CERN Accelerates Sustainability!

R. Losito, ATS-DO

15 February 2024,

Low Emittance Rings Workshop


REDUCE
REUSE
RECYCLE

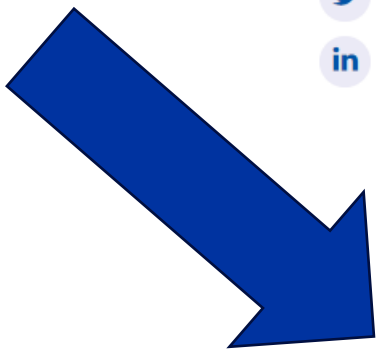
CERNCOURIER | Reporting on international high-energy physics

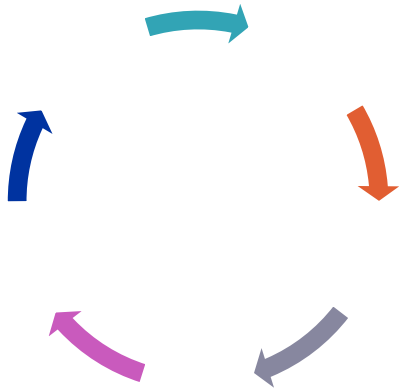
Physics ▾ | Technology ▾ | Community ▾ | In focus | Magazine

POLICY | OPINION

Less, better, recover

25 May 2022



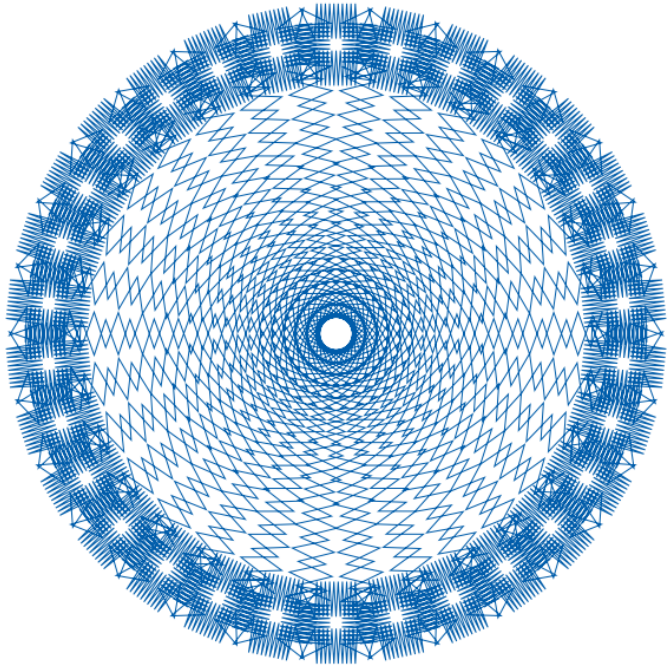


LESS **BETTER** **RECOVER**

Management Objectives 2021-2025
Commitment to SDGs

‘One of the Management’s top objectives for the next five-year period is to increase CERN’s impact on society, thereby boosting the Organization’s visibility and consolidating the support of governments and the general public’.

*‘Across all these areas of activity, **CERN** will continue to ensure that their impact also **contributes to advancing the Sustainable Development Goals (SDG)**, adopted by all United Nations Member States in 2015. Collaboration with CERN’s Member and Associate Member States, with international organisations and other partners will be enhanced to identify and pursue further synergies in support of the SDGs, building on CERN **values**, **competencies** and **technologies**’.*



CERN’S Main Objectives
for the period 2021-2025

Sustainable Development Goals
The basics

- On 25 September 2015, the United Nations General Assembly unanimously adopted Resolution 70/1, **Transforming our World: the 2030 Agenda for Sustainable Development**, laying out 17 Sustainable Development Goals, aimed at mobilising global efforts to **end poverty**, foster **peace**, safeguard the **rights and dignity** of all people, and **protect the planet**.
- The Goals are **inter-related** and **all countries** have agreed to try to meet all of them **by 2030**.
- The Goals serve to **coordinate actions** by UN agencies, non-governmental groups, businesses and any other entities working on a specific Goal.
- **Yearly meetings** are organised to present the actions undertaken and the progress made.

- Each Goal is broken down into defined and specific **targets** (169 in total) that propose concrete paths to reach each Goal; the targets are all **complementary strategies** to fulfil their respective Goal.
- Each target has then its own **indicators**, which are the variables that can be measured and assessed to report on the progress made.

Mapping
CERN contribution to the Goals

- **2017 initial mapping** => 5 Goals identified for priority
- **2021 updated mapping** => 2 further Goals added – SDG5 and SDG7 => to align with Management Objectives

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

THERAPY
Accelerators provide particle beams for more targeted cancer treatment.

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

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

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

25 BY 25 DIVERSITY & INCLUSION INITIATIVE
First ever targets-based strategy to boost the nationality and gender diversity within the Staff and Fellows population.
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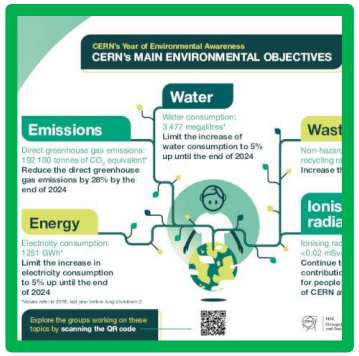
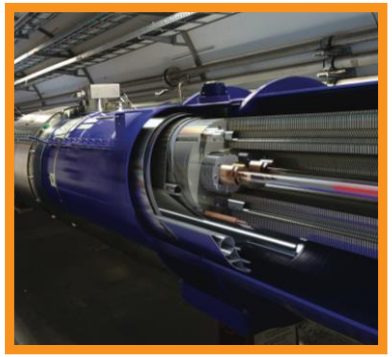
SDG 7 - ENERGY
CERN develops strategies to minimise the increase of energy consumed by the installations, increase energy efficiency and implement energy recovery.



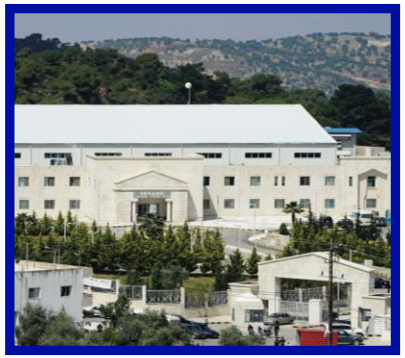
HEATING LOCAL HOUSING
Heat recovered from CERN's accelerator cooling systems to heat a new residential area in the town of Ferney-Voltaire, benefiting up to 8000 people.

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



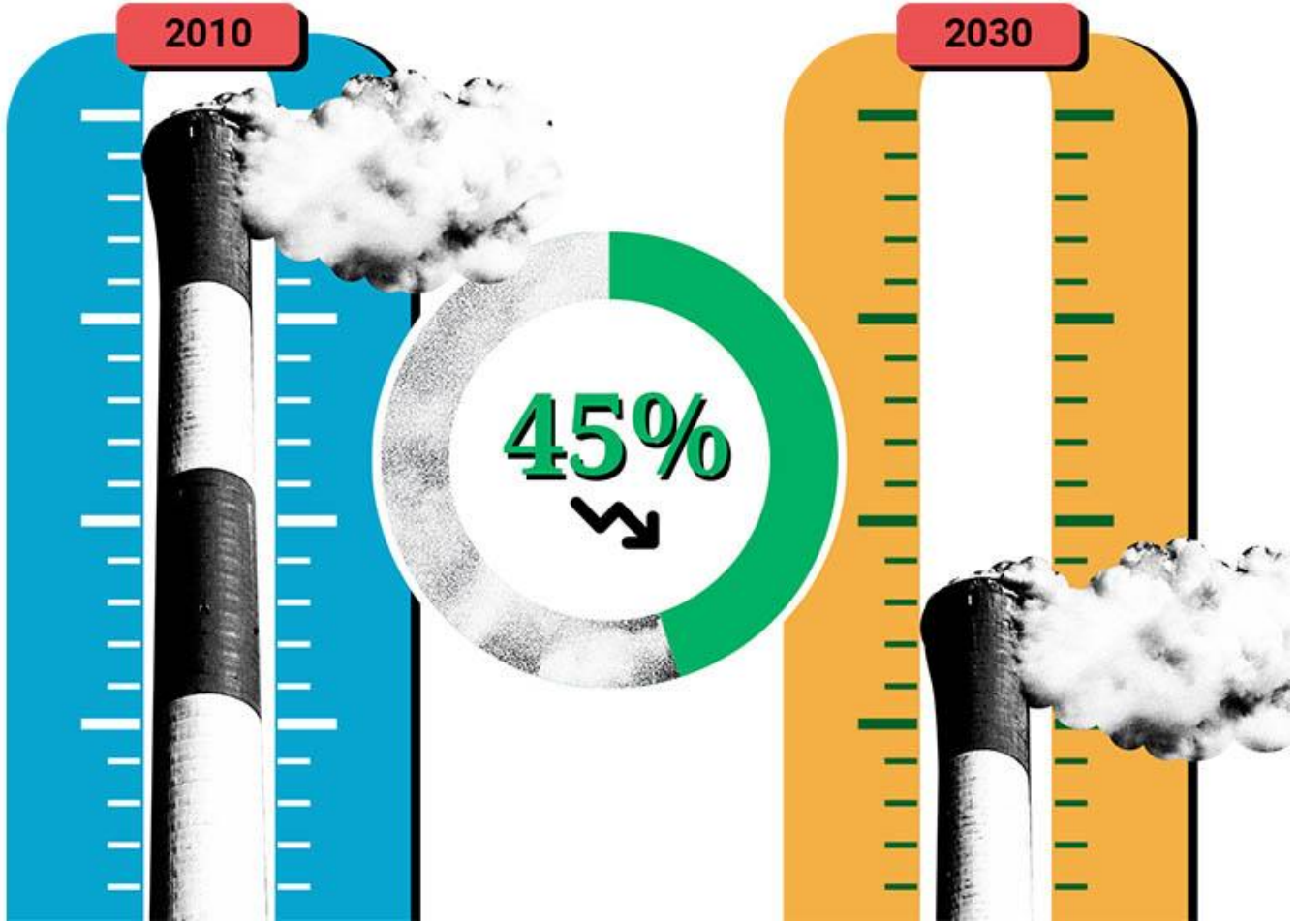
A MAGNET IN THE LHC TUNNEL
Exploring the universe requires new technologies and ingenious engineering to build the machines that explore physics at a new frontier.

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



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

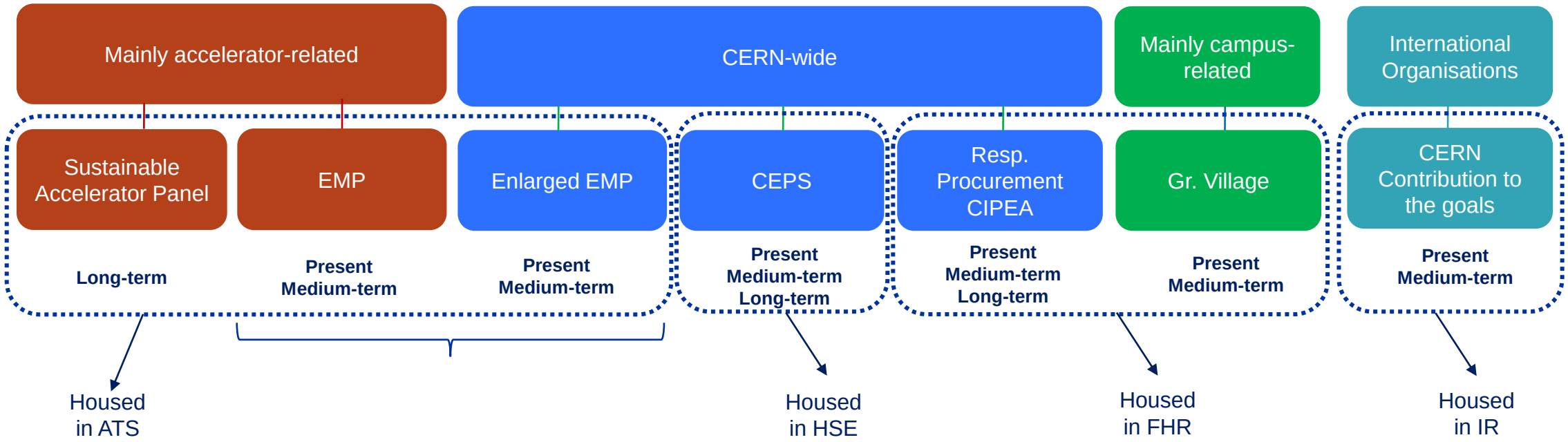
UN Climate Roadmap (Paris Agreements)



UN Climate Roadmap (Paris Agreements)

- **By 2050, we are required to become Net-Zero**
  - Reduce as much as possible emission
  - Absorb/Compensate what remains

Panels/Activities at CERN with direct impact on SDGs



CERN Environmental Protection Steering Board

- **Main body for prioritization and implementation of environmental objectives**
- **Created in 2017, involves members of the ED, line management and units for management of energy and environmental footprint.**
- **Steers projects for about 40 MCHF**
  - Retention basins and new STEP to control effluents
  - Cooling towers upgrades
  - Dismissal of oil-based transformers
  - Replacement of GHG in detectors
  - Inventory of Scope 1, 2, 3 emissions, biodiversity, Noise & waste managements….
- **Coordinates the editing of the CERN Environmental report**

In order to control you need to measure…

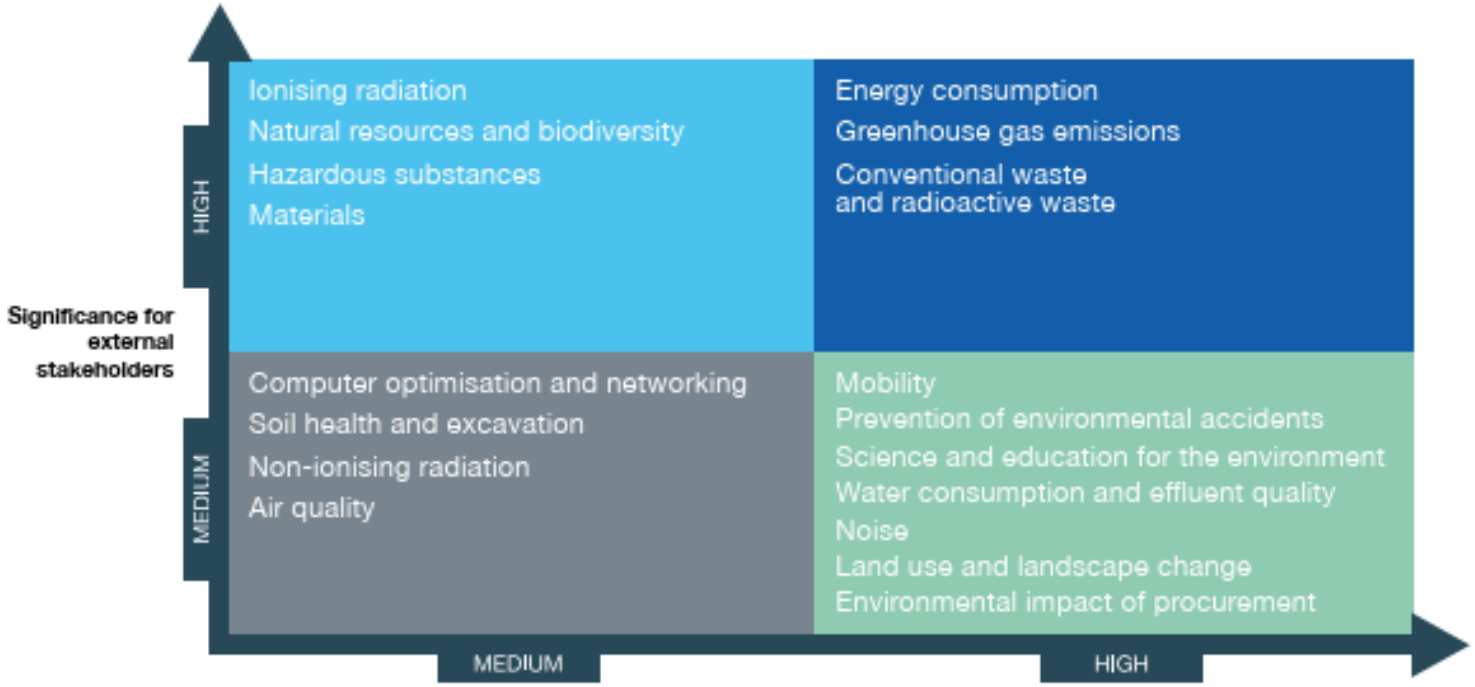
- CERN publishes since 2017 environmental reports based on the **GRI (Global Reporting Initiative)** standards

- It includes detailed information about Energy and water supply and effluents management, direct and indirect CO_2 emissions, radiological impact (emissions and waste), conventional waste, Noise.

- Measuring allows to establish objectives and allocate funds…

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.

HIGHLIGHTS

CERN AND THE ENVIRONMENT IN 2019

During the period covered by this report, 2019-2020, CERN's accelerator complex was in its second long shutdown. Due to this shutdown, several environmental indicators show a different pattern from the previous reporting time frame of 2017-2018. These highlights only include 2019 indicators, given that 2020, with the COVID-19 pandemic, was not representative of a normal year.

Energy

428 GWh

In 2019, CERN consumed **428 GWh** of electricity and **68 GWh** of fossil fuel. CERN's electricity consumption during the period was about 64% lower than when the accelerator complex is running.

The Laboratory is committed to **limiting rises in electricity consumption to 5%** up to the end of 2024 (baseline year: 2018), while delivering significantly increased performance of its facilities. CERN is also committed to increase energy re-use.

Emissions

78 169 tCO_2e

In 2019, CERN's direct greenhouse gas emissions (scope 1) were **78 169 tonnes of CO_2 equivalent** (tCO_2e), which is less than half of the amount emitted annually over the period 2017-2018 when the accelerators were running.

Indirect emissions arising from electricity consumption (scope 2) were **10 672 tCO_2e**. In addition, indirect emissions from water purification, waste treatment, business travel, personnel commutes and catering (scope 3) were **12 098 tCO_2e.**

CERN's immediate target is to **reduce direct emissions by 28%** by the end of **2024** (baseline year: 2018).

Water

2006 ML

In 2019, CERN drew **2006 megalitres (ML)** of water, mostly from Lake Geneva. This is about 47% less than in operational years.

The Laboratory is committed to **keeping its increase in water consumption below 5%** up to the end of 2024 (baseline year: 2018), despite a growing demand for water cooling of upgraded facilities.

Waste

57% recycled

In 2019, CERN eliminated 5589 tonnes of non-hazardous waste, of which **57% was recycled**. The Laboratory also eliminated 1868 tonnes of hazardous waste.

CERN's objective is to increase the current recycling rate.

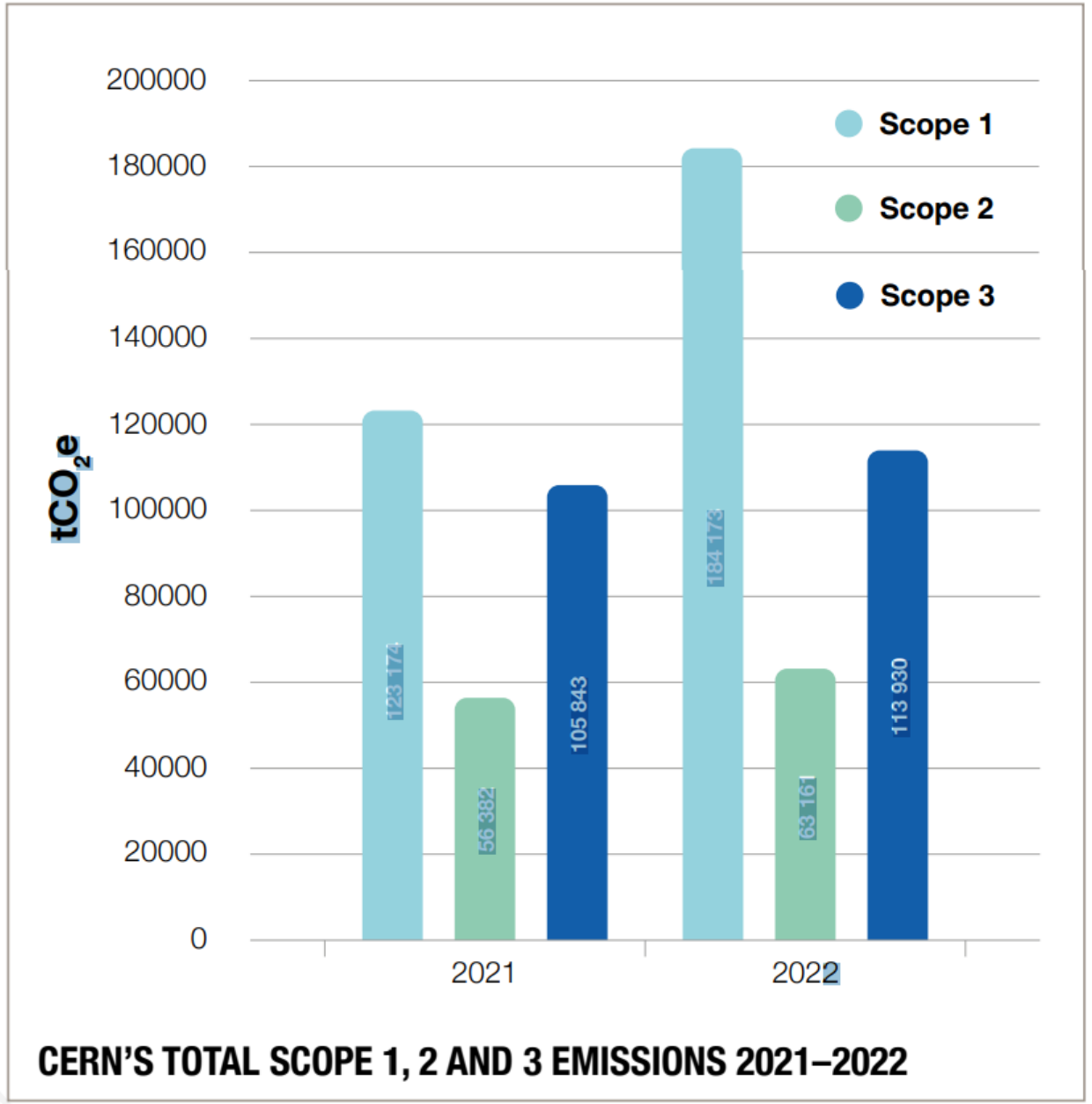
Biodiversity

16 species of orchids

In 2019, a new species of orchid was discovered on CERN's sites, bringing the total to **16 species**. CERN land includes **258 hectares** of cultivated fields and meadows, **136 hectares** of forest and three wetlands.

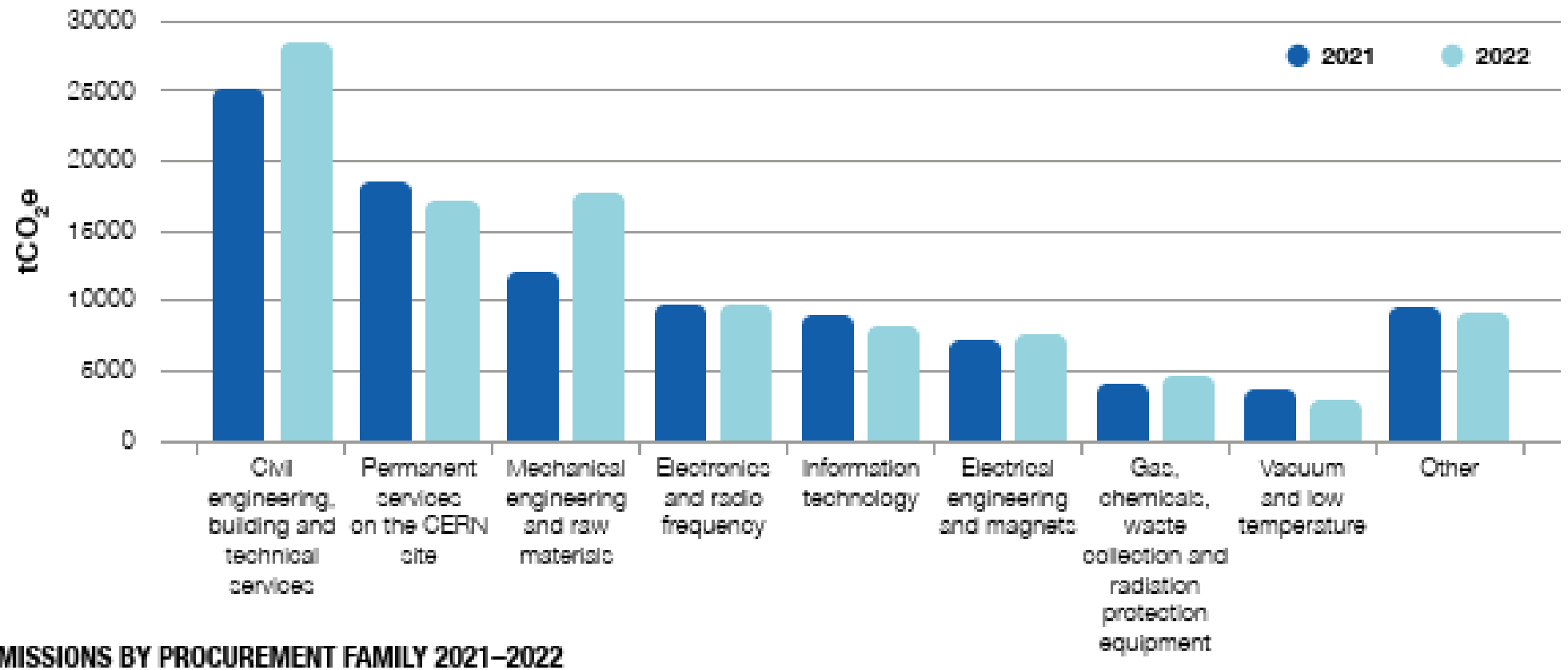
Were are the main drivers of CO2 in a new project?

- **Environment Report 21-22**
- **Contribution n. 1: LHC experiments**
  - FCC Detectors will not use those gases
  - Other projects as well
  - WP dedicated in the Detector R&D Roadmap
- **Contribution n 2:**
  - Raw materials
  - Services (transport etc…)
- **Publishing Scope 3 emissions is a step forward towards its optimization, but requires a real cultural change.**
  - Our suppliers are often not ready, need to work with them to ensure transition at affordable cost…



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

SCOPE 3 emissions detail by class



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.

Context for future projects: Energy

Area needed to generate 1.3 TWh/y

(no contingency, no distribution, no storage…)

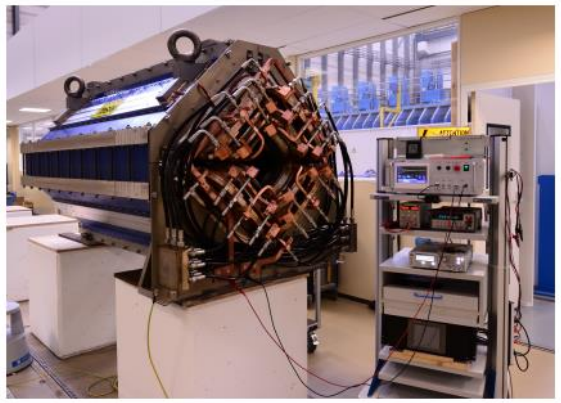
SDG 7: Affordable and clean Energy

- **CERN is managing its electrical consumption responsibly since at least 10 years, well before the establishment of the SDGs.**
- **Recently issued an Energy* policy with three pillars:**
  - **LESS** : Reduce consumption (consolidation & operation)
  - **BETTER** :
    - Precise Forecasting & Measurement
    - Raising awareness
  - **RECOVER** : Waste energy

**Energy is not only electricity…*

LESS: Improved efficiency, recent cases

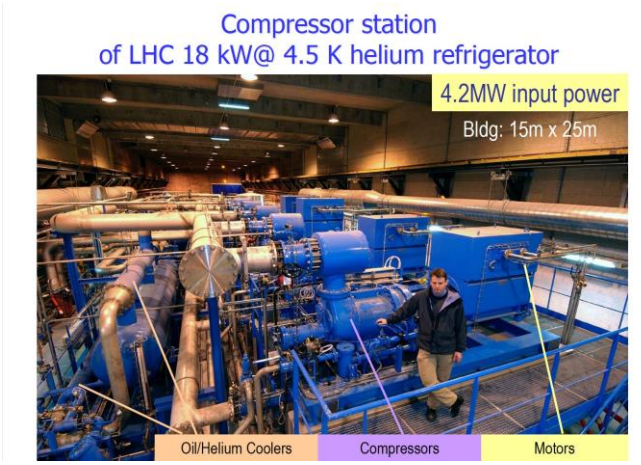
Facility upgrades: East Area Renovation (done during recent LS2)

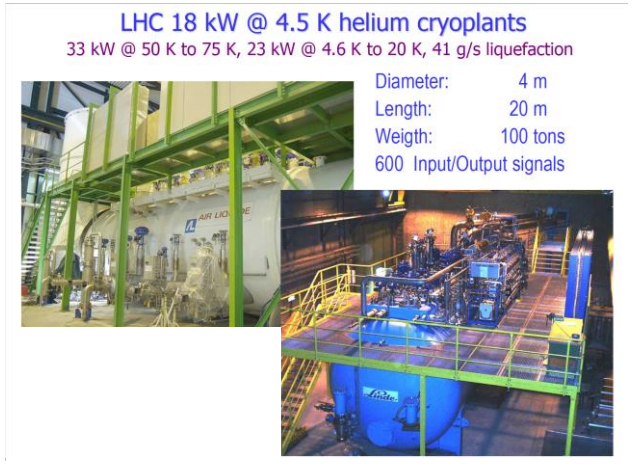


Powering energy:
From 11 GWh/year to around 0.6 GWh/year
(> 90% reduction)

Warning: Optimisation of a system (powering, cooling) makes sense only when considering collective effects on users !!!

New equipment (Cryogenic Refrigerators for HL-LHC)



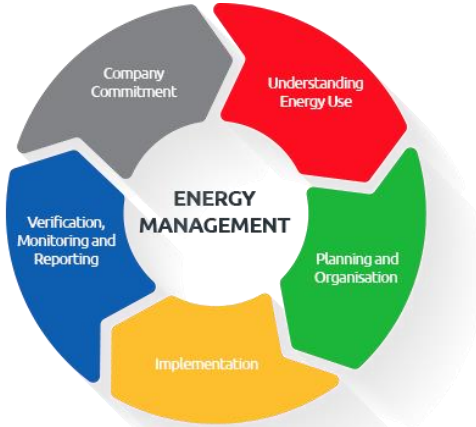


A set of requirements (performance, technology) to allow industry to provide the optimum for a given scenario:

Adjudication: CAPEX + OPEX (10 years)

BETTER: ISO 50001 certification

- CERN is the first Laboratory ISO 50001 certified.
- Certification implies the establishment of improvement goals, and of continuous monitoring.
- The process is not limited to the experts on the field: the line and top management have to be continuously informed of the status of the KPIs and take action.
- The Energy Management Panel (standard and Enlarged) are the bodies used to manage and control Electricity Consumption.



afaq
AFNOR CERTIFICATION

Certificat
Certificate

N° 2023/103380.1 Page 1 / 1

AFNOR Certification certifie que le système de management mis en place par :
AFNOR Certification certifies that the management system implemented by:

Organisation européenne pour la Recherche nucléaire (CERN)
European Organization for Nuclear Research (CERN)

pour les activités suivantes :
for the following activities:

RECHERCHE FONDAMENTALE EN PHYSIQUE DES PARTICULES.

FUNDAMENTAL RESEARCH IN PARTICLE PHYSICS.

a été évalué et jugé conforme aux exigences requises par :
has been assessed and found to meet the requirements of:

ISO 50001 : 2018

et est déployé sur les sites suivants :
and is developed on the following locations:

Adresse	N° SIREN
Esplanade des Particules 1 CH-1211 GENÈVE 23	
9001, route de Saint-Genis FR-01280 PREVESSIN MOENS	445403488

(L'ensemble des activités de l'entreprise sur les sites donnés est couvert par la certification)
(The scope of certification covers all activities carried out on the above-mentioned locations)

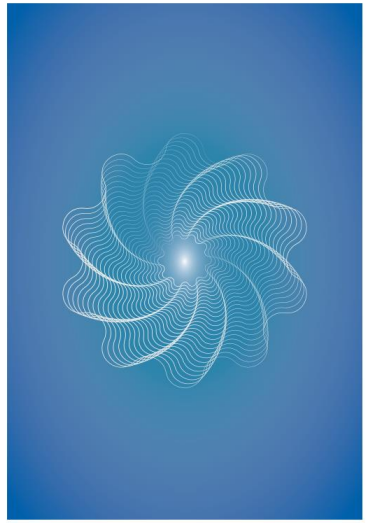
Ce certificat est valable à compter du (année/mois/jour) 2023-02-02 Jusqu'au 2026-02-01
This certificate is valid from (year/month/day) *until*

Julien NIZRI
Directeur Général d'AFNOR Certification
Managing Director of AFNOR Certification

Flashez ce QR Code pour vérifier la validité du certificat

BETTER: Energy performance plan (2022-2026)

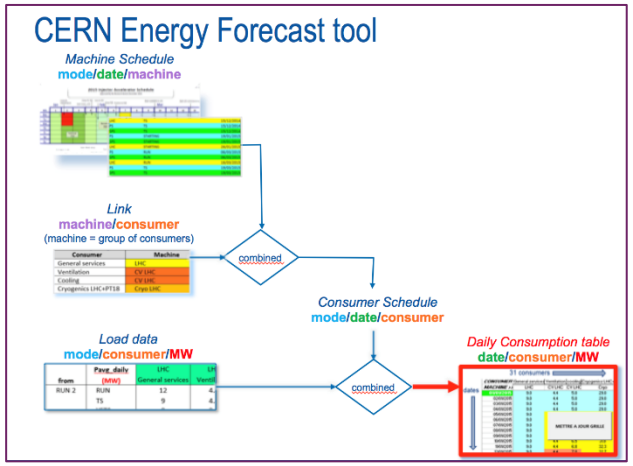
- Main technical document together with the « energy review » including the:
  - Retained perimeter
  - Energy baseline
  - Summary of actions carried out in the past
  - Energy performance indicators
  - Objectives and targets for the next 5 years
  - Action plan for the next 5 years
  - Benchmark against other research institutes
- Definition of 8 Significant Energy Uses (SEUs)
  - Energy use accounting for substantial energy consumption and/or offering considerable potential for energy performance improvement



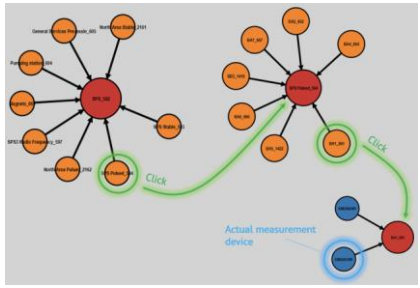
Use sector or use	Energy	Average consumption 2015–2018 (GWh)	Significance of energy use/consumption in %
LHC	Electricity	657 GWh	55%
SPS	Electricity	324 GWh	27%
PS complex	Electricity	125 GWh	10%
Data centres (Meyrin and ALICE and LHCb experiments)	Electricity	32 GWh[4]	3%
Meyrin buildings	Electricity	35 GWh	3%
Prévessin buildings	Electricity	16 GWh	1%
Meyrin heating	Gas	52 GWh LHV	82%
Prévessin heating	Gas	11 GWh LHV	18%

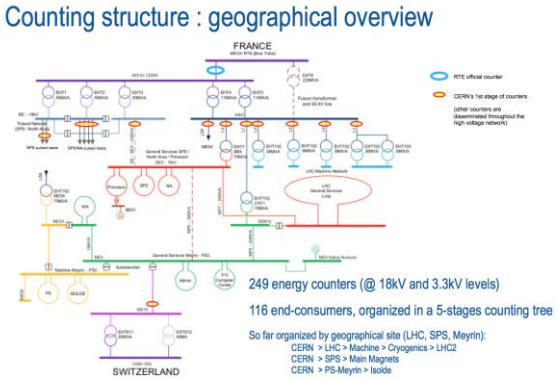
95%

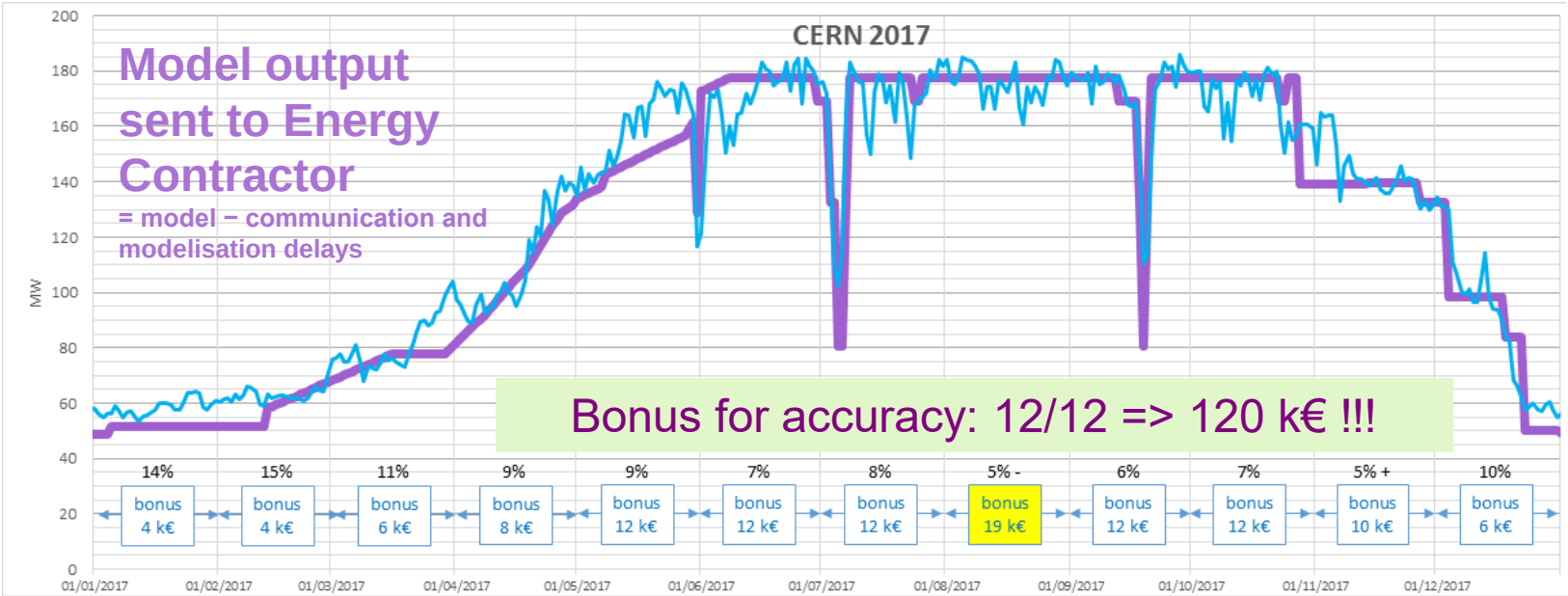
BETTER: Forecasts & measures



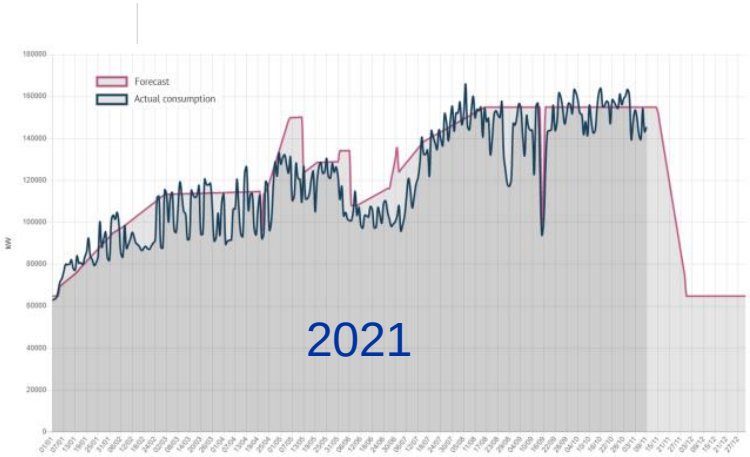
2nd version, integrated in **Web-Energy** tool to combine forecasts & measures





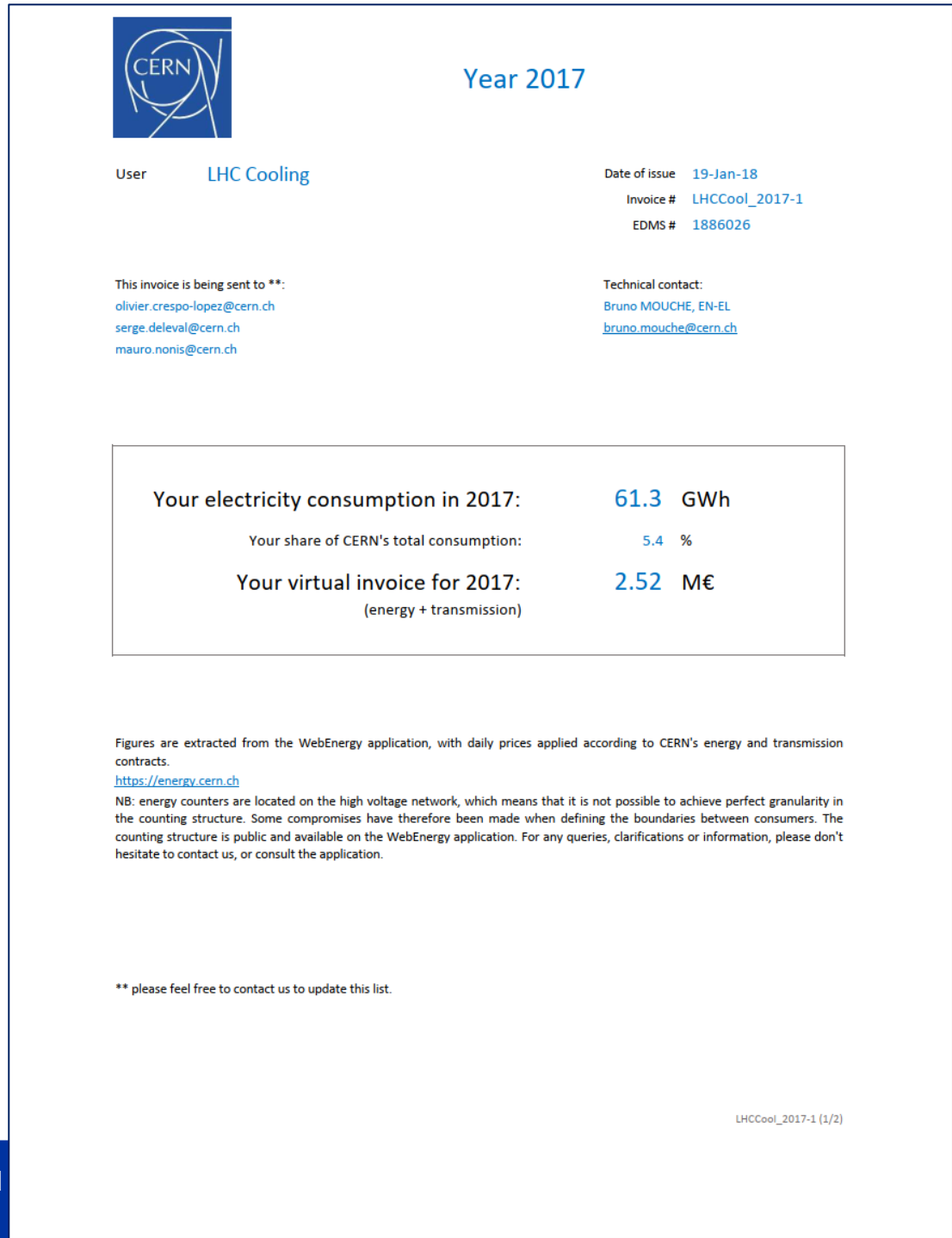


Measures: global accuracy better than 1% !



BETTER: Forecasts & awareness

- In order to raise awareness, already since years the line management (group leaders, equipment owners) receive a “virtual” invoice for the equipment under their responsibility
- It is virtual in the sense that groups are not charged with the mentioned cost, but gives them a sense of the impact of their work, and the possibility to follow up along the years.



Year 2017

User LHC Cooling

Date of issue 19-Jan-18
Invoice # LHCCool_2017-1
EDMS # 1886026

This invoice is being sent to **:
olivier.crespo-lopez@cern.ch
serge.deleval@cern.ch
mauro.nonis@cern.ch

Technical contact:
Bruno MOUCHE, EN-EL
bruno.mouche@cern.ch

Your electricity consumption in 2017:	61.3	GWh
Your share of CERN's total consumption:	5.4	%
Your virtual invoice for 2017: (energy + transmission)	2.52	M€

Figures are extracted from the WebEnergy application, with daily prices applied according to CERN's energy and transmission contracts.
https://energy.cern.ch
NB: energy counters are located on the high voltage network, which means that it is not possible to achieve perfect granularity in the counting structure. Some compromises have therefore been made when defining the boundaries between consumers. The counting structure is public and available on the WebEnergy application. For any queries, clarifications or information, please don't hesitate to contact us, or consult the application.

** please feel free to contact us to update this list.

LHCCool_2017-1 (1/2)

Lifecycle assessment

Concrete

- **We will need concrete for any new project**
- **Production of concrete is inherently producing CO_2**
- **From Limestone ($CaCO_3$), through calcination (heating at 1450°C):**
- **$CaCO_3$ → CaO + CO_2**

- **For all projects, already today (and even more in 2050) the impact of construction of new accelerators will overcome the impact of their operation because of concrete!**

Concrete

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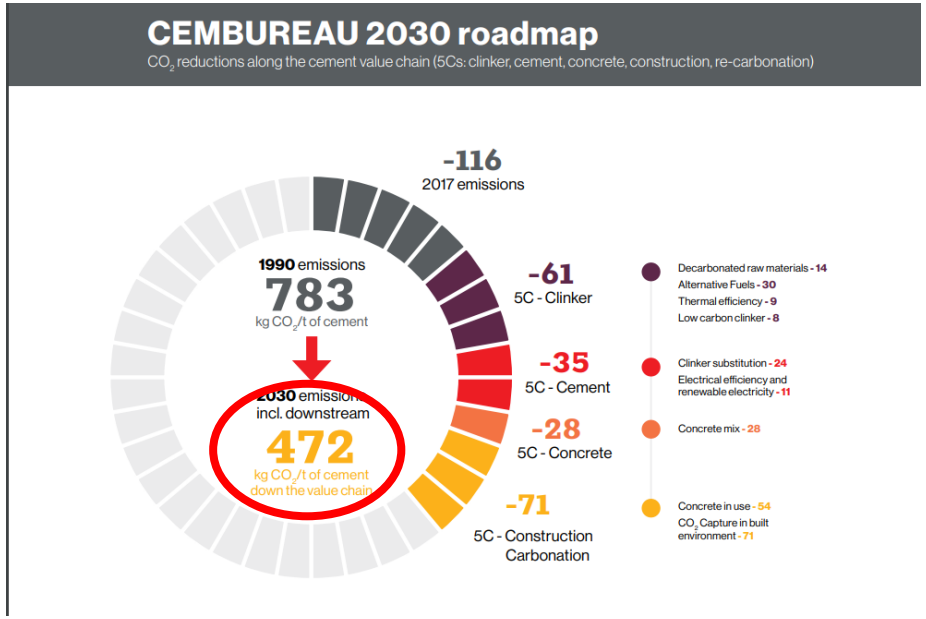
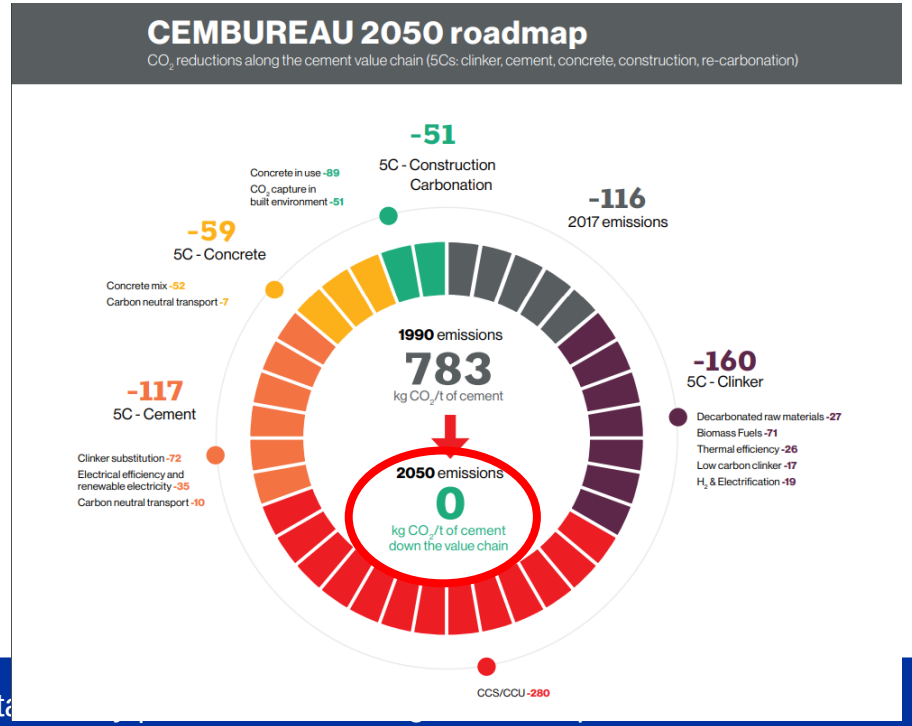
- Production of concrete is inherently producing CO_2
- From Limestone ($CaCO_3$), through calcination (heating at 1450°C):
- $CaCO_3 \rightarrow CaO + CO_2$

- For all projects, already today (and even more in 2050) the impact of construction of new accelerators will overcome the impact of their operation because of concrete!

Concrete: is there hope?

- The cement Industry in Europe is trying to move towards a more sustainable future.
- In 2024 a new plant in Norway will start producing cement with low CO2 emissions
- We don’t know which quantities they can produce, how much it will cost, and how fast competitors will react.
- 6 more plants in Europe are on the way to be completed.
- By 2030, we might have a decent probability to purchasing low CO2 cement
  - At what price?





Karlsruhe Institute of Technology

KIT TESTFELD für Energieeffizienz und Netzstabilität in großen Forschungsinfrastrukturen

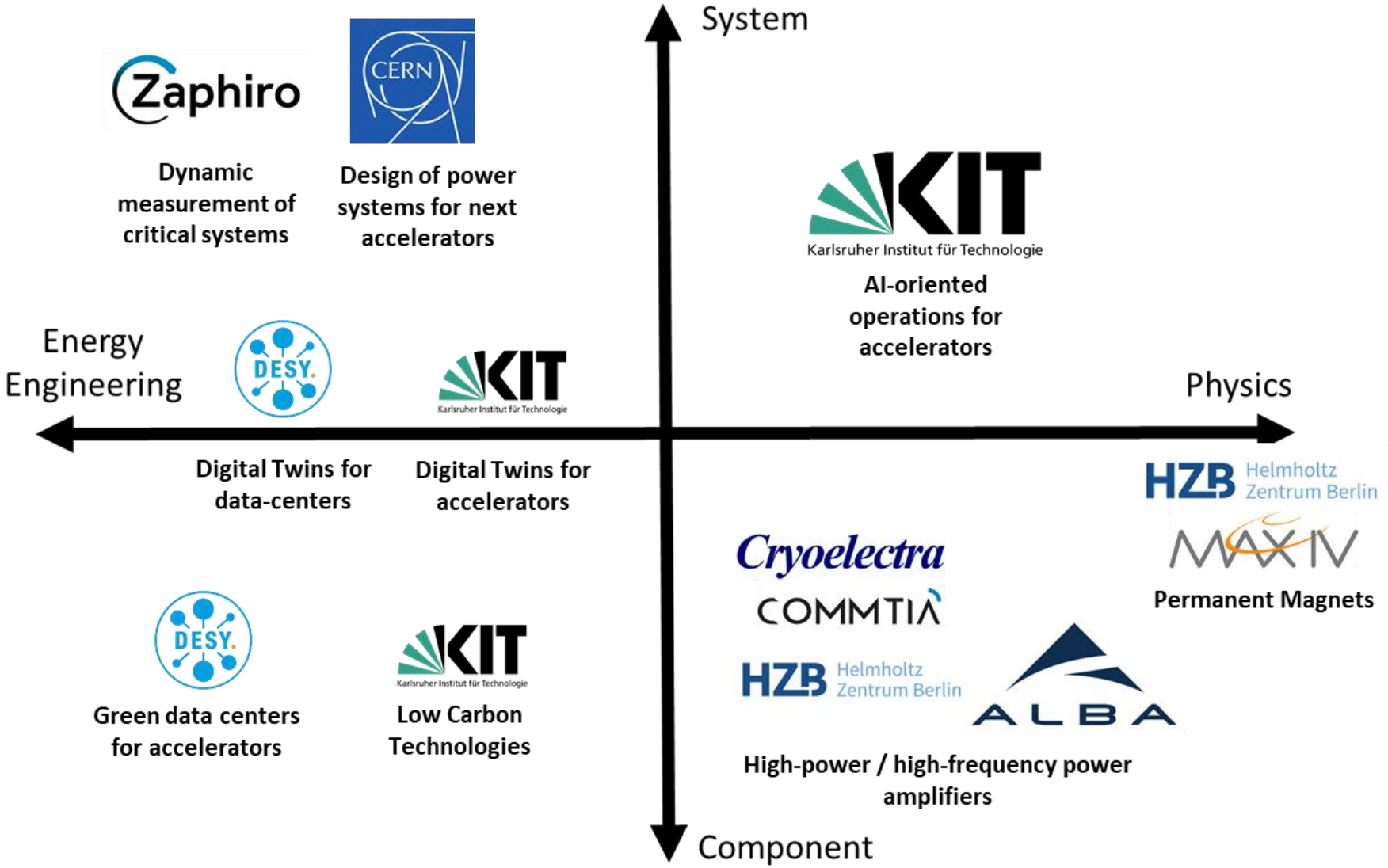
Research Facility 2.0: Towards a more energy-efficient and sustainable path

TT-Prof. Dr.-Ing. Giovanni De Carne, Prof. Dr. Anke-Susanne Müller, Dr. Andrea-Santamaria Garcia, Dr. Falastine Abusaif, M.Sc. Mashid Zadeh, Dr. Erik Bründermann, Dr. Julian Gethmann

Karlsruhe Institute of Technology – ATS Sustainable Panel - 05/10/2023

RF2.0 Consortium

- **10 partners**
- Accelerators
  - ALBA (Spain)
  - CERN (Switzerland)
  - DESY (Germany)
  - HZB (Germany)
  - MAX IV (Sweden)
- University
  - KIT
- Manufacturers
  - Commtia (Spain)
  - Cryoelectra (Germany)
  - Zaphiro (Swiss)

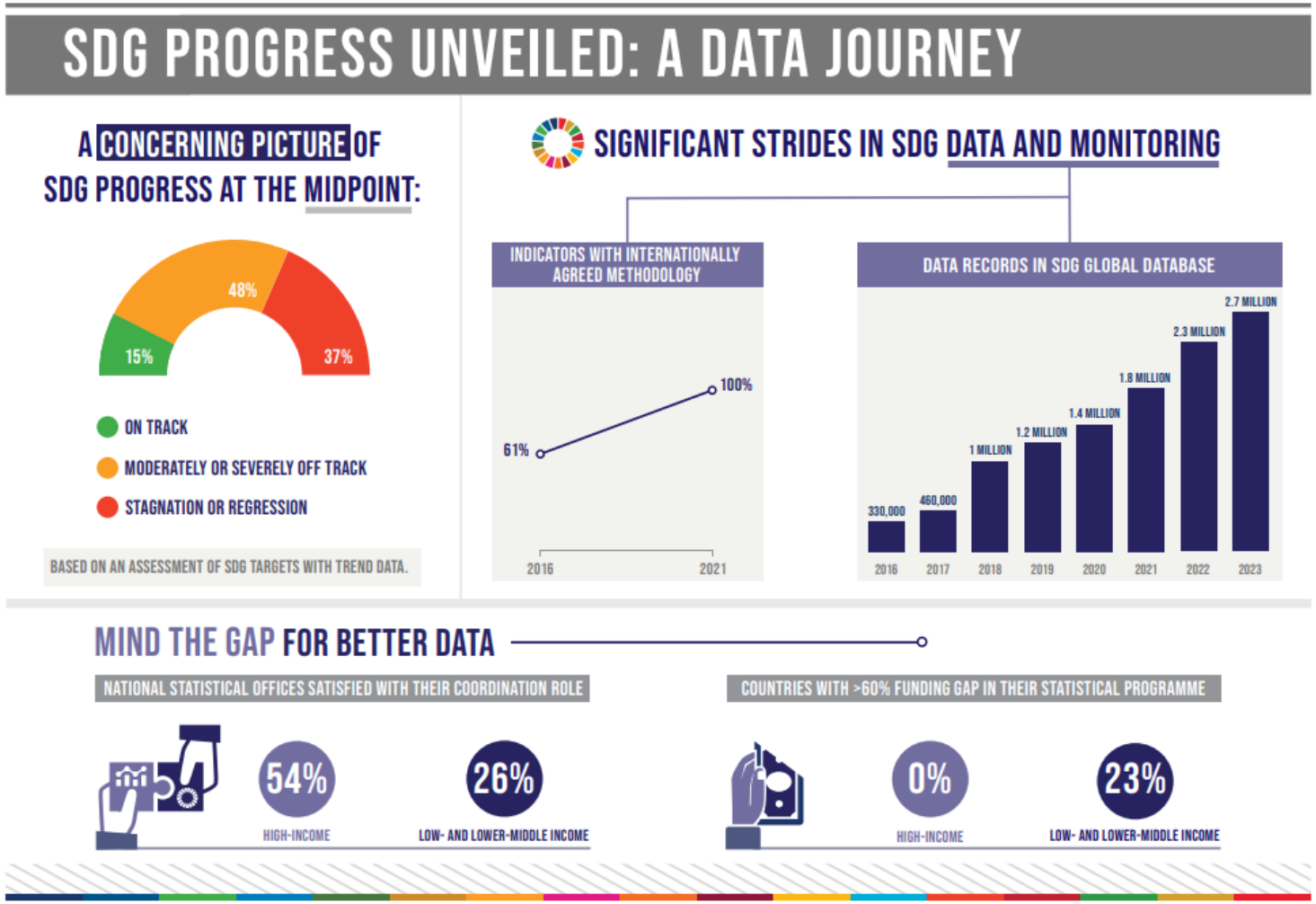


CONCLUSIONS

- **Building and operating a CO_2 free Accelerator is not easy**
- **It risks to be more expensive in the period until 2035, then hopefully new technologies will help us and become standard**
- **The management of resources (electricity, water etc…) will become more and more complex**
  - Managerial challenges need to be properly taken in consideration,
  - sufficient personnel must be devoted to energy management, responsible purchasing, environmental monitoring and protection
- **Cultural Change is a must! Training to Lifecycle assessment must become common practice**
- **It's an investment that will bring gain and economic sustainability at medium term (5 to 10 years)**

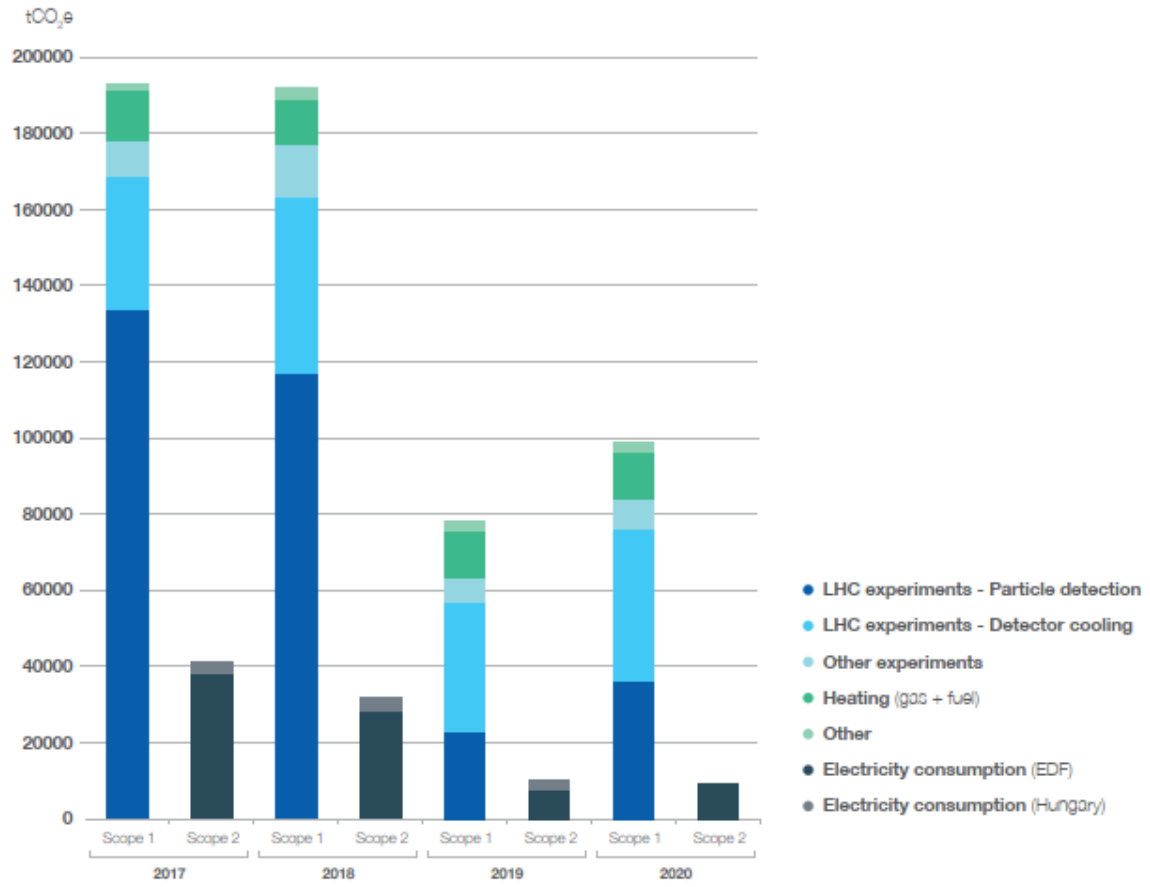
SPARE SLIDES

UN Report on SDGs 2023



https://unstats.un.org/sdgs/report/2023/The-Sustainable-Development-Goals-Report-2023.pdf

CO2 Emissions, Scope 1 (Direct) and 2 (Indirect)



CERN SCOPE 1 AND SCOPE 2 EMISSIONS FOR 2017-2020 BY CATEGORY.

Other includes air conditioning, electrical insulation, emergency generators and CERN vehicle fleet fuel consumption. Emission factors for electricity: EDF Bilan des émissions de GES 2002-2020 for EDF and Bilan Carbone® V8 for Hungary.

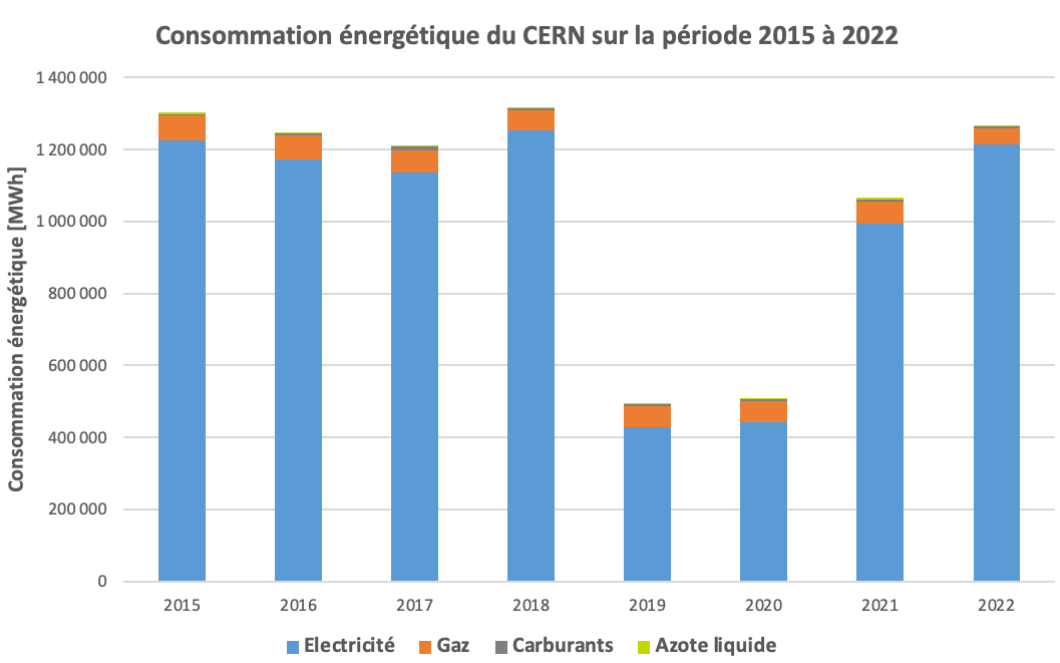
- Scope 1 emissions dominate CERN's emissions
- Most of them due to (now) obsolete design of detectors
- Difficult to eliminate in near future in LHC, but experiments have promised to reduce by at least ~30% with LS3.
  - Repair leaks
  - Change fluids
    - Massive use of CO_2 as coolant
- **For the next generation of colliders, this line will *(almost)* not be there anymore!!!**

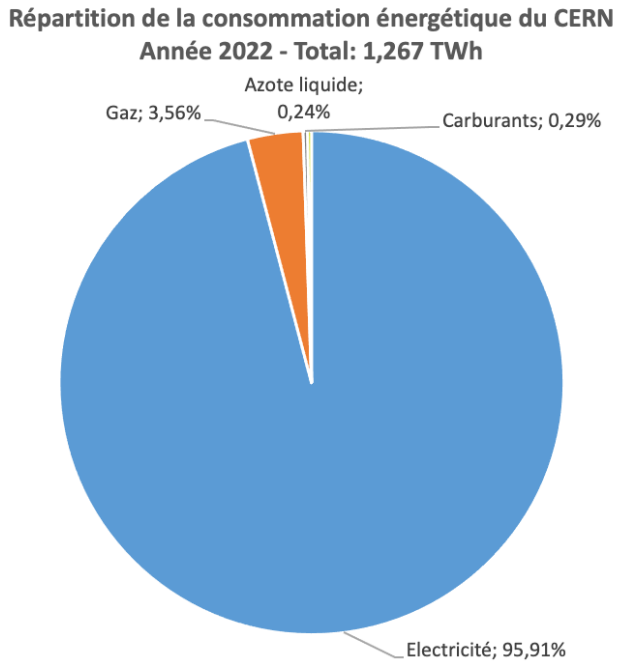
Energy consumption at CERN

- New: Addition of liquid nitrogen as an energy source (following certification audit)

  → 7.3 GWh/year when cooling down the LHC, 3.1 GWh/year otherwise

- Consolidated figures





Enabling framework for renewables

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Enabling framework for renewables

The EU aims to accelerate renewable energy projects, remove administrative obstacles in the permitting processes and further empower citizens.

PAGE CONTENTS

- Simplifying permitting processes
- Power purchase agreements
- Study and public consultation
- Workshops

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Electricity in FRANCE

SLIDE courtesy of N. Bellegarde

Electricity contracts at CERN

- French electrical network – Main source

The biggest component of CERN's electricity cost

EDF — Supply of Energy

\+

RTE — Transmission costs

- Swiss electrical network – Back-up source (limited to 60 MVA)

ALPIQ — Supply of Energy

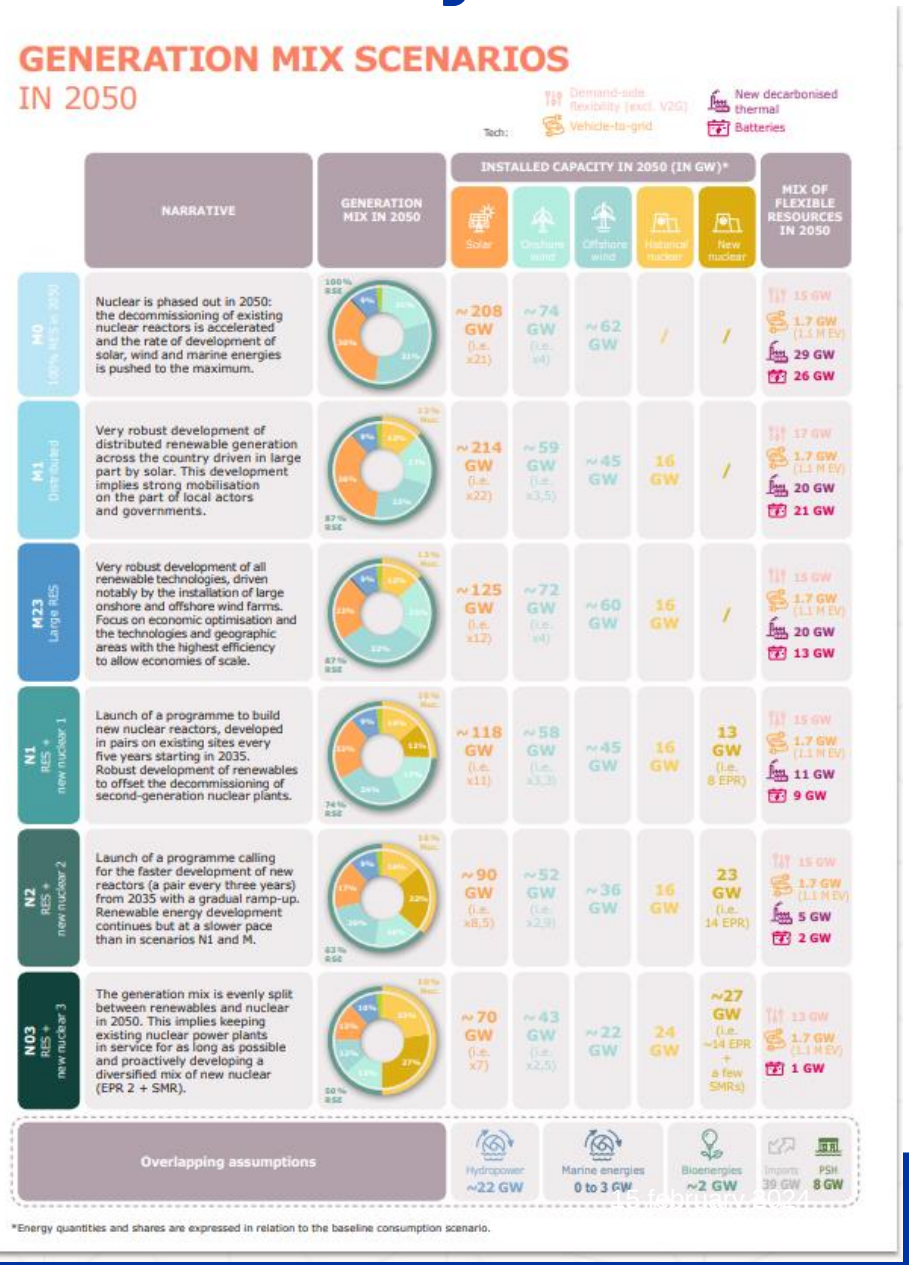
\+

SIG — Transmission costs

Supply contracts: Best Value For Money

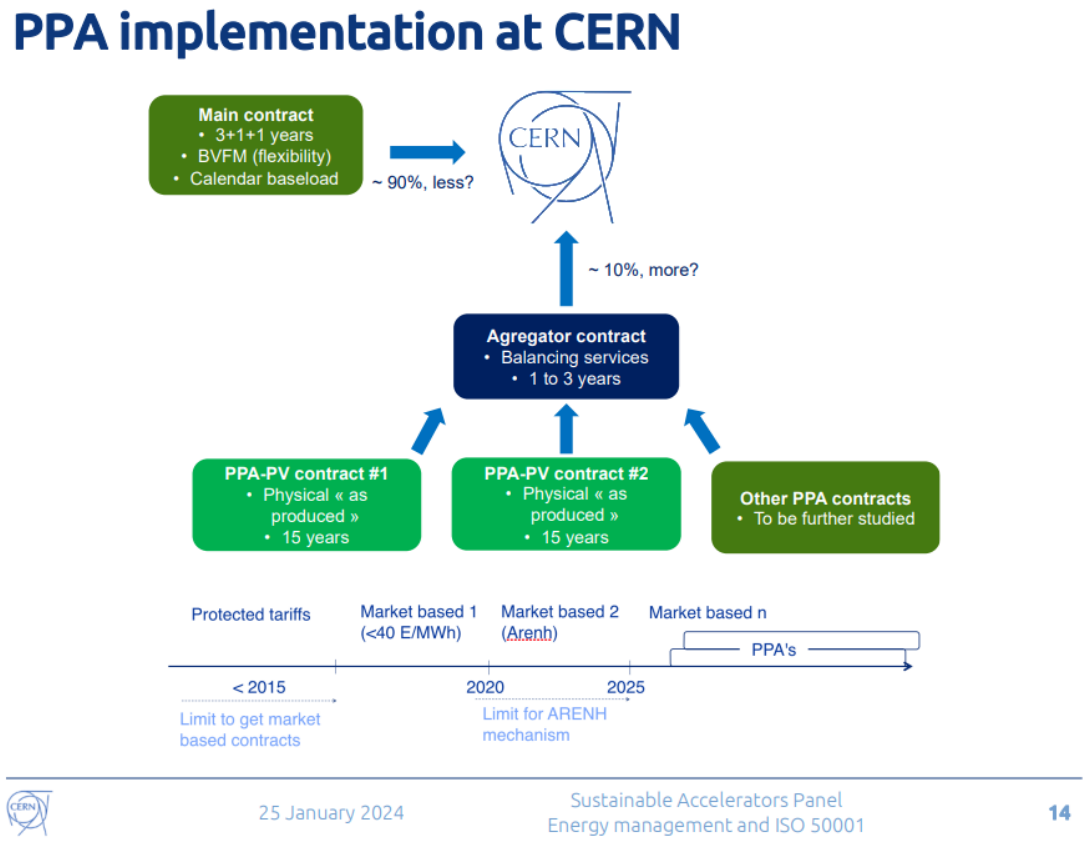
Transmission contracts: Monopoly

Electricity in FRANCE in 2050



- **Several Scenarios possible, including or not Nuclear.**
- **Source: RTE**
- **Which option will become reality is not only a political choice:**
- **Technology breakthroughs are necessary to use renewables**
  - Increase efficiency of sources
  - Development of environmentally-friendly energy storage technologies
- **…but also political…**
  - Acceptance from local communities to have sources in their backyard
  - Simplification of authorisation procedures with reduction of time needed to implement new plants
  - Doing all that in respect of the environment…

Electricity in FRANCE for CERN



SLIDE courtesy of N. Bellegarde

- The management of PPA contracts will be complex
- The mix of sources (Solar, Wind Onshore and offshore, Nuclear) shall have to be carefully considered to ensure our constant baselod is affordable and cost effective
- Also, we will have to assure the flexibility we have now, or reconsider the lifecycle of the accelerators (e.g. day/night, summer/winter…)
- We will most probably need storage onsite, need to hope in breakthroughs, or help/invest in R&D