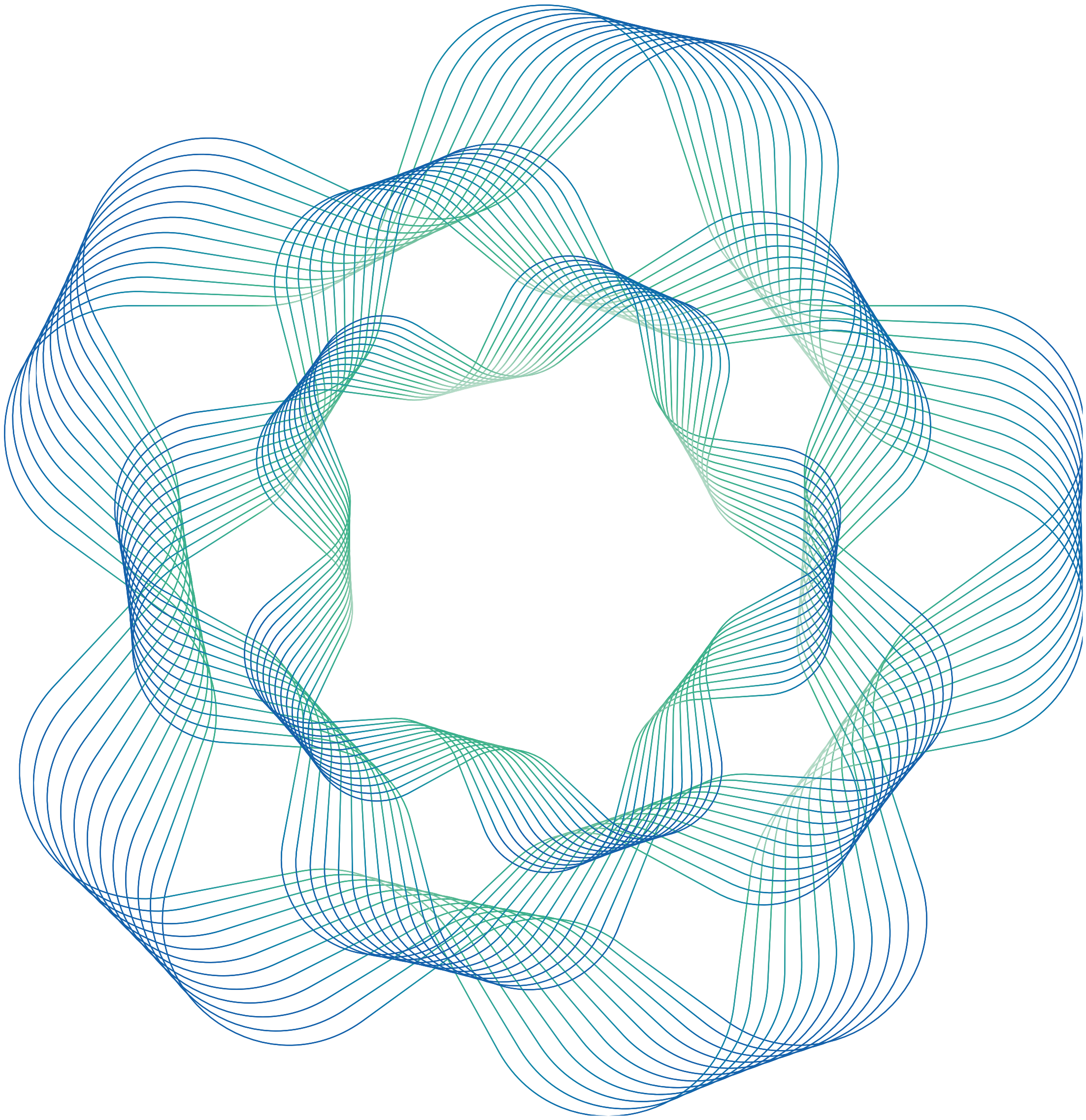

Environment Report

2021–2022

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FOREWORD

A message from the Director-General

CERN was established in 1954 as a focal point for fundamental physics research in Europe, providing facilities that are beyond the reach of individual countries and fostering cooperation between European states through science. Today, the Laboratory has grown to provide a unique set of research infrastructures serving a worldwide community of scientists and has become a model of global collaboration. CERN also aspires to be a model for a sustainable and environment-friendly research organisation and to ensure that some of its technologies can help society to protect the planet.

Over recent years, climate and environment awareness has grown considerably. While CERN has always taken its environmental stewardship seriously, today we are making extra efforts to ensure that we can deliver all our objectives with minimum environmental impact while making a maximum contribution to society. This applies both to potential future facilities and to existing ones.

In 2020, the European particle physics community published an update of the European Strategy for Particle Physics and recommended that CERN carry out a feasibility study for a Future Circular Collider (FCC). It also recommended that “A detailed plan for the minimisation of environmental impact and for the saving and re-use of energy should be part of the approval process for any major project”. In other words, sustainability will be built into any future project at CERN.

For that reason, the FCC feasibility study team is looking closely at the environmental feasibility of the FCC, examining aspects ranging from the preservation of biodiversity to the use of excavated materials, developing more energy-efficient technologies and deploying renewable energy solutions. We will keep you fully informed of developments in this area in future reports.

Today, climate change and protecting the environment are among the greatest challenges that humanity faces. It is incumbent on all of us to play our part in mitigating the impact of human activity on it. Business as usual is not an option, and we at CERN are actively investigating how we can continue to advance the frontiers of human knowledge while minimising the environmental footprint of our facilities and being a positive contributor of solutions.

Fabiola Gianotti, Director-General

Fabiola Gianotti

A word from the Head of the Occupational Health and Safety and Environmental Protection unit

CERN’s third Environment Report covers the years 2021 and 2022, a period that was marked by the continuing COVID-19 pandemic and the emergence of war in Europe following Russia’s invasion of Ukraine. Both have had an impact on the data you will find in this report. Like most of the world, COVID-19 has changed the way in which CERN operates. Although the Laboratory has come back to life with people physically returning to the workplace, many now take advantage of the new possibility to telework part time and the amount of travel has significantly decreased. The result of this is clearly visible in our commuting and travel statistics and the accompanying environmental data. The Russian invasion contributed to volatility in the energy markets. Consequently, CERN has implemented additional energy-saving measures as a mark of social responsibility.

For a large part of this reporting period, CERN’s accelerator complex was undergoing a long shutdown for maintenance and upgrades. CERN’s environmental footprint during a long shutdown is markedly different to what it is in a period of accelerator operation. Our energy and water consumption are lower, for example, but our waste treatment rate is higher as we replace worn out and obsolete equipment.

Despite the challenging backdrop of the continuing pandemic, the shutdown objectives were all accomplished, and the accelerators progressively came back to life in 2021–2022, culminating in the successful restart of CERN’s flagship project, the Large Hadron Collider (LHC), in July 2022. The work carried out during the shutdown was designed to improve the performance of the accelerators and detectors and to improve their environmental credentials. The accelerator complex is now more efficient, delivering more data per unit of energy consumed. The experiments invested much effort in repairing leaks in their gas systems and worked towards replacing the current gases with more environmentally friendly ones.

This report also covers the new CERN Innovation Programme on Environmental Applications (CIPEA), which was launched in March 2022 and is funding its first eight projects. We include, for the first time, data on the scope 3 greenhouse gas emissions arising from procurement. Over the years since we embarked on our first environment report, we have learned a great deal about our footprint, implemented mechanisms to better understand and control it and increased our efforts to identify and develop technologies stemming from our core research that have the potential to benefit the environment. Although there is still some way to go, we have made considerable progress, which I encourage you to explore in this report.

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

ENERGY
1215 GWh

The Laboratory is committed to limiting rises in electricity consumption to 5% up to the end of Run 3 compared to the 2018 baseline year, which corresponds to a maximum target of 1314 GWh, while delivering significantly increased performance of its facilities. It is also committed to increasing energy reuse.

In 2021 and 2022, CERN consumed 991 GWh and 1215 GWh of electricity respectively.

In addition, the Organization consumed 67 GWh (240 TJ) and 51 GWh (184 TJ) of energy generated from fossil fuels in the two years respectively.

EMISSIONS
184 173 tCO_2e

CERN's objective is to reduce direct emissions by 28% by the end of Run 3 compared to the 2018 baseline year, which corresponds to a maximum target of 138 300 tCO_2e.

The scope 1 emissions in 2021 and 2022 were 123 174 and 184 173 tonnes of CO_2 equivalent (tCO_2e) respectively.

The total amount of scope 2 greenhouse gas emissions due to CERN's electricity consumption was 56 382 and 63 161 tCO_2e in 2021 and 2022 respectively.

Total scope 3 emissions arising from business travel, personnel commuting, catering, waste treatment and water purification amounted to 7813 and 8956 tCO_2e in 2021 and 2022 respectively.

Scope 3 emissions arising from procurement, which are reported for the first time, amounted to 98 030 tCO_2e and 104 974 tCO_2e in 2021 and 2022 respectively.

WASTE
69% recycled

CERN's aim has been to increase its recycling rate for non-hazardous waste. The recycling rate rose from 56% in 2018 to 69% in 2022.

In 2021 and 2022 respectively, CERN disposed of 5111 tonnes and 8812 tonnes of non-hazardous waste, and of 1544 tonnes and 1295 tonnes of hazardous waste, including 307 and 519 tonnes of radioactive waste.

NOISE
45 dBA at night

CERN is committed to restricting noise at its site perimeters to 70 dBA during the day and 60 dBA at night.

Over this reporting period, CERN implemented measures to improve its noise management, including the installation of an online real-time monitoring system at Point 2 of the LHC and Point 4 of the SPS. Average noise levels measured on the boundaries of CERN's sites are typically around 50 dBA during the day and 45 dBA at night.

WATER AND EFFLUENTS
3234 ML

The Laboratory is committed to keeping the increase in its water consumption below 5% up to the end of Run 3 compared to the 2018 baseline year, which corresponds to a maximum target of 3651 ML, despite a growing demand for water cooling at the upgraded facilities.

In 2021 and 2022, CERN used 2661 and 3234 megalitres of water respectively.

IONISING RADIATION
< 0.01 mSv

The European annual dose limit for public exposure to artificial sources is 1 mSv. CERN is committed to keeping its contribution to no more than 0.3 mSv per year.

The actual dose received by any member of the public living near the Laboratory was less than 0.01 mSv in the reporting period, which is more than 100 times lower than the average annual dose received from medical exposure per person in Switzerland.

IN BRIEF 2021–2022

This reporting period saw the completion of the second long shutdown and the restart of the accelerator complex (Run 3) with a view to reaching the new collision energy of 13.6 TeV at the Large Hadron Collider (LHC). In some domains environmental indicators may be very different during shutdown years compared to operation years, so they are shown for both years to highlight this, where relevant. 2022 indicators are prominently shown for those domains where priority objectives have been defined, namely Energy, Emissions and Water and Effluents.

BIODIVERSITY
18 species of orchids

Inventories of flora and fauna were conducted in 2022. A further two species of orchid were identified, bringing the total on the CERN sites to 18, as well as 62 species of Lepidoptera and 32 species of Orthoptera.

KNOWLEDGE TRANSFER
8 environmental projects

In 2022, CERN launched the Innovation Programme on Environmental Applications (CIPEA), which spans four focus areas where CERN's know-how can be of use, namely renewable and low-carbon energy; clean transportation and future mobility; climate change and pollution control; and sustainability and green science.

Eight projects were selected for implementation with the financial support of external partners or the CERN Knowledge Transfer fund.

ABOUT CERN

Founded in 1954, the European Organization for Nuclear Research, CERN, is the world's leading laboratory for particle physics. Its mission is fundamental physics, finding out what the Universe is made of and how it works.

A WORLDWIDE LAB

CERN is an intergovernmental organisation headquartered in Meyrin, in the Canton of Geneva, Switzerland, and has two main campuses: the original Meyrin site, which straddles the French-Swiss border, and the Prévessin site in France. It also has several smaller sites in both countries, located around the Large Hadron Collider (LHC) and the Super Proton Synchrotron (SPS).

Cooperation between nations, universities and scientists is the driving force behind CERN's research. More than 16 000 people from around the world work together at CERN to push back the frontiers of science and technology. Among them, just over 3500 employed members of the CERN personnel take part in the design, construction and operation of the research infrastructure. They also contribute to the preparation and operation of the experiments, as well as to the analysis of the data gathered for the vast community of users, which comprises over 12 000 scientists from institutes in more than 82 countries.

DISCOVERY MACHINES

CERN provides a unique range of particle-accelerator facilities that enable research at the forefront of human knowledge. The flagship facility, the LHC, is the world's largest and most powerful particle accelerator. It collides beams of protons or heavy ions, and the results of these collisions are recorded by several particle detectors. The LHC's evolution will culminate with the High-Luminosity LHC (HL-LHC), which will run from 2029 to 2041.

Lead times for new facilities in particle physics are long, and although the LHC will run until 2041, planning for a successor has already begun. The current front-runner, which has been identified through the European Strategy for Particle Physics, is a large circular machine with a circumference of about 91 km. The CERN Council has mandated CERN to carry out a feasibility study for this future circular collider (FCC), and this study is ongoing. The study team will report on the financial, environmental, geological and technological feasibility of the FCC in 2025 (see In focus). In parallel, R&D is under way on a range of other potential future facilities that could carry CERN research through to the end of the 21st century. To develop new research tools, CERN is pushing several technologies, including superconductivity, vacuum, computing and electronics, to their limits. In the long term, these innovations could benefit society as a whole (see Knowledge and technology for the environment).

INSPIRING AND EDUCATING NEW GENERATIONS

The science and technology underpinning CERN's research have great potential to inspire students to pursue careers in science and engineering, as well as to enthuse and engage citizens of all ages in the wonders of science and its impact on our daily lives. The Laboratory is a much-favoured visitor destination, with around 150 000 visitors from 95 countries (2019) taking part in guided tours every year.

Education is a pillar of CERN's mission. The Science Gateway, due to open in 2023, will be an emblematic education and outreach facility. The various initiatives to inspire and educate students of all ages include the Summer Student programme for undergraduates, the Beamline for Schools competition for high-school students and the Be a Scientist programme for primary schoolchildren. The Organization also runs programmes for high-school teachers.

ETHICS AND INTEGRITY

CERN is committed to pursuing its mission of research, innovation, training and collaboration while respecting the highest ethical standards of behaviour. The CERN Staff Rules and Regulations are the overarching framework that defines the roles and responsibilities of the Organization and its personnel. In addition, the Organization has a full-time ombudsperson and a Diversity & Inclusion Programme.

The CERN Code of Conduct builds on CERN's values, namely integrity, commitment, professionalism, creativity and diversity. It provides common basic standards of behaviour to help its staff understand how to conduct themselves and treat others and how they can expect to be treated. It applies to everyone on the CERN site, whether personnel or visitors. This is part of a comprehensive framework that underpins the Organization's duty of care and is complemented by relevant bodies and structures designed to ensure the wellbeing of all personnel and provide them with the support they need. This framework covers employment-related rights, safety at CERN and institutional due diligence.

A SUSTAINABLE RESEARCH ENVIRONMENT

CERN strives to be a role model for environmentally responsible research. To this end, an awareness campaign to inform personnel of the actions taken across key environmental themes was launched in June 2021. This campaign closed with a general meeting in September 2022 that included presentations from Department Heads and was designed to ensure that everyone working at CERN had the opportunity to familiarise themselves with the Organization’s environmental goals and learn how they can contribute to achieving them. In October 2022, CEPS (CERN Environmental Protection Steering board) organised a two-day workshop on CERN and the Environment. This went into more depth than the general meeting, featuring dedicated sessions on energy, the status of research on environmentally friendly coolants and detector gases, water, the local environment, mobility, travel, food and procurement.

The science and work carried out at CERN have an impact across many of the United Nations Sustainable Development goals (SDGs). Five have been identified as particularly relevant for the Laboratory: good health and well-being (3); high-quality education (4); industry, innovation and infrastructure (9); peace, justice and strong institutions (16); and partnerships for the goals (17). The Organization strives to contribute actively towards their implementation. In addition, CERN’s aim to limit its impact on the environment is aligned with other SDGs (see GRI content index).

CERN is a member of the European Intergovernmental Research Organisation forum (EIROForum), which brings together eight of Europe’s largest research organisations. In October 2021, together with key leaders and researchers from major US and European science laboratories, including the other EIROforum members, CERN took part in a videoconference ahead of the United Nations Framework Convention on Climate Change Conference of Parties (COP26). Sharing the same values and convinced that science performs best through collaboration, the participating institutes issued a joint press release, affirming their common commitment to uniting science towards a sustainable and resilient global society and economy.

In parallel, the EIROforum working group on environmental sustainability, created in 2020 and chaired by CERN, met twice per year in 2021 and 2022 to review the activities carried out by each member and to identify areas of common interest where synergies could be developed. The autumn 2022 meeting included a chance for the organisations to share their response to the energy crisis.

Ensuring that CERN’s knowledge and technologies reach society as a whole is enshrined in the Organization’s founding Convention, which states that: “the results of its experimental and theoretical work shall be published or otherwise made generally available”. In 2020, the Office of the High Commissioner for Human Rights (OHCHR), UNESCO, WHO and CERN published a joint appeal for Open Science, in which it was underlined that it is a human right and plays an important role in reaching SDGs.

GOVERNANCE

CERN had 23 Member States, ten Associate Member States and six Observers as of the end of 2022. The Observer status of the Russian Federation and the Joint Institute for Nuclear Research (Dubna, Russia), were suspended by a CERN Council Resolution in March 2022. The CERN Council is the highest authority of the Organization and decides on CERN’s activities in scientific, technical and administrative matters. The Council is assisted by its five subordinate bodies, including the Scientific Policy Committee, Finance Committee, Audit Committee, Tripartite Employment Conditions Forum, and the Pension Fund Governing Board. The Member States appoint their own delegates and each state has a single vote, with most decisions requiring a simple majority.

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.

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 Staff Association, the ombudsperson, the Human Resources department and the Users Office, and dedicated bodies are in place to address specific concerns.

A GLOBAL COLLABORATION

CERN cooperates with a number of national and international scientific institutions and organisations and is represented on several scientific committees, such as the European Committee for Future Accelerators (ECFA) and the International Committee for Future Accelerators (ICFA). CERN also has Observer status at the United Nations General Assembly.

IN FOCUS

Luisa Ulrici is the deputy leader of CERN’s Environment group and was the link person for the "Mining the Future” competition.

— What was the context of this competition?

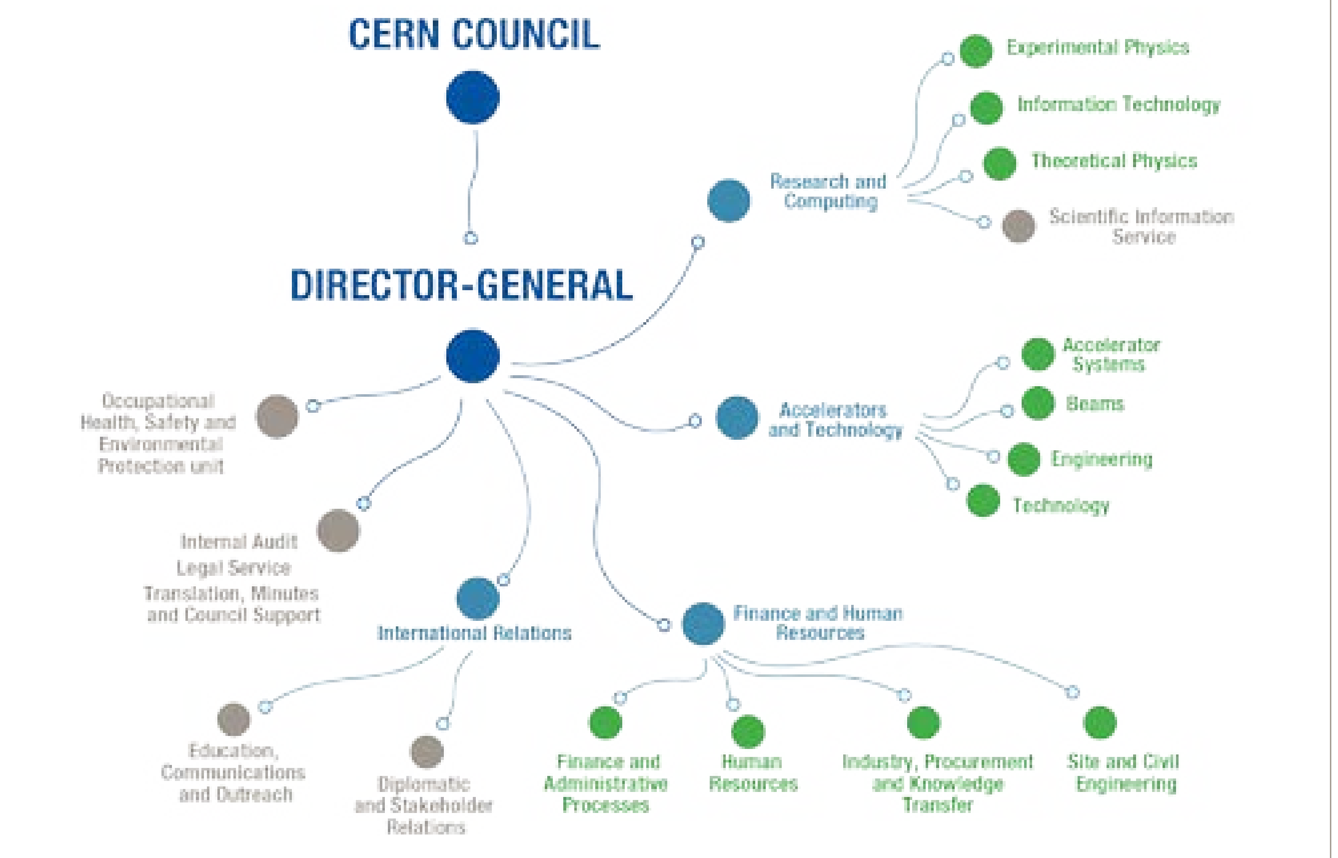
LU: The FCC feasibility study aims to establish the environmental sustainability of a future flagship research facility, in line with the recommendations of the European Strategy for Particle Physics 2020 update.

Constructing a new 91 km subsurface infrastructure that could provide exciting physics results until the end of the 21st century will generate considerable amounts of excavation material, mainly molasse. No reuse pathway on an industrial scale currently exists for this material, a heterogeneous sedimentary rock that is prevalent in the region. This is why the FCC collaboration, CERN and the University of Leoben, with the support of the EU-funded H2020 FCC Innovation Study project, launched the Mining the Future competition. This international competition aimed to identify credible technologies and processes that could be brought to market by the time a new infrastructure is built.

— The competition results were announced in a ceremony on 27 September 2022. What was the outcome?

LU: We received 12 very interesting applications, from which four excellent proposals were shortlisted. The winner was selected based on four evaluation criteria: technical feasibility, economic viability, social value and project relevance.

A consortium led by BG Ingénieurs Conseils presented the winning proposal, “Molasses is the new ore”, an innovative way to apply a near real-time flow analysis already used in cement plants to separate excavated material for further processing on site. The winning consortium received an award designed to support its further R&D to bring the technology to maturity.



CERN's ORGANISATIONAL STRUCTURE IN 2021–2022

MANAGEMENT APPROACH

A STRATEGY FOR THE ENVIRONMENT

Strong environmental stewardship stands prominently among the Management's objectives and is embedded in every corner of the Organization. The European Strategy for Particle Physics, updated in 2020, sets out a coherent and globally coordinated approach to the development of the field in Europe and at CERN. The Strategy also highlights the importance of the environment, stating that the environmental impact of particle physics should continue to be carefully studied and minimised.

The Organization's environmental strategy spans three key lines of action: minimise the Laboratory's impact on the environment; reduce energy consumption and increase energy reuse; and develop technologies that can help society to preserve the planet. The Occupational Health and Safety and Environmental Protection unit (HSE) is CERN's centre of competence in environmental matters and the driving force behind the Organization's Safety Policy. This policy spans all matters relating to health, safety and environmental protection, and includes the explicit goal of limiting the impact of the Organization's activities on the environment. In addition to its Safety Policy, CERN has an environmental protection strategy that prioritises certain key areas.

CERN applies the precautionary principle in all aspects of environmental management, taking action to avoid the possibility of serious environmental impact. This applies under all circumstances: if the scientific data does not permit a complete evaluation of the risk, precautionary measures are nevertheless deployed.

A COMPREHENSIVE FRAMEWORK

The Organization launched the CERN Environmental Protection Steering board (CEPS) in 2017. CEPS's mandate is to identify and prioritise environmental areas to be addressed, in line with the environmental protection strategy, and to propose programmes of action across 11 high-priority environmental domains. Objectives are approved at the highest level of management at CERN, the Enlarged Directorate, which comprises all Directors and Departments Heads. Once the programme of activities and the allocation of resources have been approved by the Directorate, CEPS follows up on the programme's implementation. CEPS steers the action plan related to the priorities set in 2017, which are periodically reviewed according to new areas of focus. In addition, CERN has an Energy Management Panel (EMP), which was set up in 2015 to examine CERN's energy consumption, identify measures to improve efficiency and promote energy reuse. The energy crisis in 2021–2022, the period covered by this report, accentuated the focus on responsible energy management (see Energy).

Several tools, including the Radiation Monitoring System for the Environment and Safety (RAMSES, see Ionising radiation) and the CERN Chemical Register for Environment, Health and Safety (CERES, see Environmental compliance and management of hazardous substances) complete the environmental management framework.

COLLABORATION WITH THE HOST STATES

CERN works closely with its Host States, France and Switzerland, in matters of environmental protection. As an organisation straddling two countries, CERN develops its own regulations, based on those of the Host States. Where no specific CERN regulation exists, the relevant laws and regulations of the Host States apply on a territorial basis.

Together with the Canton of Geneva (Switzerland) and the Prefecture of Ain (France), CERN established a tripartite committee for the environment (CTE) in 2007 under a memorandum of cooperation on non-radiological environmental aspects. It holds two plenary meetings per year, as well as regular technical meetings.

The Laboratory signed a tripartite agreement on radiation protection and radiation safety in 2010 with the Swiss Federal Council, represented by the Office of Public Health (FOPH) and the French Government, represented by the Nuclear Safety Authority (ASN). This replaced previously existing bilateral agreements and created a legal framework for discussing topics related to radiation protection. The agreement provides for regular technical meetings, as well as high-level plenary meetings chaired by CERN's Director for Accelerators and Technology. In addition, the Organization formally reports to the FOPH and ASN on matters of radiation protection.

FUNDING MECHANISMS

CEPS regularly updates CERN's environmental strategy recommendations. Resources from CERN's budget (some 48 MCHF over the period 2019–2023) fund the activities in these domains, which include, for example, R&D on new, environmentally friendly gases for particle physics detectors and the construction of water retention basins to limit the risk of pollution.

To maximise the Organization's return to society, CERN's Knowledge Transfer (KT) fund provides funding that can be used to support environmental projects proposed by personnel. This mechanism helps to take early-stage, innovative projects from the Laboratory to society, bridging the gap between research and societal applications. The KT fund is supported through revenue from commercial agreements. In 2021 and 2022, the fund allocated a total of 950 kCHF to ten projects, eight of which were related to environmental applications (see Knowledge and technology for the environment).

A new funding framework, the CERN Technology Impact Fund, was launched in 2021 with support from CERN's Knowledge Transfer group and the CERN & Society Foundation. It seeks to support CERN technologies with a strong potential to address existing global societal issues, as identified by the United Nations Sustainable Development Goals (SDGs).

SUPPLY CHAIN

Procurement has been identified as an important subject for CERN's environmental stewardship. CERN shapes its own procurement rules and processes due to its status as an intergovernmental organisation. These currently involve competitive tendering and the adjudication of contracts to the lowest compliant bidder or the bidder offering the best value for money. CERN strives to ensure a balanced industrial return for all its Member and Associate Member States. A policy on environmentally responsible procurement at CERN is being developed. This policy provides for engagement with suppliers in matters of responsible business conduct (see Emissions).

SCOPE AND TOPIC BOUNDARIES

CERN is an intergovernmental organisation that also functions as a user facility for people and universities and institutes around the world. The data presented in the report refers exclusively to the impact of CERN's facilities in the Geneva region, unless stated otherwise. The production of research equipment under the responsibility of collaborating institutes is not considered here.

CERN's main product is data, which is transformed into knowledge by scientists around the world using the Worldwide LHC Computing Grid (WLCG) (see Energy). This is a distributed network and is covered here only insofar as the facilities are on CERN's premises.

CHANGES TO CERN'S ACCELERATOR SCHEDULE

The Laboratory's main environmental objectives were set by CEPS in 2017, with a horizon stretching to the end of 2024, when the accelerators were to enter the third long shutdown. Since the last report, the accelerator schedule has been updated with the end of Run 3 being moved to the end of 2025 and the start of the third long shutdown to 2026. Subsequently, the objectives communicated in past reports have also been amended accordingly.

MATERIALITY

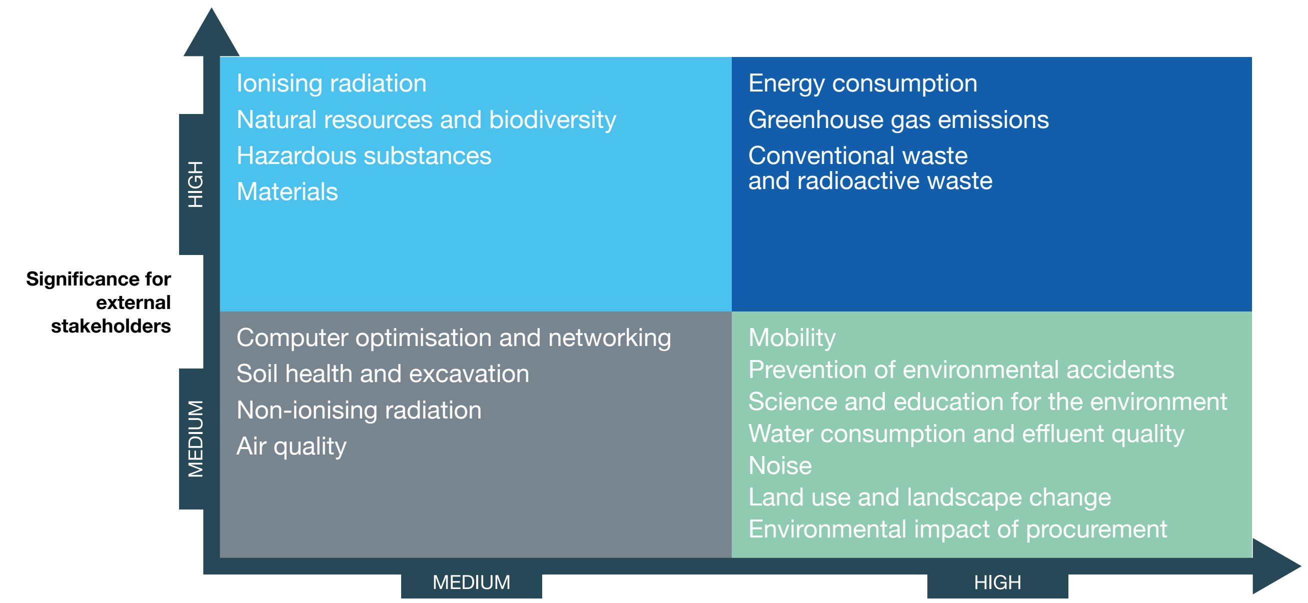
CERN carried out its first materiality analysis in 2019, and the resulting set of topics and disclosures were covered in both the first and second environment reports. The analysis was updated in 2022 following stakeholder interviews on topics drawn from the GRI Sustainability Reporting Standards, as well as on some CERN-specific topics not covered by the GRI Standards but deemed by CERN and key stakeholders to be of material importance in the CERN context.

The process, run in collaboration with an external consultant, involved the creation of a focus group, on which both internal and external stakeholders chosen to represent the diversity of viewpoints at CERN were represented, in order to prioritise the topics to be covered. These interviews served to establish the relative importance of topics to CERN stakeholders. The topics were subsequently prioritised based on severity and likelihood, resulting in the materiality matrix that was approved by the Enlarged Directorate in October 2022.

The topics deemed to be of high significance for sustainable development are the main focus of this report. Soil health and excavation, non-ionising radiation, air quality, computer optimisation and data transfer arose as topics to be addressed but did not have high significance for all stakeholders. As a result, these topics are not comprehensively covered in this report but have been identified for future consideration. Although lower priority was given to effluent quality than in the previous materiality assessment it was decided to maintain it for the sake of continuity and transparency. Finally, some external stakeholders identified materials as a topic of high importance. This heading includes optimising the use of core materials such as metals and helium and favouring the use of recycled or secondary resources to minimise the environmental and human rights impacts caused throughout the materials' life cycle. Given the complexity in tracing the material through its whole life cycle, an in-depth analysis will be undertaken to establish a reliable way in which to report on this topic.

Internal stakeholders	External stakeholders
- CERN Directors - Heads of CERN Departments - CERN Council president and delegates (Member State representatives) - Representatives of the user community and of the Staff Association - Project leaders of potential future research infrastructures at CERN - Personnel responsible for communications and other aspects of external relations	- Host State participants in meetings held under the tripartite agreement on radiation protection and radiation safety - Host State participants in meetings held under the tripartite committee for the environment (CTE) - Representatives of some local communities with a strong CERN presence - Representatives of local environmental associations - Representatives of Host State media

STAKEHOLDERS INTERVIEWED FOR THE MATERIALITY ASSESSMENT UPDATE



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

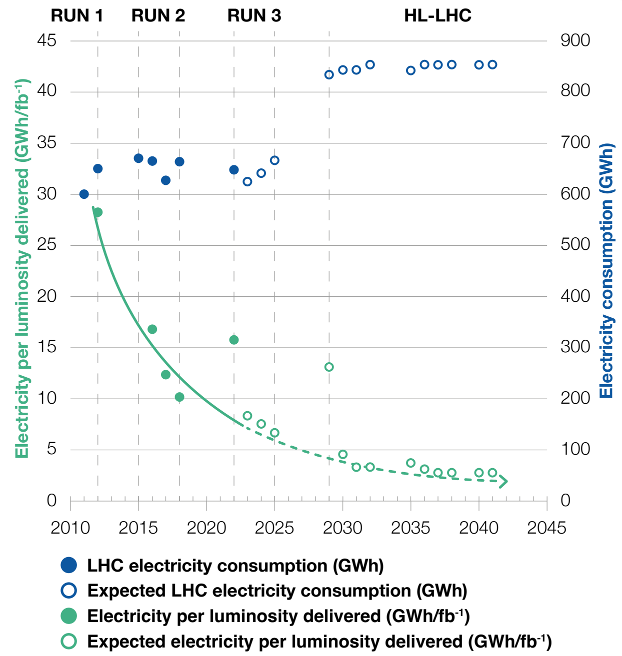
Accelerators account for more than 90% of CERN's energy consumption during run periods. As powerful research instruments, these machines make a unique scientific programme possible and support a global community of scientists. CERN makes every effort to run them in the most energy-efficient way possible, with its main immediate goal being to limit the increase in energy consumption up to the end of Run 3 to 5% with respect to 2018, despite the higher beam energy and intensity. The initial target date of 2024 to achieve this objective has been shifted in line with the change in the accelerator schedule, with Run 3 now expected to end in 2025.

POWERING UP FOR RUN 3

Powering CERN's unique array of accelerators, detectors and infrastructure primarily requires electricity, which represents about 95% of CERN's energy use. Under normal circumstances, this is procured entirely from France, where the energy grid mix is about 90% low-carbon (2022). CERN's energy needs depend on annual accelerator operation cycles, peaking at some 1250 GWh/year during operation with beam, with the Large Hadron Collider (LHC) accounting for 55% of the total consumption. Following its second long shutdown, the LHC gradually resumed operations in 2021 and Run 3 was officially launched in July 2022. In 2021 and 2022, CERN consumed 995 GWh and 1215 GWh of electricity, respectively.

In addition to electricity, CERN also uses natural gas for heating, fuel for its fleet of vehicles and diesel for emergency generators. It also uses commercial liquid nitrogen for cooling and photovoltaic energy produced on site. In 2021 and 2022, CERN consumed 67 GWh (240 TJ) and 51 GWh (184 TJ) of fossil fuels, respectively. Energy procurement represents around 5% of CERN's annual budget when the accelerators are running, and less during shutdown periods. This is expected to change markedly as of 2023, in light of the rising costs of energy worldwide.

CERN constantly strives to deliver more data to the experiments. At the LHC, this is measured using a parameter known as luminosity. Higher luminosity of the colliding beams leads to more data and increased potential for new discoveries, but can come at the cost of greater electricity consumption. CERN therefore aims to increase the energy efficiency of its facilities in terms of luminosity delivered per unit of energy consumed. The efficiency of the LHC in these terms increased by a factor of three between the start of Run 1 and the end of Run 2 and is expected to be multiplied by a factor of four in the High-Luminosity LHC (HL-LHC) era.



ELECTRICITY INTENSITY OF THE LHC

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

CERN'S ENERGY STRATEGY

The overarching principles of CERN's energy strategy, guided by the Energy Management Panel (EMP) established in 2015, can be summarised in three key concepts : use less, increase efficiency and recover waste energy.

The EMP has driven major efforts to reduce electricity consumption through optimisation and dedicated actions, resulting in savings of some 100 GWh/year since 2010. The process of defining and agreeing upon longer-term objectives continues and these will be set out in future reports.

CERN began the process to obtain ISO 50001 energy management certification in 2022 (see In focus). In this context, the Organization published an Energy Policy in October 2022, designed to continuously improve CERN's energy performance by keeping the energy required for its activities to a minimum, improving energy efficiency and recovering waste energy. CERN's Management led efforts to reinforce the existing frameworks for energy governance, in line with ISO 50001 requirements. A full-time energy coordinator was appointed, and the EMP was expanded to cover all of CERN's activities beyond the accelerator complex.

ENERGY DIVERSIFICATION AND HEAT RECOVERY

CERN strives to further diversify its energy mix and, to that end, is looking to incorporate more renewable energy sources in the future. Various solutions are being investigated, such as power purchase agreements (PPA – contractual agreements between energy buyers and sellers). Studies and negotiations with potential suppliers have begun in order to explore concrete possibilities, notably with regard to photovoltaic energy for the Organization's long-term requirements. More locally, solar panels installed on the new Science Gateway building, which is due to open in 2023, will inject unused photovoltaic energy into CERN's grid.

In line with the priority to recover waste energy, the equipment that has been installed at LHC Point 8 to collect heat from CERN facilities to heat a residential area in neighbouring Ferney-Voltaire is ready to be connected. Two further heat recovery projects were approved during the period covered by this report. They aim to recover waste heat from CERN's core activities, such as data processing, cooling and LHC operation, for reuse on the Meyrin and Prévessin sites. Their completion is anticipated in 2026–2027.

COMPUTING AND IT INFRASTRUCTURE

CERN's main product is data, which is produced in particle beam collisions and recorded by the LHC experiments. This data is analysed on the WLCG, one of the world's largest computing infrastructures, which is managed and operated by a worldwide collaboration consisting of CERN, the LHC experiments and the participating computer centres. The WLCG energy consumption statistics included in this report relate only to the facilities owned or operated by CERN.

By the time the HL-LHC starts up in 2029, the total computing capacity required by the experiments is expected to have grown by up to a factor of 10. To meet these increased needs, a new data centre in Prévessin, the construction of which began in April 2022, will provide computing resources of up to a total energy power requirement of 12 megawatts, which will be delivered in three phases. The objective is to achieve a power usage effectiveness (PUE—an indicator used for measuring the energy efficiency of a data centre) of around 1.1. For context, the global average PUE for large data centres is around 1.5, with new data centres typically achieving between 1.2 and 1.4 (the closer to 1.0, the better the score). The PUE of the existing CERN Data Centre in Meyrin is about 1.5.

Energy efficiency is a key consideration in this project, which includes plans for a system to recover heat to heat all 73 buildings on the Prévessin site.

Furthermore, to save resources and energy in the HL-LHC era, a key focus is on efforts to modernise code, develop ways for it to run more efficiently on the latest hardware and improve data management. Establishing innovative new approaches to key computing tasks, often based on machine learning and other related technologies, also contributes to reducing the overall amount of computing resources needed and thus plays a vital role in minimising energy consumption increases.

COLLABORATION WITH THE HOST STATES

To optimise its energy management approach, CERN collaborates closely with its stakeholders, notably with its main electricity supplier, Électricité de France (EDF), and with the Host States, through the tripartite committee for the environment (CTE), which was established in 2007.

Throughout 2022, CERN engaged in constant discussions with EDF, the local authorities and the Member States and reduced its energy consumption as a mark of social responsibility. Concrete measures were implemented, with a view to energy and cost savings, including bringing forward the 2022 year-end technical stop (YETS) by two weeks, resulting in savings of some 35 GWh. Furthermore, in 2023, accelerator operation will be reduced by 20% and the YETS will be extended to 19 weeks in order to reduce energy consumption, leading to savings of about 70 GWh.

POWERING THE CAMPUS

The energy that the Organization needs to power its buildings and general infrastructure represents about 5% of the Laboratory's total consumption. While this is only a small fraction of the total, efforts made to save energy at campus-level can still make a meaningful difference. This is achieved through a range of actions, including a comprehensive consolidation programme for the heating, ventilation and air conditioning systems, which is updated annually and covers a five-year period. In 2022, CERN launched a dedicated strategy to save energy on the campus. This included delaying the start-up of heating in buildings, reducing the temperature of the heating boilers, replacing halogen lamps with LEDs and switching off outdoor lighting from 11 p.m. to 5 a.m. on both the Meyrin and the Prévessin sites.

IN FOCUS

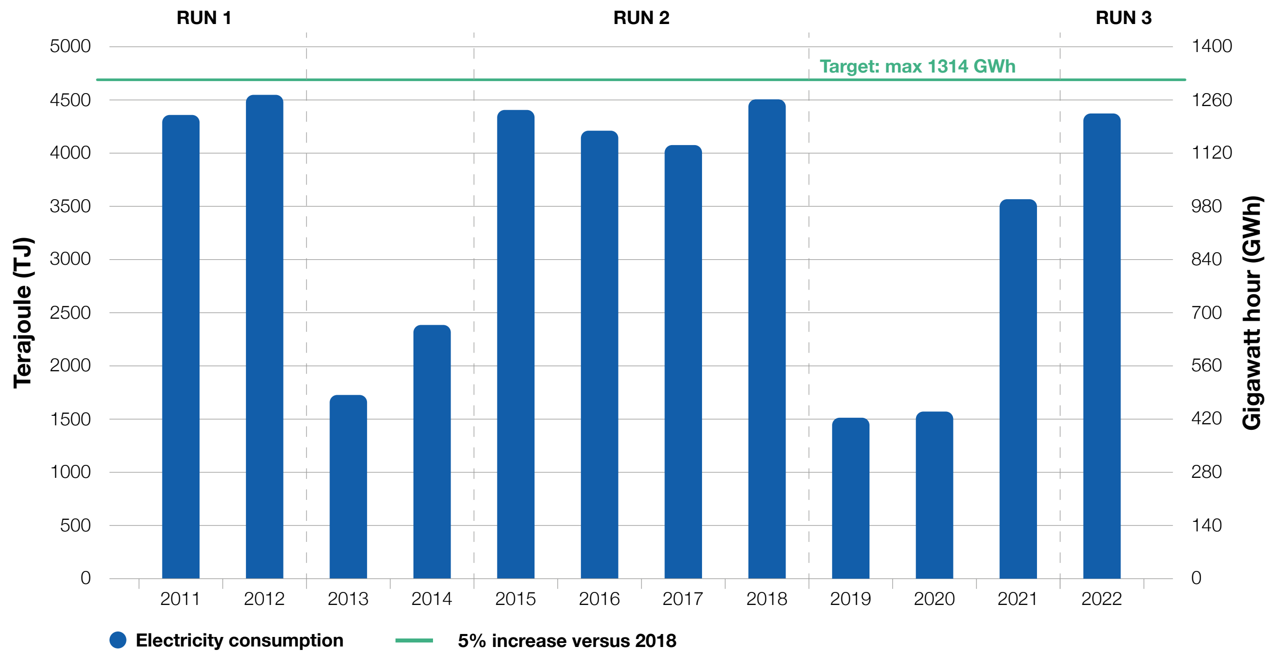
Nicolas Bellegarde is CERN's energy coordinator. He managed CERN's application for the ISO 50001 certification.

— What did the process entail?

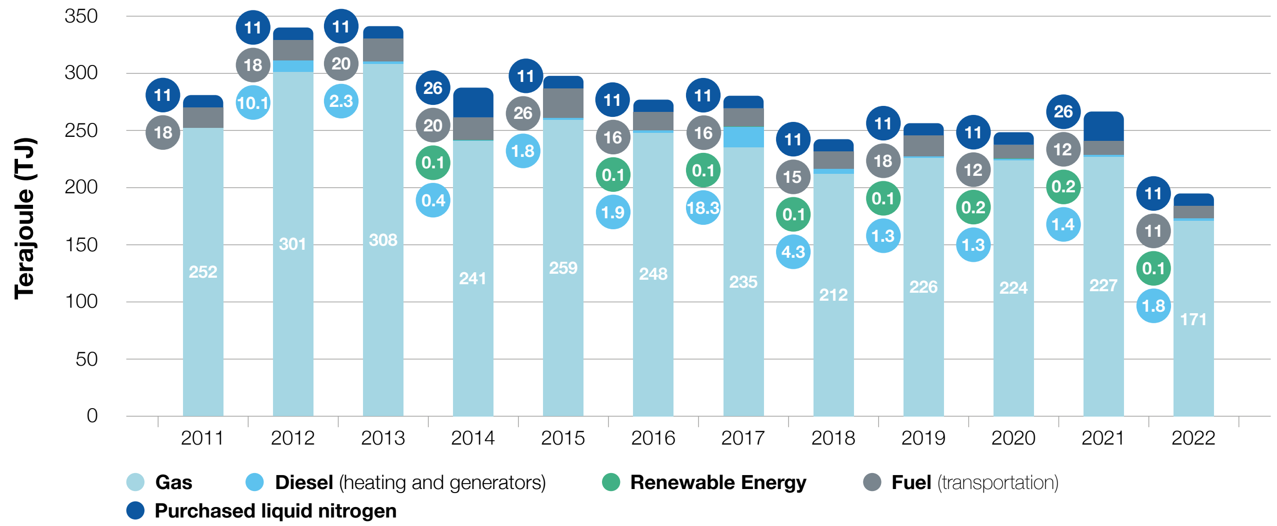
NB: This reference international standard provides a practical way to improve energy performance and allows organisations to integrate energy management into their overall efforts to improve environmental management. The Organization began the ISO 50001 certification process in 2022, covering all of its sites, activities and energy profiles. As part of the associated continual improvement process, CERN submitted its energy performance plan for 2022–2026 to the French authorities in June 2022 and developed a comprehensive Energy Management System throughout 2022. The ISO 50001 certification audit took place at the end of the year and was carried out by the French national organisation for standardisation, AFNOR.

— What are the next steps?

NB: Once certification is awarded, annual surveillance audits are carried out to ensure compliance and continuous improvement of energy performance by defining, monitoring and updating guidelines, objectives and indicators based on an initial energy baseline and concrete measures to meet these targets. An energy management system compliant with the ISO 50001 standard is the mainstay. Training and awareness raising among the CERN community are also required, along with the monitoring of trends, regulatory developments and best practices in energy performance.



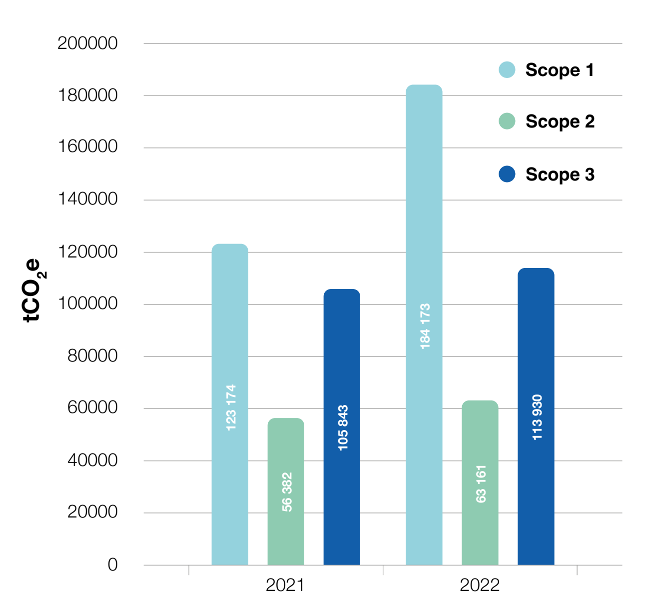
CERN'S ELECTRICITY CONSUMPTION 2011–2022
Run periods refer to the years in which the accelerators are in operation, with occasional technical stops as and when necessary. Outside these periods, the accelerator complex enters 'long shutdowns' for essential maintenance and consolidation.



CERN'S ENERGY CONSUMPTION – OTHER CATEGORIES OF ENERGY 2011–2022
Minor discrepancies were identified for diesel consumption in 2017, 2018 and 2019. These have been corrected in this report.

EMISSIONS

CERN reports on all emissions over which it has operational control. CERN's greenhouse gas emissions are estimated in accordance with the internationally recognised methodology of the Greenhouse Gas Protocol, which categorises such emissions into three "scopes". Scope 1 refers to the direct emissions resulting from an organisation's facilities and vehicles, while scope 2 refers to indirect emissions related to the generation of electricity, steam, heating or cooling purchased for an organisation's own use. Scope 3 refers to all other indirect emissions occurring upstream and downstream of an organisation's activities, such as business travel, personnel commutes, catering and procurement.

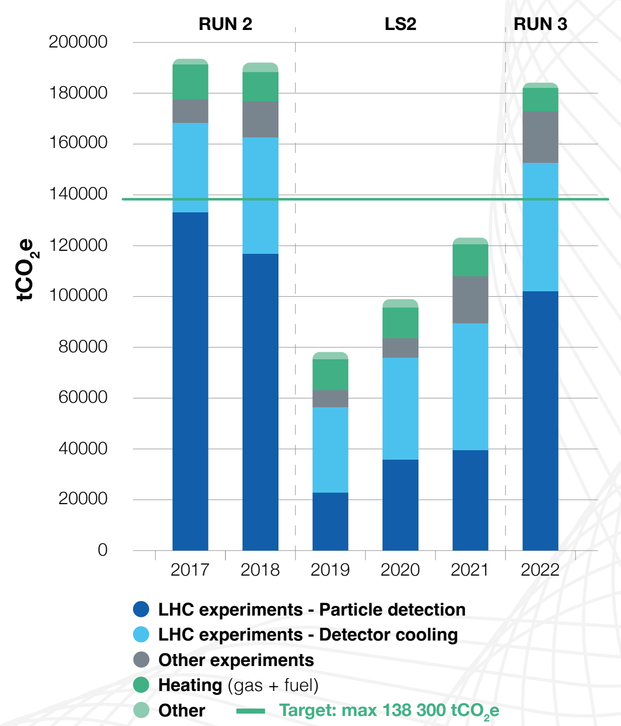


CERN'S TOTAL SCOPE 1, 2 AND 3 EMISSIONS 2021–2022

DIRECT EMISSIONS – SCOPE 1

CERN's direct greenhouse gas emissions (scope 1) arise from the Laboratory's industrial infrastructure and on-site activities. Approximately 90% of CERN's scope 1 emissions come from its experiments. These use a wide range of gas mixtures for particle detection and detector cooling, including fluorinated gases (F-gases) which have a high global warming potential (GWP) and therefore account for about 78% of the Organization's direct emissions. The large experiments represent the main focus of CERN's efforts to mitigate its greenhouse gas emissions. The main gases used are HFCs, PFCs and SF_6 for particle detection, PFCs and HFCs for detector cooling and HFOs/HFCs for standard air conditioning systems. SF_6 is also used for electrical insulation in power supply systems.

With the gradual restart of the accelerator complex in 2021 ready for the launch of Run 3 of the LHC in mid-2022, the total amount of scope 1 greenhouse gas emissions was higher than in the period 2019–2020, when the accelerators were not running, namely 123 174 and 184 173 tonnes of CO_2 equivalent (tCO_2e) in 2021 and 2022 respectively. CERN continuously improves its management, traceability and monitoring of F-gases, notably thanks to the awareness raised among stakeholders by the Working Group on F-Gases, which completed its work in 2021. In the reporting period, the large experiments have improved their approach and to minimise emissions, as reported below. Test facilities and other, smaller experiments have also improved their ability to trace emissions and are therefore now also included in the calculations for 2021 and 2022 to provide a complete view of scope 1 emissions.



CERN SCOPE 1 EMISSIONS FOR 2017–2022 BY CATEGORY
"Other" includes air conditioning, electrical insulation, emergency generators and the fuel consumption of the CERN vehicle fleet.

A STRATEGY TO REDUCE SCOPE 1 EMISSIONS

As for all other objectives that were set in the first environment report and whose original target date was 2024, the target has shifted concomitantly with the shift in the accelerator schedule. CERN's objective is therefore to reduce its scope 1 emissions by 28% by the end of Run 3 (baseline: 2018).

The current strategy to optimise the use of gases in the experiments rests on the following pillars: gas recirculation, gas recovery and the search for more environmentally friendly alternatives to the gases currently used. During Run 2 of the Large Hadron Collider (LHC), CERN tested a prototype plant for the recuperation of HFC-134a gas using a real detector. The results show a recovery efficiency of close to 80%. An updated prototype has been finalised and will be operational in the CMS experiment by March 2023.

A new CF_4 recovery plant was designed, built and successfully implemented for the RICH2 detector in the LHCb experiment.

Intense R&D activity is under way to identify possible alternatives to the greenhouse gases currently used in particle detection. New gases with a lower GWP, as well as the partial replacement of HFC-134a with CO_2, are currently being tested for the future.

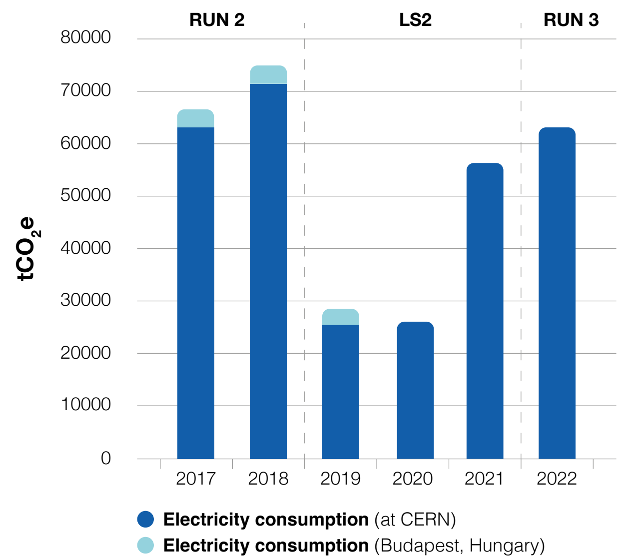
The main contributors to CERN's F-gas emissions are small leaks in the detectors caused by their light construction, which is dictated by the need to ensure that they fit inside the compact spaces that house them. As leaks occur regularly, systematic leak-repair campaigns are organised to ensure that they are contained and minimised. The leak-repair campaign launched by the ATLAS and CMS experiments during the second long shutdown (LS2) progressed well in the reporting period. It will continue in a later shutdown, when access will be possible again. Both experiments continued to invest in R&D to reduce detector leaks and prepare for a transition from PFCs to CO_2 cooling.

GROUP	GASES	tCO_2e 2021	tCO_2e 2022
Perfluorocarbons (PFCs)	CF_4, C_2F_6, C_3F_8, C_4F_{10}, C_6F_{14}	55 921	68 989
Hydrochlorofluorocarbons (HFCs)	HFC-23 (CHF_3) HFC-32 (CH_2F_2) HFC-134a ($C_2H_2F_4$) HFC-404a HFC-407c HFC-410a HFC-507	36 557	86 211
Other F-gases	SF_6, NF_3	16 838	18 355
Hydrofluoroolefins (HFO)/HFCs	R-449 R1234ze NOVEC 649	86	199
	CO_2	13 771	10 419
Total Scope 1		123 174	184 173

BREAKDOWN OF SCOPE 1 EMISSIONS BY GAS TYPE 2021–2022
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.

INDIRECT EMISSIONS – SCOPE 2

The total amount of scope 2 greenhouse gas emissions due to CERN's electricity consumption was 56 382 and 63 161 tCO_2e in 2021 and 2022 respectively. EDF, CERN's principal electricity supplier, generates low-carbon electricity, mainly of nuclear origin, which contributes to keeping energy-related emissions relatively low. In this report, CERN reviewed the CO_2 emission factors that it applies in order to ensure that the figures quoted remain as accurate as possible. For CERN's internal purposes, both the market-based and the location-based methodologies of the Greenhouse Gas (GHG) Protocol are followed. Market-based emission factors take into account the actual sources of purchased energy. The location-based methodology uses emission factors that provide an average of the emissions from all power sources within a specific geographic region over a given period of time. The results of the location-based methodology are provided in this report, with calculations based on average yearly emission factors taken from ADEME Base Empreinte©. All years in the period 2017–2022 have been recalculated, as shown in the graph.



CERN SCOPE 2 EMISSIONS FOR 2017–2022
Emission calculations for electricity follow a location-based methodology, with average yearly emission factors taken from ADEME Base Empreinte©. 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

Emissions from business travel, personnel commutes, catering, waste treatment and water purification were assessed using an operational control approach. CERN applied the Ecoinvent emission factors to activity-based data and used the 2021 GWP values of the Intergovernmental Panel on Climate Change (IPCC), which include all gases from the report "AR6 Climate Change 2021: The Physical Science Basis". The data from 2019 and 2020 has been recalculated using the same methodology and updated emission factors, which has resulted in changes to the previously reported data. As required by the GRI standards and the Greenhouse Gas 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, which is reported separately) amounted to 7813 and 8956 tCO_2e in 2021 and 2022 respectively (832 and 1209 tCO_2e biogenic emissions). This represents less than 10% of all of the Organization's 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 public wastewater treatment plants. Indirect emissions arising from waste treatment in 2021 and 2022 amounted to 1718 tCO_2e and 1875 tCO_2e respectively (636 and 980 tCO_2e biogenic). Scope 3 emissions related to water purification amounted to 151 and 176 tCO_2e in 2021 and 2022 respectively (137 and 146 tCO_2e biogenic).

BUSINESS TRAVEL

In this report, for business travel and personnel commutes only travel by personnel on CERN's payroll was considered (some 5000 people), as travel by CERN users was outside the topic boundaries (see Management approach). Furthermore, users' business travel is usually paid for and managed by their host institutions, and CERN has only limited control and oversight in the matter. Due to the large size of CERN's user community, it is likely that travel-related emissions for users are several times higher than those for the personnel on CERN's payroll.

Emissions arising from business travel amounted to 151 tCO_2e and 827 tCO_2e in 2021 and 2022 respectively (0.4 and 2 tCO_2e biogenic). Most of the emissions resulted from air travel, mainly long-haul flights. The volume of travel continued to be impacted by the lasting effects of the COVID-19 pandemic.

A Duty Travel Working Group was set up in April 2022 to develop recommendations for CERN-wide duty travel with the goal of reducing travel-related emissions (see In focus). Following benchmarking with other organisations, the working group delivered its recommendations to the CERN Environmental Protection Steering board (CEPS) in October 2022. These recommendations will be refined and implemented in 2023.

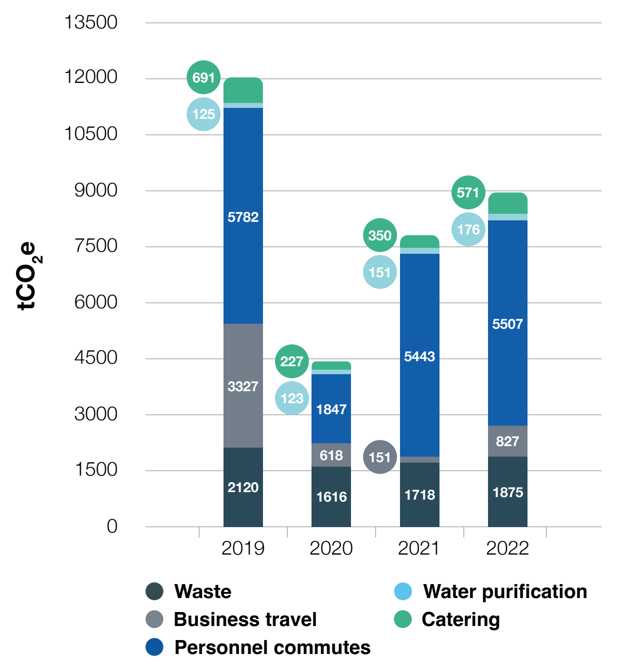
PERSONNEL COMMUTES

Commuting emissions amounted to 5443 tCO_2e and 5507 tCO_2e in 2021 and 2022 respectively (24 tCO_2e biogenic emissions for both years). As with business travel, emissions resulting from commuting were calculated for employed and associated members of personnel on CERN's payroll. In addition, some 11 000 users regularly visit CERN for variable periods of time. Their emissions are not included in the calculations.

CERN's goal for 2025 is to keep individual motorised vehicle commuting constant, despite a growing scientific community, and to encourage alternative modes of transportation, such as public transport, cycling and car pooling. CERN carried out a new survey of the mobility habits of its personnel at the end of 2022. This showed that 61% of CERN personnel use individual motorised vehicles for their commuting, a reduction of 7% compared to the last survey in 2018. For the 70% of CERN personnel who commute to work from France, this is due in part to a lack of adequate public transport. Overall, the fraction of those walking and cycling has increased and now constitutes 24% of all commutes (17% in 2018). The results of this survey will serve to guide further internal and external actions and objectives and to update the mobility plan that was first published in 2019.

CERN has a fleet of approximately 550 bicycles that are available free of charge to its personnel, making it the largest such fleet among companies and organisations in Switzerland. The Laboratory also operates a rental car fleet and a shuttle service for inter- and intra-site mobility. A dedicated mobility working group meets regularly to review all aspects of mobility services and processes, including safety, parking, green mobility, public transport and site access. Its activity is aligned with the general objectives that have been set for mobility in CERN's 2040 Masterplan and in the mobility plan.

In this reporting period, CERN implemented various measures to promote the environmentally friendly mobility of its personnel, such as pilot schemes for e-bikes and e-scooters. Following the success of these pilots, the schemes have been adopted CERN-wide. The general approach is to decrease rather than increase the number of parking spaces. For example, the Science Gateway is being built on what was previously a car park, and as a result the number of parking spaces in the vicinity will be reduced from 400 to 240. The internal shuttle routes are being optimised, and electric car charging stations are being installed. Plans are underway to optimise the CERN car fleet, currently composed of some 700 vehicles, to progressively introduce electric vehicles. Furthermore, CERN is in constant dialogue with the local authorities to promote the use of public transport. This led, for example, to the construction in 2022 of two new bus stops at the entrance of the Prévessin site, which are due to be commissioned at the start of 2023.



CERN'S SCOPE 3 EMISSIONS 2019–2022 (EXCLUDING PROCUREMENT)
"Waste" includes the waste that is sent through the different elimination pathways, as well as the water that is sent to wastewater treatment plants. For emissions related to business travel and personnel commutes, only personnel on CERN's payroll are included. The calculation methodology is aligned with the GHG protocol; the emission factors were retrieved from the Ecoinvent database, and the impact method used was IPCC 2021 GWP100 V1.01. All data from previous reporting years has been recalculated for this report. Emissions arising from procurement are not included and are reported separately.

CATERING

CERN has several restaurants, cafeterias and vending machines on its sites, all run by external companies. The main provider is NOVAE, which operates three restaurants, five cafeterias and the majority of the vending machines. While the number of meals served per day has seen a general decrease following a change in the habits of personnel in the wake of the COVID-19 pandemic, the restaurants operated by NOVAE served an estimated average of 2000 meals per day in 2022. The emissions related to food and beverages are derived from the food products purchased by NOVAE 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 350 tCO_2e and 571 tCO_2e in 2021 and 2022 respectively (35 and 57 tCO_2e biogenic). Red meat and dairy products make the biggest contributions to these emissions.

NOVAE has a well-defined sustainability roadmap, which favours fresh, seasonal produce from local suppliers and includes continued efforts to optimise its carbon "foodprint" (a term coined by NOVAE). The company aims to have 100% of its staff trained in environmental matters and 40% of all meals served vegetarian by 2025. At CERN, the "ReCIRCLE" project, whereby meals are served in reusable packaging, was fully implemented during the reporting period, while efforts to reduce single-use plastics continued, despite having been heavily hampered by the pandemic.

PROCUREMENT

Procurement is the biggest contributor to the Organization's scope 3 emissions and is also the hardest to quantify. The nature of CERN's work demands a wide diversity of supplies and services, while the Organization's procurement strategy and policy strives to balance return to all of CERN's Member and Associate Member States. In 2021, a method for evaluating scope 3 emissions due to procurement was implemented and a project to assess how to implement environmentally responsible procurement at CERN was launched.

SCOPE 3 EMISSIONS ARISING FROM PROCUREMENT

Scope 3 emissions for procurement are presented for the first time in this report. In 2021 and 2022 respectively, CERN spent around 471 MCHF and 462 MCHF on purchases, including goods, services and supplies. Emissions related to purchased goods and services and capital goods amounted to 98 030 tCO_2e and 104 974 tCO_2e in 2021 and 2022 respectively.

These emissions were calculated using the Greenhouse Gas Protocol spend-based method and emission intensity factors taken from the 2021 EXIOBASE 3 database, using the Climatiq Procurement Endpoint model based on basic prices and including adjustment for inflation. This database is an Environmentally Extended Multi-Regional Input-Output (EE MRIO) table and contains data that describes the complex network of global economic relationships between industries and their environmental consequences. While these calculations have limitations and varying levels of uncertainly, CERN used this calculation method to understand the relative quantity of emissions that result from procurement in comparison with other direct and indirect emissions. Procurement emissions represent about 92% of the total CERN scope 3 emissions, and around 32% of all CERN emissions.

This method helps CERN to identify procurement families for which the reduction and optimisation of CO_2 emissions is possible and thus to better prioritise its decarbonisation efforts. In 2021–22, 267 suppliers accounted for 80% of CERN's procurement emissions. Construction and machinery suppliers were responsible for the highest portion of these emissions.

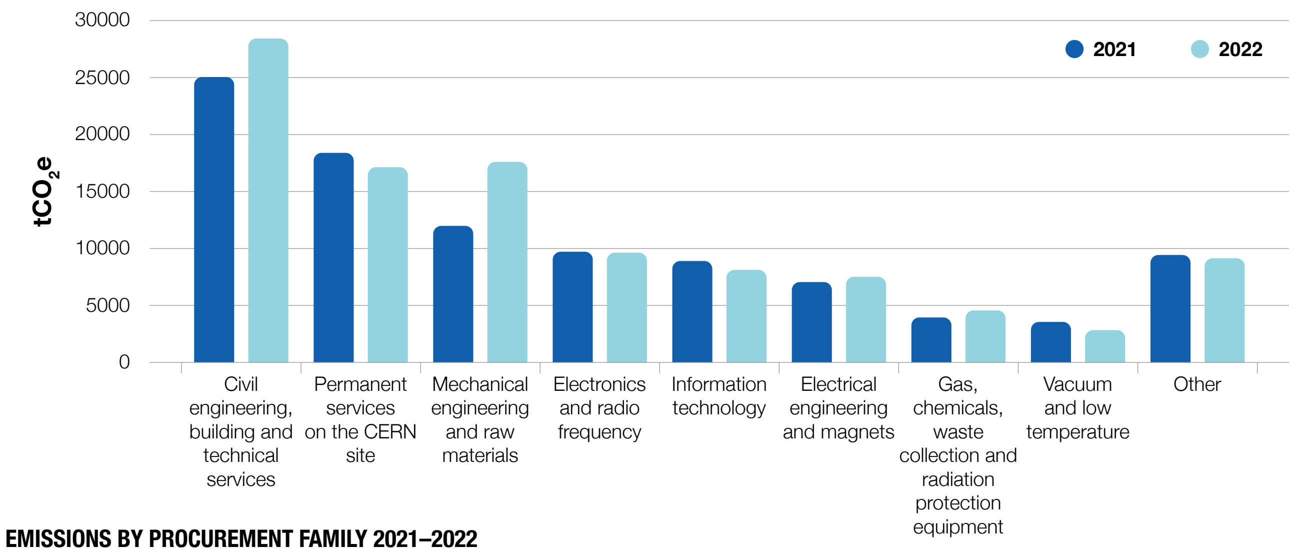
CERN appreciates the limitations of the spend-based methodology and will seek to improve the granularity of procurement emission measurements by working with suppliers to obtain activity-based emissions data. This will allow the Organization to further refine its understanding of the challenges and priorities to be addressed, with due consideration of its complex infrastructure and governance mechanisms.

LAUNCHING THE CERP3 PROJECT

The CERN Environmentally Responsible Procurement Policy Project (CERP3) was launched in September 2021. Its strategic aim is to gradually improve CERN's procurement approach to bring it closer to the ISO 20400 Sustainable Procurement Guidance Standard.

As a starting point, an Environmentally Responsible Procurement Policy has been drafted. It was submitted to the Management for consideration in November 2022, and builds environmental responsibility factors and objectives into CERN's procurement process based on the principles of exemplarity, environmental integrity, equity and governance. Subsequently, CERN has begun work to establish clear communication and monitoring across all procurement categories. The technical and procurement officers are closely involved in the process of establishing common goals and commitments. The aim is to better understand the most CO_2-emitting procurement families with a view to developing and prioritising action plans. A proposal for their implementation will be made in 2023. A supplier engagement programme for suppliers that make up the top 80% of CERN emissions will be rolled out. It is designed to measure emissions, set science-based emission reduction targets and accelerate the suppliers' own decarbonisation journeys. Environmentally responsible procurement key performance indicators, as well as a training module for CERN procurement and technical officers, will also be developed.

As a result of these activities, the Organization has made an important step in understanding its procurement emissions and identified a number of actions to be taken, while continuing to strive for balanced returns for the Member and Associate Member States. Progress on all these developments will be covered in future CERN environment reports.



EMISSIONS BY PROCUREMENT FAMILY 2021–2022
"Other" includes: office supplies, furniture, transport, handling and vehicles; centralised expenses and codes for internal use; particle and photon detectors; health, safety and environment; optics and photonics.

IN FOCUS

Valerie Domcke is a physicist in CERN's Theory department who co-chaired the Duty Travel Working Group that was set up in 2022.

— Can you tell us about the inception of the working group?

VD: Travel is a natural part of theoretical physicists' lives owing to the worldwide scientific collaborations of which they are members. These collaborations require international exchanges and the sharing of ideas to nurture the scientific inspiration that drives our mission. Many of us have taken stock of and recognise the environmental impact of extensive professional travel, particularly by air, that is customary in our scientific community and subscribe to the urgent need to reduce our greenhouse gas emissions. At the same time, we value international exchange as a pillar of scientific progress at CERN and beyond. We recognise that this is particularly important for early-career researchers, as well as for researchers from geographic regions that are under-represented in given disciplines. Following discussions with the chair of CEPS, the creation of a dedicated working group was proposed to take this further and investigate concrete measures that will benefit CERN as a whole and reduce the emissions linked to the Laboratory's duty travel.

— What did the working group's work entail?

VD: The working group first benchmarked other academic institutions and international organisations for inspiration and to ascertain what best practices exist. These had to be reflected upon in order to design recommendations that would best fit CERN as an organisation and to propose pragmatic and effective measures to tangibly reduce the emissions incurred by duty travel and to catalyse behavioural change. Although these emissions represent just a small fraction of CERN's total emissions, acting on them is important as, whatever their scale or scope, all actions contribute to minimising CERN's environmental impact.

— What are the next steps?

VD: The working group's recommendations were presented to CEPS at the end of 2022. CEPS provided important feedback that will help the work to advance. The next stages will see the refinement of the measures that have been proposed with a view to their progressive implementation within the duty travel framework applicable to personnel on the CERN payroll. In the longer term, the analysis will be expanded to cover the broader CERN community.

IONISING RADIATION

At CERN, ionising radiation is produced by the collisions of particle beams with matter. CERN's unique facilities use innovative approaches to minimising the exposure of workers, the public and the environment, making CERN one of the recognised leaders in this field.

LIMITING EXPOSURE

In Europe, the annual dose limit for public exposure from artificial sources, with the exception of exposure for medical reasons, is 1 millisievert (mSv). CERN is committed to keeping its contribution to no more than 0.3 mSv. The actual dose received by any member of the public living near the Laboratory was less than 0.01 mSv in 2022, which is more than 100 times lower than the average annual dose received from medical exposure per person in Switzerland.

At CERN, while the majority of radiation workers are subject to a regulatory limit of 6 mSv/year, a limit of 3 mSv/year is applied in practice. Over the reporting period, no radiation worker at CERN was exposed to more than 1.3 mSv, and 91% of the workers registered a null dose (0 mSv). As a reference, the mean annual exposure to natural and artificial sources in Switzerland is 6 mSv per person per year.

RESPONSIBLE REPORTING

CERN adheres and contributes to internationally recognised radiation protection and safety systems. Following the precautionary principle, the Organization continuously optimises its facilities and practices to minimise its radiological impact. A tripartite agreement signed with the Host States in 2010 ensures transparency and alignment with best practice in radiation protection and safety. As part of this agreement, CERN reports quarterly on its radiological monitoring of the local environment to the Swiss and French authorities. The Organization always strives to apply the latest developments in applicable standards and to adapt to changes in Host State legislation.

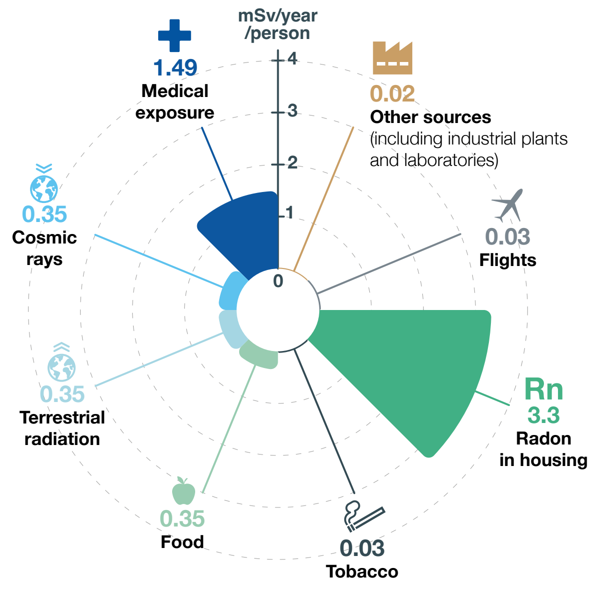
STATE-OF-THE-ART MONITORING

Ionising radiation is constantly monitored inside and outside the CERN perimeter. The Laboratory operates an extensive network of environmental radiation monitors and online sampling systems. In 2022, the environmental monitoring programme included 130 measuring stations comprising 640 monitoring channels, 494 of which are dedicated to radiological monitoring.

This robust radiation monitoring infrastructure is underpinned by the Radiation and Environment Monitoring Unified Supervision (REMUS) tool. This innovative system developed by CERN provides supervision, control and data acquisition for the entire suite of monitoring stations and is continually upgraded to ensure that it evolves with the Organization's needs.

The methods used to evaluate the doses that members of the public could potentially receive are based on widely recognised models and standards and consider the specific nature of CERN's facilities. A revision of the models was completed in 2022 and was agreed with the Host States authorities. The revised models will be used from now on for all future assessments of CERN's radiological environmental impact.

CERN collaborates with the Host States to allow their own services to monitor stray radiation and environmental radioactivity inside and outside the CERN perimeter. A network of thermoluminescent dosimeters for assessing ionising radiation around the sites is completed by a high-volume aerosol sampler for sensitive laboratory analyses. A monitoring device on CERN's Meyrin site sends real-time data to the Swiss Federal Office of Public Health (FOPH). In addition, the FOPH conducts annual site measuring campaigns.



IONISING RADIATION
Average radiation doses received per person per year in Switzerland (in mSv/year/person). CERN's activities fall under the category "Other sources". (Source: Swiss Federal Office of Public Health, 2022)

IN FOCUS

Heinz Vincke is the deputy leader of the CERN Radiation Protection group.

— With accelerators moving towards higher intensity over time, what are the main implications for radiation protection?

HV: Higher intensity would inevitably lead to more radiation. To mitigate this, we have a formalised approach to optimising the design of entire installations and to work coordination, work procedures and the handling of tools.

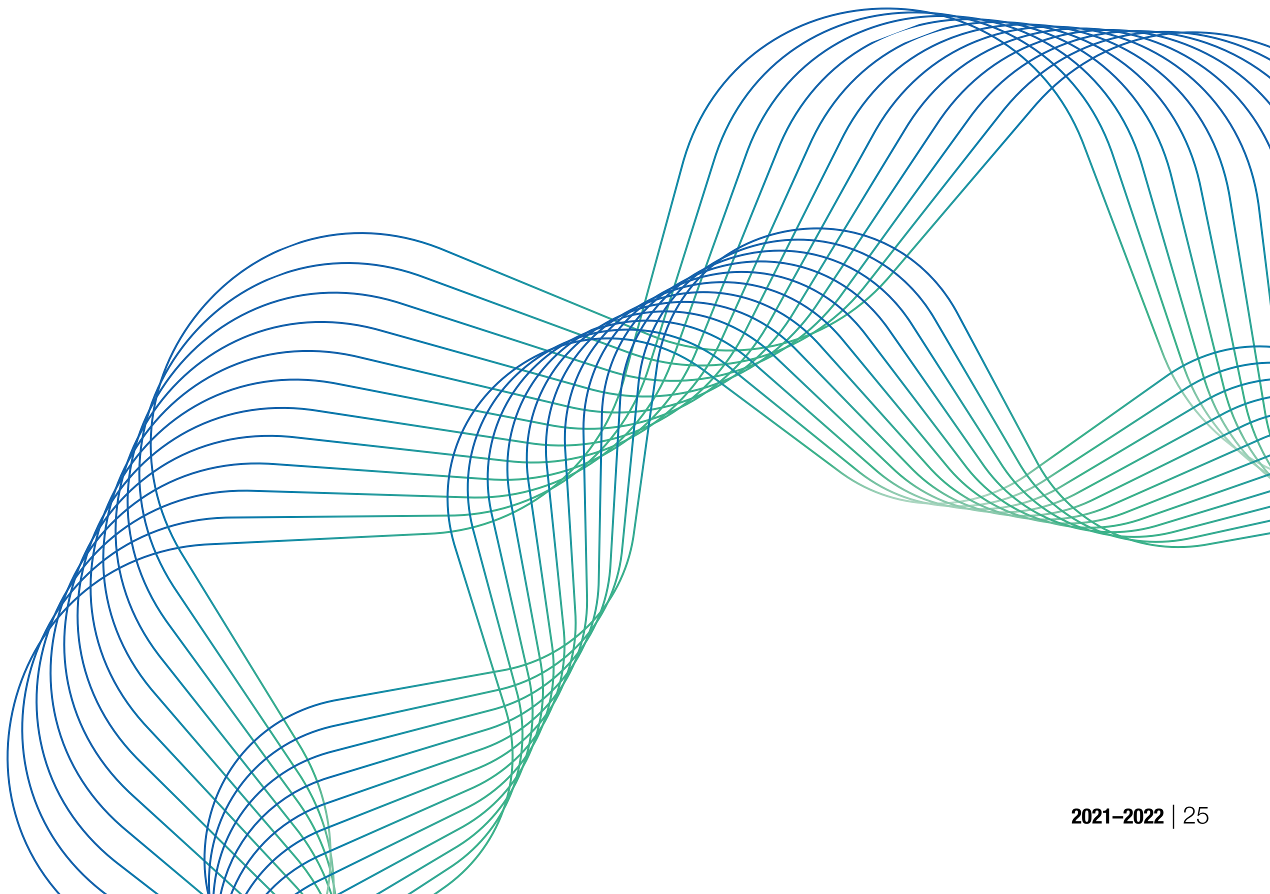
— What approaches and tools are used for optimal radiation protection management?

HV: During the design stage, we must choose the right materials, shielding and location to minimise the amount of radiation. We mainly use computer-based simulations to ensure optimised dose reduction for personnel and the environment. Furthermore, we use the ActiWiz software, which was developed by the CERN Radiation Protection group. It applies a customised risk assessment model to allow us to choose materials with low activation risks. CERN has developed additional tools that allow us to respect most stringent regulations, such as OPEDOSI for monitoring operational doses received by personnel working in radiation areas, TREC for recording and tracing radioactive material and RAISIN, a database covering all radiation areas at CERN. The Intervention Management Planning and Activity Coordination Tool (IMPACT) facilitates the assessment of risk, including radiation risk, and ensures a formalised approval process for work in radiation areas. The radiation monitoring tools REMUS (Radiation and Environment Monitoring Unified Supervision) and ERGO (Environment and Radiation Graphic Observer), the visualisation counterpart of REMUS, are further examples of the comprehensive suite of tools in place.

— What about repairing equipment?

HV: The repair of equipment brings specific challenges, especially when we need to work in high-activation areas. For some installations, we can handle equipment or do repairs remotely using robots. When this is not possible, we optimise the work procedure and tools, for example by using mock-up models, so that the time spent in the area of concern is kept to the minimum.

Thanks to this comprehensive approach, CERN has succeeded in continuously reducing the doses to which its personnel and the environment are exposed over the last decade.



BIODIVERSITY, LAND USE AND LANDSCAPE CHANGE

CERN's sites cover a total of 625 hectares. In addition to land used for buildings and infrastructure, this area comprises 409 hectares of cultivated fields, recreational land and meadows, 104 hectares of woodland and three wetlands. All this land teems with wildlife, including some rare species. To best preserve all land and biodiversity under its management, CERN has a dedicated programme that allows it to understand and valorise its environment and thereby meet its evolving needs with minimal impact.

PRESERVING THE LANDSCAPE

In 2015, CERN published its first Masterplan, which reflected the Organization's vision in terms of future campus development for the period until 2030 for both of its main sites, Meyrin and Prévessin. This important tool, which was updated at the end of 2021 to cover the Organization's vision until 2040, enables CERN to understand the practical consequences of development and to manage it in a responsible way. From measures to preserve biodiversity to optimised mobility solutions, careful building management and consolidation and the integration of facilities into the surrounding landscape, the Masterplan takes into account the current and future needs of the Laboratory, along with those of its neighbours, including potential development outside the current fenced area. In close collaboration with the Host States, France and Switzerland, the objective is to allow the development of CERN and to guarantee the functionality of the site while preserving and enhancing the surrounding rural and forest areas.

During the reporting period, work for the High Luminosity LHC (HL-LHC) project was carried out at Points 1 and 5 of the LHC ring. At Point 1, this required 0.9 hectares of new constructions on formerly agricultural land, while at Point 5 it was possible to accommodate the necessary work on the existing built site. Construction of the Science Gateway, CERN's new education and outreach centre due to open in 2023, also got under way. The centre occupies what was previously a car park.

PROTECTING BIODIVERSITY

In 2020, the Organization set up a working group on biodiversity with key objectives spanning the conservation and protection of natural spaces, biodiversity development across the site and the definition of indicators for improved monitoring. The group proposed an action plan for 2021–2025 consisting of several measures, two of which have already been funded and set in motion. A third measure, entailing a preliminary study of heat islands, began to be implemented in 2022.

The first of these measures involved drawing up guidelines on how biodiversity considerations should be taken into account for new constructions at CERN. A total of eleven guidelines were issued, inspired by Host State regulations and best practices in the biodiversity field. They cover a range of subjects, such as management of invasive species, green roofs and planting new trees as a compensation measure. In this vein, 100 trees have been planted on the Meyrin site to compensate for trees that were previously felled due to ageing or to construction work. Furthermore, at the end of November 2022, CERN started planting more than 400 mature trees of eleven different varieties around CERN's future education and outreach centre, the Science Gateway. Specific measures have been developed not only to preserve CERN's natural heritage, but also to strengthen biodiversity on the land managed by CERN, according to an approach based on low-intensity maintenance, minimum watering and elimination of fertilisers and chemicals wherever possible.

Sickle-bearing bush-cricket (*Phaneroptera falcata*)

EXPLORING CERN'S FLORA AND FAUNA

The second measure entailed surveys of the various species of fauna and flora present on the CERN sites. These were completed in 2022 and identified "areas of interest" to be classed as a priority for preservation in the event of any planned works and projects. These areas will be integrated in the Organization's Geographical Information System.

Conducting surveys is crucial for monitoring populations, identifying zones of biological interest and prioritising their importance such that concrete protection measures can be defined and implemented. Based on expert recommendations, the inventories focused on flora, amphibians, insects and birds. The inventory of amphibians revealed two protected frog species and two protected species of the newt family. The insect-based surveys focused on Lepidoptera (butterflies) and Orthoptera (locusts, grasshoppers and crickets), as these groups reflect the quality of the environments and of the maintenance practiced there. The surveys identified 62 species of Lepidoptera and 32 species of Orthoptera across the sites. The flora inventory led to the identification of 13 threatened species of flora, as well as two new orchid species on the CERN site, bringing the total number of identified orchid species to 18 (including two subspecies).

IN FOCUS

Alison Lacroix is a botanist and project engineer at "Atelier Nature Paysage", the consultant that coordinated CERN's flora and fauna inventories in 2022.

— What is the importance of making inventories of flora?

AL: From a general point of view, flora inventories are important for characterising natural environments and identifying those that are of particular interest, for example because they harbour flora (as well as related fauna) that develops only in certain conditions. They can also identify rare, threatened or protected plants.

From a more specific point of view, carrying out inventories makes it possible to monitor the effect of changes in management and maintenance practices by allowing a comparison of the data before the change and the data five years later, for example.

— What specific observations do you have regarding the 2022 inventory?

AL: The richness of the Meyrin and Prévessin sites in terms of orchids was already known. However, the 2022 inventory has highlighted the great diversity of environments, some of which are of interest for their characteristics or because they host rare plants such as *Lathyrus tuberosus* (tuberous pea) and *Ophioglossum vulgatum* (southern adder's-tongue). The inventory also made it possible to identify three areas of interest for orchids within the fenced CERN domain. Personally, I had never observed such a density of *Ophioglossaceae* (although they seem to have suffered from years of drought), nor of *Himantoglossum hircinum* (lizard orchids).

Large copper butterfly (*Lycaena dispar*)

WATER AND EFFLUENTS

Water is essential for the cooling systems of CERN's scientific facilities, and responsible water management is of the utmost importance to the Laboratory.

WATER WITHDRAWAL AND CONSUMPTION

CERN strives to minimise its water consumption through continuous consolidation and improvement of its cooling and sanitation infrastructures. Since 2000, CERN has radically decreased its water consumption by some 80%, from 15 000 megalitres that year to 3234 megalitres in 2022, notably by changing the water circuits in its cooling towers from open to semi-open or closed ones during LS2.

All water supplied to CERN is of drinking quality and is either used as is or demineralised. The Services Industriels de Genève (SIG) supply most of CERN's water, which comes from Lake Geneva. About 1%, consisting mainly of groundwater, is provided by the Régie des Eaux Gessiennes in the Pays de Gex, France, which is a water-stressed area. The suppliers send monthly or annual water consumption reports, allowing CERN to monitor its water use.

Around 80% of CERN's water supply is dedicated to industrial activities, primarily the cooling of the accelerator complex, the detectors and computing facilities, and 20% is used for sanitation purposes. As of 2021, and especially since the restart of physics after the Large Hadron Collider's (LHC) second long shutdown (LS2), the amount of water required to cool the research facilities has gradually increased. Nonetheless, CERN's overall water consumption in 2021 and 2022 (2661 and 3234 megalitres, respectively) was lower than in its previous operation year, 2018 (3477 megalitres), due to the gradual ramp-up of accelerator and detector operation after LS2.

WATER DISCHARGE AND MONITORING

The Organization releases 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 regularly samples the neighbouring watercourses to evaluate its impact and reports on its monitoring programme to the Host State authorities on a quarterly basis. Effluent quality is continuously monitored according to CERN-defined criteria that are compliant with Host State regulations. Intervention plans exist as part of CERN's emergency preparedness in the event of an incident. The Laboratory has procedures in place to mitigate the consequences and to alert the relevant Host State authorities and emergency services. No event detrimental to the environment that would have led to a fine or non-monetary sanction occurred during the period covered by this report (see Environmental compliance and management of hazardous substances).

EFFLUENT QUALITY

CERN's cooling towers evaporate some of the water used for cooling the accelerators. Some is also released as effluent water. The latter contains residuals of treatments used to prevent scaling, corrosion and bacteria, including legionella. To minimise the quantity of effluents and improve their quality, the Organization is modifying its cooling towers, either by adding demineralised water or by installing a system to recycle the blowdown water. This has led to a reduction in releases to the neighbouring watercourses. 70% of the circuits were modified during LS2 and the remainder will be adapted during LS3, starting in 2026.

As a result of increased activity in the North Area of the Prévessin site, with concomitant increase in water flow, a new water monitoring station was installed in January 2022 to check the quality of the effluents released into the nearby Lion river.

CERN's new retention basin downstream of the Prévessin site, which includes a hydrocarbon separator for treating accidental pollution, has proven effective in regulating the flow and ensuring the quality of water releases from the site. An additional retention basin will be built inside the Prévessin site in 2023 to manage stormwater runoff surplus.

On the Meyrin site, CERN is studying the construction of a new retention basin to collect rainwater using an existing installation under one of the hostel buildings. For the last few years, all new projects on the Swiss watershed of the Meyrin site have included retention basins, either on the roof, buried, or in the open air when possible.

The Charter of the Nant d'Avril also includes plans for new retention basins to regulate the flow into this watercourse, as well as improvements in the quality of effluent coming from the cooling towers. The quality of CERN effluents is discussed with the local Host State authorities in the framework of the tripartite committee for the environment.

RENOVATING WATER NETWORKS AT CERN

In 2021, the Laboratory started its ten-year Technical Galleries Consolidation programme to refurbish the 80 galleries and their related infrastructure. One part of this project concerns the renovation of the water circuits, such as those that supply drinking water and water used by the CERN Fire and Rescue service (see In focus). The project further encompasses the sewage and sanitation networks, for which pipe permeability is an issue, and the implementation of a procedure to control the infiltration of water into the accelerator tunnels. An in-depth inspection campaign to update the mapping of the full network began in 2022.

LOOKING AHEAD

As for all other objectives set in the first environment report, the target year, which was originally 2024, has shifted concomitantly with the change in the accelerator schedule. CERN is now committed to limiting its increase in water consumption to 5% by the end of Run 3 in 2025 (baseline year 2018).

In preparation for the high-luminosity era of the LHC (HL-LHC), CERN has approved the construction of a cooling water recycling plant at Point 1 of the LHC ring. It will collect and process the water from the LHC and SPS cooling circuits with a view to recycling and reinjecting it at Point 1. Residual effluents from the treatment process will be released into the sewage network, thus reducing the impact on the Nant d'Avril river. Building this recycling plant will also help keep water consumption down in the future, when the need for cooling will increase due to the HL-LHC and the LHC experiment upgrades.

Given the increased computing capacity that will be required, a new data centre, due to come online at the end of 2023, is being constructed in Prévessin. It will be cooled using the latest technologies to achieve high power efficiency. Dry coolers will provide adiabatic cooling during hot periods, which will lead to water savings. In addition, a recirculation circuit will be added to the dry coolers to further minimise the amount of water used. The new data centre will also recover heat to warm all 73 buildings on Prévessin site (see Energy).

IN FOCUS

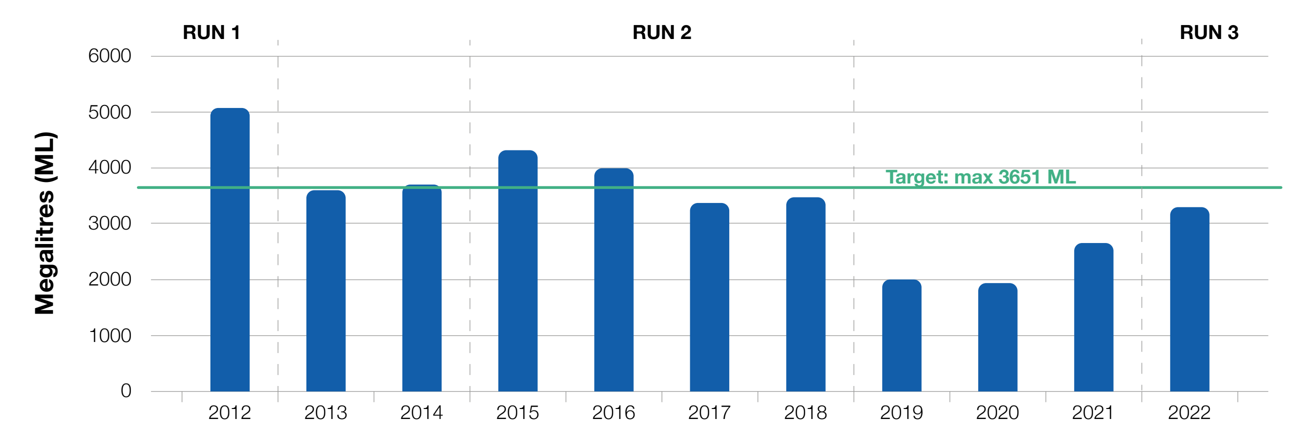
Esther Amarilla is the work package leader for cooling and ventilation in the Technical Galleries Consolidation programme.

— How did this project come about?

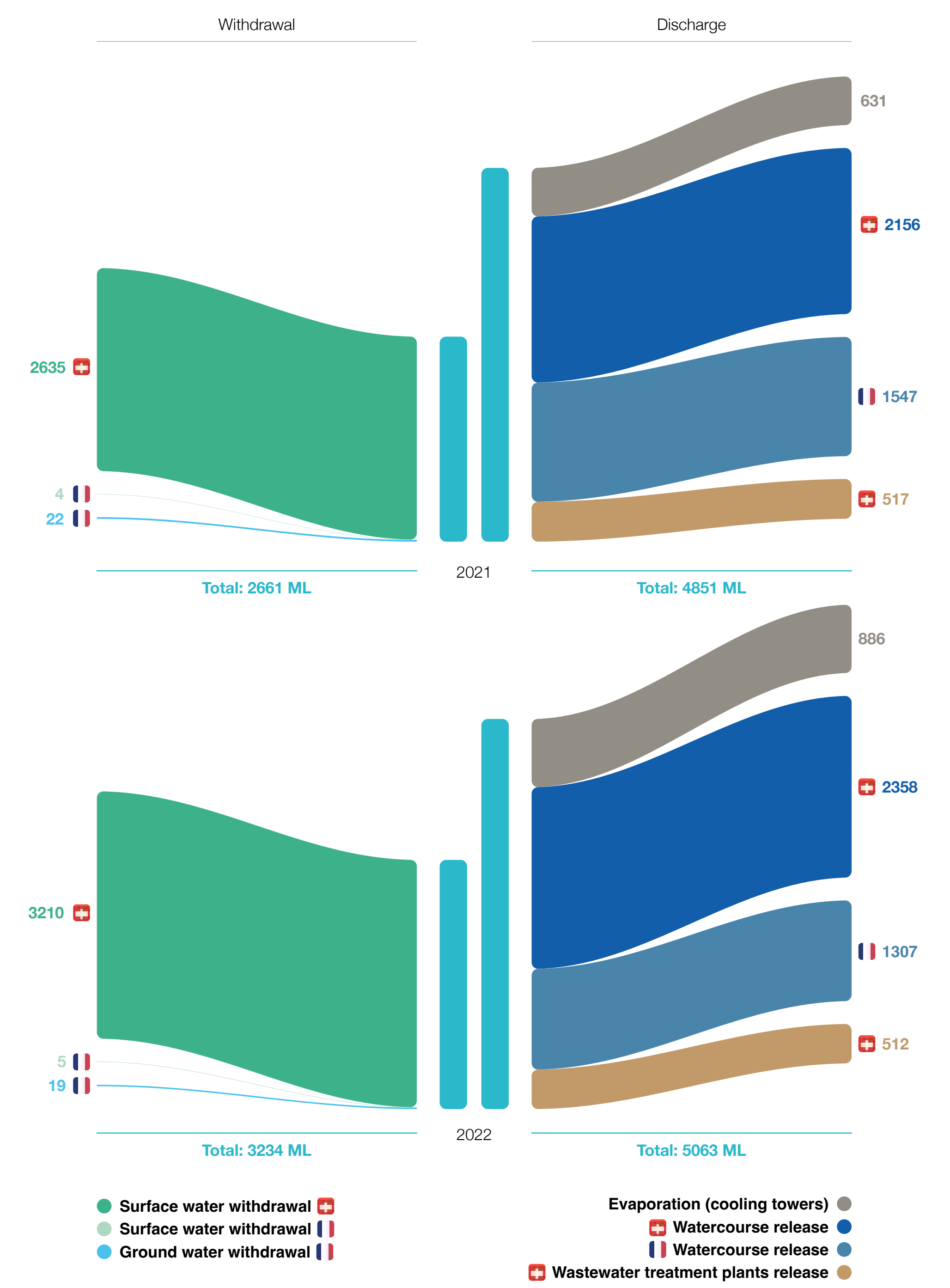
EA: Some parts of the networks are more than 60 years old and in dire need of refurbishment and replacement.
For the water networks, we did a full status review in 2021, in close collaboration with SIG, as they supply the water and know the typical shortcomings of this type of network. Starting with the west area of the Meyrin site, where the impact on CERN's scientific activities will be the slightest, we will work in stages over the course of ten years to replace the network on both the Meyrin and the Prévessin sites.

— What are the main objectives of replacing the drinking water networks?

EA: It's a matter of increasing the reliability of the various networks, such as drinking, cooling and effluent, and improving their water quality. Replacing the old networks will minimise the risk of leaks. The piping volume will be reduced in the new design, diminishing the risk of stagnant water. It is a very ambitious programme that is invisible to many, but highly impactful.



CERN'S WATER CONSUMPTION 2012–2022



WATER WITHDRAWAL AND DISCHARGE 2021–2022
Data shown for discharge into watercourses includes infiltration water, rainwater and cooling tower blowdown.

WASTE

CERN's strategy aims to ensure the appropriate management of waste in a way that is safe for people and the environment.

MANAGING CONVENTIONAL WASTE

CERN's scientific activities generate the majority of the Organization's waste. The Laboratory's conventional waste can be divided into three broad categories: campus, industrial and worksite waste. It is further categorised as either non-hazardous (metals, glass, PET, paper and cardboard, coffee capsules, biodegradable waste, household waste, and electrical and electronic equipment – the latter being subject to monitoring according to the Swiss regulation OMod), or hazardous (chemicals and their containers, batteries, printer cartridges, lightbulbs and any type of equipment and materials contaminated by hazardous substances). In 2021 and 2022, CERN disposed of 5111 tonnes and 8812 tonnes of non-hazardous waste and of 1544 and 1295 of hazardous (both conventional and radioactive) waste respectively.

CERN has a centralised waste management system that oversees all conventional waste collection and the transportation of campus and industrial waste. The system also includes an inventory of the waste leaving CERN in order to ensure the traceability of waste pathways. Hazardous waste is temporarily stored in a buffer zone, where it is collected weekly.

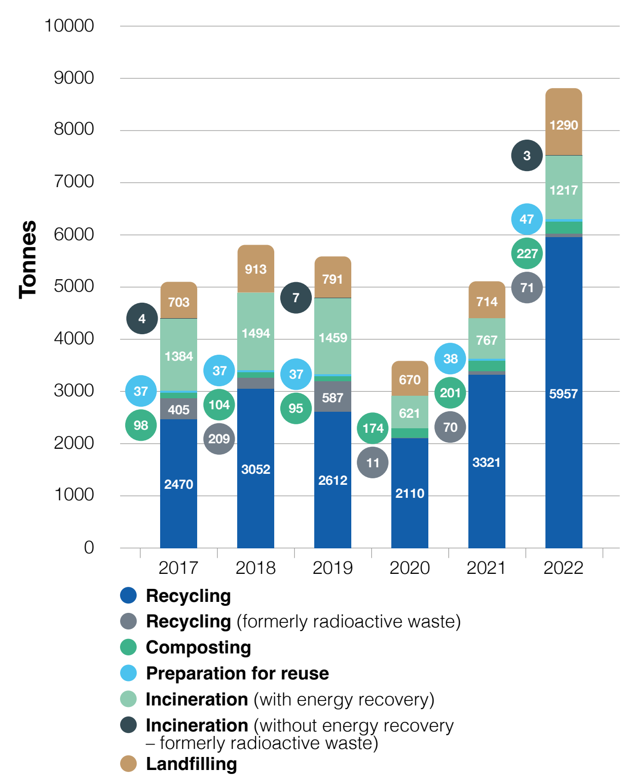
The Laboratory works with authorised third-party service providers to manage the disposal of conventional waste other than metals and electronic waste. The latter two are among those sorted and sold for recycling. Data on end-of-life equipment picked up by or sent back to the supplier is not included in this report. Data on worksite waste generated by contractors is also not included, as contractors manage waste disposal themselves in accordance with the relevant Host State regulations. CERN strives to constantly increase the traceability of the waste disposed of by its contractors.

REUSE AND RECYCLE

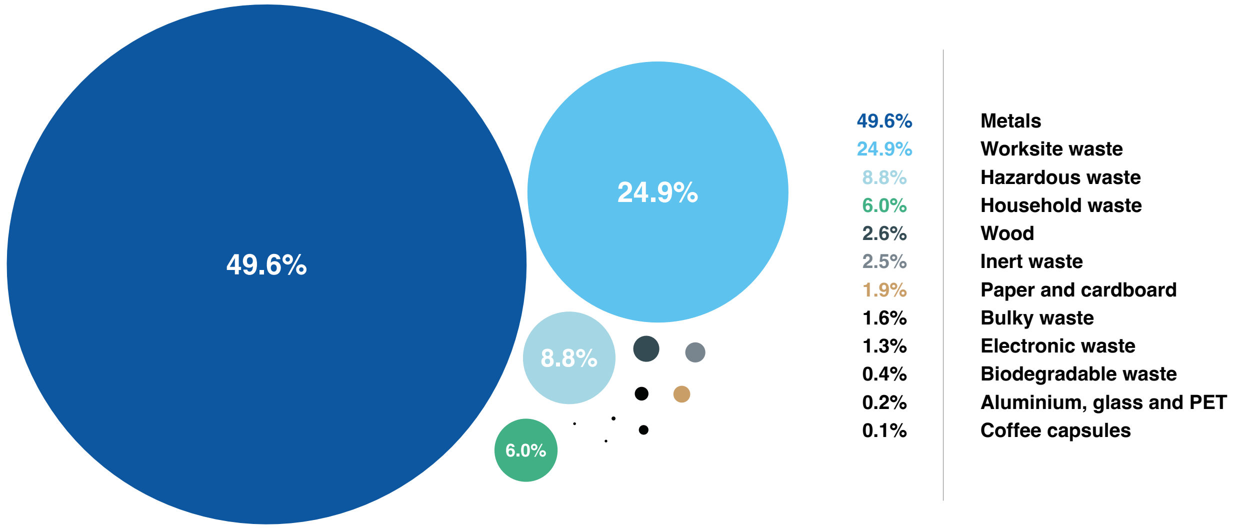
CERN's aim over the reporting period has been to increase its recycling rate for non-hazardous waste, which represents over 70% of the total waste generated. In 2022, this recycling rate was 69%, compared to 56% in 2018. The marked increase in 2022 is due in part to the large quantity of metals that are being recycled following the second long shutdown (LS2). Furthermore, a pathway for the recuperation, reconditioning and sale of viable equipment, including furniture, IT and electronic equipment, is in place.

The pilot project involving centralised sorting bins for campus waste that was launched in 2019 has been expanded to cover more buildings and some workshops and to include the sorting of different metals. The project has made it easier for personnel to sort their waste close to their place of work. Even though the total amount of waste generated has remained the same, the recycling of paper and PET has markedly improved.

CERN's approach to waste management follows the "reduce, reuse and recycle" principle. In this vein, the Organization aims to become an eco-exemplary campus, continuing to fully comply with the applicable French and Swiss regulations in terms of waste management and waste disposal. A dedicated waste management roadmap was published in August 2022, paving the way for additional and more refined objectives that will be covered in future reports.



NON-HAZARDOUS WASTE BY ELIMINATION PATHWAY 2017–2022
The continuous improvement in waste categorisation and accounting, along with the tools used for tracing radioactive waste, as described in the hazardous waste graph caption, have resulted in a redistribution, compared to the previous report, of the amounts shown under the "Recycling" and "Recycling (formerly radioactive waste)" headings for the years 2017, 2018 and 2019.



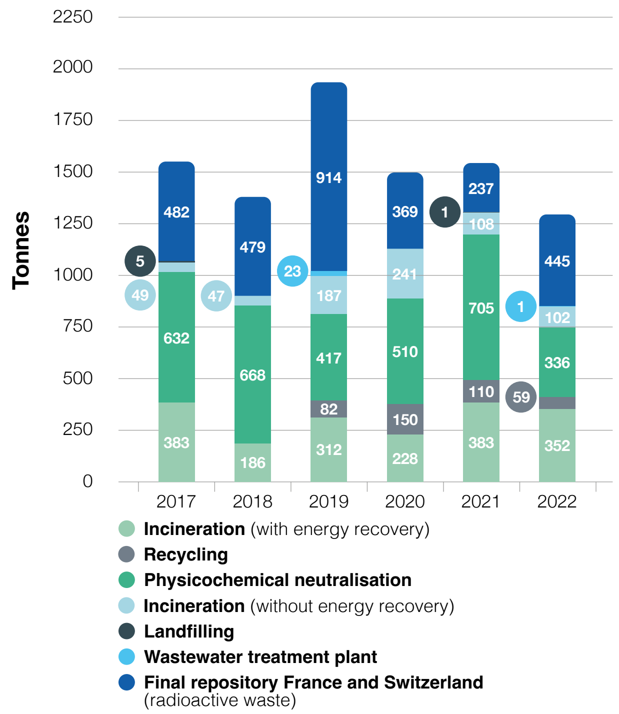
CERN'S CONVENTIONAL WASTE BY TYPE IN 2022

MANAGING RADIOACTIVE WASTE

CERN's scientific activities produce radioactive waste, classed as hazardous waste, with low and intermediate levels of activity, which are generated by the interaction between particle beams and equipment present inside the accelerator complex and detectors. Equipment that is activated by this process, such as beam dumps (see In focus), is managed as radioactive waste at the end of its life cycle. Radioactive waste consists, for example, of metal components, cables and ventilation filters, as well as items potentially contaminated during maintenance and upgrade work, such as gloves and overalls. In 2021 and 2022, CERN disposed of 307 and 519 tonnes of radioactive waste respectively.

The Organization minimises the amount of radioactive waste in the design, operation and decommissioning of accelerators, experiments and other equipment by avoiding, reusing or recycling activated material, such as activated shielding components. In 2021, a total of 2077 tonnes of steel, cast iron and concrete was reused. In 2022, this figure was 906 tonnes. A further 259 and 135 tonnes of processed radioactive waste was diverted from disposal in 2021 and 2022, respectively, for reuse inside CERN facilities.

CERN's specialised radiation protection team monitors and categorises radioactive waste. It is processed in a dedicated facility where it is sorted, compressed and packaged according to the treatment and elimination criteria applicable to radioactive waste. Before being eliminated, radioactive waste is temporarily stored in a dedicated storage area.



HAZARDOUS WASTE BY ELIMINATION PATHWAY 2017–2022
This graph presents updated data for radioactive waste for the years 2017–2020, which takes into account the continuous improvement in waste categorisation and accounting, and the tools used for tracing radioactive waste. The higher figures in this report for the years 2017–2020 compared to the previous report result from a change in how mass is accounted for, i.e. moving from net mass to gross mass (whenever the container is buried together with the waste), in compliance with the accounting approach required by the Host State repositories.

COLLABORATION WITH HOST STATES

Radioactive waste management has always been a high priority for CERN. It is handled in the framework of the tripartite agreement with the Host State authorities on radiation protection and radiation safety (see Management approach).

CERN's radioactive waste is disposed of through agreed pathways in France and Switzerland. In Switzerland, CERN makes use of the possibility for clearance, whereby waste that no longer qualifies as radioactive according to the Swiss ordinance for radiation protection (ORaP) is treated as conventional waste.

NEW DECISION ON FAIR SHARE

As France and Switzerland have different approaches to radioactive waste management and elimination pathways, the tripartite agreement requires that CERN optimise its radioactive waste elimination by choosing the most appropriate solution for each category of waste. It also requires that these solutions ensure an equitable distribution between the two countries, known as the fair share principle. The implementation of the principle was revised in 2022, reflecting the experience gained and lessons learnt over the last ten years. The new decision outlines what type of waste will go to which country and through which elimination pathway. It also makes it easier to compare and measure the share between the two Host States. The share is monitored using three indicators: the volume eliminated, radiotoxicity and elimination costs. These indicators will be followed up at the annual plenary tripartite meetings with the Host State authorities.

IN FOCUS

Angelo Infantino is a nuclear engineer in CERN's Radiation Protection group.

— The LS2 of the LHC allowed major maintenance and upgrade works to be performed in which the Radiation Protection group was involved. Can you tell us about this in the context of the LHC beam dump core autopsy?

AI: For context, a beam dump is a device designed to absorb the energy of particles once they are no longer useful for scientific research purposes. Over time, beam dumps become activated. The LHC beam dump core autopsy was a multidisciplinary project undertaken during LS2, revolving around the unprecedented action of dismantling the two LHC beam dumps at Point 6 ready for an upgrade for Run 3 of the LHC. This long and complex intervention allowed teams to gather crucial information needed for Run 3 operation and for designing future generations of beam dumps for the next upgrade of the LHC.

— What were the main challenges of this operation?

AI: The two key challenges of the project were removing the dumps from the accelerator and preparing these highly activated objects for elimination as radioactive waste.

The beam dump selected for autopsy was cut into pieces, which later allowed us to inspect the state of the inner graphite disks it contains. The dumps are also among the first items in the "intermediate and low-level radioactive waste" category, which contains nuclides with short half-lives (FMA-VC waste). This category will be subjected to new, dedicated disposal pathways that CERN is currently discussing with the French authorities. ANDRA, the operator of France's radioactive waste repositories, visited CERN's worksite to gather knowledge and understanding of the properties of such types of waste and how it is treated.

— Why is this project important?

AI: The project was important as it combined two key aspects: an autopsy, which provided crucial information needed for the design of future beam dumps, and waste treatment. This allowed considerable savings to be made in terms of time, resources and doses. The project was highly successful, demonstrating the capability of the teams at CERN to face challenges.

NOISE

Since the accelerator complex resumed operation in 2022, noise has been kept within 2018 reference levels thanks to robust and effective noise modelling predictions and permanent local monitoring systems.

MANAGING CERN'S NOISE FOOTPRINT

CERN's host region has evolved over time, with housing being constructed increasingly closer to the Laboratory's existing facilities. CERN monitors noise at its perimeters and throughout its sites and takes action to reduce noise during accelerator operation, through measures such as noise barriers and silencers.

Most of CERN's surface installations are in France. In 2019, the Laboratory published a noise reduction policy and implementation strategy, which were agreed with the Host State authorities. This policy has proved effective and remains under regular review.

To keep its existing noise footprint under control, CERN commits not to exceed the reference noise levels by more than 3 dBA at its perimeters, based on measurements carried out in 2018 when all CERN accelerators were running (reference operation year). CERN carries out yearly noise measurement campaigns at 70 locations, during both day- and night-time, to verify that the noise levels remain within set limits. The typical noise levels measured at CERN's site perimeters are around 50 dBA during the day and 45 dBA at night.

The 2022 restart of the accelerator complex saw increased noise levels, due notably to ventilation, cooling and the operation of electrical transformers, which had been put on hold during the second long shutdown. Over the reporting period, three complaints were received and promptly addressed with stakeholders.

CERN collaborates with the towns where its sites are located, providing them with the results of the yearly noise monitoring campaigns at the site perimeters. The Organization also liaises with local authorities regarding plans for new residential areas and provides information and updates concerning ongoing noise claims. Further, for any significant new project, CERN systematically carries out a noise impact assessment to complement the construction permits submitted to the local authorities (see In focus).

NOISE CHARACTERISATION, MODELLING AND REAL-TIME MONITORING

At the end of 2021, CERN implemented an online real-time monitoring system at Point 2 of the LHC and Point 4 of the SPS. This, coupled with CERN's operational data visualisation tools which overlay acoustic data on activity graphs, helps identify dominant noise sources. For example, it enabled the rapid identification of a chiller that was generating excessive noise due to a faulty compressor. Monitoring data checks are performed daily and alarms are set up to trigger rapid intervention where excess noise occurs.

In 2022, noise characterisation was carried out on 130 items of existing equipment at Points 2 and 4 of the LHC, providing input for the creation of 3D noise models. These will enable easier determination of the contribution of each source and may lead to further noise control measures for the most significant sources.

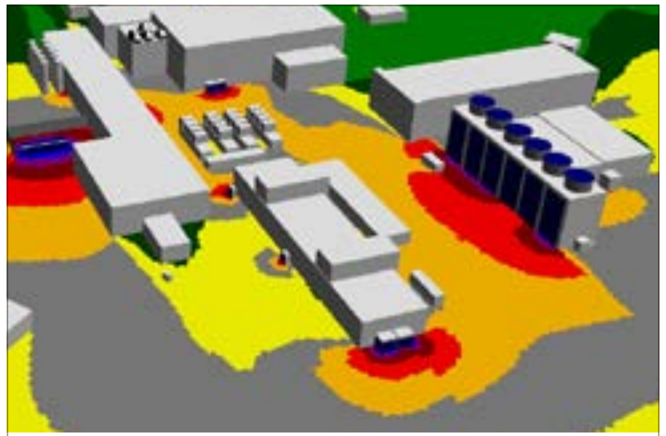
IN FOCUS

Roberto Bozzi is an engineer and leader of the Projects section of the Cooling and Ventilation group.

— Can you tell us about the SF58 project and how noise management has been a determining factor in this context?
RB: In the High Luminosity LHC era and beyond, the CMS experiment will have increased data processing needs and a new, more powerful data centre is therefore planned. The objective of the SF58 project is to build new cooling towers for this future data centre. Together with CERN's noise experts, we performed a complete analysis of the potential noise impact in 2021, using a 3D model of the whole site, in addition to existing acoustic studies from 2016 onwards. The data allowed us to select the cooling towers with the best acoustic performance and integrate this information into the building permit proposal. The results of our analysis were further confirmed by a consultant who conducted a parallel, independent acoustic study.

— Why is this a milestone in terms of noise management?
RB: The noise study played a critical role in confirming that we had selected the most suitable cooling towers to comply with CERN's noise policy. The study also helped us to formalise a list of key points to consider for the optimisation of noise management in our facilities, and thus sets a precedent for the integration of noise management in future projects.

Monitoring of noise generated by cooling towers at LHC Point 2



> 35.0 dB	> 55.0 dB
> 40.0 dB	> 60.0 dB
> 45.0 dB	> 65.0 dB
> 50.0 dB	> 70.0 dB

3D NOISE MODEL OF LHC POINT 2

ENVIRONMENTAL COMPLIANCE AND MANAGEMENT OF HAZARDOUS SUBSTANCES

As an intergovernmental organisation CERN benefits from privileges and immunities as required for its functioning, including the right to establish its own regulations. These regulations apply on its site and replace national laws. However, CERN strives to ensure continued compliance with its Host States' legal frameworks. To keep the environmental impact of its existing and planned activities as low as possible, the Occupational Health and Safety and Environmental Protection unit carries out an environmental monitoring programme that includes both radiological and physicochemical parameters.

PREVENTING CONVENTIONAL ENVIRONMENTAL ACCIDENTS

CERN has put procedures and monitoring in place to avoid accidental chemical releases. In compliance with CERN's Safety Policy, CERN's departments are responsible for putting in place adequate measures for preventing environmental accidents and following up on all environmental events and near misses, as well as the related remedial actions.

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, no conventional pollution event occurred that would have led to a fine or other 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 sites.

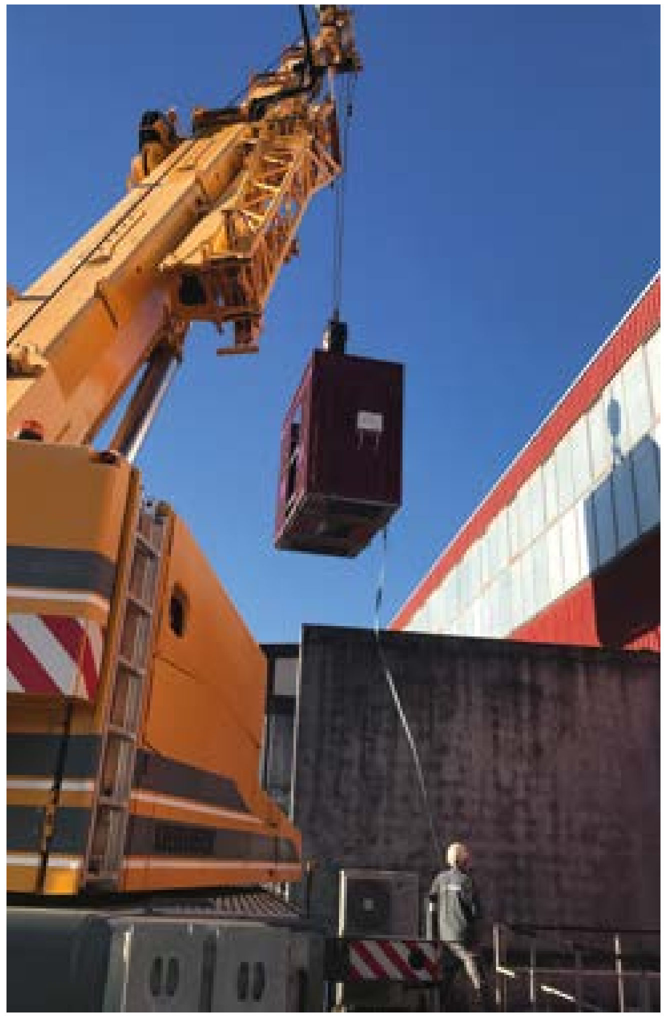
MANAGING HAZARDOUS SUBSTANCES

CERN has a regulatory framework in place that governs the use of hazardous substances with the potential to cause soil and water pollution. This framework is continuously adapted in line with the evolution of the Host States' regulations, and hazardous substances are subject to regular monitoring and reporting. The internal and external transport of hazardous substances is also subject to strict regulations and monitoring. Specifically, the transport of hazardous material using public roads must comply with ADR regulations (European Agreement concerning the International Carriage of Dangerous Goods by Road).

Monitoring is facilitated by dedicated tools, which have been developed in-house to meet CERN's specific needs. The CERN Chemical Register for Environment, Health and Safety (CERES), the inventory tool for liquid, solid and gaseous chemicals present on CERN's sites, was created in 2020. Users of hazardous substances continuously update the register, which distinguishes standard chemicals from those that meet pre-defined criteria to be considered as "high risk" for the environment. By the end of 2022, a total of more than 4000 items were registered in CERES, a quarter of which were considered as high risk. This inventory is the basis on which departments carry out their in-depth periodic reviews and update the mitigation measures to be implemented. Since 2022, in the spirit of knowledge and technology transfer, CERN has made CERES available as an open source tool.

The CERN PoLiChem (Prevention of Pollution by Liquid Chemical Agents) working group identified the replacement of oil transformers by dry ones as a priority action in 2018. This project targets more than 100 units over a period of 10 years. The programme began in 2021, with 10% of the transformers replaced in the period (see In focus).

Radioactive material represents a distinct category of hazardous substances. Its use and transport are subject to dedicated rules. Any radioactive material at CERN is controlled and traced throughout its life cycle, and radiological risk assessments are performed before it is handled. A comprehensive radiation protection training programme is in place to allow the users to assess radiological risks and apply the related radiation protection rules and procedures.



Installation of a dry transformer

IN FOCUS

Vincent Chareyre leads the Electrical Network Maintenance section in the Electrical group of the Engineering department (EN-EL) and Valérie Montabonnet leads the Electrical Power Converters group in the Systems department (SY-EPC). Both are involved in the programme to replace oil-filled transformers.

— What concrete actions have been taken?

VC: This project is divided into two parts, one overseen by us in EN-EL, which deals with power distribution transformers, and the other by SY-EPC, which deals with power transformers for converters. In EN-EL, we started at the beginning of 2021 with 134 oil-filled transformers that had been identified either for replacement or for elimination, whenever possible, as part of the optimisation and consolidation of the electrical network. Of the 134 transformers, 103 are in operation today. The rest are spare units used in the event of a major failure. By the end of 2022, we had replaced ten units and eliminated two, which also allowed us to eliminate 13.6 tonnes of mineral oil.

— What are the challenges associated with this project?

VC: Each transformer and its installation are unique and is thus treated as a separate project. Each project involves very specific processes and requires timely coordination to minimise the impact on the end-users while the process of swapping the electric power supply of the downstream installations from the old to the new transformer is under way.

— Valérie, what actions has SY-EPC been able to take?

VM: The transformers that our group deals with have different requirements to those of EN-EL; the challenges are of a more complex nature and require a careful design phase so that each transformer meets the specifications. The design studies have begun, as has the investigation of existing oil leaks and non-compliant oil retention pits. Oil transformers that are no longer in use have been disposed of or recycled. We eliminated 42 tonnes of mineral oil in 2022 and will pursue the replacement and consolidation programme during the next technical stops and long shutdowns.

KNOWLEDGE AND TECHNOLOGY FOR THE ENVIRONMENT

CERN actively strives to identify and develop technologies with the potential to contribute to environmental protection.

ACCELERATING INNOVATION

In pursuing its mission to perform world-class research in fundamental physics, CERN pushes the frontiers of technology. It also identifies key technologies with a potential impact on a wide range of applications of benefit to society, notably for the environment.

A NEW PROACTIVE APPROACH TO ENVIRONMENTAL APPLICATIONS

The Laboratory has defined a preliminary high-level strategy for transforming CERN technology into environmental applications (see In focus). In 2022, the CERN Innovation Programme on Environmental Applications (CIPEA) was endorsed by the CERN Management, marking the first step in building a roadmap to expand the development of CERN's technologies that can potentially help to protect the environment. The programme invited the CERN community to come up with innovative ideas for environmental applications based on CERN's technologies, knowledge and facilities, around four focus areas where CERN's know-how can be of use. These are renewable and low-carbon energy; clean transportation and future mobility; climate change and pollution control; and sustainability and green science.

Over thirty ideas were discussed, fifteen were submitted for consideration and eight were selected for further development with the financial support of external partners or CERN's Knowledge Transfer fund. The selected projects range from accelerator systems for cleantech and reduced pollution to vacuum technologies for the large-scale distribution of renewable energy, machine-learning algorithms for climate modelling and innovative systems for reducing greenhouse gas emissions at CERN and beyond.

CERN-AIRBUS PARTNERSHIP ON FUTURE CLEAN AVIATION

In 2022, CERN signed a collaboration agreement with the Airbus subsidiary UpNext to explore the potential use of CERN's superconducting technologies in future low-emission aeroplanes. Superconductivity could markedly reduce the weight of an aircraft's electrical distribution systems and help cleaner hybrid aeroplanes to become a reality. The partnership focuses on the development of a demonstrator known as SCALE (SuperConductors for Aviation with Low Emissions). If the expected performance and reliability objectives are achieved, this could be an enabling technology from CERN that contributes to the ambitious target of flying a fully integrated prototype within the next decade.

MOTORSENSE PROJECT FOR ENERGY SAVINGS IN COOLING AND VENTILATION

CERN and ABB Motion, a global company specialising in digitally enabled motor and drive solutions to support future low-carbon industry, infrastructure and transportation, started a collaboration in 2021 to improve the energy efficiency of CERN's cooling and ventilation infrastructure. The condition-monitoring platform, installed in 2022, will collect data from CERN infrastructures. These data insights, paired with expert analysis, will allow energy reduction scenarios to be simulated and tested. Results and best practices from this collaboration will be disseminated publicly and will hopefully inspire other large facilities to follow this path.

CERN-ESA COLLABORATION ON QUANTUM COMPUTING AND ARTIFICIAL INTELLIGENCE FOR EARTH OBSERVATION

Earth observation is one of the main tools for monitoring the health of our planet. Quantum technologies have the potential to revolutionise the way we handle satellite data by solving previously intractable problems. Taking part in this research boom, CERN strengthened its strategic partnership with the European Space Agency (ESA) for applications in the fields of quantum technology and artificial intelligence to include Earth observation (QUAI4EO), using generative models and time series analysis. Expected to last three years, this collaboration is relevant in the context of CERN's Quantum Technology Initiative and the ESA Φ-lab programme on Earth observation.

TESTING CRYOGENIC TECHNOLOGIES FOR FUTURE DECARBONISED TRANSPORTATION

Hydrogen is a promising candidate for transport decarbonisation, but its safe high-density storage in liquid phase at cryogenic temperatures (20 K, -253 °C) remains a challenge. In 2022, to help address this issue, CERN partnered with the Spanish company Applus+ to support it in developing new testing capabilities for the mechanical characterisation of composite materials used for hydrogen tanks. A cryostat based on a CERN model, adapted to the company's needs thanks to CERN's experience in cryogenics, will be built by the company at its premises. The cryostat will then be used to provide testing services for organisations developing compact liquid hydrogen storage solutions.

INSPIRING FUTURE GENERATIONS

In 2022, the EU-funded Innovation Fostering in Accelerator Science and Technology (I.FAST) project held its annual challenge-based innovation project for students. The theme was the environmental applications of accelerator technology. The winning project aims to eliminate toxic green algae blooms in lakes using a compact electron beam accelerator to tackle excess build-up of nutrients in the water.

IN FOCUS

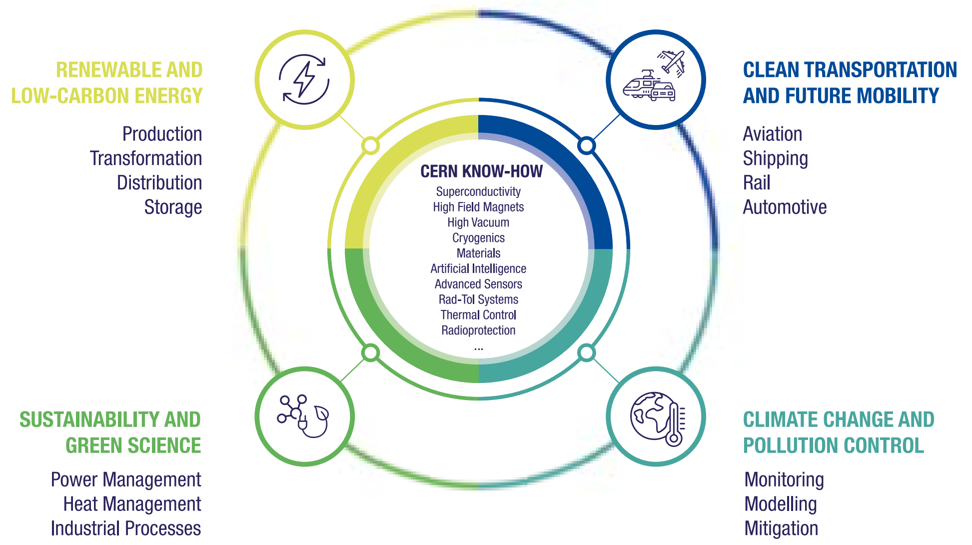
Enrico Chesta, Environmental and Aerospace Applications Coordinator in CERN's Knowledge Transfer group.

— How can CERN's technology and know-how contribute to making our planet more sustainable?

EC: The CIPEA call for ideas we organised in 2022 helped to underline the potential of the CERN community's competences to help to tackle climate change. In parallel, we were solicited by external partners actively engaged in cleantech developments, as they wanted to benefit from CERN's unique expertise to accelerate their innovation. This is why we started working on a preliminary roadmap for environmental applications and defining poles of competence where CERN resources can be clustered and fostered to achieve the most impactful results.

— What are some examples of promising CERN poles of competence in environmental applications?

EC: CERN expertise could greatly contribute to the development of compact magnetic confinement fusion reactors or accelerator-driven systems for nuclear waste transmutation. Superconducting transmission lines can help to distribute electricity without losses for grid and on-board applications. Know-how in materials, vacuum and cryogenics is critical for developing liquid-hydrogen storage systems. CERN's detectors and irradiation facilities can help to improve the performance of instruments for in-situ and remote environmental monitoring, for instance through the development of compact radiation-tolerant equipment for Earth observation satellites. CERN's AI platforms can support global climate models. Finally, many CERN-driven engineering systems optimised for low greenhouse gas emissions, such as integrated cooling systems or waveguide circulators without fluorinated gases, can be adopted by other research infrastructures facing similar challenges. The same is true for CERN's high-energy efficiency systems, such as advanced klystrons or injection-locked magnetrons.



CERN KNOW-HOW
Four main sectors with high potential impact on society and strong synergies with CERN's technical domains of expertise.

GLOSSARY

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

The **Autorité de sûreté nucléaire (ASN)** is the French Nuclear Authority, which 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 Organization-wide and promote energy reuse.

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 Management, follow up their implementation.

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

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 Prefecture of Ain (France), 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 and support European research through synergies.

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 matters 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 environmental impact by providing 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 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.

The **Large Hadron Collider (LHC)** is the world's largest and most powerful particle accelerator. It started operation in 2009 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 on internal and external stakeholders.

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

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

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

The **Prevention of Pollution by Liquid Chemical Agents (PoLiChem)** working group was established to update and consolidate the inventory of the quantities and types of liquid chemical agents present on the CERN sites, including performing risk assessments and establishing risk severity scores.

Science Gateway is CERN's new flagship facility for scientific education and outreach. It will significantly expand CERN's educational activities and serve as a beacon to encourage 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 energy indirect greenhouse gas emissions, 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 energy indirect greenhouse gases (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 **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 (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 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 is clearly presented, in a manner consistent with the Standards, and that the references for disclosures 2-1 to 2-5, 3-1 and 3-2 are aligned with the appropriate sections in the body of the report.

For the SDG Mapping Add-on, GRI Services reviewed that the GRI disclosures included in the content index are appropriately mapped against the SDGs. 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 2021 to 31 December 2022

Standards and Disclosures	Title	Chapters / Pages / Information	Reasons for omission	UN Sustainable Development Goals (SDG)
GRI 1: FOUNDATION 2021				
GRI 2: GENERAL DISCLOSURES 2021				
The organisation and its reporting practices				
2-1	Organizational details	About CERN (p. 9)		
2-2	Entities included in the organization's sustainability reporting	Management approach (p. 13)		
2-3	Reporting period, frequency and contact point	CERN publishes biennial environment reports. This report covers the period 2021-2022 and was published on 4 December 2023. Any questions can be sent to environment.report@cern.ch.		
2-4	Restatements of information	Management approach (p. 13)		
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, ionising radiation and noise emissions.		
Activities and workers				
2-6	Activities, value chain and other business relationships	About CERN (p. 9), Management approach (p. 12)		
2-7	Employees	This information is published in CERN's Annual Personnel Statistics. The Statistics for 2021 can be found on https://cds.cern.ch/record/2809746, and those for 2022 can be found on https://cds.cern.ch/record/2858688.		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. 10-11)		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://cds.cern.ch/record/2692901/files/English.pdf.		SDG 5, SDG 16
2-11	Chair of the highest governance body	About CERN (p. 10)		SDG 16
2-12	Role of the highest governance body in overseeing the management of impacts	Management approach (p. 12) 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://council.web.cern.ch/en/content/convention-establishment-european-organization-nuclear-research.		SDG 16
2-13	Delegation of responsibility for managing impacts	Management approach (p. 12)		
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://cds.cern.ch/record/2007473/files/IntegrityCERN.pdf.		SDG 16
2-16	Communication of critical concerns	Management approach (p. 12)		
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.		
2-18	Evaluation 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://council.web.cern.ch/en/content/convention-establishment-european-organization-nuclear-research.		
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://cds.cern.ch/record/1993099/ (not publicly available).		
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) = 0.2. Note 1: total compensation (average 2021–2022) includes basic salary, responsibility award, performance payment. Excluded are payments for shift work 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), Management approach (p. 12)		
2-23	Policy commitments	This information can be found on https://hse.cern/environment-report-2021-2022/policy-commitments.		SDG 16
2-24	Embedding policy commitments	About CERN (p. 10)		
2-25	Processes to remediate negative impacts	About CERN (p. 9), Water and effluents (p. 28), Noise (p. 34), Environmental compliance and management of hazardous substances (p. 36)		
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. 36)		
2-28	Membership associations	About CERN (p. 10) More information can be found on https://international-relations.web.cern.ch/stakeholder-relations/international-organizations.		
Stakeholder engagement				
2-29	Approach to stakeholder engagement	Management approach (p. 14)		
2-30	Collective bargaining agreements	The Staff Association is the only statutory organ for personnel representation. Its existence is ratified by Chapter VII of the Staff Rules and Regulations: "Within the framework of the present Rules, and independently of the normal hierarchical channels, the relations between the Director-General of the Organization and the members of the personnel shall be either direct with the individual or on a collective basis with the Staff Association as intermediary." The CERN Staff Association represents the entire personnel on the Tripartite Employment Conditions Forum (TREF). Besides the Staff Association, TREF is composed of representatives of the Member States and the Management. TREF examines the conditions of pay and employment at CERN and its recommendations, if adopted by the Council, apply to all personnel. Information about the Staff Association's mission and mandate can be found on https://staff-association.web.cern.ch/association/mission-and-mandate.		SDG 8
GRI 3: MATERIAL TOPICS 2021				
3-1	Process to determine material topics	Management approach (p. 14)		
3-2	List of material topics	Management approach (p. 14)		

GRI content index

Standards and Disclosures	Title	Chapters / Pages / Information	Reasons for omission	UN Sustainable Development Goals (SDG)
MATERIALS				
GRI 301: MATERIALS 2016				
GRI 3: Material Topics	3-3 Management of material topics	N/A	Information unavailable / incomplete. See Management approach (p. 14). Given the complexity in tracing the material through its whole life cycle, an in-depth analysis will be undertaken to establish a reliable way in which to report on this topic.	SDG 8
301-1	Materials used by weight or volume	N/A	Information unavailable / incomplete. See Management approach (p. 14). Weight / volume data unavailable for the reporting period.	SDG 8
ENERGY CONSUMPTION				
GRI 302: ENERGY 2016				
GRI 3: Material Topics	3-3 Management of material topics	Energy (p. 15)		
302-1	Energy consumption within the organisation	Energy (p. 15, 17)		SDG 7, SDG 12, SDG 13
302-3	Energy intensity	Energy (p. 15)		SDG 7, SDG 12, SDG 13
302-4	Reduction of energy consumption	Energy (p. 15, 17)		SDG 7, SDG 8, SDG 12, SDG 13
WATER CONSUMPTION AND EFFLUENT QUALITY				
GRI 303: WATER AND EFFLUENTS 2018				
GRI 3: Material Topics	3-3 Management of material topics	Water and effluents (p. 28)		
303-1	Interactions with water as a shared resource	Water and effluents (p. 28)		SDG 6, SDG 12
303-2	Management of water discharge-related impacts	Water and effluents (p. 28)		SDG 6
303-3	Water withdrawal	Water and effluents (p. 28, 30)		SDG 6
303-4	Water discharge	Water and effluents (p. 28, 30)		SDG 6
303-5	Water consumption	Water and effluents (p. 28)		SDG 6
NATURAL RESOURCES AND BIODIVERSITY				
GRI 304: BIODIVERSITY 2016				
GRI 3: Material Topics	3-3 Management of material topics	Biodiversity, land use and landscape change (p. 26)		
304-2	Significant impacts of activities, products and services on biodiversity	Biodiversity, land use and landscape change (p. 26)		SDG 6, SDG 14, SDG 15
GREENHOUSE GAS EMISSIONS				
GRI 305: EMISSIONS 2016				
GRI 3: Material Topics	3-3 Management of material topics	Emissions (p. 18)		
305-1	Direct (scope 1) GHG emissions	Emissions (p. 18)		SDG 3, SDG 12, SDG 13, SDG 14, SDG 15
305-2	Energy indirect (scope 2) GHG emissions	Emissions (p. 19)		SDG 3, SDG 12, SDG 13, SDG 14, SDG 15
305-3	Other indirect (scope 3) GHG emissions	Emissions (p. 20)		SDG 3, SDG 12, SDG 13, SDG 14, SDG 15

Standards and Disclosures	Title	Chapters / Pages / Information	Reasons for omission	UN Sustainable Development Goals (SDG)
CONVENTIONAL AND RADIOACTIVE WASTE				
GRI 306: WASTE 2020				
GRI 3: Material Topics	3-3 Management of material topics	Waste (p. 31)		
306-1	Waste generation and significant waste-related impacts	Waste (p. 31)		SDG 3, SDG 6, SDG 11, SDG 12
306-2	Management of significant waste-related impacts	Waste (p. 31)		SDG 3, SDG 6, SDG 8, SDG 11, SDG 12
306-4	Waste diverted from disposal	Waste (p. 31)		SDG 3, SDG 11, SDG 12
306-5	Waste directed to disposal	Waste (p. 31)		SDG 3, SDG 11, SDG 12
ENVIRONMENTAL IMPACT OF PROCUREMENT				
GRI 308: SUPPLIER ENVIRONMENTAL ASSESSMENT 2016				
GRI 3: Material Topics	3-3 Management of material topics	Emissions (p. 22)		
308-2	Negative environmental impacts in the supply chain and actions taken	Emissions (p. 22)		
CERN-SPECIFIC				
	HAZARDOUS SUBSTANCES			
GRI 3: Material Topics	3-3 Management of material topics	Environmental compliance and management of hazardous substances (p. 36)		
	IONISING RADIATION			
GRI 3: Material Topics	3-3 Management of material topics	Ionising radiation (p. 24)		
	SCIENCE AND EDUCATION FOR THE ENVIRONMENT			
GRI 3: Material Topics	3-3 Management of material topics	Knowledge and technology for the environment (p. 38)		
	LAND USE AND LANDSCAPE CHANGE			
GRI 3: Material Topics	3-3 Management of material topics	Biodiversity, land use and landscape change (p. 26)		
	MOBILITY			
GRI 3: Material Topics	3-3 Management of material topics	Emissions (p. 20)		
	NOISE			
GRI 3: Material Topics	3-3 Management of material topics	Noise (p. 34)		
	PREVENTION OF ENVIRONMENTAL ACCIDENTS			
GRI 3: Material Topics	3-3 Management of material topics	Environmental compliance and management of hazardous substances (p. 36)		

CERN
Esplanade des Particules 1
P.O. Box
1211 Geneva 23, Switzerland
http://home.cern

Images:
Quel est cet animal?: p. 26
Erik Karits: p. 27
CERN: all other images

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