 2010, CERN signed a tripartite agreement on radiation protection and radiation safety with the Swiss Federal Office of Public Health (FOPH) and the French Nuclear Safety Authority (ASNR, formerly ASN), which provides a legal framework for radiation-related matters and fosters ongoing cooperation and reporting between CERN and these authorities.

FUNDING SCHEMES FOR ENVIRONMENTAL INITIATIVES

CERN continually updates its environmental strategy, identifying high-priority projects across several environmental domains. These initiatives have been allocated a budget of some 66 MCHF for the years 2019 to 2024. Projects include heat recovery systems, building consolidation, R&D on environmentally friendly gases and gas systems for detectors, and the construction of water retention basins.

In addition, CERN's Knowledge Transfer (KT) fund, launched in 2011 to bridge the gap between research and industry, supports projects that apply CERN's technologies for the benefit of the environment. The fund has allocated 1 MCHF to the projects of the CERN Innovation Programme on Environmental Applications (CIPEA) since the Programme was launched in 2022 (see Knowledge and Technology for the Environment). This sum is complemented by a nearly equivalent amount directly contributed by the various departments to support these projects. Between them, these internal contributions represent some 20% of the total equivalent budget supporting the programme, with the remaining 80% provided by the external commercial and institutional partners, either in cash or in kind.

SUSTAINABLE PROCUREMENT AND SUPPLY CHAIN

CERN's commitment to environmental responsibility extends to its procurement processes. As an intergovernmental organisation, CERN shapes its own procurement rules standards, prioritising competitive tendering and balanced returns for its Member and Associate Member States. In June 2023, the Organization adopted the CERN Environmentally Responsible Procurement Policy, committing CERN to achieve sustainable results both internally and throughout its supply chains, integrating relevant best practices in its processes, measuring their impact, and communicating with and raising the awareness of all stakeholders. The Policy, approved by the Enlarged Directorate in June 2023, came into force on 1 January 2024 (See Procurement and Materials).

MATERIALITY AND REPORTING SCOPE

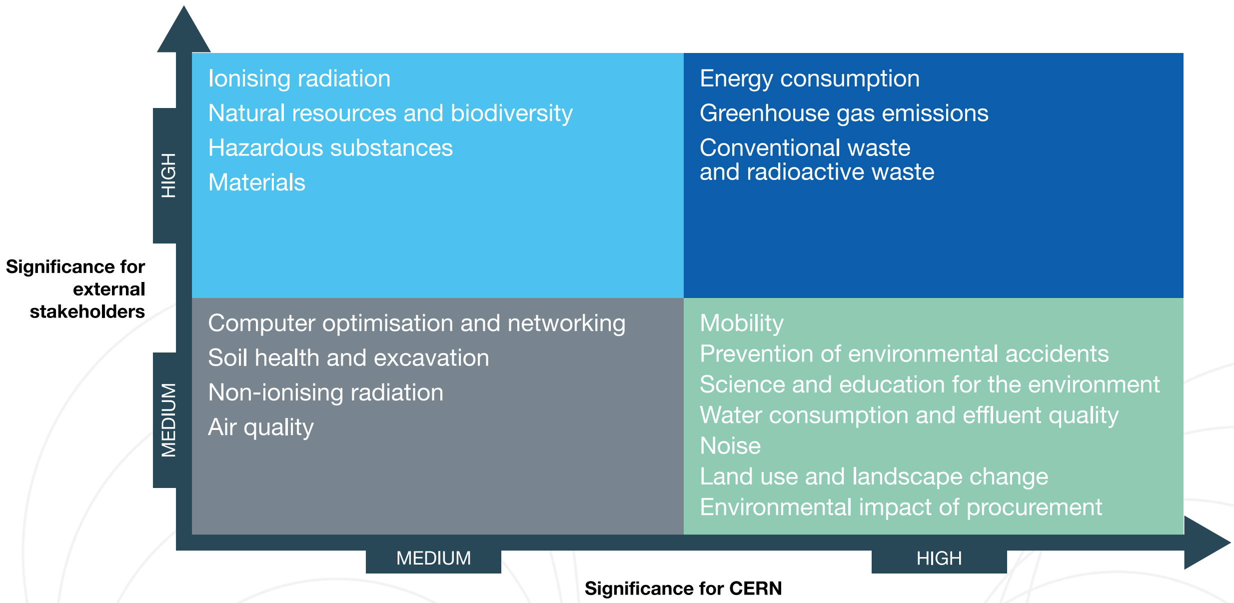
In 2022, CERN updated its materiality analysis to address topics deemed significant by both internal and external stakeholders, following the sustainability reporting standards of the Global Reporting Initiative (GRI), as well as addressing several CERN-specific issues. This analysis, whose results determined the focus areas of this report, also identified topics including soil health, non-ionising radiation and air quality as areas for future focus, while other topics such as effluent quality were identified as a lower priority but are still reported on for continuity and transparency.

The data presented in this report reflects the impact of its facilities in the Geneva region, focusing exclusively on CERN-managed infrastructure. The production of equipment by collaborating institutes is excluded from the scope of the report. The Worldwide LHC Computing Grid (WLCG), while global, is included only where CERN facilities are directly involved.

In 1955, as an international organisation, CERN created its own social security system, including a pension scheme: the CERN Pension Fund. In 1968, CERN and the European Space Observatory (ESO) signed an agreement whereby ESO personnel joined the Fund. The purpose of the Fund is to insure its members and beneficiaries and members of their families against the economic consequences of disability, old age and death. In November 2021, the Pension Fund Governing Board (PFGB) adopted an Environmental, Social and Governance (ESG) policy as an integral part of the Fund's Statement of Investment Principles. At the same time, the PFGB approved an ESG implementation work plan, with an explicit focus on addressing climate-related risks and opportunities. The results are reported yearly as an integral part of the Fund's annual report and, given the distinct context, approach and framework, are not included in the scope of this report.

INTRODUCING ENVIRONMENTAL OBJECTIVES FOR THE PERIOD UNTIL 2030

CERN's first environmental objectives covering the years 2020 until 2025, the anticipated end of Run 3, were defined by the CEPS in 2019 and approved by the Organization's Enlarged Directorate in early 2020. In 2024, a revised schedule for the operation and shutdown of the accelerator complex was approved, delaying the end of Run 3 and the start of the third Long Shutdown to mid-2026. While this report provides an update on progress with respect to these original objectives, environmental objectives covering the period until 2030 have been developed and discussed by the CEPS as part of a participative and iterative process. These objectives were formally presented to and approved by the Enlarged Directorate in January 2024 and are set out in the relevant chapters of this report, where applicable.



CERN MATERIALITY MATRIX 2022
The topics identified as being of lower significance to all stakeholders are not comprehensively covered in this report but are subject to monitoring by CERN.

ENERGY

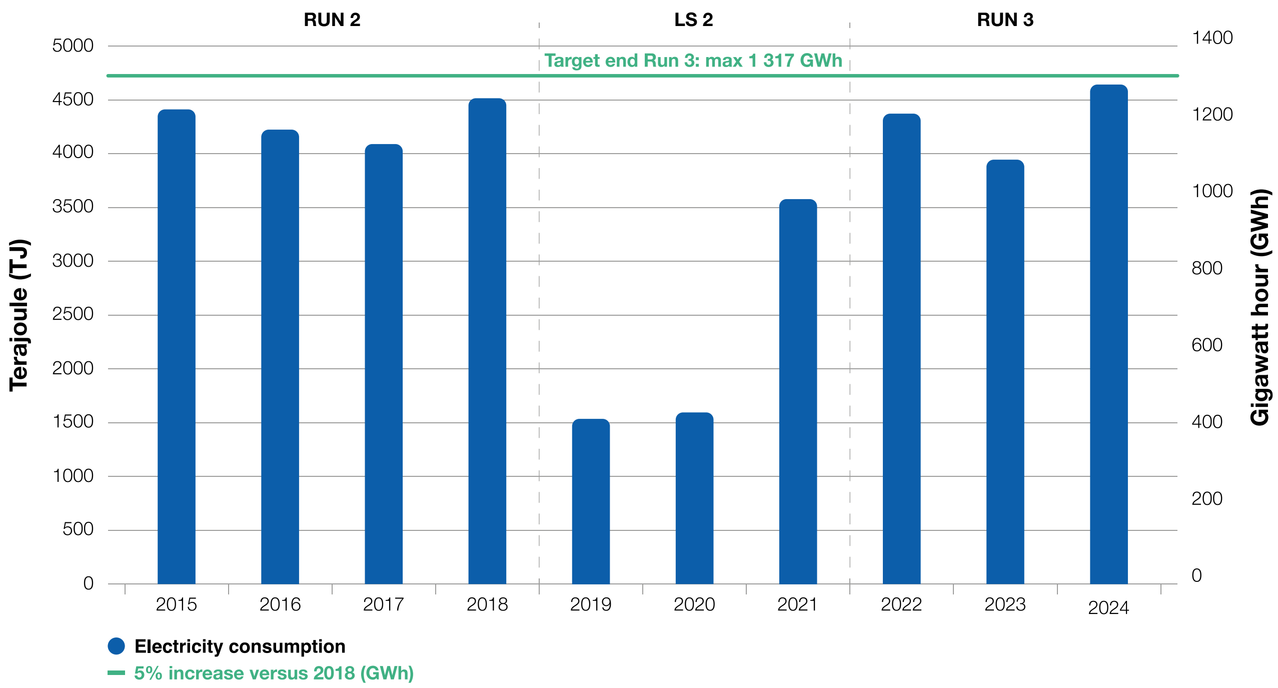
One of the main pillars of CERN's efforts to minimise its impact on the environment is the pursuit of actions and technologies aimed at energy savings and reuse, with a commitment to operate the accelerators and related infrastructures as efficiently as possible. A key objective is to limit the increase in electricity consumption to no more than 5% above 2018 levels until the end of Run 3.

POWERING SCIENCE

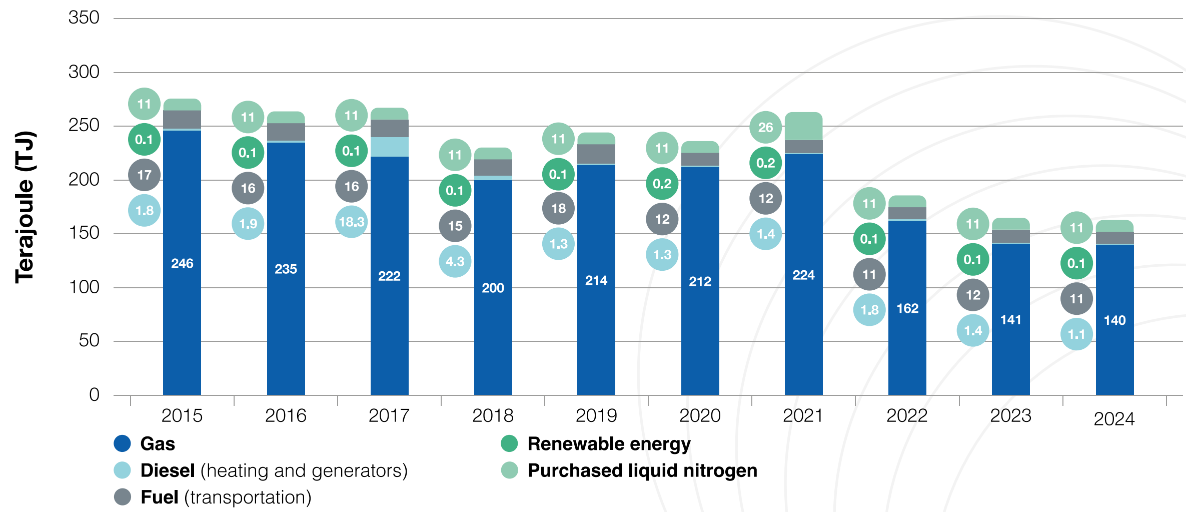
CERN's unique array of accelerators, detectors, computing and other technical infrastructure is primarily powered by electricity, accounting for about 95% of CERN's total energy use. Its flagship accelerator, the Large Hadron Collider (LHC), accounts for some 55% of the total consumption. In 2023 and 2024, which were both operation ('Run') years, CERN's electricity consumption amounted to 1 096 GWh (3 946 TJ) and 1 290 GWh (4 645 TJ), respectively. In 2023, in the wake of the energy crisis, accelerator operation was reduced by 20% by extending the Year End Technical Stop (YETS) to 19 weeks, leading to savings of about 70 GWh of electricity.

Specific projects to renovate the ventilation and cooling systems of the accelerators are under way with a view to achieving energy gains of 8 GWh per year. In this vein, during the reporting period, the ventilation system that cools the Meyrin data centre was fully renovated, including installation of variable-speed drives. Since 2022, to further foster energy savings, the LHC cryogenic installations have been operating in "eco mode" whenever possible, leading to energy savings of up to 20 GWh per year.

The Laboratory also uses natural gas for heating, fuel for its fleet of vehicles and diesel for emergency generators, and consumed 43 GWh (154 TJ) of fossil fuels in both 2023 and 2024. It also uses commercial liquid nitrogen for cooling and small amounts of photovoltaic energy produced on the CERN site.



CERN'S ELECTRICITY CONSUMPTION 2015–2024
Runs refer to the years in which the accelerators are in operation, with annual year-end technical stops and additional technical stops as and when necessary. Outside these periods, the accelerator complex enters 'long shutdowns' for essential maintenance, renovation and upgrades. In 2023, a technical issue led to the stop of the machine for one month, with an impact on electricity consumption. Note: following the award of the ISO 50001 certification, the energy data calculation process has changed from a monitoring-based approach to an invoicing-based approach, incurring very small variations with respect to previous years' data, which has been updated in the graph accordingly. Notably, the target for the end of Run 3 has been recalculated as 1 317 GWh, compared to 1 314 GWh previously.



CERN'S ENERGY CONSUMPTION – OTHER CATEGORIES OF ENERGY 2015–2024
In line with ISO 50001 certification requirements, notably the transition to more accurate invoice-based data collection, all values have been adjusted for previous years.

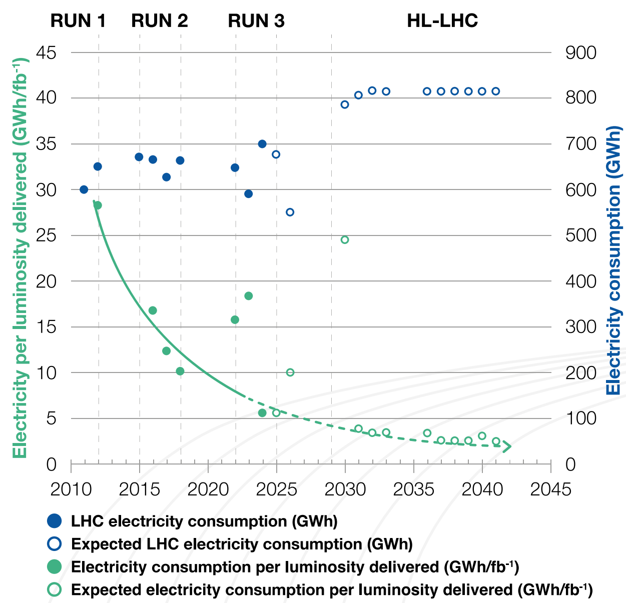
CERN's frontier physics programme relies upon ever more data being delivered to the experiments, which is measured in the LHC by a parameter known as luminosity. Higher luminosity increases the number of proton-proton collisions, hence data collection, enhancing statistical precision and the potential for discoveries. However, it can also lead to higher electricity consumption. In addition to limiting the increase in electricity consumption to 14% during High-Luminosity LHC (HL-LHC) compared with the consumption in Run 3, CERN is committed to improving energy efficiency by maximising the luminosity delivered per unit of energy consumed. Between Run 1 and the end of Run 2 (i.e., from the start of the LHC to 2018), the LHC's efficiency in this regard tripled. With the HL-LHC, a further improvement by a factor of four is projected.

CERN's ENERGY STRATEGY

CERN's Energy Management Panel (EMP), established in 2015, drives CERN's energy strategy, which spans three pillars: increase efficiency, use less, and recover waste energy. CERN's energy management approach is further strengthened by the CERN Energy Policy (published in 2022), a dedicated energy coordinator and the enlarged EMP, which meets regularly to include all of CERN's activities beyond the accelerator complex. Furthermore, CERN collaborates closely with its Host States through the tripartite committee for the environment (*Comité Tripartite pour l'Environnement* - CTE), which was established in 2007, and with its grid operators and electricity suppliers.

Energy procurement currently represents 5 to 10% of CERN's annual budget when the accelerators are running, and less during shutdown periods. Electricity is primarily procured from France, whose energy grid mix is more than 95% low carbon (2024).

In the context of CERN's Environmentally Responsible Procurement Policy Project (see Procurement and Materials), procurement guidelines for equipment, products and services have been established in which energy performance over the planned or expected operating lifetime is one of the criteria. This applies to the procurement of any item where power exceeds 500 kW or annual energy consumption exceeds 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 (LS), while the accelerator is being brought back online and progressively ramped up, the luminosity delivered is not at its maximum – as seen in 2022 and expected for 2030. The outliers in 2023 are due to the technical issue that led to the stop of the LHC machine for one month, with an impact on electricity consumption. The outliers forecast for 2026 are due to the partial operation of the machine (LS starting mid-year).

ISO 50001 CERTIFICATION

The ISO 50001 standard provides guidance and tools to improve energy performance and integrates energy management into overall efforts to improve quality and environmental management. CERN was awarded the ISO 50001 certification on 2 February 2023 for a period of three years, covering the entire perimeter of the Organization across all sites, as well as all activities and energies. In this context, mandatory annual surveillance audits are carried out by the French national organisation for standardisation, AFNOR. Successful external and internal audits (two of each) were carried out in the reporting period; the results confirmed that the organisational structure and technical measures implemented by the Organization meet and often exceed the required standards and are effective in optimising energy management processes.

The official AFNOR ISO 50001 certification logo. (Image: AFNOR)

OPTIMISING ENERGY ACROSS THE CAMPUS

The energy that the Organization needs to power its buildings and general infrastructure represents about 10% of its total consumption. Continuous optimisation efforts are underpinned by an extensive consolidation programme that spans five years and is reviewed annually in the case of the heating, electrical, ventilation and air conditioning infrastructure. The *Office Cantonal de l'Energie* (OCEN) in Geneva, Switzerland, notably contributes to financing such consolidation work on the Meyrin site.

Specific measures further support CERN's efforts to minimise energy use. These measures include delaying the annual start-up of district heating, adapting it to the weather conditions and reducing the temperature of the boilers, representing gas savings of 15 GWh per year compared to pre-2022 levels. A campaign was launched in 2023 to replace halogen lamps with energy-efficient LEDs in tertiary buildings. By the end of 2024, the project was 95% complete with some 50 000 lamps replaced, resulting in total electricity savings of approximately 3 GWh per year.

HEAT RECOVERY

Waste energy recovery is a priority for the Organization, with several dedicated projects at various stages of advancement. These are critical to achieving considerable gas savings by 2030 of some 60% compared to 2018.
In February 2024, CERN inaugurated its new state-of-the-art data centre located on the Prévessin site. The new building is equipped with an efficient heat-recovery system that will be connected up in the winter of 2026/2027 and will contribute to heating all the buildings on the Prévessin site. Another project on the Meyrin site, consisting in recovering heat from the LHC Point 1 cooling towers, got under way during the reporting period. Both projects represent total energy savings of some 25–30 GWh per year as of 2027.

At LHC Point 8 near Ferney-Voltaire in France, the final stage of the work to connect up the equipment needed to heat a neighbouring residential area was completed on CERN's side at the end of 2024. It is estimated that, as of 2026, some 20 GWh per year will thus be recovered from the cooling towers at Point 8.

ALTERNATIVE ENERGY SOURCES

Diversifying its energy mix, notably with photovoltaic energy, is an important aspect of CERN's responsible energy management framework. An extensive study of the use of the roofs and car parks on CERN's sites for installing photovoltaic panels was performed in the reporting period, and the associated energy and cost benefits were found to be minimal. Consequently, in the search for suitable solutions to achieve its objective of covering part of its electricity needs through renewable energy, CERN signed three physical power purchase agreements (PPAs) with energy providers in France at the end of 2024. These PPAs will provide solar power covering approximately 140 GWh of CERN's annual electricity consumption from 2027 onwards (see In Focus). This represents 30% of the electricity consumption during shutdown periods and about 10% during operation ('Run') years.

On a smaller scale, the CERN Science Gateway building on the CERN site, which was inaugurated in October 2023, comprises 1855 solar panels each measuring two square metres. These panels cover the building's energy needs, and inject any surplus photovoltaic energy into CERN's grid.

COMPUTING AND IT INFRASTRUCTURE

CERN's main objective is to provide extensive data to scientists in order to further fundamental physics research and hone our understanding of the Universe. This data, of the order of ~200 Petabytes in 2024 for the LHC experiments only, is generated mainly by the particle beam collisions captured by the experiments. The Worldwide LHC Computing Grid (WLCG) is a global collaboration bringing together CERN and some 160 computing centres in more than 40 countries to link up national and international computing infrastructures and thus provide the global computing resources necessary to store, distribute and analyse these vast amounts of data. The energy consumption figures provided in this report relate exclusively to facilities owned or operated by CERN.

The High-Luminosity LHC (HL-LHC) project is expected to deliver a tenfold increase in the amount of physics data collected during its period of exploitation (scheduled to end in 2041) compared to the original LHC design, leading to a considerable rise in the computing capacity required by the experiments. CERN is committed to balancing the associated rise in energy needs through strategic planning aimed at optimising the computing infrastructure and its hardware and software tools. Ongoing efforts focus on modernising code, optimising its performance for the latest hardware, and improving data management. By developing innovative approaches to key computing tasks – including machine learning and related technologies – CERN is making progress towards reducing the overall computing resources required, helping to limit energy consumption growth.

The new data centre in Prévessin, inaugurated in February 2024, is designed to provide up to 12 megawatts (MW) of power capacity for computing, to be deployed in three phases in line with CERN's evolving needs. The upgrade to Phase 2 (8 MW) is scheduled for 2027/2028 to meet the demands of the first run of HL-LHC (Run 4). The data centre targets a power usage effectiveness (PUE) of around 1.1 — a level of energy efficiency significantly better than the industry average, where large data centres typically operate at PUEs of 1.5 and new facilities achieve between 1.2 and 1.4 (with a score closer to 1.0 indicating higher efficiency). The Meyrin data centre, with a PUE of below 1.5, is housed in a 1970s building that was not originally designed for modern computing equipment, making further optimisation challenging. It will continue to operate, focusing mainly on storage activities that are better suited to its lower power density. Plans to enhance its power efficiency and improve sustainability, for example by reducing the number of UPS systems and batteries, are under discussion.

Growing awareness across computing and physics communities, along with rising energy costs and regulatory requirements, are driving a stronger commitment to sustainable computing practices. The WLCG collaboration at large is engaged collectively in assessing new methods and technologies to minimise environmental impact. In this vein, the first WLCG sustainability workshop was held in December 2024 to further foster collaboration, share best practices and drive efficiency across the network. The first main objectives include setting up a framework to collect information related to energy efficiency, to facilitate the use of more energy-efficient hardware where possible and to develop and promote a sustainability plan to improve energy efficiency and reduce carbon footprint. The objectives cover software, computing models, facilities, and hardware technology and lifecycle.

GOALS FOR 2030

By 2030, CERN aims to continuously improve the Organization's energy performance by minimising the energy required for its activities, enhancing energy efficiency and recovering waste energy. During Run 4 (2030–2033), the collision rate will increase by a factor of five compared to the nominal LHC design and this increase could reach a factor of 7.5 when the ultimate performance starts to be reached in Run 5. Despite this, CERN is committed to limiting its electricity consumption to 1.5 TWh per year, representing an increase of 14% compared to the original target for the end of Run 3. The objectives also include covering 10% of electricity needs through power purchase agreements (PPAs) based on renewable energies and reducing gas consumption by 60% compared to 2018 (on a weather-normalised basis).

The Prévessin data centre.

IN FOCUS

Nicolas Bellegarde is CERN's energy coordinator.

— What steps did CERN take to evaluate the potential use of solar energy to meet part of its electricity needs?

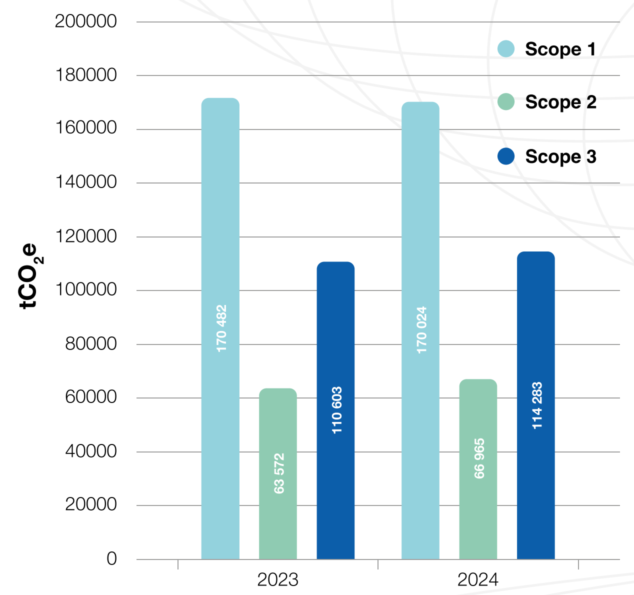
NB: Diversification of energy sources is part of the Organization's energy strategy, in line with the ISO 50001 requirements. Photovoltaic power has been under consideration for some time and we first revisited whether the CERN campus infrastructure, through use of its roofs and car parks, could be leveraged to install sufficient solar panels to meet 10% of our electricity needs. A study was undertaken in collaboration with Swiss Solar City, a company that specialises in equipping car parks and roofs with solar panels. This revealed that the potential accessible areas at CERN spanned some 100 parking spaces and a further 5 000 - 10 000 m² of roof surfaces, with no tangible technical or economic benefits. We therefore continued our search with external partners in the form of power purchase agreements (PPAs).

— What is the scope of the resulting PPA contracts signed at the end of 2024?

NB: The PPAs concerned will secure the supply of electricity from planned solar power plants in the Lozère, Bouches-du-Rhône and Var departments in southern France, giving access to a total area of approximately 90 hectares (900 000 m²) of solar panels, equivalent to more than 120 football pitches. This is equivalent to about 40% of CERN's fenced area; a project of this scale would have been unfeasible on the CERN site. The aim is that CERN should start to receive electricity from these plants as of January 2027. CERN has committed to purchasing electricity produced by the solar plants, representing a total of 95 MW peak power and a supply of 140 GWh/year over a period of 15 years.

EMISSIONS

CERN's commitment to minimising its impact on the environment includes a proactive approach to reducing its direct and indirect emissions, as defined by the internationally recognised methodology of the Greenhouse Gas Protocol and over which it has operational control. At CERN, scope 1 refers to the direct emissions resulting from the Organization's facilities (including its experiments) and vehicles, while scope 2 refers to indirect emissions related to the electricity purchased for the Organization's own use. Scope 3 refers to all other indirect emissions at CERN, arising from business travel, personnel commutes, catering, waste, water purification and procurement.



CERN'S TOTAL SCOPE 1, 2 AND 3 EMISSIONS 2023–2024

DIRECT EMISSIONS – SCOPE 1

The majority of CERN's direct greenhouse gas (GHG) emissions come from its large experiments, which are the main focus of the Organization's reduction efforts. These experiments use a range of gas mixtures for particle detection and detector cooling, with specific properties and characteristics, selected in order to optimise performance. These are mainly synthetic gases and refrigerants, including fluorinated gases (F-gases), some with a high global warming potential (GWP).

F-gases are widely used at CERN because they are highly effective for both detector cooling and particle detection. In cooling systems, they ensure that stable temperatures are maintained, which is crucial for highly sensitive equipment. In detectors, they play a key role in capturing particle interactions by detecting the passage of charged particles, offering excellent spatial and timing accuracy and in some cases providing light signals (Cherenkov radiation) allowing identification of different types of particles.

While intense R&D efforts to identify suitable alternative gases with a lower GWP continue, CERN published an F-Gas Policy in 2024 that formalises the Organization's commitment and strategy to minimise the emissions of these gases. The policy will be implemented through a variety of measures ranging from efficient management and monitoring of the procurement and use of F-gases to appropriate training of personnel and proactive communication to stakeholders.

The reporting period spans two full accelerator operation ('Run') years. The total amount of scope 1 emissions was 170 482 tonnes of CO_2 equivalent (tCO_2e) in 2023 and 170 024 tCO_2e in 2024. This is slightly lower than in 2022, the year in which Run 3 began, when 184 173 tCO_2e were emitted.

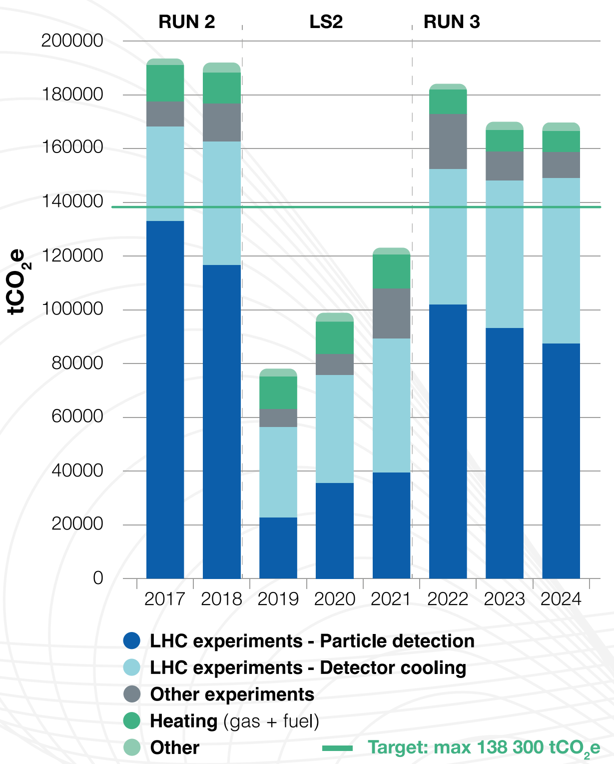
A THREE-PILLAR EMISSION REDUCTION STRATEGY

CERN has a dedicated strategy to reduce its direct emissions arising from particle detection, detector cooling and detector design. The strategy comprises three pillars: gas recirculation, gas recovery and the search for alternative ecofriendly gases.

In the context of particle detection, the main contributors to CERN's F-gas emissions are leaks in the gas distribution systems of some of the detectors. These leaks result from the complex mechanical integration of the detectors, which is driven by the need to fit them within the compact spaces that house them. This also complicates the task of identifying the origin of leaks. As leaks occur regularly, systematic leak-repair campaigns are organised to ensure that they are contained and minimised. The major leak-repair campaigns launched in ATLAS and CMS during the second Long Shutdown, LS2, continued in each Year End Technical Stop (YETS) and will resume in earnest during LS3, which is due to start in the middle of 2026. The leak repair procedure is carried out according to an optimised protocol, ensuring stable and reliable performance. In addition to repairing existing leaks, ATLAS has developed a new technique, which was applied during the last YETSs, consisting in injecting resin into the gas-inlet boxes to prevent the development of new leaks at the inlets. Preliminary results are promising, with a significant reduction of the development of new leaks observed in the boxes concerned.

Another strategy to reduce emissions from particle detectors involves diluting the mixtures that are currently used with gases with a lower GWP. In this vein, CO_2 was introduced to replace 30% of the HFC-134a gas in the resistive plate chamber (RPC) detectors of the ATLAS experiment, and to replace some 10% of the CF_4 gas in the LHCb experiment's RICH2 detector.

For the detector cooling systems, the experiments are advancing in the transition to CO_2-based cooling. Due to its efficiency in the temperature range around - 50 °C, CO_2-based cooling is a key component of CERN's strategy to reduce its direct scope 1 emissions by 28% by the end of Run 3. Several systems have already adopted CO_2 cooling, and significant progress was made with the upgrades of the ATLAS and CMS inner detector cooling systems during the reporting period. In 2024, surface installation of the primary CO_2 cooling plants began, while underground installation of the secondary CO_2 plants is under way and will continue into the next Long Shutdown.



CERN SCOPE 1 EMISSIONS FOR 2017–2024 BY CATEGORY
"Other" includes air conditioning, electrical insulation, emergency generators and the fuel consumption of the CERN vehicle fleet.

GROUP	GASES	tCO_2e 2023	tCO_2e 2024
Perfluorocarbons (PFCs)	CF_4, C_2F_6, C_3F_8, C_4F_{10}, C_6F_{14}	65 223	75 177
Hydrofluorocarbons (HFCs)	HFC-23 (CHF_3), HFC-32 (CH_2F_2), HFC-134a ($C_2H_2F_4$), HFC-404a, HFC-407c, HFC-410a, HFC-507, HFC	80 988	64 092
Other F-gases	SF_6, NF_3	14 906	21 567
Hydrofluoroolefins (HFOs)	R-449, R-1234ze, NOVEC 649, R-1233ef	145	1
	CO_2	9 220	9 187
Total Scope 1		170 482	170 024

BREAKDOWN OF SCOPE 1 EMISSIONS BY GAS TYPE 2023–2024
The tCO_2e values have been calculated based on the real consumption of the different gases, weighted by their GWP. The GWP is based on the IPCC Fourth Assessment Report, 2007 (AR4), which is also the reference used in EU Regulation 517/2014 on fluorinated greenhouse gases. Future reports will adopt updated GWP values based on the IPCC Sixth Assessment Report (AR6). All previously reported emissions and associated reduction targets will be realigned accordingly.

SEARCHING FOR ALTERNATIVE GASES

In addition to the increased use of CO_2 to cool the detectors, the search for alternatives to the GHGs currently used in particle detection is a priority for CERN and the experiments. This applies to both currently installed and future detectors and requires extensive testing to guarantee good detector performance and lifetime.

Intensive research is under way to develop new gases with a lower GWP to replace SF_6 and HFC-134a, focusing mainly on the hydrofluoroolefin (HFO) gas family. CERN and the experiments are testing new gas mixtures, including HFO-1234ze, for use in RPC detectors. Since the experiments are intended to operate for the decade following LS3, it is crucial to find gas mixtures that will not degrade components or affect performance over time.

RECIRCULATION AND RECOVERY

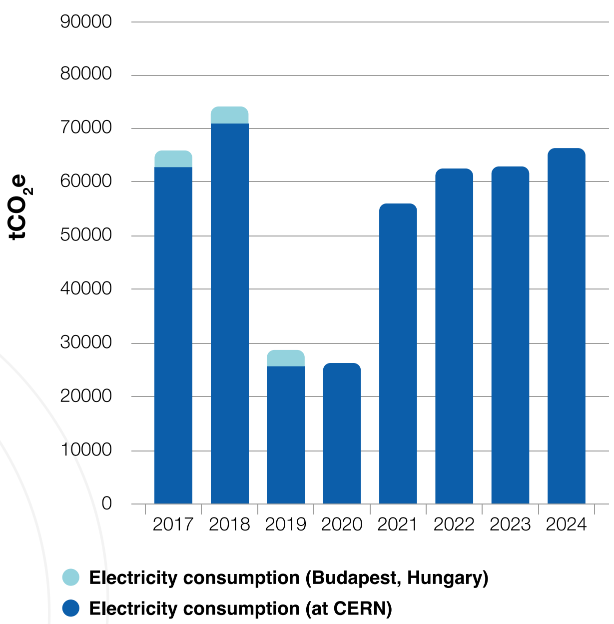
Gas recirculation systems within an experiment reduce the need for new gas and cut down on emissions. Large-scale recirculation systems installed at CERN have proven their effectiveness in optimising gas use in a context where environmental impact and cost criteria are ever greater considerations. In order to decrease the relatively small contribution of emissions incurred during laboratory tests, in the reporting period CERN developed a micro-recirculation system for small-scale laboratory use, available as a “DIY” kit at low cost. Such a system is used for demonstrations at the CERN Science Gateway and has already been used in some laboratories in and outside CERN.

Gas recovery captures used gases, removes impurities and allows the valuable parts to be reused instead of being released into the atmosphere. A custom-made plant for the recovery of HFC-134a from the specific RPC detector gas mixture has been designed at CERN and has been fully operational at the CMS experiment since 2024. The plant is running at 80% recovery efficiency. Ongoing research is focused on developing a new system based on a different separation method to get as close as possible to the maximum recovery efficiency of about 90%. Furthermore, a new C_4F_{10} recovery plant for the RICH1 detector of the LHCb experiment was designed in 2024 and is under construction. It is due to be operational from 2025. This completely new design integrates two different working principles, flash evaporation and distillation column, to reach higher efficiency compared to the previous installation that dates back to the 1980s.

Picture of the first HFC-134a recovery plant for the specific RPC detector gas mixture. The plant was developed at CERN and has been operational at the CMS experiment since 2024.

INDIRECT EMISSIONS – SCOPE 2

EDF, CERN’s principal electricity supplier, generates low-carbon electricity, mainly of nuclear origin, which contributes to keeping energy-related emissions relatively low. The Organization reports according to the location-based methodology, with calculations based on average yearly emission factors taken from ADEME Base Empreinte©. In 2023 and 2024 respectively, scope 2 greenhouse gas emissions due to CERN's electricity consumption were 63 572 and 66 965 tCO_2e (see Energy).



CERN SCOPE 2 EMISSIONS FOR 2017-2024
Emission calculations for electricity follow a location-based methodology, with average yearly emission factors taken from ADEME Base Empreinte© database. From 2017 to 2019, CERN operated a data centre at the Wigner Centre in Budapest, Hungary, for which the emissions are also shown. The location-based emission factors used for Hungary were taken from Bilan Carbone® V8.4.

OTHER INDIRECT EMISSIONS – SCOPE 3

CERN's scope 3 emissions span waste treatment and water purification, business travel, personnel commutes, catering and procurement. The emissions for all categories—with the exception of procurement, which is reported separately below—were assessed using an operational control approach based on the GHG Protocol accounting standard, applying the ecoinvent and AGRIBALYSE emission factors to activity-based data, and used the 2021 GWP values of the Intergovernmental Panel on Climate Change (IPCC), which include all gases covered by the report "AR6 Climate Change 2021: The Physical Science Basis". As required by the GRI standards and the GHG Protocol, biogenic emissions have been calculated using the IPCC 2021 methodology and are also reported in this chapter alongside fossil emissions. This is to account for the emissions from the biodegradation or combustion of biomass. CERN does not participate in any offset scheme.

Total scope 3 emissions excluding procurement amounted to 10 091 and 11 553 tCO_2e in 2023 and 2024, respectively (1 487 and 1 794 tCO_2e, respectively, for biogenic emissions). This represents less than 10 % of the Organization's total scope 3 emissions.

WASTE TREATMENT AND WATER PURIFICATION

Waste includes the waste that is sent through the different elimination pathways, as well as the water that is sent to wastewater treatment plants. Indirect emissions arising from waste treatment amounted to 1 522 tCO_2e and 1 312 tCO_2e in 2023 and 2024 respectively (543 and 497 tCO_2e, respectively, for biogenic emissions). Scope 3 emissions relating to water purification amounted to 152 and 144 tCO_2e in 2023 and 2024 respectively (226 and 223 tCO_2e, respectively, for biogenic emissions).

BUSINESS TRAVEL

This report focuses on business travel and commutes by personnel on the CERN payroll (approximately 5 000 people), as travel by CERN users falls outside the defined boundaries (see Management Approach). The travel of users is typically funded and managed by their host institutions, limiting CERN's oversight. Given the size of CERN's user community, their travel-related emissions are likely to significantly exceed those of personnel on CERN's payroll, leading to a broader impact of the user network on travel emissions.

Emissions arising from business travel amounted to 3 304 tCO_2e and 3 658 tCO_2e in 2023 and 2024 respectively (4 tCO_2e biogenic emissions in both years). Most of the emissions resulted from air travel, mainly long-haul flights.

A dedicated Duty Travel Working Group was set up in 2022 to provide guidelines on reducing duty-travel emissions without having a detrimental impact on CERN's operations. The recommendations were approved by the CERN Enlarged Directorate in January 2024. They recognise and integrate the crucial importance of international collaboration for the advancement of CERN's mission and research, while encouraging everyone to collectively set an example by reducing duty-travel-related carbon emissions. The recommendations include the objective of reducing air travel by considering virtual participation in meetings and conferences and discouraging single-day trips requiring air travel. Furthermore, the use of land transport (particularly train transport) is recommended for distances of up to 700 km, as transport options allow, taking into account time- and cost-efficiency. The recommendations also cover event guidelines to encourage organisers and participants to make mindful, environmentally conscious choices.

In parallel, travel services were optimised in 2024 with the implementation of a new travel booking system, which includes a feature indicating approximate emissions related to selected travel options, in a bid to further raise awareness among the CERN community.

PERSONNEL COMMUTES

Emissions resulting from commuting were calculated for employed and associated members of the personnel on CERN's payroll. They amounted to 5 340 tCO_2e and 5 382 tCO_2e in 2023 and 2024 respectively (36 tCO_2e biogenic emissions in both years). In addition, some 12 000 users regularly visit CERN for variable periods of time. Their emissions, as well as those of the contractors working on the site, are not included in the calculations.

By 2025, CERN aims to maintain current levels of individual motorised vehicle commuting, even as the scientific community grows. To encourage minimum reliance on private vehicles for its personnel, the Organization promotes alternative transport options, such as public transport and carpooling, and constantly seeks to improve the soft mobility infrastructure on its sites. A survey of mobility habits launched at the end of 2024 showed that 62% of CERN personnel use motorised vehicles to commute to CERN, including car sharing, which is stable compared to the last survey in 2022. 70% of CERN personnel commute to work from France, where the offer of public transport is less extensive than in Switzerland and the proportion of car users is slightly higher. The proportion of those walking and cycling to work is also stable and constitutes 23% of all commutes (24% in 2022). CERN's mobility plan is embedded in the CERN Masterplan 2040, the Organization's vision in terms of future campus development for both of its main sites, Meyrin and Prévessin (see Biodiversity, Land Use and Landscape Change). A dedicated mobility working group meets regularly to review all aspects of mobility services and processes, including safety, car and bicycle rental solutions, public transport, soft mobility infrastructure and site access optimisation. Collaboration with the Host States aims at optimising the Laboratory's transport infrastructure and accessibility while contributing to soft mobility projects of benefit for neighbouring towns.

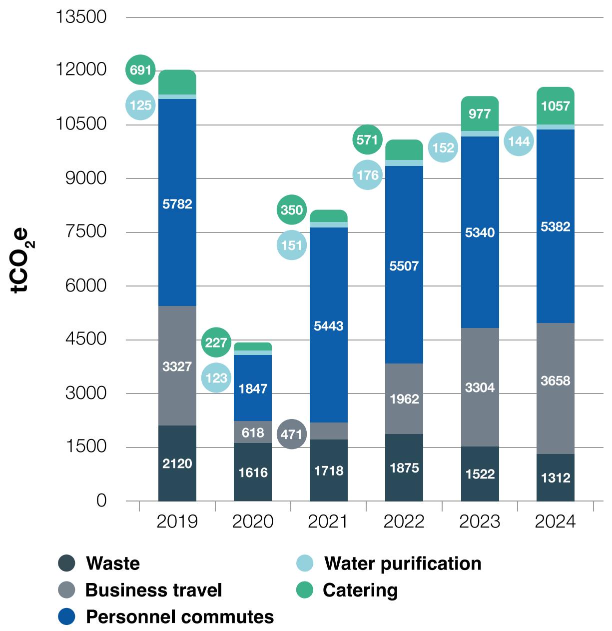
In the reporting period, 95 e-bicycles and 20 e-scooters were added to the established fleet of some 500 bicycles available free of charge to members of the personnel, while the number of recharging stations for e-vehicles and bicycle and bus shelters increased. 1 000 new bicycle spaces, built on existing car parks, were created in the two years. CERN also operates a car sharing service, a rental car fleet and a comprehensive intra- and inter-site shuttle service. CERN's professional car fleet comprises fewer than 700 vehicles and a plan for its progressive reduction by 25% and the introduction of electric cars – of which there are 20 to date – has been endorsed. The objective is to increase the number of electric vehicles to 50% of the fleet by 2030.

CATERING

CERN has three restaurants, six cafeterias and 75 vending machines on its sites, all run by external companies. The main provider is NOVAE, which operates all of the restaurants, five of the cafeterias and 45 of the vending machines. The restaurants served an estimated average of 2000 meals per day in 2024. The associated emissions are derived from the food products purchased before preparation and serving, while the energy used in the on-site kitchens for refrigeration and food preparation is included in CERN's scope 2 data. CERN's catering-related emissions were 977 tCO_2e and 1 057 tCO_2e in 2023 and 2024 respectively (678 and 1 034 tCO_2e biogenic emissions). Red meat and dairy products make the biggest contributions to these emissions. Data granularity has improved and the application of updated methodology and emission factors, combined with a return to pre-pandemic levels in the use of the CERN restaurants, has led to an increase in emissions related to catering compared to previous years (see graph).

Continuous improvements are being made to further reduce single-use plastics and other waste.

NOVAE is updating its sustainability roadmap for the period until 2030, optimising its operations with a focus on food supply and origin, increasing the use of seasonal produce from local suppliers and making a continuous effort to reduce its carbon footprint; the company had managed to reduce the latter by 29% in 2024 by banning the use of air transport for its supplies, paying close attention to the provenance of fresh produce and exotic fruit and favouring produce of European origin. At CERN, in a bid to reduce waste, the "ReCIRCLE" initiative involves serving meals in reusable packaging, which is subject to the payment of a deposit. The "No Gaspi" campaign comprises four consecutive weeks each year dedicated to measuring food waste, identifying the sources of waste and developing action plans to reduce it. In this campaign, the CERN restaurants scored highly with respect to the recommendations of the Swiss Confederation, meeting the best-practice target of 45 grammes of waste per meal; below this threshold, food waste is deemed to be well managed. The average number of vegetarian dishes sold in NOVAE restaurants reached 30% in 2024 and efforts to encourage uptake continued, with a wider variety on offer. CERN's main restaurant was awarded the 2050Today prize in the "Concours à Table!" sustainable catering competition run by the City and Canton of Geneva. The prize rewards community restaurants in international Geneva that provide an attractive and sustainable culinary offering (local, seasonal products, diversity of vegetarian options) and show initiative in reducing food waste.



CERN'S SCOPE 3 EMISSIONS 2019–2024 (EXCLUDING PROCUREMENT)

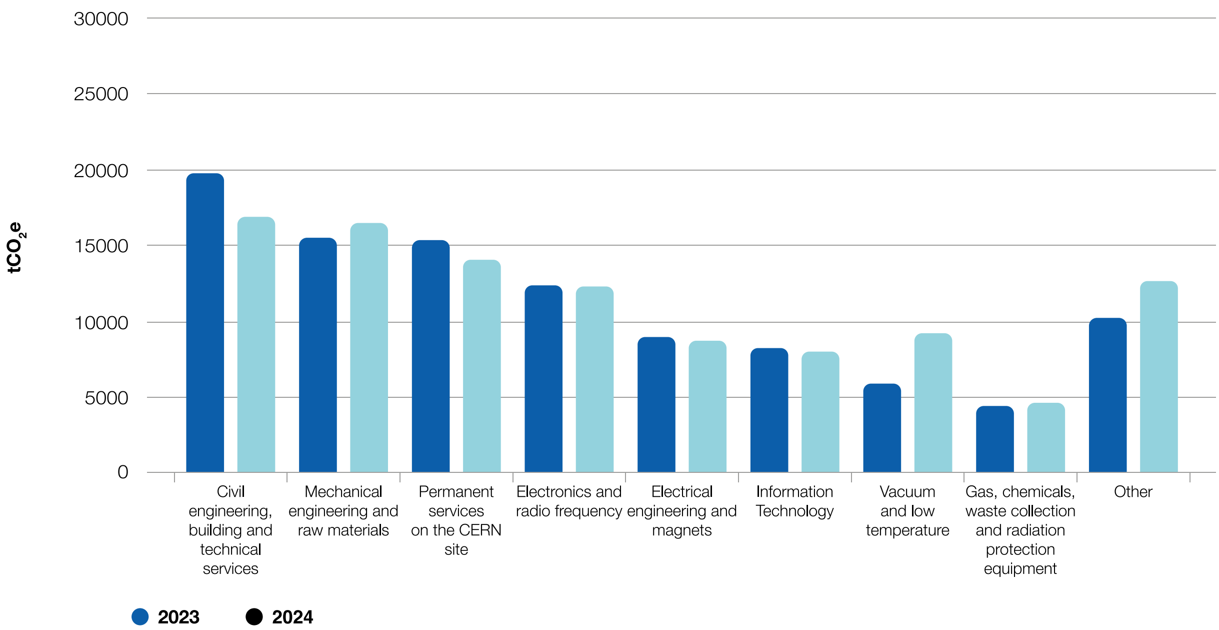
The calculation methodology is aligned with the GHG Protocol. The emission factors for 2023 and 2024 were retrieved from the ecoinvent 3.10 database for personnel commutes, waste and water and from the AGRIBALYSE 3.1 database for catering. The impact method used was IPCC 2021 GWP100 V1.01. Note that data for previous reporting years has not been recalculated for this report. Concerning business travel, a change in the source data used to compile travel data in 2021 led to miscalculations for the years 2021 and 2022, with return flights counted as one-way journeys. This has been corrected in the present report. Emissions arising from procurement are not included and are reported separately below.

SCOPE 3 EMISSIONS ARISING FROM PROCUREMENT

In 2023 and 2024, respectively, CERN's spending on supplies, services and utilities amounted to around 573 MCHF and 612 MCHF. Of this, 484 MCHF in 2023 and 510 MCHF in 2024, i.e. some 84% of the total, was spent on supplies and services, whose emissions are classified as scope 3. Associated emissions amounted to 100 512 tCO_2e in 2023 and 102 730 tCO_2e in 2024. Procurement emissions represent some 90% of the total CERN scope 3 emissions, and around 29% of all CERN emissions.

The methodology used to calculate procurement emissions follows the Greenhouse Gas Protocol spend-based method, which establishes a direct correlation between expenses and the related amount of emissions, using emission intensity factors taken from the 2021 EXIOBASE 3 database; these factors have been updated with country-specific inflation rates for 2023 and 2024. The methodology also incorporates data derived from the Climatiq Procurement Endpoint model, which is based on basic prices and includes adjustment for inflation. Given the recognised limitations of the spend-based approach, CERN is proactively engaged in evolving towards the more precise activity-based methodology.

In 2023, the Enlarged Directorate approved the CERN Environmentally Responsible Procurement Policy, with which several specific implementation actions are associated and under way (see Procurement and Materials).
With regard to scope 3 emissions in particular, a comprehensive programme of engagement with CERN suppliers was initiated with a view to progressively moving to activity-based information that will improve the precision of procurement emission calculations. This approach will provide deeper insight into the key challenges and priorities, taking into account the complexity of CERN's infrastructure and governance systems (see In Focus).



EMISSIONS BY PROCUREMENT FAMILY 2023-2024
"Other" includes: office supplies, furniture, communication and training; transport, handling and vehicles; centralised expenses and codes for internal use; particle and photon detectors; health, safety and environment; optics and photonics. Note: the reported amounts concern both CERN budget expenses and expenditure on external funds for collaborations and experiments.

IN FOCUS

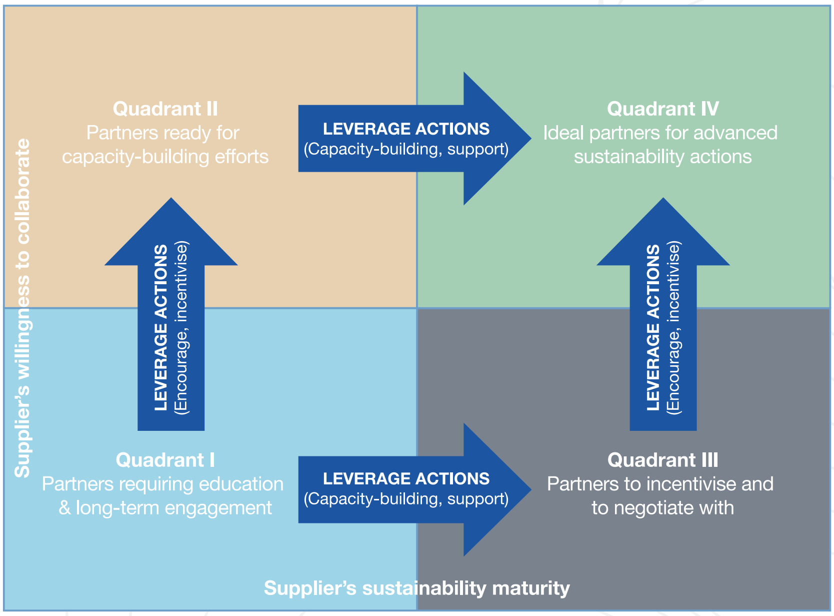
Enrico Cennini is the leader of the CERN Environmentally Responsible Procurement Policy Project (CERP3) in CERN's Procurement and Industrial Services group.

— How has CERN engaged with its suppliers to better understand the impact of procurement on CERN emissions across its supply chain?

EC: The spend-based method we currently use at CERN to calculate emissions arising from procurement is effective in helping us to understand the indirect emissions arising from the supply chain and to identify those procurement families on which CERN can focus its decarbonisation efforts. As part of CERN's supply chain capacity building initiative, we launched a survey of the largest suppliers in terms of spending and those responsible for 80% of scope 3 emissions (267 suppliers). The objective was to collect data on their environmental performance and more specifically on their carbon reduction strategies, classify them according to the Steel & Court Supplier Preferencing Model and elaborate tailored action plans for each category and procurement family (see figure). We focused on the six highest CO_2-emitting areas: civil engineering; mechanical engineering and raw materials; services on the CERN site; electronics and radiofrequency; electrical engineering; and IT. These plans aim to enhance sustainability maturity across the supply chain and align efforts with CERN's sustainability objectives. Sharing knowledge and engaging with peers is an essential building block of our efforts to refine our approach. In this vein, we participated in the international Scope 3 Peer Group Strategy Days in 2023 and 2024, which are designed to allow us to understand the latest evolutions and integrate best practices and lessons learnt in mitigating scope 3 emissions from procurement activities.

— What future actions are you planning?

EC: Our objective is to continuously evolve our procurement practices, internally and in close collaboration with our suppliers. On the one hand CERN will proactively embed environmental considerations wherever appropriate in tendering processes and request more detailed reporting from suppliers on their emissions. To support suppliers in embedding sustainability in their supply chain, we aim to facilitate access to relevant capacity-building resources and materials, such as CO_2 emission calculation tools. Workshops will be organised to facilitate knowledge exchange and joint objective setting, with the first in 2025 for companies providing services on the CERN site. Additionally, we will evaluate a supplier sustainability due diligence tool in order to build a CERN supplier sustainability database. As part of our ongoing collaboration with peer laboratories, we will share insights on CERN's sustainable procurement practices through presentations at established relevant working groups and conferences such as the Big Science Business Forum, which focuses on high-technology and innovation to bridge the gap between research infrastructures and industry in Europe.



Matrix based on the Steel & Court (1996) Supplier Preferencing Model elaborated to classify CERN suppliers and used to develop tailored action plans to enhance sustainability in the CERN supply chain.

GOALS FOR 2030

By 2030, CERN's scope 1 objective is to reduce emissions of greenhouse gases resulting from the Organization's activities by 50%.

With regard to scope 2, CERN aims to keep direct and indirect emissions linked to energy constant with respect to 2018.

The objectives for scope 3 are: for commuting, to reduce individual motorised transport to 50%; for business travel, to reduce emissions by 30% compared to 2019; and for catering, to increase the offer of vegetarian/vegan meals to up to 50% of the total offer. For procurement, objectives are under development in the framework of the Environmentally Responsible Procurement Policy Project and will be reported in future reports.

PROCUREMENT AND MATERIALS

CERN's procurement rules focus on ensuring that the acquisition of supplies, services and utilities supports the Organization's scientific mission while adhering to principles of transparency, impartiality, efficiency and sustainability. The Organization procures a wide range of materials, goods, services and utilities from suppliers across its Member and Associate Member States to support its operational needs and infrastructure development.

PROCUREMENT AT CERN

CERN strives to ensure balanced returns for its Member and Associate Member States and prioritises competitive tendering to optimise the use of its resources, with an emphasis on collaboration with suppliers to foster innovation and compliance with environmental standards.

In 2023 and 2024 respectively, CERN spent around 573 MCHF and 612 MCHF on supplies, services and utilities. Procurement is the biggest contributor to the Organization's scope 3 emissions, representing some 90% of the total (see Emissions).

ENVIRONMENTALLY RESPONSIBLE PROCUREMENT

During the reporting period, the Organization took an important step towards integrating sustainability into its procurement processes by adopting an Environmentally Responsible Procurement Policy along with an implementation strategy, both approved by CERN's Enlarged Directorate in 2023. The CERN Environmentally Responsible Procurement Policy Project (CERP3), launched in 2021, established organisational and technical levers for sustainable procurement and their implementation was initiated in collaboration with several services with a view to integrating environmentally responsible practices into their purchases and ensuring engagement with all stakeholders across the supply chain.

In this vein, the Organization published the CERN Supplier Code of Conduct in 2024, outlining what CERN expects from its suppliers and the principles that apply to them, which place emphasis on ethical, sustainable and responsible business practices. To be eligible for CERN business, suppliers must acknowledge and adhere to this Code. CERN also started testing a supplier sustainability due diligence tool to assess and engage with suppliers based on their environmental performance. Additionally, pilot projects helped to gather information about the maturity of existing and prospective suppliers and evaluate the integration of environmental criteria into market surveys and invitations to tender.

An important lever for the implementation of the Environmentally Responsible Procurement Policy is the mobilisation and capacity building of internal stakeholders. To engage the Organization's personnel with the Policy, a general e-learning course on the environmental impact of procurement and the implementation of the Policy in accordance with ISO 20400:2017 (the sustainable procurement guidance standard) has been deployed, and a more specific training course for procurement officers has been developed. A pilot inter-departmental workshop on embedding environmentally responsible practices in procurement was held in 2024, bringing together the procurement service and the campus and supply chain services, and paved the way for future workshops to disseminate knowledge and best practices across the Organization.

In 2024, CERN launched a survey of the suppliers responsible for 80% of scope 3 emissions in order to collect essential data on the suppliers' environmental performance and, more specifically, on their carbon reduction strategies (see Emissions). Tailored actions have been launched in 2025 for the most-emitting procurement families and a complete review is planned at the end of the year. This will pave the way for future decisions regarding how to further embed sustainability in tendering procedures.

By integrating environmental responsibility into purchasing practices and engaging suppliers in tailored strategies, CERN seeks to support more sustainable procurement in complex research environments and share its experience openly with collaborating institutes. Although time is necessary to embed change and evolution, these efforts reflect the Organization's commitment to reducing its environmental impact while fostering collaboration with its supply chain to achieve its environmental goals.

MANAGEMENT OF MATERIALS

CERN's materials management practices are reported for the first time. CERN's material needs are driven by the demands of cutting-edge scientific research and infrastructure, which require materials of exceptional quality and unique characteristics. Balancing these stringent requirements with ethical and environmentally responsible procurement practices is a significant challenge. Materials management ranges from optimisation of the use of core materials such as metals and helium to the use of recycled or secondary resources to minimise the environmental and human rights impacts throughout the materials' lifecycle.

A VARIETY OF MATERIALS FOR COMPLEX REQUIREMENTS

CERN's operations depend on a wide variety of materials that support its research and infrastructures. These include:

- Metals, such as high-purity copper, niobium and titanium, crucial for constructing magnets and other particle accelerator components.
- Construction materials, notably concrete and steel for tunnels, shielding and building infrastructure.
- Electronic components and advanced electronics, such as silicon detectors and radiation-hardened semiconductors for particle detection and other systems.
- Cryogenic gases, mainly liquid helium and nitrogen for cooling superconducting magnets and other systems, and other gases for detector cooling and particle detection (see Emissions).

Given the complexity of tracing materials throughout their whole lifecycle, the reporting period focused on reviewing the procurement framework to start mapping CERN's material flows and identifying opportunities for better traceability and impact assessment. This is driven by input from dedicated groups to guide materials selection in critical domains such as metals, cables, connectors and vacuum technologies (see In Focus). Further, the CERN Supplier Code of Conduct emphasises environmentally responsible practices, ensuring that suppliers focus on sustainable material sourcing, prioritise recyclable resources and minimise hazardous substances.

To address current challenges and improve material sustainability, CERN plans to collaborate further with suppliers to improve data on recycled content, with the objective of continuously increasing the latter and reducing material waste. Further, the Organization will develop processes to improve the traceability of materials across their lifecycle and will extend pilot projects to incorporate recycled and secondary materials into procurement contracts wherever feasible.

KEY MATERIALS AND SUSTAINABILITY FOCUS

Efforts to improve the sustainability of CERN's operations target the following key materials:

- Helium: a by-product of liquid natural gas, helium is non-renewable and its supply is tied to finite fossil fuel reserves. CERN aims to design cryogenics systems with optimised helium tightness, ensuring continuous improvement of operations to minimise losses while exploring alternative sourcing methods and reducing reliance where possible.
- Nitrogen: while it is a naturally abundant element in ambient air, the supply of liquid nitrogen for industrial purposes depends heavily on energy-intensive processes. The plants supplying CERN are located in France. CERN's liquid nitrogen consumption falls under the Organization's overall energy management strategy, which follows ISO 50001 standard (see Energy).
- Metals, construction materials and electronics: while finite, these materials offer significant recycling potential. CERN is committed to increasing the use of recycled content, enhancing circular economy practices and improving traceability through supplier engagement.

Further investigations are under way to assess the percentage of recycled materials currently in use and set goals for increasing recycled content. This ongoing commitment reflects CERN's broader mission to integrate sustainability into every aspect of its operations.

The following table shows the quantities of key raw materials, including gases (helium and nitrogen), metals, plastics and wood, delivered to CERN in the reporting period. Volumes vary year on year, depending on the needs of the Organization.

	2023 (metric tonnes)	2024 (metric tonnes)
Renewable		
Wood	6.8	5
Non-renewable		
Gases		
Helium	31.8	30.5
Nitrogen	6 284	8 240
Metals		
Aluminium, aluminium alloys	47.7	44.3
Copper, copper alloys	50.1	40.8
Iron	1	1.2
Nickel alloys	1.4	1.1
Stainless steel	251.4	111.6
Steel	67.1	56.9
Titanium, titanium alloys	0.008	0.03
Tungsten	0	0.71
Plastics	10	9

KEY MATERIALS DELIVERED TO CERN 2023 – 2024

IN FOCUS

Leila Akhouay is the metal raw materials referencing specialist in CERN's Services and Supply Chain group. Ana Teresa Perez chairs the CERN Standardisation Technical Sub-Committee (CSTSC) for metal raw materials.

— What is CERN's approach to procuring metal raw materials?

LA: CERN has a dedicated referencing team that coordinates the long-term procurement of metal raw materials that are essential for its operations. This team ensures easy access to industrial-standard metals, as well as highly specific materials required for CERN's unique applications.

Our priority is to maintain stock with full traceability, including Material Origin Certificates, ensuring quality and compliance. Collaboration and effective communication are at the heart of our processes. We work closely with end users, onsite workshops, technical experts and trusted suppliers to source specific metals such as high-purity copper, austenitic stainless steel, aluminium and titanium.

These specific metals are necessary to withstand CERN's demanding environments, including ultra-high and high-vacuum, radiation and cryogenic conditions. This means not only sourcing the highest-quality materials but also going one step beyond by implementing rigorous quality controls throughout the entire manufacturing process. From raw material selection to final delivery, we closely monitor each stage, including forging, rolling, pre-machining, heat treatment, etc., ensuring that every product meets CERN's stringent technical specifications.

We also receive some special requests from our users, which need expert input, inspections and supplier discussions to ensure that the requested quality product is obtained. This approach adds value also when materials are needed on a large scale, as it ensures consistency, reduces non-conformities and allows supply challenges to be anticipated. Additionally, we optimise procurement by grouping needs together and minimising transport to reduce environmental impact.

— What role does the standardisation sub-committee play in this process?

ATP: Industry standards are not always aligned with CERN's specific needs. That's why the Organization established a standardisation sub-committee on metal raw materials in 2022, alongside two others focused on vacuum equipment and cables/connectors. This sub-committee helps to define CERN's standards, evaluates metal raw material needs, defines and updates technical specifications and develops procurement strategies.

Beyond setting standards, we stay up to date on market trends, new processes and innovations. Knowledge sharing helps us to anticipate changes and implement best practices effectively.

Decisions from the sub-committee are validated by the CERN Standardisation Committee (CSC), and then shared with the referencing team which works closely with users to consolidate and optimise orders. A constant exchange between teams allows us to tailor solutions with due consideration of sustainability and reliability. This process ensures a comprehensive view of CERN's needs and promotes efficient and environmentally responsible procurement.

IONISING RADIATION

At CERN, ionising radiation is produced by the collisions of particle beams with matter. It is also produced by radioactive sources that are used to test and calibrate equipment to ensure its safe operation. CERN's commitment to the continuous improvement of its procedures and systems in order to minimise the exposure of workers, the public and the environment makes the Organization a benchmark in the field.

What is ionising radiation?

Ionising radiation is a natural phenomenon. It comes from certain minerals in the earth, from space through cosmic rays or from UV radiation. However, it can also be produced artificially for medical or diagnostic purposes such as X-Rays. Industrial and research facilities can also generate and use ionising radiation.

All humans are naturally exposed to, and receive daily, small doses of ionising radiation due to these natural and human-made sources. The limits for exposure to ionising radiation are defined by regulations, which are based on the consideration that health risks increase in proportion to exposure. Evidence suggests that cells can repair radiation damage at low doses. Over a normal year, we receive a dose of about 3 mSv from radiation of natural origin. Some activities, such as flying, smoking and medical X-rays result in an increased dose.

MANAGING IONISING RADIATION AT CERN

CERN implements internationally recognised radiation protection and radiation safety systems and also contributes to their development. The Organization continuously improves procedures to minimise the risk of radiation exposure and the dissemination of radioactive material. In particular, it adheres to the internationally recognised As Low As Reasonably Achievable (ALARA) principle, which is applied from the design and operation of installations through to their dismantling.

CERN's legal framework for radiation protection covers the protection of CERN personnel, the public and the environment and is based on Host State legislation, as well as on applicable European and international standards and best practice in matters of radiation protection and radiation safety. A tripartite agreement between CERN and its Host States has been in force since 2010, providing the legal framework for the discussion of CERN-wide radiation safety and radiation protection matters in a transparent and collaborative way (see Management Approach).

In this context, CERN issues quarterly environmental monitoring reports spanning both radiological and physicochemical aspects to the Swiss and French authorities.

MONITORING AND PREDICTING

The Laboratory operates an extensive network of environmental radiation monitors and online sampling systems. In 2024, the environmental monitoring programme comprised 131 monitoring stations for various purposes, 35 of which are dedicated to stray radiation, 60 to ventilation and radiological monitoring of water, 16 to physicochemical monitoring and the remainder to aerosol sampling and weather monitoring. The monitoring programme is supplemented by use of thermoluminescent dosimeters and measurement of environmental samples.

Ventilation monitoring station on the Meyrin site.

The environmental monitoring infrastructure is part of CERN's automated control and safety systems. The Radiation and Environmental Monitoring Unified System (REMUS) allows operators to view radiation levels in real time across the site and receive alerts if any abnormalities are detected.

CERN's models to evaluate the doses that members of the public could potentially receive are based on widely recognised models and standards, despite the specific nature of CERN's facilities. In April 2023, these models were reviewed and endorsed by the Host State authorities. The endorsed models are now used in all assessments of CERN's radiological environmental impact, including both retrospective evaluations of current operations and prospective impact studies for future projects.

Furthermore, the Swiss Federal Office for Public Health (FOPH) and the French *Autorité de sûreté nucléaire et de radioprotection* (ASNR, formerly ASN) place their own monitoring devices on the CERN site to monitor stray radiation and environmental radioactivity inside and outside the CERN perimeter. This contributes to broader annual measuring campaigns beyond CERN's borders, both in Switzerland and in France.

MINIMAL RADIOLOGICAL IMPACT

The radiological impact of CERN on the public is very small. In 2024, the dose received by any member of the public living near the Laboratory was below 0.01 millisievert (mSv), over one hundred times lower than the Host States' limit for public exposure from all regulated sources, which is 1 mSv in a year.

At CERN, all workers who could potentially be exposed to ionising radiation (radiation workers) are provided with personal dosimeters to monitor their exposure. Exposure frequency varies concomitantly with machine operation and shutdown periods. CERN's provisions and measures ensure that the Organization stays well below the regulatory limits of 6 mSv for category B radiation workers and 20 mSv for category A radiation workers, as defined by Swiss and EU regulations. The majority of radiation workers register a null dose (0 mSv).

GOALS FOR 2030

Despite an expanding physics programme, CERN's objective in the period until 2030 is to keep its radiological environmental impact negligible by continually optimising its facilities and activities to ensure that doses potentially received by the public are kept below 0.02 mSv per year.

IN FOCUS

Angela Goehring-Crinon is the legal adviser for the HSE unit and the person responsible for links with the radiation protection and radiation safety authorities in the Host States. Stefan Roesler is the Head of the CERN Radiation Protection group. Both share their perspectives on the impact of the tripartite agreement on radiation protection and radiation safety, which was signed in 2010.

— 15 years after its signature, how has the tripartite agreement shaped CERN's approach to the regulatory framework regarding radiation protection and radiation safety at CERN?

AGC: The tripartite agreement creates a unified legal framework to discuss how the common objective of protecting people working on the CERN site and the public against ionising radiation can best be achieved in the context of CERN's activities. Keeping CERN in line with standard best practice in the Host States and in Europe whilst taking the Organization's specific technical and organisational characteristics into account is a challenge that is addressed through an open and constructive dialogue between the parties. An example of this collaboration is the development of an original classification method for transporting CERN's radioactive materials, which ensures compliance with the agreement concerning the international carriage of dangerous goods by road (ADR) transport procedures in its unique cross-border context. The Host States also facilitate CERN's functioning by recognising authorisations issued by the other country and by allowing CERN to eliminate its radioactive waste through the most suitable pathway in either country, in line with the fair share principle (see Waste).

— From a technical perspective, how has the tripartite agreement influenced the development and implementation of radiation protection measures?

SR: The tripartite agreement ensures uniform radiation protection measures across all CERN installations, regardless of their location. It covers the entire lifecycle of a facility, from its design to operational radiation protection practices and radioactive waste management.

A good example is the simplified clearance method for components from radiation areas with negligible activation risks. The method was developed in house and approved by the Host States. It enables rapid radiological classification of components that are removed during shutdowns, which is essential for CERN's efficient functioning, while ensuring that radiation protection requirements are met.

The agreement has also made it possible to streamline radioactive waste management, centralising treatment before disposal at CERN's dedicated facility and leveraging Host State infrastructure for sustainable waste elimination.

Finally, worthy of mention is the method developed for assessing CERN's radiological impact on the public and the environment which has been agreed with the Host State authorities. It is tailor-made to allow CERN's emissions to be monitored in its particular context.

BIODIVERSITY, LAND USE AND LANDSCAPE CHANGE

At the end of 2024, the CERN site spanned 624 hectares, broken down into 116 hectares dedicated to buildings and road infrastructure, 413 hectares of cultivated fields, meadows and recreational areas and 95 hectares of forests and woodland. It also includes four wetlands. All these areas harbour a rich diversity of wildlife, including rare species. CERN has implemented a dedicated programme that ensures environmental preservation, fostering biodiversity while meeting the Organization's evolving needs with minimal impact.

THE CERN MASTERPLAN

CERN's Masterplan, first published in 2015 and revised in 2021, reflects the Organization's vision for the period until 2040. This important tool reflects the current and future needs of the Laboratory, including potential development outside the present fenced area, along with those of its neighbours. It centres on four pillars: urban planning, mobility, environmental protection and landscaping, and serves as a guide for the Organization to ensure optimal, coherent growth while balancing operational efficiency, energy use and environmental considerations.

CERN's fenced site is constantly evolving, and specific areas are consequently impacted. Every consideration is therefore given to minimising the environmental impact of planned works or work to consolidate external spaces (e.g. building construction, consolidation of a car park, roof renovation) that are deemed essential for the continued good functioning of the Organization. In such cases, certifications such as BREEAM (Building Research Establishment Environmental Assessment Method) provide a solid framework for taking all environmental aspects into account, from the design phase to construction and operation. The BREEAM approach entails evaluating a future building's environmental performance according to multiple criteria, including energy, water management, greenhouse gas emissions, interior air quality, use of sustainable materials, waste management, ecology and biodiversity. This methodology has notably been followed for the design of a new emblematic building on the Prévessin site that was initiated in 2023, whose construction is due to be completed by 2027. This state-of-the-art building of some 13 000 m^2 is intended to provide office space for approximately 475 people, as well as laboratory and workshop space, meeting rooms and a restaurant. The certification's findings allow the development of suitable measures to integrate this building into the environment as efficiently and effectively as possible in order to optimise the preservation of the ecological surroundings and biodiversity based on the initial state surveys.

Environmental preoccupations are considered at the very beginning of large projects. For example, the creation of the Open Sky Laboratory (OSL) at the LHC Point 5 site in Cessy, France, has converted 10 000 m^2 of CERN land, part of which was formerly used for HL-LHC works, into a dedicated area for tests of molasse (sedimentary rocks) extracted during the HL-LHC excavations. The objective of the OSL is to determine the feasibility of transforming the molasse into functional soil, using natural substances only, for use in landscaping, forestry and renaturation. The reuse potential of the excavation material is one of the factors that will contribute to the environmental acceptability and cost efficiency of constructing future underground accelerator projects.

The plot of land located near LHC Point 5 (CMS, Cessy, France), which hosts the Open Sky Laboratory.

Optimising the use of existing infrastructure is central to CERN's consolidation approach. In this context, continuous efforts are made to review the need for storage spaces to prevent them from encroaching on green spaces and to optimise their management through better centralisation and consolidation. This aligns with the Organization's strategy, which emphasises avoiding and reducing environmental impacts as a priority. Where such impact is unavoidable, comprehensive plans are developed to implement measures aimed to reduce it. Compensation is only considered as a last resort, when all impacts have not been avoided or sufficiently reduced.

Further, a study has been initiated, with the support of the Canton of Geneva, to develop a comprehensive landscape integration charter that will supplement the CERN Masterplan and is aligned with the Swiss sectoral plan and CERN's future needs. The results of this study will be published in future reports.

PRESERVING THE LANDSCAPE, FOSTERING BIODIVERSITY

CERN has implemented several measures to promote biodiversity on its land, following an approach based on low-intensity maintenance to foster biodiversity preservation, keeping watering to a minimum and avoiding fertilisers and chemicals wherever possible. Late mowing allows plants and animals to complete their reproductive cycle, while grazing with sheep supports meadow management of dedicated sectors that cover a total of 10 hectares on the Meyrin site and 25 hectares on the Prévessin site.

CERN’s 2021-2025 biodiversity action plan, developed by a dedicated biodiversity working group set up in 2020 and founded upon Host State regulations and best practices in the field of biodiversity, comprises a set of initiatives to preserve and enhance the Organization’s natural environment. The inventory of fauna and flora completed in 2022 identified some 50 hectares of areas of ecological interest, to be classed as a priority for preservation in the event of any planned works and projects. This data is now fully integrated in the Organization’s Geographical Information System (GIS) database. In the meantime, the inventory was complemented by a detailed census of the diverse species of trees around the sites, and their actual size and crown diameter were integrated in the GIS database to ensure better understanding of the CERN environment and improved management and monitoring of the impact of projects and worksites. Among the more than 2 200 trees that were inventoried, a number of remarkable species were identified, including old oak, ash and lime. A further action based on the inventory in the reporting period consisted in the creation of an online, virtual walk around the CERN sites to allow everyone to discover its biodiversity on an interactive journey.

In addition to its fenced site, CERN owns 95 hectares of forests and woodland, the majority of which are located in France and are jointly managed by CERN and the French forestry commission (*Office National des Forêts* – ONF). In the reporting period, a forest management plan with a biodiversity focus was developed for CERN's forest plots. Developed in collaboration with the ONF and due to be published in March 2025, this plan aims to enhance the ecological function of the areas concerned through targeted management strategies. Some of these strategies include free evolution, trail security and fencing, selective harvesting to enhance mature trees, enrichment through anticipatory planting to support natural regeneration, seed-based regeneration from standing trees, and improvement cutting to promote biodiversity.

Future efforts in the context of biodiversity preservation will include reducing light pollution, combating invasive species, promoting sustainable agriculture and creating a tree-planting plan to mitigate heat islands (see In Focus).

Bee orchids on the Prévessin site.

IN FOCUS

Jean-Paul Bergoeing is an environmental engineer in the Environmental Prevention section of CERN's Environment group.

— What is the importance of the heat islands study and how did you go about it?

JPB: The study of heat islands is important to understand how urbanised areas can create local temperature increases compared to their surroundings, often referred to as "urban heat islands" (UHI). These temperature differences may have health and environmental impacts, affecting the comfort and productivity of personnel, increasing energy consumption, disrupting the local fauna and flora and worsening air quality, particularly during extreme heat waves.

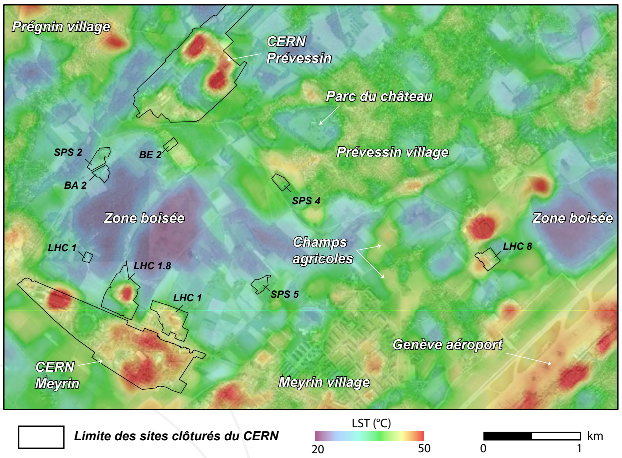
Our study used geomatic data-processing techniques to characterise CERN's tree cover and assess heat distribution. We applied a remote sensing approach using Landsat-8 images, which affords access to large amounts of data and wide spatial coverage. Landsat-8 is a satellite that captures high-resolution images of the planet that are in the visible, near-infrared and thermal infrared spectrum, providing detailed information about the Earth's surface. Using this information we can infer the Land Surface Temperature (LST) as an indication of the intensity of UHI phenomena.

— What has CERN learned from this study and how will it be used in future planning?

JPB: The study highlighted the areas of CERN's fenced sites that present surface temperatures significantly higher than the surrounding ambient temperature, with impermeable parking surfaces and building rooftops contributing to this issue.

In addition, CERN found that the areas with low tree canopy cover and impermeable surfaces are the hottest, proving that a reduced tree canopy plays a critical role in generating the UHI effect. Thankfully, space for new trees exists in roughly 35% of the total surface of the fenced sites, including some 4% on currently impermeable surfaces such as car parks.

This information can be used to create a tailored tree-planting plan that takes different types of heat islands, complex infrastructure constraints and personnel needs into account. The outcome of this study will be used in future planning to foster a cooler, healthier campus. The data will also guide the creation of a vegetation strategy to mitigate the urban heat island effect and simultaneously enhance biodiversity and ecosystems on the CERN site.



Land Surface Temperature (LST) distribution map for part of CERN's fenced site and some of the surrounding area, showing zones with temperatures up to 15°C higher than wooded areas. Map generated from a Landsat-8 image taken at 10.36 on 07/07/2022.

GOALS FOR 2030

By 2030, CERN's objective with respect to biodiversity is to conserve and enhance the Organization's natural, agricultural and forest areas, by preserving fauna and flora in the identified areas of ecological interest (shrublands, meadows, woodlands and wetlands) and reducing the presence of urban heat islands on the CERN sites.

WATER AND EFFLUENTS

Water is a critical resource for CERN's operations, particularly for cooling its accelerator complex. The Organization is committed to the continuous improvement of its installations in order to minimise water consumption and allow the quality of its effluents to be monitored.

MANAGING WATER CONSUMPTION

The majority of CERN's water consumption is due to its "industrial" activities, mainly the cooling of the accelerator complex, while a smaller fraction is used for sanitary purposes. 99% of CERN's water supply comes from the local *Lac Léman* and is provided by *Services Industriels de Genève* (SIG); the small remaining fraction comes from groundwater provided by the *Régie des Eaux Gessiennes* in France and is mainly used for sanitary and drinking purposes on the LHC sites. The water is of drinking quality and is used as it is or else demineralised. In 2023 and 2024, which were both operating periods, CERN's water consumption was 2 830 megalitres and 2 895 megalitres, respectively. These figures are lower than for the previous reference operation year, 2018 (3 477 megalitres), a reduction that represents an outstanding achievement.

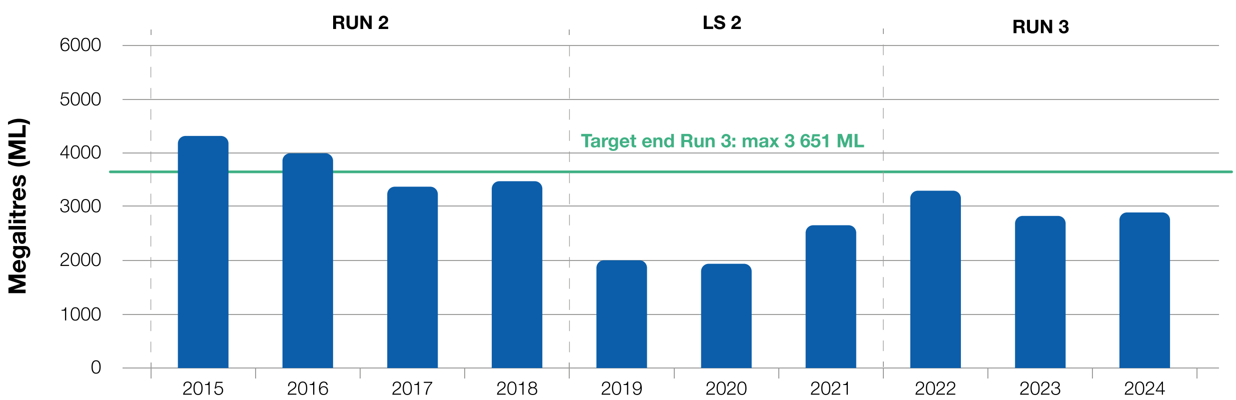
The tripartite environment committee meets regularly to allow CERN to exchange on water protection issues with the local Host State authorities, based on input from CERN's water monitoring programme (see Management Approach). CERN's environmental emergency preparedness framework includes intervention plans to address any incidents that may arise, along with procedures to mitigate the potential consequences for local watercourses and to notify the relevant Host State authorities and emergency services. Their effectiveness was tested and demonstrated during the reporting period, with a significant leak occurring in CERN's water distribution network, caused by drilling work. The incident was resolved in collaboration with the local services and authorities. No fine or sanction was incurred in the reporting period (see Environmental Compliance and Management of Hazardous Substances).

OPTIMISING THE WATER INFRASTRUCTURE

CERN is committed to keeping the increase in its water consumption below 5% up to the end of Run 3 (baseline year: 2018). Despite an increase in cooling needs anticipated with the upgrade of facilities, CERN is engaged in a continuous programme of improvement of its water infrastructure, optimising cooling towers and water networks to reduce effluent water, improve its quality and minimise water consumption. A good example of achievements in this area is the North Area cooling tower recycling plant, which, since commissioning in 2018, has undergone continuous optimisation to enhance yield and reduce water consumption. In 2023, more than 14 000 m³ of blowdown water was treated and recycled and reintegrated into the cooling towers.

The next major project concerns the renovation of the Antiproton Decelerator (AD) cooling infrastructure, which will lead to marked water consumption reductions as of 2027.

In the reporting period, CERN's two demineralised water production units, which feed the water networks of the various sites, were modified and optimised; renovation works on one of the two units further improved yield and contributed to the reduction of CERN's water consumption. The modifications led to a total reduction of water consumption of 12 000 m³ in 2024, while the renovation project is expected to bring a further reduction of some 20 000 m³/year.



CERN'S WATER CONSUMPTION 2015-2024

During the 2024 Year End Technical Stop, CERN implemented an automated system to streamline the monitoring and management of demineralised water ratios in its cooling circuits. This innovation aims to prevent overconsumption while maintaining optimal system performance. Initial tests have demonstrated promising results, and further dedicated trials are under way on selected circuits. These efforts are paving the way for a potential full-scale deployment across all circuits.

CERN's Technical Galleries Consolidation programme, launched in 2021 and spanning two decades, focuses on renewing key services such as the hot water distribution, drinking water and firefighting networks. Significant improvements in reliability, energy efficiency and water quality have been achieved. On the Meyrin site, the drinking water and firefighting networks in the West Area were completed, with over 3 km of new piping installed. Work has begun on upgrading the hot water circuit to reduce energy loss, and is due to be completed by 2028. Future renovation work to ensure that CERN's infrastructure meets modern standards will be aligned with the constraints of LS3.

In the next five years, two new cooling towers for the HL-LHC project and one for the CMS detector upgrade will be installed and will be operational towards the end of LS3.

WATER RELEASE AND EFFLUENT QUALITY

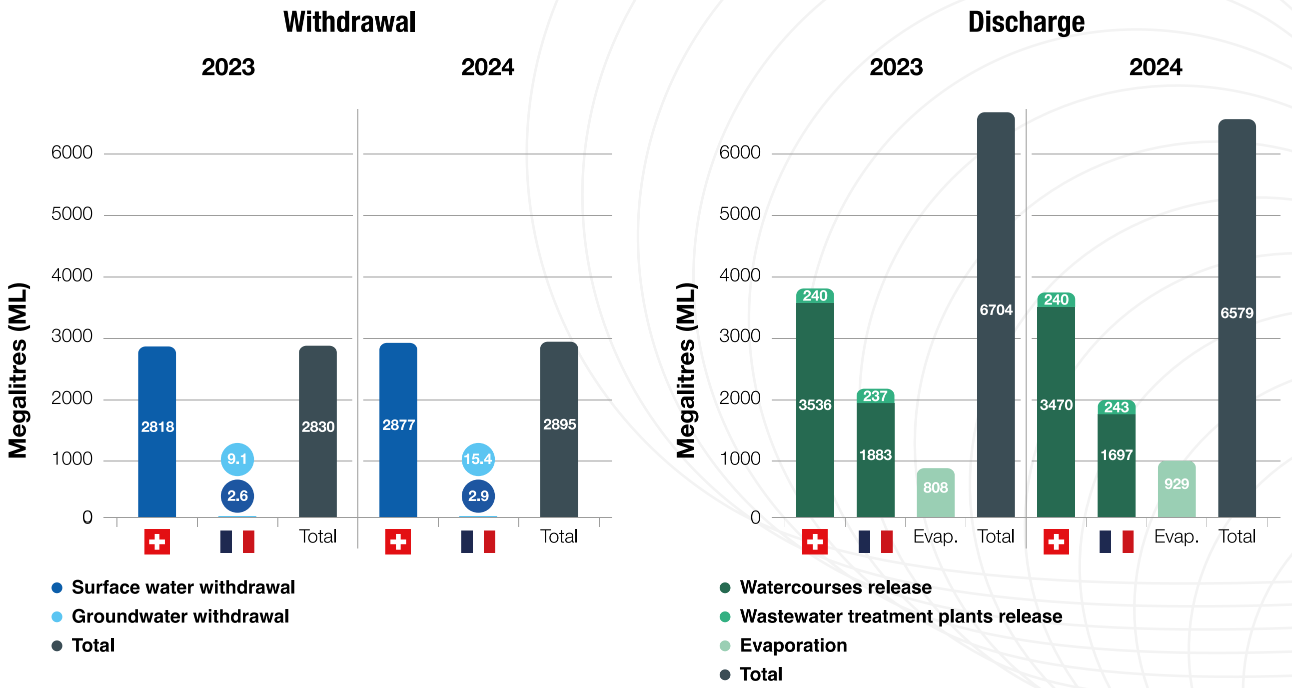
The Organization discharges rainwater, infiltration water and cooling water into local watercourses, some of which are small and sensitive to the quality of the effluents they receive. CERN continuously monitors the quality of its effluents in accordance with CERN-defined criteria that comply with Host State regulations and conducts regular sampling of the adjacent rivers to assess the impact of its operations. The results are provided quarterly to the Host State authorities.

A large part of the water used for cooling the accelerators is evaporated by CERN's cooling towers. A fraction is released as effluent water, which contains the residues of treatments to prevent scaling, corrosion and bacterial growth, including legionella. In 2024, CERN renewed its water treatment contract, which was used as an opportunity to eliminate the use of phosphate in such treatments.

A major project to consolidate the cooling towers started in 2016 with a view to improving the quality of effluent releases. As part of this project, the addition of demineralised water after the recycling process to allow blowdown water to be reused in cooling towers is proving effective in reducing releases into the neighbouring watercourses. Between 2018 and 2023, the total volume of effluent releases from the cooling towers on the Meyrin site was reduced from some 81 000 m^3 to just over 52 000 m^3. The next Long Shutdown, starting in 2026, will see the completion of the project to modify the cooling circuits, 70% of which were modified during LS2. The remaining 30% are the larger LHC and SPS circuits; a study was launched in the reporting period with a view to installing a new cooling water recycling plant at LHC Point 1 during LS3. The release of residual effluents from the recycling plant directly into the sewage network will limit the impact on the *Nant d'Avril* river.

Rainwater management on the CERN sites is another priority for the Organization, in line with the Masterplan 2040. According to the present strategy, all new projects affecting the Swiss watershed of the Meyrin site include rainwater retention solutions, either on the roof or in the form of basins that are buried or, where possible, in the open air. Retention basins are also a key feature of the Charter of the *Nant d'Avril*, signed in 2020, which aims to regulate the flow from the Meyrin site and prevent environmental incidents that could impact the watercourse.

CERN has implemented several rainwater retention initiatives to manage water runoff and improve water quality. On the Prévessin site, the retention basin built in 2020, located downstream of the site that includes a hydrocarbon separator for treating accidental releases, has proven its effectiveness in regulating the flow and managing the quality of water releases. An additional basin on the Prévessin site with a capacity of 3 000 m^3 was finalised in 2023 to manage stormwater runoff surplus and help to regulate the flow of release into the nearby *Lion* river. In the reporting period, it was decided to build two additional basins on the Meyrin site, namely a 2 800 m^3 storage tank to collect rainwater under one of the hostel buildings and a 1 000 m^3 vegetated pond designed to regulate rainwater flow, enhance biodiversity and limit the impact on the *Nant d'Avril* river.



WATER WITHDRAWAL AND DISCHARGE 2023 - 2024
Data shown for discharge into watercourses includes infiltration water, rainwater and cooling tower blowdown.
Evaporation (Evap.) refers to the water evaporated by CERN cooling towers.

IN FOCUS

Michela Lagioia is an HVAC engineer in the Site and Civil Engineering department's Site Asset Management team.

— What was the motivation behind upgrading the cooling of nine buildings on the Meyrin site?

ML: This project is part of the recurrent consolidation plan for the CERN site, which spans ten years and is reviewed annually. These particular buildings, constructed between 1961 and 1967, have an outdated cooling system, with over 20 units requiring frequent maintenance and generating high operational costs. The system comprises a cooling plant that supplies several workshops and laboratories, including the CO_2 laboratory, and a plasma cell for the AWAKE experiment, as well as offices. The goal was to replace it with a centralised, modern system to reduce the environmental impact, improve energy efficiency and simplify maintenance.

The chillers have been sized to take into account the existing needs, as well as possible future expansion needs. This upgrade supports CERN's environmental objectives while ensuring reliability for the labs, workspaces and workshops in these buildings.

— Can you describe the key improvements achieved through this project?

ML: The project was completed in three phases: installing a chilled water loop, centralising cooling production and upgrading the distribution systems. The new centralised cooling plant, which has been operational since summer 2024, supplies chilled water to laboratories and offices via an efficient network. This has significantly lowered energy consumption, reduced maintenance needs and enhanced overall reliability, marking a major step forward in modernising CERN's infrastructure.

GOALS FOR 2030

Over the period until 2030, CERN aims to optimise the Organization's water consumption, increase water retention and improve the quality of effluents released into watercourses.

The objective is to keep the water consumption below 3 600 megalitres despite the growing demand for cooling water, reduce the zinc load in effluents to the *Nant d'Avril* river in Switzerland by 90% and increase the water retention volume available on the CERN sites.

WASTE

CERN's strategy is designed to ensure the effective management of waste in a manner that prioritises safety for both individuals and the environment.

CONVENTIONAL WASTE MANAGEMENT

The majority of waste produced by CERN stems from its operations. Conventional waste is classified into three main categories: campus waste, industrial waste and worksite waste, and is further sub-divided into non-hazardous and hazardous waste.

CERN has a centralised waste management system in place that monitors the collection and transport of all conventional waste from campus and industrial sources. This system also maintains an inventory of waste exiting CERN to ensure the traceability of waste disposal routes. For grouping and optimisation purposes, hazardous waste is temporarily stored in a designated buffer zone that complies with the applicable safety regulations. It is collected on a weekly basis. The Laboratory collaborates with authorised third-party service providers for the disposal of conventional waste, excluding metals and electronic waste, which is sorted and sold for reuse and/or recycling in line with circular economy principles.

Data regarding end-of-life equipment collected by or returned to suppliers is not included in this report. CERN is committed to improving the traceability of the worksite waste managed by its contractors, who bear the responsibility for disposing of their own waste in accordance with the relevant Host State regulations and for duly reporting this to CERN. Accordingly, only partial data on worksite waste is included in this report, but more granular data will be provided in future reports.

In 2023 and 2024 respectively, CERN disposed of 3 625 tonnes and 3 419 tonnes of non-hazardous waste, and of 1 379 tonnes and 975 tonnes of hazardous waste (both conventional and radioactive).

Examples of conventional non-hazardous waste	Examples of conventional hazardous waste
Metals, glass, PET, paper and cardboard, coffee capsules, biodegradable organic waste, household waste, bulky items.	Chemicals and their containers, batteries, printer cartridges, lightbulbs, and equipment or materials contaminated with hazardous substances. Electrical and electronic equipment is monitored in accordance with the Swiss OMod regulation.

A DEDICATED ROADMAP FOR CONVENTIONAL WASTE

The Organization aspires to establish itself as an environmentally responsible campus, in full compliance with the relevant French and Swiss regulations regarding waste management and disposal. A comprehensive waste management roadmap was first published in August 2022 and is periodically reviewed to ensure that it continues to comply with best practices.

One of the pillars of CERN’s waste management strategy is the “5 R” principle: Refuse, Reduce, Reuse, Recycle and Return to Earth. The Organization strives to reduce the volume of waste at source and is improving its sorting to ensure a continuous increase of recycling and reuse rates, as well as to improve operations and traceability through better accounting of waste categories. The strategy is underpinned by a comprehensive data monitoring programme that informs decision making. The engagement of the CERN community at large is key to reaching these objectives, and continuous communication and awareness raising campaigns are undertaken to promote responsible waste management.

Increasing the rate of recycling of non-hazardous waste, which constitutes over 70% in weight of the total waste produced at CERN, is an ongoing priority. However, given CERN’s increased commitment to repurposing waste for reuse, the focus for 2030 has shifted from recycling alone to the more holistic notion of recovery: this term combines reuse and recycling and is more representative of CERN’s efforts to minimise waste (see Goals for 2030). In 2023 and 2024 respectively, 60 and 56 tonnes of non-hazardous waste were diverted from disposal.

To make it easier for all personnel to sort and dispose of waste close to their workstations, centralised sorting bins for campus waste, including various metals, are now available across the Organization’s many buildings and workshops. In addition, so-called ‘Ecopoints’ allow the sorting of larger waste to be centralised and improve the quality of sorting by providing clearly labelled containers for different types of waste.

CERN also operates a dedicated recovery and sales centre, which ensures that waste is appropriately prepared for reuse or recycling and sorted into the right channels. The service handles and sells hardware, which comes from the campus and facilities that are no longer in operation. It also takes care of low-value items from around the Laboratory and its offices. This includes computers, furniture, various metals, all types of batteries, electronic and IT equipment, light sources (neon lights, bulbs), refrigeration appliances, paper and cardboard, plastic, glass, rubble, bulky items and wood.
A system is in place for the recovery, refurbishment and sale of usable equipment, including furniture, IT equipment and

electronic devices, through an internal web catalogue. Plans to refurbish the centre, starting in 2025, were approved in 2024. The aim of the work is to bring the centre up to the highest standards of safety, including environmental safety, provide more space for items that can be reused and expand the offer to include a more diverse range of waste.

RADIOACTIVE WASTE MANAGEMENT

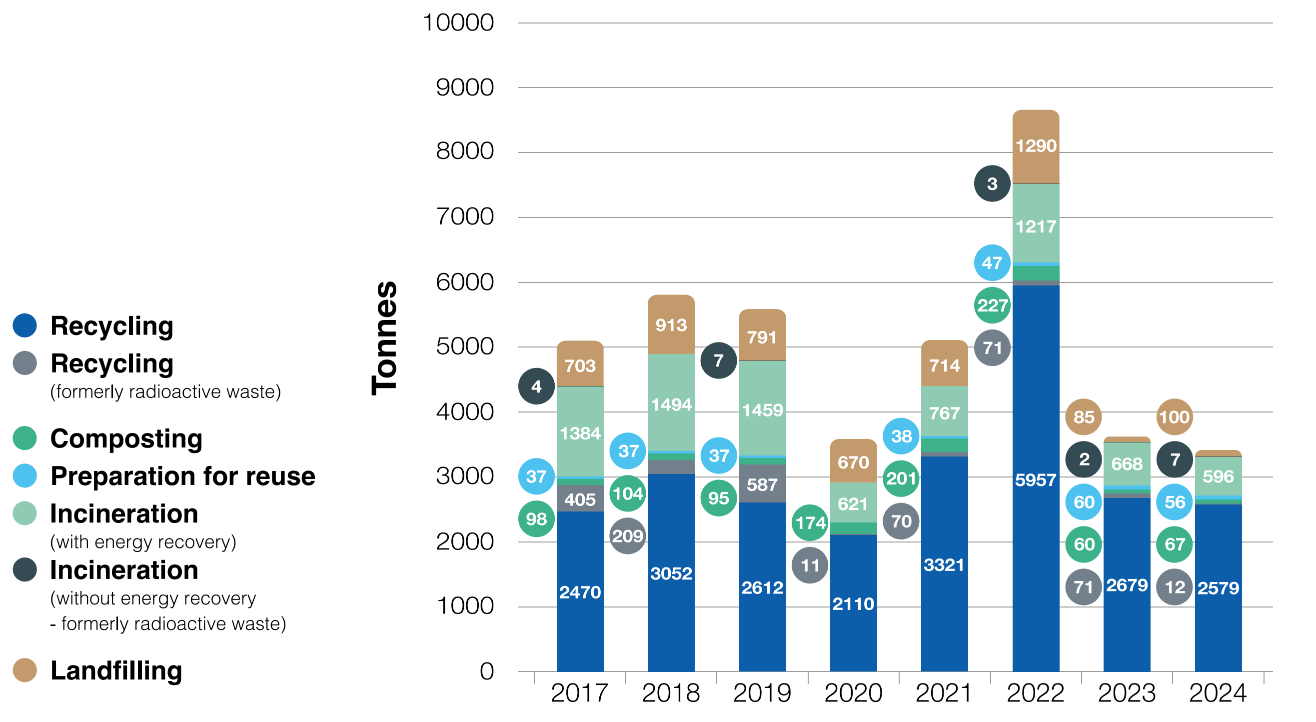
Responsible management of its radioactive waste is a high priority for CERN. Generated primarily from the interactions of particles with accelerator equipment, this waste typically exhibits very low to intermediate activity levels. It includes materials like metals, cables and accelerator components, as well as some maintenance-related items such as gloves and filters that may be slightly contaminated by radioactive dust. CERN implements strategies to minimise radioactive waste, either at source or through reuse. Those activated materials that present very low-level residual activity are recycled. CERN's specialised radiation protection team oversees the monitoring and classification of waste in the accelerator facilities, while sorting and packaging according to the applicable treatment and elimination criteria is done in a dedicated facility. Before being disposed of, radioactive waste is temporarily stored in a dedicated storage area.

CERN disposes of its radioactive waste through agreed pathways in France and Switzerland. The Organization continuously optimises the existing pathways and investigates new possibilities for intermediate-level radioactive waste. In Switzerland, clearance options are available for waste that no longer qualifies as radioactive according to the Swiss ordinance for radiation protection (ORaP). Metallic and cable waste is targeted for clearance or recycling, with the aim of minimising the total volume of waste sent to the radioactive waste repositories in the Host States while concomitantly reducing costs (see In Focus).

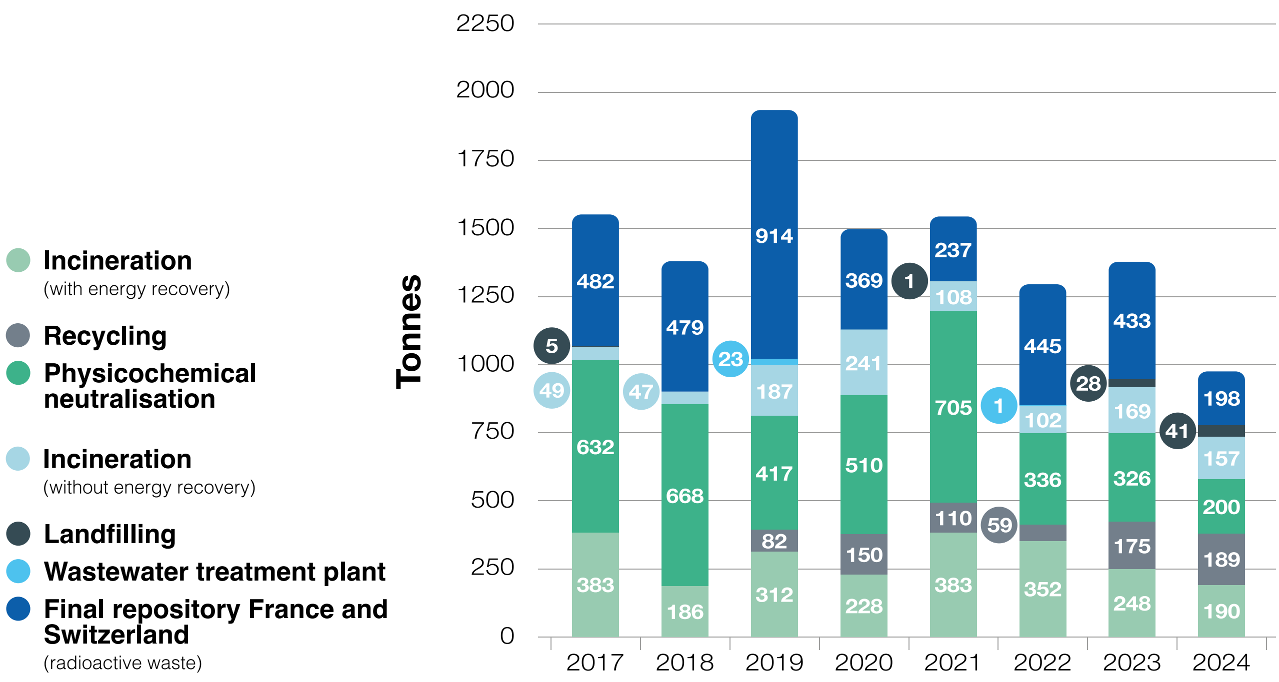
In 2023 and 2024, CERN disposed of 506 and 217 tonnes of radioactive waste respectively. The Organization successfully reused 457 tonnes of steel, cast iron and concrete in 2023, and 1 435 tonnes in 2024.

RADIOACTIVE WASTE STUDY

In the framework of the tripartite agreement on radiation protection and radiation safety between CERN and its Host States, CERN regularly publishes a comprehensive Radioactive Waste Management Study detailing its waste inventory and elimination strategies. The latest update to the Study was published in July 2024, following an iterative process with the Host States. It includes forward-looking 20-year estimates of radioactive waste production and elimination, based on data from 31 December 2022. Given the different radioactive waste elimination approaches applied by France and Switzerland, classes of waste are allocated to one of the two countries and their respective pathways according to the fair share principle, which is enshrined in the tripartite agreement, ensuring an equitable distribution between them. The implementation of the study's recommendations is monitored through indicators including waste volume, radiotoxicity and elimination costs, and is reviewed annually with the Host States.



NON-HAZARDOUS WASTE BY ELIMINATION PATHWAY 2017–2024
Fluctuations in absolute metric tonnes over time are primarily driven by worksite activities and civil engineering projects as required by the scientific programme. In this context, contractor worksite waste is only partially included in the above figures, and work is under way to improve data collection and centralisation with a view to including the data in future reports.



HAZARDOUS WASTE BY ELIMINATION PATHWAY 2017–2024

IN FOCUS

Gérald Dumont leads the Radioactive Waste Management section in CERN's Radiation Protection group.

— The Radioactive Waste Study sets out different pathways for different classes of waste. What solutions have been investigated for metallic waste in particular?

GD: About 90% of the volume of all low- and intermediate-level (or "FMA") waste at CERN is metallic. Setting up a treatment and elimination process for this class of waste is therefore critical. Proven technologies exist to treat FMA metallic radioactive waste. Among them, melting is the most promising: it reduces the waste volume optimally, allows accurate radiological characterisation and minimises handling at CERN, as resulting ingots can be directly eliminated from the foundry at the final repository in France, ANDRA.

— How did CERN go about implementing this melting solution?

GD: As part of the FMA waste disposal strategy, which was developed in 2018, we set up the Melting of Activated STeel (MAST) project in 2019. Its aim was to run a pilot campaign for the treatment and elimination of CERN's metallic FMA waste by melting. A pilot batch of 19 m^3 of metallic FMA waste was successfully melted at the end of 2022, with a resulting volume reduction factor of 10. The pilot ingots were disposed of at ANDRA in June 2023, marking the end of the project and the successful inauguration of this first FMA elimination pathway.

— What future pathways are planned to manage the radioactive metallic waste that cannot be treated in this way?

GD: A new pathway for bulky metallic waste that is unsuitable for fusion, which includes use of the French repository ANDRA, was launched in 2022 to supplement the MAST pathway. This project is named ABEILLE (ANDRA Bulky Elimination of Intermediate and Low Level wastE). After packaging at CERN in standardised 5 or 10 m^3 containers, the metals concerned will be cemented at the ANDRA CSA facility (*Centre de stockage de l'Aube*), using established processes and acceptance criteria. The project has already successfully passed three of the four stringent stages of the ANDRA approval process (definition of the applicable requirements, development of the elimination process and production of validated pilot packages). The final step entails formal approval of the pathway by ANDRA, following which CERN will send a pilot batch of 15 m^3 to the facility in 2025. The objective is ultimately to dispose of an annual volume of some 10 to 40 m^3.

GOALS FOR 2030

CERN has committed to maintaining the rate of recovery of its non-hazardous waste above 70% in terms of weight. With respect to the reference year 2022, the Organization aims to increase the total rate of reuse by 10% by 2030 and to reduce the campus "household waste" per person on site by 5% (all in terms of weight).

For radioactive waste, the objective for the period is to limit the production of radioactive waste resulting from the Organization's activities and to keep the amount of formerly radioactive waste recycled following clearance above 55 tonnes/year.

NOISE

CERN's infrastructure is very diverse, with installations and specific equipment that produce varying levels of noise across its sites. The Organization manages its noise footprint through a noise monitoring programme, planning processes for new projects and the implementation of mitigation measures when needed, in accordance with CERN's noise reduction policy.

MANAGING CERN's NOISE FOOTPRINT

CERN's noise reduction policy, published in 2019 and agreed with the Host State authorities, is effective and is subject to regular review. This policy commits the Organization to not exceed the reference noise levels at its perimeters by more than 3 dBA. The reference levels are based on measurements carried out in 2018 when all the accelerators were running (reference operation year).

As part of its noise management strategy, CERN carries out yearly noise measurement campaigns at 70 locations, both during the day and at night, to verify that the noise levels remain within the set limits and are compliant with the Host State regulations. The average noise levels measured at CERN's site perimeters are typically 50 dBA during the day and 45 dBA at night. Noise measurement reports are provided to the local authorities and presented to the tripartite committee for the environment (See Management Approach).

CERN's neighbouring environment is constantly evolving, with the construction of new residential buildings close to some of its installations. CERN collaborates with the municipalities in which its sites are located and liaises with them on plans for new residential areas and its own future projects. This liaison includes submitting noise impact assessments to the local authorities for any new significant project at the same time as the application for a construction permit.

CERN's accelerator complex was in operation throughout the reporting period, and noise was generally kept within the 2018 reference levels. However, some cases of exceedance were reported in three specific locations, which were duly addressed using noise modelling predictions to design corrective actions. These actions are supported by 24/7 noise monitoring in the locations concerned, which allows measures to be taken based on real-time measurements. Over the reporting period, four claims were received, three associated with the noise produced by electrical equipment and a fourth concerning noise produced by cooling equipment due to high outdoor temperatures. The first three claims were addressed by installing shielding blocks (see In Focus). For the other claim, a solution to replace the cooling equipment during the next Long Shutdown is under investigation.

THE NOISE MONITORING PROGRAMME

In the reporting period, to further optimise noise management across the CERN sites, the Organization took the decision to develop a new noise monitoring tool to be integrated into its environmental monitoring framework. The objective is to deploy permanent acoustic monitoring points, featuring real-time data integration with the Radiation and Environment Monitoring Unified Supervision (REMUS) platform, to allow sound level analysis and exceedance alerts.

Acoustic barriers installed at LHC Point 4 (Échenevex, France) to reduce the noise impact of the electrical transformers.

IN FOCUS

Jordan Minier is an acoustics engineer in the Environmental Prevention section of the Environment group.

— Can you tell us about how claims regarding noise levels are handled?

JM: When we receive a claim about noise or detect a case of exceedance during our measurement campaigns, we follow a structured process. It begins with a thorough site inspection to identify the noise source. Using data taken during machine operation, we correlate high noise levels with the operating conditions of specific equipment. Next, we characterise the acoustic emissions of the source and design tailored mitigation measures to ensure a long-lasting solution. These measures are developed and implemented collaboratively with the equipment owner so as to minimise noise while preserving the equipment's operational performance. Their ultimate implementation also depends on the operation and shutdown schedules of the accelerators.

— What kind of situations do you encounter and what solutions are typically effective?

JM: Noise can come from various sources, such as ventilation systems, cooling equipment and electrical devices. Effective solutions often involve using acoustic silencers or screens to mitigate the propagation of sound in the environment. In some situations, we deploy concrete blocks, which are primarily designed for radiation protection but have also proven to be effective noise barriers. For example, when dealing with noise generated by electrical transformers, we use concrete blocks to create a barrier, avoiding the need for extensive and dangerous digging around the high-voltage transformers.

— What are the final stages in managing a claim?

JM: We perform compliance tests to ensure that we have achieved the required noise levels. If the results are unsatisfactory, we repeat the site inspection and run through the steps needed to ensure that a suitable solution is promptly found. If the noise levels are compliant, we implement preventive actions, including 24/7 noise measurements with alert systems, and issue monthly internal reports for our monitoring and follow-up purposes.

Noise monitoring station at LHC Point 4 (Échenevex, France).

GOALS FOR 2030

CERN's priority is to control and reduce the noise footprint resulting from its activities. Concretely, over the period until 2030, CERN intends to reduce noise hotspots (>40 dBA) in residential areas, by means of systematic environmental noise impact assessments for new infrastructures and major consolidation work. In addition, CERN will continue to monitor the evolution of residential areas next to its sites, keeping noise footprint maps and 3D noise models up to date.

ENVIRONMENTAL COMPLIANCE AND MANAGEMENT OF HAZARDOUS SUBSTANCES

In accordance with its intergovernmental status, CERN establishes its own regulatory framework as necessary for its functioning, including in matters of safety. This framework covers all activities and sites and takes into account Host States' and EU regulations, as well as international standards. CERN is committed to limiting its impact on the environment and implements an extensive array of measures to this end, including environmental monitoring.

PREVENTING CONVENTIONAL ENVIRONMENTAL ACCIDENTS

CERN's Safety Policy encompasses all aspects of safety, including occupational health and safety, radiation protection, the protection of the environment and the safe operation of CERN's installations, including radiation safety. Adequate measures for preventing environmental accidents, environmental events and near misses, along with remedial actions, fall under the responsibility of the departments concerned. Their follow-up is overseen by the CERN Environmental Protection Steering Board (CEPS - see Management Approach).

To keep the impact of CERN's activities on the environment to the minimum, an extensive environmental monitoring programme spanning both radiological and physicochemical parameters is implemented by the Occupational Health and Safety and Environmental Protection unit. In the event of an anomaly or accidental chemical release, dedicated procedures involving trained teams are in place to guarantee a prompt response in order to stop and limit the impact.

CERN has defined a clear framework for classifying events according to their potential impact. It has also implemented a robust procedure for communication and follow-up with the local authorities.

During the period covered by this report, a significant water leak was reported and duly resolved (see Water and Effluents), but no event occurred that would have led to a fine or a non-monetary sanction.

PREVENTING RADIOLOGICAL ENVIRONMENTAL ACCIDENTS

CERN has robust radiation safety and radiation protection rules in place (see Ionising Radiation). No environmental radiological accident has ever occurred on the CERN site.

MANAGING HAZARDOUS SUBSTANCES

CERN's regulatory framework for hazardous substances addresses potential risks to soil and water and is continuously adapted in line with the relevant Host State regulations. These substances are subject to regular monitoring and reporting. The CERN Chemical Register for Environment, Health and Safety (CERES) is a web-based tool for tracking chemicals at CERN and identifying the associated risks and their locations. This in turn allows the preventive measures in place to be adjusted to mitigate risk and operational measures to be designed to handle potential incidents.

The tool is continuously updated by users and features an in-built system for checking the reliability of their entries. Depending on the quantity and type of the product, an environmental risk analysis may be required that takes into account a specific set of criteria as well as all CERN infrastructure considerations, such as the presence of water retention basins at site boundaries. These features also help to identify buildings with potential activities involving hazardous substances that entail specific technical requirements based on quantity, toxicity and substance type, and generally require priorities and action plans to be defined. At the end of 2024, the register comprised more than 3 000 validated entries, of which some 1 400 had recently been checked by the users, and just over 850 were subject to an environmental risk analysis.

One of the priorities is reducing the quantity of mineral oil present on the CERN site in transformers. In this context, a project to replace oil transformers by oil-free alternatives was launched in 2021. It targets more than 100 transformers over a period of ten years. Over the reporting period and up to March

2025, more than 25 will have been replaced and a further 20 eliminated, resulting in the removal of more than 100 m^3 (around 80 tonnes) of mineral oil. This project also includes the clean-up of the transformer retention pits, which are filled with pebbles exhibiting varying degrees of oil concentration. In 2024, CERN conducted a sustainability analysis that included technical, logistical, economic, operational and environmental aspects to identify the most effective solution for ensuring the treatment and recovery of these pebbles in alignment with European and local directives on waste management. Various options were tested in collaboration with suppliers, including on-site washing and storage, reinforcing CERN's role as a testing ground for optimising recycling and waste management practices. After assessing the environmental impact and the site constraints, it was established that sending the pebbles to a local specialised waste management contractor for treatment and recycling would be the most effective approach. This solution prioritises reuse over landfill, repurposing the material for applications such as cement production and road surfacing.

Radioactive materials are a unique category of hazardous substance and are strictly regulated throughout their lifecycle, including with respect to use, handling and transport. Radiological risk assessments are conducted before handling, and users undergo comprehensive radiation protection training to be able to assess radiological risks and apply the related radiation protection rules and procedures. The transport of such materials both on and off the CERN site is closely monitored, with public road transport conforming to ADR (European Agreement concerning the International Carriage of Dangerous Goods by Road) regulations.

IN FOCUS

Sabrina Schadegg leads the Environmental Prevention section of the CERN Environment group. She is a member of the HSE Operational Response (HOR) project, which was launched in 2022 by CERN's Occupational Health and Safety and Environmental protection (HSE) unit to clarify and refine the operational response capabilities of all HSE unit services in collaboration with teams across the Organization.

— How has the HOR project helped to refine cross-team collaboration, notably with the CERN Fire and Rescue Service?

SS: One of the project's six work packages is dedicated to the appropriate response to emergencies affecting the environment and the Organization's assets which aims to future-proof CERN's ability to protect the environment in the event of a significant environmental event, such as a chemical spill, fire or any other unforeseen environmental incident.

Thanks to the actions of the PoLiChem (Prevention of Pollution by Liquid Chemical Agents) working group—which ran from 2015 to 2018 to recommend actions, monitored by the CEPS, to reduce pollution risks—and to the subsequent implementation of the CERES tool, CERN has markedly improved its approach to preventing environmental incidents. Some of CERN's facilities are quite dated and small-scale environmental incidents can occur given that collective retention measures, such as centralised retention basins upstream of water outlets into rivers, were not systematically integrated in the original designs. The CERN Fire and Rescue Service (CFRS) is suitably equipped and trained to respond autonomously to environmental events, including alarms generated by CERN's environmental monitoring stations, hence the importance of updating the existing response protocol as a priority.

— What were the key challenges in updating the existing response protocol, and how was it tested?

SS: The biggest challenge was creating a procedure that was comprehensive yet simple enough for the intervention teams. It needed to cover the highest possible percentage of predictable incidents, ideally up to 90%, while allowing flexibility in the event of unforeseen situations. The new protocol was developed over two years and tested in a large-scale exercise in summer 2024. This exercise highlighted the strengths and provided valuable insights for further improvement. Importantly, it fostered strong relationships between CFRS, the environment team, the CERN Control Centre operators—who oversee the technical infrastructure—and colleagues responsible for the equipment, thereby ensuring seamless collaboration in real emergencies. The protocol sets a clear benchmark for integrated operational response systems for use in case of environmental events.

Environmental incident exercise involving the CFRS.

GOALS FOR 2030

During the period until 2030, CERN's objective is to reduce the potential environmental impact of hazardous substances used for the Organization's activities. Concretely, the aim is to reduce the quantity of transformer oil present on the CERN sites by 120 m^3 (compared to the 2023 baseline of 1784 m^3).

KNOWLEDGE AND TECHNOLOGY FOR THE ENVIRONMENT

In pushing back the boundaries of science, CERN actively engages in the identification and development of technologies that can benefit society. This is achieved through innovation in environmental applications, in collaboration with academia and industry, and also by making the campus available to institutes and research consortia as a testbed for sustainable solutions.

PARTNERSHIPS FOR ENVIRONMENTAL INNOVATION

The driving force behind CERN's technology transfer activities is a thriving and growing partnership with industrial, academic and research institutes across five focus areas, including the environment.

The CERN Innovation Programme on Environmental Applications (CIPEA) was launched in 2022 as a call for ideas from the CERN community to stimulate environmental application innovation based on CERN's technologies, know-how and facilities. The programme was expanded in 2023-2024 to include projects selected in collaboration with external partners, mainly from industry, in the key areas identified during the process of drawing up the 2022 strategy. The eight CERN community projects initially selected are generating the first results. Together with the new projects defined in collaboration with industry, this brings the total number of projects at an advanced level of maturity to 25 today. 80% of the funding for the CIPEA programme is external, mostly coming from industrial partners in the Member States. The projects under way focus on four key areas: low-carbon energy; clean transportation and future mobility; climate change and pollution control; and sustainability and green science.

RENEWABLE AND LOW-CARBON ENERGY

Many CERN technologies can be applied in the emerging field of fusion energy, which has the potential to become a reliable and sustainable low-carbon alternative to fossil fuels and nuclear fission that generates no greenhouse gases (GHG) and minimal radioactive waste. CERN collaborates with several industrial partners such as Rolf Kind GmbH, a German steel manufacturer, to test the capability of advanced stainless-steel forgings to withstand extreme loads at cryogenic temperatures in future fusion plants.

Further, CERN has established long-term strategic partnerships with public and private entities, such as EUROfusion, Gauss Fusion and Eni, to look for synergies between fusion energy and particle accelerator technologies, including in the fields of muon collider development and high-temperature superconductors.

In 2023, CERN signed a partnership with SuperNode in Ireland with the goal of enhancing energy transmission technology essential for integrating renewable energy sources. Leveraging its expertise in vacuum systems, CERN is assisting SuperNode in developing advanced cryostats to ensure the thermal insulation of their superconducting cables. These cables are designed to transfer bulk electricity, produced for instance by off-shore wind farms, over vast distances—including across the oceans—with minimal electrical losses and maintenance needs.

CLEAN TRANSPORTATION AND FUTURE MOBILITY

Transport is one of the fastest-growing sources of GHG emissions, and CERN's technology transfer efforts aim to find cleaner, safer and more efficient mobility solutions in the aviation, shipping, rail and automotive fields.

A specific example concerns the development of technologies for the maritime transport of liquid hydrogen from producers to customers across the world, thus fostering a sustainable hydrogen economy. Hydrogen is a particularly promising energy source as it generates no GHG emissions and allows large-scale energy storage. For efficient transport and storage, hydrogen must be cooled to liquid form, at -253°C, placing challenging thermal design requirements on the on-board tanks. Ensuring minimal leakage is also critical for safety, as hydrogen is very volatile and flammable. In this context, CERN is collaborating with Gaztransport & Technigaz (GTT) to develop large liquid hydrogen (LH2) storage tanks for maritime transport. The project focuses on adapting liquefied natural gas (LNG) carrier designs for LH2 by optimising materials specifications, welding procedures for leak tightness and vacuum insulation layer materials.

Launched in 2022, a partnership between CERN and the Airbus subsidiary UpNext explores the use of CERN's superconducting technologies in future low-emission aircraft.

A key milestone was reached in 2023 with the successful development, construction and testing at CERN of SCALE ("Super-Conductors for Aviation with Low Emissions"), a one-off demonstrator for a superconducting powertrain transmission line.

CLIMATE CHANGE AND POLLUTION CONTROL

CERN's expertise and technologies contribute to advances in environmental modelling and monitoring through Earth observation. These processes play an essential role in assessing pollution, managing resources and responding to natural disasters.

CERN is contributing with its machine learning know-how to EMP2 (Environmental and Modelling Prediction), a groundbreaking project being carried out in collaboration with Forschungszentrum Jülich (Germany) and the ECMWF (European Centre for Medium-Range Weather Forecasts) to develop an AI-powered digital twin for atmospheric dynamics. Trained on 40 years of hourly data from Copernicus, the tool improves weather predictions through precise "nowcasting" (forecasts for up to six hours), enhanced resolution of extreme weather phenomena (downscaling from 32 km to 6 km) and correction of precipitation biases. Leveraging open source software like ATMOREP, this innovative approach enables very fast and robust predictions of extreme events and outperforms traditional numerical weather models. The EMP2 model will be used in the ambitious EU-funded Weather Generator project, with the goal of combining all data sources in a general model for multiple tasks. It will also be used in the framework of the recently signed partnership between CERN and the World Food Programme to forecast seasonal crop production and address world hunger issues.

Edge SpAIce, funded by the EU, is a collaboration between CERN, EnduroSat in Bulgaria, NTU Athens in Greece and AGENIUM Space in France. The project leverages CERN's cutting-edge AI technology to monitor the Earth's ecosystems from space in order to detect and track plastic pollution in our oceans. Its aim is to develop a dedicated on-board system for satellites that will make it possible to acquire and process high-resolution pictures using a DNN (Deep Neural Network). The system uses the Edge AI approach, in which data is processed in near real-time directly on the satellite, mirroring the efficient filtering of LHC data in particle detectors at CERN.

The UTMOST CLEEN project focuses on enabling exhaust gas purification for hard-to-abate sectors like shipping and the semiconductor industry by developing compact and durable electron beam flue gas treatment (EBFGT) technology to reduce noxious gas (SOx and NOx) emissions from transportation and industrial sources. This innovative technology can reduce SOx emissions by up to 95% and NOx emissions by up to 80%, significantly cutting harmful emissions.

SUSTAINABILITY AND GREEN SCIENCE

The MotorSense project is a collaboration between CERN and ABB that leverages smart sensors and digital twins to optimise energy use in cooling and ventilation systems. Since its start in 2022, over 100 smart sensors have been installed on more than 800 low-voltage motors to monitor output power, speed, vibration and operating efficiency. Enhanced sensor algorithms and digital twins provide data-driven recommendations for energy savings, identifying opportunities to reduce electricity consumption by 17.4% (up to 31 GWh annually). This innovative approach is scalable to other infrastructures with similar cooling and ventilation requirements.

In the context of minimising its GHG emissions, an area of focus for CERN is the search for suitable alternatives to the GHG gases it uses in various applications, notably SF_6 for detector cooling and particle detection (see Emissions). SF_6, a greenhouse gas with a very high global warming potential, is also used in radiofrequency systems across various accelerator applications, including in medical hadron facilities. SF_6 provides excellent dielectric and insulating properties that help to prevent electrical breakdown in high-power applications. With a view to eliminating SF_6 in this particular context, CERN has partnered with AFT Microwave in Germany on a project to develop a vacuum-compatible, high-power waveguide circulator to protect generators from reflected power without the use of SF_6. This innovation could also benefit the circuit breaker industry by promoting sustainable solutions in high-power applications.

CERN's GREEN VILLAGE

CERN's Green Village initiative was recently launched with a view to allowing European research consortia and individual industry innovators to collaborate, test and scale up their sustainable solutions. In this context, the Organization offers access to its versatile campus and infrastructure, technologies and green spaces, as well as to its engineers, scientists and multi-disciplinary students participating in the project-based innovation courses at CERN's IdeaSquare. The objective is to act as a demonstration partner in Horizon Europe consortium projects and/or as a testbed for early-stage sustainable solutions or technologies developed by individual companies and start-ups. Nine specific focus areas have been identified, including the development of innovative solutions for energy generation, transport, storage, logistics, sustainable construction, pollution and waste generation reduction. Strategies are also being developed to protect and enhance biodiversity using big data analysis techniques to reduce overall carbon footprints.

Concretely, in 2024, CERN established a collaboration framework with *Université de Nice Côte d'Azur*, which includes a project to evaluate so-called IoT-based biodiversity monitoring systems on the CERN sites, leveraging innovative, low-cost environmental sensors and Edge AI. This will provide valuable insights into the biodiversity across the Organization and its potential for growth and preservation. Further, the University of Trento's ELEDIA@UniTN group is testing Smart Electromagnetic Environment (SEME) solutions at CERN's Green Village. Using static passive 6G reflectors, this initiative addresses connectivity challenges in tunnels and urban areas by reducing signal dead spots without the need for energy-intensive base stations. The project involves GIS/CAD design, prototyping and benchmarking, leveraging CERN's infrastructure to develop sustainable, cost-effective wireless solutions for future networks.

"We are in the midst of a global race for the technologies that will shape the world of tomorrow, from clean tech to quantum, from AI to fusion […] Your core mission at CERN has always been fundamental research. But all along your history, you have produced countless positive spillovers for our society and economy… You are constantly working with European industries, to build low-emission aeroplanes or to create new solutions to transport liquid hydrogen […] We need more of these partnerships between research and business; more ideas that go from the laboratory to the factory."

Ursula Von der Leyen, President of the European Commission, CERN 70th anniversary official ceremony

GLOSSARY

The French ***Agence nationale pour la gestion des déchets radioactifs*** **(ANDRA – National Agency for Radioactive Waste Management)** is responsible for identifying, implementing and guaranteeing safe solutions for the management of radioactive waste, in order to protect present and future generations from the risks inherent in such substances.

The French ***Autorité de sûreté nucléaire et de radioprotection*** **(ASNR – Nuclear Safety and Radiation Protection Authority)** is responsible for the oversight of nuclear safety and radiation protection in order to protect people and the environment.

CERN's **Energy Management Panel (EMP)** examines CERN's energy consumption and identifies measures to improve efficiency and promote energy reuse Organization-wide.

The **Enlarged Energy Management Panel** was set up in 2023 to specifically oversee the provisions of the ISO 50001 energy management certification.

The **CERN Environmental Protection Steering Board (CEPS)** was established in 2017. Its mandate is to identify environmental areas to be addressed, rank them in order of priority, propose programmes of action and, once the latter have been endorsed by the Enlarged Directorate, follow up their implementation.

The **CERN Safety Policy** is the Organization's reference document for all matters relating to occupational health, safety and environmental protection. The Policy includes the explicit goal of limiting the impact of CERN's activities on the environment.

The **CERN Environmentally Responsible Procurement Policy Project (CERP3),** launched in 2021, aims to integrate environmentally responsible practices into purchases by establishing technical and organisational levers for sustainable procurement in collaboration with multiple internal services and ensuring engagement with all stakeholders across the supply chain.

The **CERN Innovation Programme on Environmental Applications (CIPEA)** was launched in 2022 as a call for ideas from the CERN community to stimulate environmental application innovation based on CERN's technologies, know-how and facilities.

The ***Comité Tripartite sur l'Environnement*** **(CTE)** is a tripartite committee comprising representatives of CERN and of the environmental authorities of the Canton of Geneva (Switzerland) and the *sous-préfecture de Gex* (Ain - France). It was set up to examine non-radiological environmental matters.

The **European Intergovernmental Research Organisation forum (EIROforum)** is a consortium that brings together eight of Europe's large intergovernmental research organisations to promote the quality and impact of European research.

The **FCC (Future Circular Collider) Feasibility Study** arose from the 2020 update of the European Strategy for Particle Physics. It includes a scientific component and numerous technical considerations, as well as administrative and financial considerations and extensive territorial feasibility studies relating to geology, environmental impact, infrastructures and civil engineering.

The **Global Reporting Initiative (GRI)** is an independent international organisation that helps private and public bodies to understand and communicate their impact by developing a sustainability reporting framework and guidelines.

Global Warming Potential (GWP) is a value that describes the radiative forcing impact of one unit of a given greenhouse gas, relative to one unit of CO_2 over a given period of time. The GWP values convert greenhouse gas emissions data for non-CO_2 gases into units of CO_2 equivalent.

The **High-Luminosity LHC (HL-LHC)** is an upgrade of the LHC designed to achieve instantaneous luminosities of a factor of five larger than the LHC's nominal value, thereby enabling the experiments to enlarge their data sample by one order of magnitude compared with the LHC baseline programme.

The **Occupational Health and Safety and Environmental Protection (HSE) unit** is responsible for all matters relating to health and safety and environmental protection at CERN.

ISO 50001 is the reference international standard that defines systems and processes for organisations to implement in order to continuously improve their energy performance. It requires CERN to set up, monitor and improve an energy management system aligned with its energy policy and with relevant legislation.

The **Large Hadron Collider (LHC)** is the world's largest and most powerful particle accelerator. It first started up on 10 September 2008 and consists of a 27-kilometre ring of superconducting magnets with a number of accelerating structures to boost the energy of the particles along the way.

Materiality is a term used in sustainability reporting. In this report, material topics are those that deal with the environmental impact of CERN and/or influence internal and external stakeholders.

The Swiss ***Office fédéral de la santé publique* (FOPH – Federal Office for Public Health)** is responsible for public health in Switzerland, including in matters of radiation protection.

The Swiss ***Ordonnance sur les mouvements des déchets* (OMoD – ordinance governing the movement of waste)** regulates the transport of special waste and other waste that is subject to control within Switzerland, as well as the transboundary movement of all types of waste and the transport of special waste between third countries where a Swiss company organises or participates in the operation.

The ***Ordonnance sur la radioprotection* (ORaP – radiation protection ordinance)** is the Swiss regulation on the protection of people and the environment against ionising radiation.

The CERN Science Gateway is an education and outreach facility next to the Globe of Science and Innovation. Inaugurated on 7 October 2023, it is a beacon that encourages young people to aim for careers in science, technology, engineering and mathematics (STEM).

Scope 1 refers to direct greenhouse gas emissions, i.e. emissions from sources that are owned or controlled by an organisation.

Scope 2 refers to indirect greenhouse gas emissions related to energy, i.e. emissions that result from the generation of acquired and consumed electricity, steam, heat or cooling.

Scope 3 refers to other indirect greenhouse gas emissions, i.e. emissions that occur outside the organisation, both upstream and downstream, that are not included in the indirect greenhouse gas emissions related to energy (scope 2).

The **United Nations Sustainable Development Goals (SDGs)** address the global challenges the world is facing, including those related to poverty, inequality, climate change, environmental degradation, peace and justice.

The **Super Proton Synchrotron (SPS)** is the second-largest machine in CERN's accelerator complex and provides beams for experiments at CERN, as well as preparing beams for the LHC.

The **Sustainable Accelerators Panel (SAP)** was set up in 2023 to liaise with future accelerator initiatives in order to develop full lifecycle sustainability as a key consideration in the inception phase of any project and identify accelerator technologies with the potential to reduce the impact of future accelerators.

The **tripartite agreement on radiation protection and radiation safety** is an agreement between CERN, the Swiss Federal Office for Public Health (FOPH) and the French Nuclear Authority (ASNR, formerly ASN). Under the agreement, a framework has been established for the discussion of topics related to radiation protection, specifically the protection of CERN personnel and the public from ionising radiation, both on site and in the vicinity of CERN's facilities.

The **Wigner Research Centre for Physics** is a research centre near Budapest, Hungary. Until 2020, computing capacity at Wigner was remotely managed from CERN, substantially extending the capabilities of the Tier 0 activities of the Worldwide LHC Computing Grid (WLCG).

The **Worldwide LHC Computing Grid (WLCG)** is the data-storage and analysis infrastructure built and maintained for the entire high-energy physics community that uses the LHC.

CERN LHC SITES

The Large Hadron Collider (LHC) is the world's largest particle accelerator. Its 27-km ring is buried 100 metres below the French and Swiss countryside, with access points known as "sites" located around the ring.

GRI content index

For the Content Index – Essentials Service, GRI Services reviewed that the GRI content index has been presented in a way consistent with the requirements for reporting in accordance with the GRI Standards, and that the information in the index is clearly presented and accessible to the stakeholders.

GRI Services reviewed the correct mapping of the GRI disclosures presented in the GRI content index to Sustainable Development Goals (SDGs), based on the 'Goals and targets database' tool available from GRI website.The service was performed on the English version of the report.

Statement of use: CERN has reported in accordance with the GRI standards for the period from 1 January 2023 to 31 December 2024.

Standards and disclosures	Title	Pages/information	Reasons for omission	UN Sustainable Development Goals (SDG) https://sdgs.un.org/goals
GRI 1: FOUNDATION 2021				
GRI 2: GENERAL DISCLOSURES 2021				
The organisation and its reporting practices				
	2-1 Organizational details	About CERN (p. 11)		
	2-2 Entities included in the organization's sustainability reporting	Management Approach (p. 14, 15)		
	2-3 Reporting period, frequency and contact point	CERN publishes biennial Environment Reports. This report covers the period 2023-2024 and was published on 13 November 2025. Any questions can be sent to environment.report@cern.ch.		
	2-4 Restatements of information	Management Approach (p. 14)		
	2-5 External assurance	No external assurance was sought for this report. However, Host State authorities carry out independent measurements concerning CERN's water releases and ionising radiation.		
Activities and workers				
	2-6 Activities, value chain and other business relationships	About CERN (p. 11), Management Approach (p. 15), Procurement and Materials (p. 28, 29)		
	2-7 Employees	This information is published in CERN's Annual Personnel Statistics. The Statistics for 2023 can be found on https://cern.ch/personnelstats and those for 2024 can be found on https://cern.ch/personnelstats2024.		SDG 8, SDG 10
	2-8 Workers who are not employees	See above (2-7)		SDG 8
Governance				
	2-9 Governance structure and composition	About CERN (p. 11-13)		SDG 5, SDG 16
	2-10 Nomination and selection of the highest governance body	Each Member State appoints their own delegates, and their credentials must be issued to the Secretary of the Council, as stated in the Rules of Procedure of the CERN Council which can be found on https://cern.ch/councilrules.		SDG 5, SDG 16
	2-11 Chair of the highest governance body	About CERN (p. 11-13)		SDG 16
	2-12 Role of the highest governance body in overseeing the management of impacts	About CERN (p. 11), Management Approach (p. 14) A representative sample of the CERN Council, CERN's highest governing body are among the stakeholders interviewed in the materiality assessment process to identify environmental impacts. The roles of Council members are defined in the Convention for the establishment of a European Organization for Nuclear Research, which can be found on https://cern.ch/cernconvention.		SDG 16
	2-13 Delegation of responsibility for managing impacts	Management Approach (p. 14)		
	2-14 Role of the highest governance body in sustainability reporting	See above (2-12)		
	2-15 Conflicts of interest	CERN's Conflict of Interest Policy can be found on https://cern.ch/cip.		SDG 16
	2-16 Communication of critical concerns	Management Approach (p. 14), Environmental Compliance and Management of Hazardous Substances (p. 44)		
	2-17 Collective knowledge of the highest governance body	While no formal sustainability training programme is in place for Council delegates, the biennial Environment reports are formally presented to Council and relevant subordinate bodies to raise awareness, stimulate discussion and gather feedback. Further, a representative sample of Council delegates are among the stakeholders interviewed as part of the materiality assessment.		

GRI content index

Standards and Disclosures	Title	Pages/information	Reasons for omission	UN Sustainable Development Goals (SDG) https://sdgs.un.org/goals
	2-18 of the performance of the highest governance body	This is governed by the Convention for the Establishment of a European Organization for Nuclear Research, which can be found here https://cern.ch/cernconvention.		
	2-19 Remuneration policies	CERN's renumeration policy is detailed in Chapter V of the Staff Rules and Regulations which can be found on page 41 on https://cern.ch/staffrulesregs.		
	2-20 Process to determine remuneration	See above (2-19)		
	2-21 Annual total compensation ratio	The highest paid individual of the Organization is the Director-General. - Ratio of annual total compensation for the highest paid individual / median of the total compensation of all employees (CERN 'Staff members', except highest) = 2.8 - Ratio of the percentage increase in total annual compensation for the highest paid individual / median of the percentage increase of total compensation of all employees (CERN 'Staff members', except highest) = 0.5. Note 1: total compensation includes basic salary, responsibility award, performance payment. Excluded are payments for shifts and overtime. Note 2: Employed Members of the Personnel (MPE) include Staff members and Graduates. The range from the entry level salaries of CERN Employed members of the Personnel (graduate) to the highest Staff grade according to the CERN Salary grid (basic salary) is a factor of about 6.		
Strategy, policies and practices				
	2-22 Statement on sustainable development strategy	Foreword (p. 4), About CERN (p. 11), Management Approach (p. 14)		
	2-23 Policy commitments	This information can be found on https://hse.cern/policy-commitments.		SDG 16
	2-24 Embedding policy commitments	About CERN (p. 12), Management Approach (p. 14-16)		
	2-25 Processes to remediate negative impacts	About CERN (p. 12), Management Approach (p. 14), Water and Effluents (p. 37), Noise (p. 42), Environmental Compliance and Management of Hazardous Substances (p. 44)		
	2-26 Mechanisms for seeking advice and raising concerns	See above (2-23)		SDG 16
	2-27 Compliance with laws and regulations	Environmental Compliance and Management of Hazardous Substances (p. 44)		
	2-28 Membership associations	About CERN (p. 11) More information can be found on https://cern.ch/intorg.		
Stakeholder engagement				
	2-29 Approach to stakeholder engagement	About CERN (p.12), Management Approach (p. 15)		
	2-30 Collective bargaining agreements	About CERN (p. 11) Information about the Staff Association's mission and mandate can be found on https://cern.ch/samission.		SDG 8
GRI 3: MATERIAL TOPICS 2021				
	3-1 Process to determine material topics	Management Approach (p. 15)		
	3-2 List of material topics	Management Approach (p. 16)		

GRI content index

Topic specific standards		Pages/information	Reasons for omission	SDG
MATERIALS				
GRI 3: Material Topics 2021	3-3 Management of material topics	Procurement and Materials (p. 29)		
GRI 301: Materials 2016	301-1 Materials used by weight or volume	Procurement and Materials (p. 30)	Information incomplete. Data on the proportion of renewable and non-renewable is currently not available. CERN is optimising its tracing of materials to obtain more detailed data for future reports.	SDG 8, SDG 12
	301-2 Recycled input materials used	Procurement and Materials (p. 30)	Information incomplete. Data on the proportion of recycled materials used is currently not available. CERN is optimising its tracing of materials to obtain more detailed data for future reports.	SDG 8, SDG 12
ENERGY CONSUMPTION				
GRI 3: Material Topics 2021	3-3 Management of material topics	Energy (p. 17)		
GRI 302: Energy 2016	302-1 Energy consumption within the organisation	Energy (p. 17, 18)		SDG 7, SDG 12, SDG 13
	302-3 Energy intensity	Energy (p. 18)		SDG 7, SDG 12, SDG 13
	302-4 Reduction of energy consumption	Energy (p. 18, 19)		SDG 7, SDG 8, SDG 12, SDG 13
WATER CONSUMPTION AND EFFLUENT QUALITY				
GRI 3: Material Topics 2021	3-3 Management of material topics	Water and Effluents (p. 36)		
GRI 303: Water and effluents 2018	303-1 Interactions with water as a shared resource	Water and Effluents (p. 36)		SDG 6, SDG 12
	303-2 Management of water discharge-related impacts	Water and Effluents (p. 36, 37)		SDG 6
	303-3 Water withdrawal	Water and Effluents (p. 36, 38)		SDG 6
	303-4 Water discharge	Water and Effluents (p. 36, 38)		SDG 6
	303-5 Water consumption	Water and Effluents (p. 36)		SDG 6
NATURAL RESOURCES AND BIODIVERSITY				
GRI 3: Material Topics 2021	3-3 Management of material topics	Biodiversity, Land Use and Landscape Change (p. 33)		
GRI 304: Biodiversity 2016	304-2 Significant impacts of activities, products and services on biodiversity	Biodiversity, Land use and Landscape Change (p. 33)		SDG 6, SDG 14, SDG 15
GREENHOUSE GAS EMISSIONS				
GRI 3: Material Topics 2021	3-3 Management of material topics	Emissions (p. 21)		
GRI 305: Emissions 2016	305-1 Direct (scope 1) GHG emissions	Emissions (p. 21)		SDG 3, SDG 12, SDG 13, SDG 14, SDG 15
	305-2 Energy indirect (scope 2) GHG emissions	Emissions (p. 23)		SDG 3, SDG 12, SDG 13, SDG 14, SDG 15
	305-3 Other indirect (scope 3) GHG emissions	Emissions (p. 24-27)		SDG 3, SDG 12, SDG 13, SDG 14, SDG 15

Topic specific standards		Pages/information	Reasons for omission	SDG
CONVENTIONAL AND RADIOACTIVE WASTE				
GRI 3: Material Topics 2021	3-3 Management of material topics	Waste (p. 39)		
GRI 306: Waste 2020	306-1 Waste generation and significant waste-related impacts	Waste (p. 39)		SDG 3, SDG 6, SDG 11, SDG 12
	306-2 Management of significant waste-related impacts	Waste (p. 39)		SDG 3, SDG 6, SDG 8, SDG 11, SDG 12
	306-4 Waste diverted from disposal	Waste (p. 39- 40)		SDG 3, SDG 11, SDG 12
	306-5 Waste directed to disposal	Waste (p. 39-41)		SDG 3, SDG 11, SDG 12
ENVIRONMENTAL IMPACT OF PROCUREMENT				
GRI 3: Material Topics 2021	3-3 Management of material topics	Emissions (p.26-27), Procurement and Materials (p. 28)		
GRI 308: Supplier environmental assessments 2016	308-2 Negative environmental impacts in the supply chain and actions taken	Emissions (p. 26-27), Procurement and Materials (p. 28)		
CERN-SPECIFIC				
	HAZARDOUS SUBSTANCES			
GRI 3: Material Topics 2021	3-3 Management of material topics	Environmental Compliance and Management of Hazardous Substances (p. 44)		
	IONISING RADIATION			
GRI 3: Material Topics 2021	3-3 Management of material topics	Ionising Radiation (p. 31)		
	LAND USE AND LANDSCAPE CHANGE			
GRI 3: Material Topics 2021	3-3 Management of material topics	Biodiversity, Land use and Landscape Change (p. 33)		
	MOBILITY			
GRI 3: Materials topics 2021	3-3 Management of material topics	Emissions (p. 24 -25)		
	NOISE			
GRI 3: Material Topics 2021	3-3 Management of material topics	Noise (p. 42)		
	PREVENTION OF ENVIRONMENTAL ACCIDENTS			
GRI 3: Material Topics 2021	3-3 Management of material topics	Environmental Compliance and Management of Hazardous Substances (p. 44)		
	SCIENCE AND EDUCATION FOR THE ENVIRONMENT			
GRI 3: Material Topics 2021	3-3 Management of material topics	Knowledge and Technology for the Environment (p. 46)		

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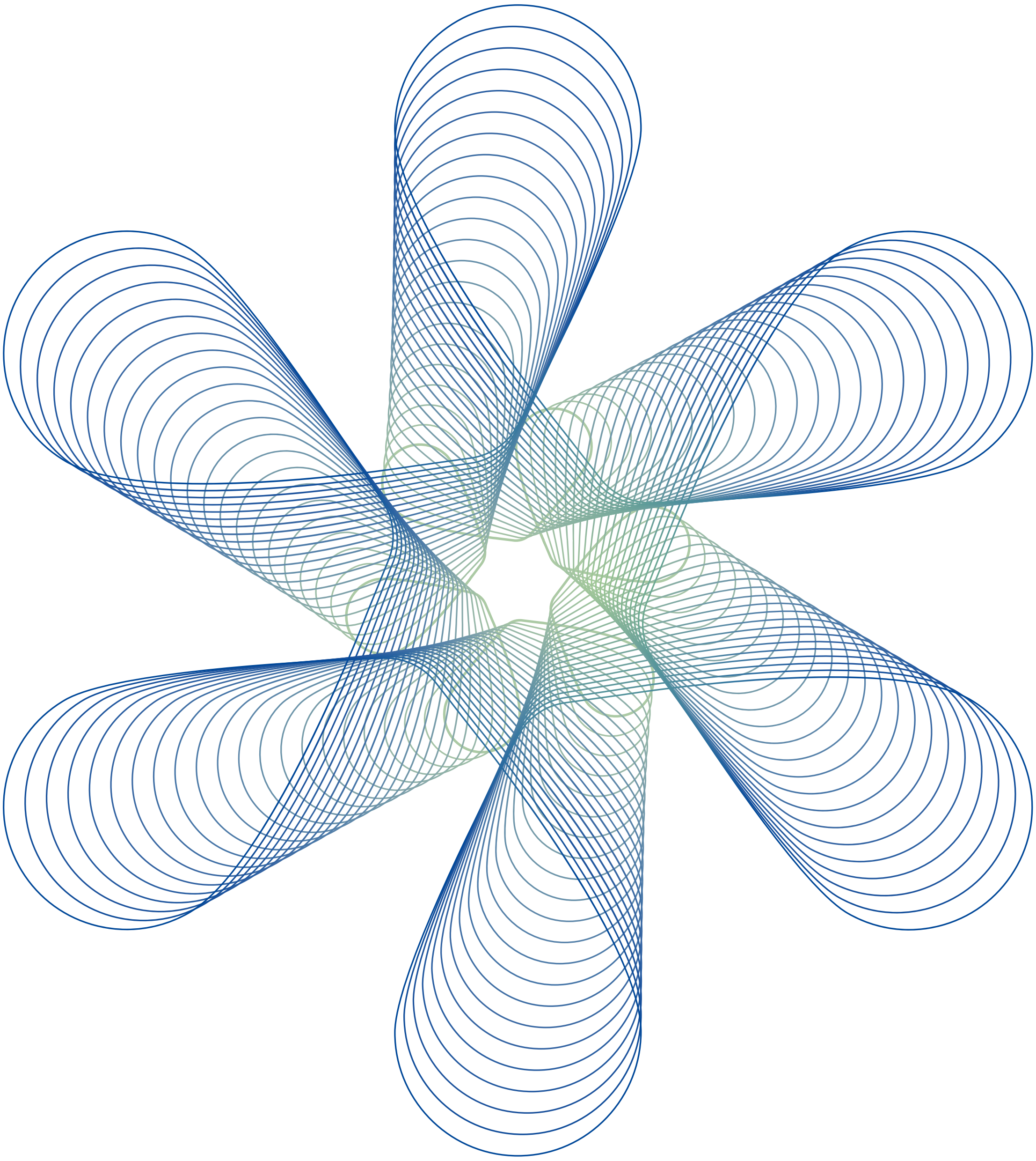

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