Sustainability in future Colliders

R. Losito, ATS-DO

20 March 2024,

ALEGRO Workshop 2024, Lisbon

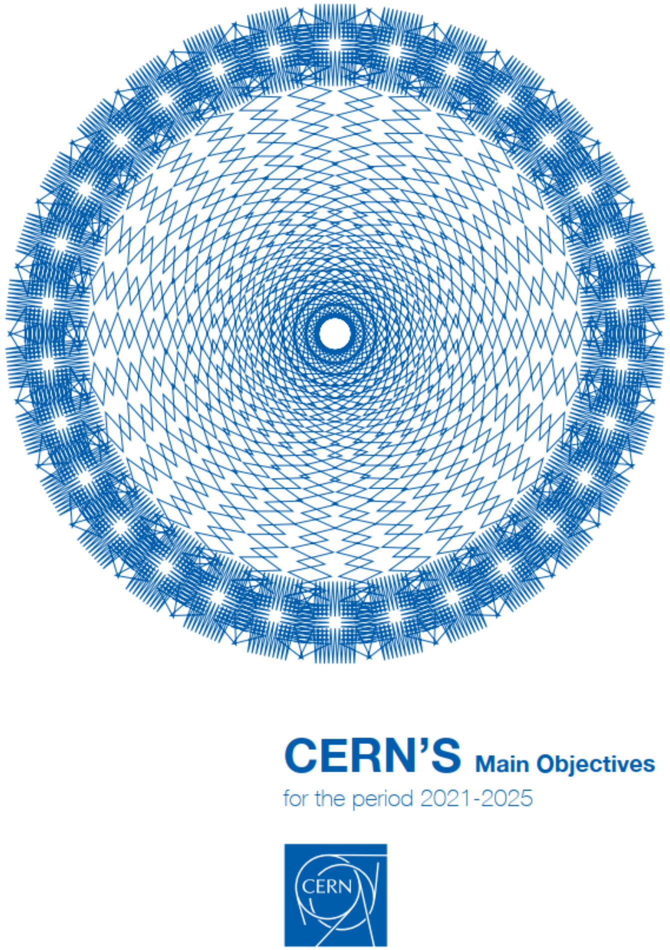
Outline

- **Where are we heading to: UN Sustainable goals**
- **What parameters are important for a Collider?**
  - Energy
  - CO_2
  - Use of Land
  - Responsible procurement…
- **Can we compare different colliders based on sustainability?**
- **Conclusions**

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**’.*

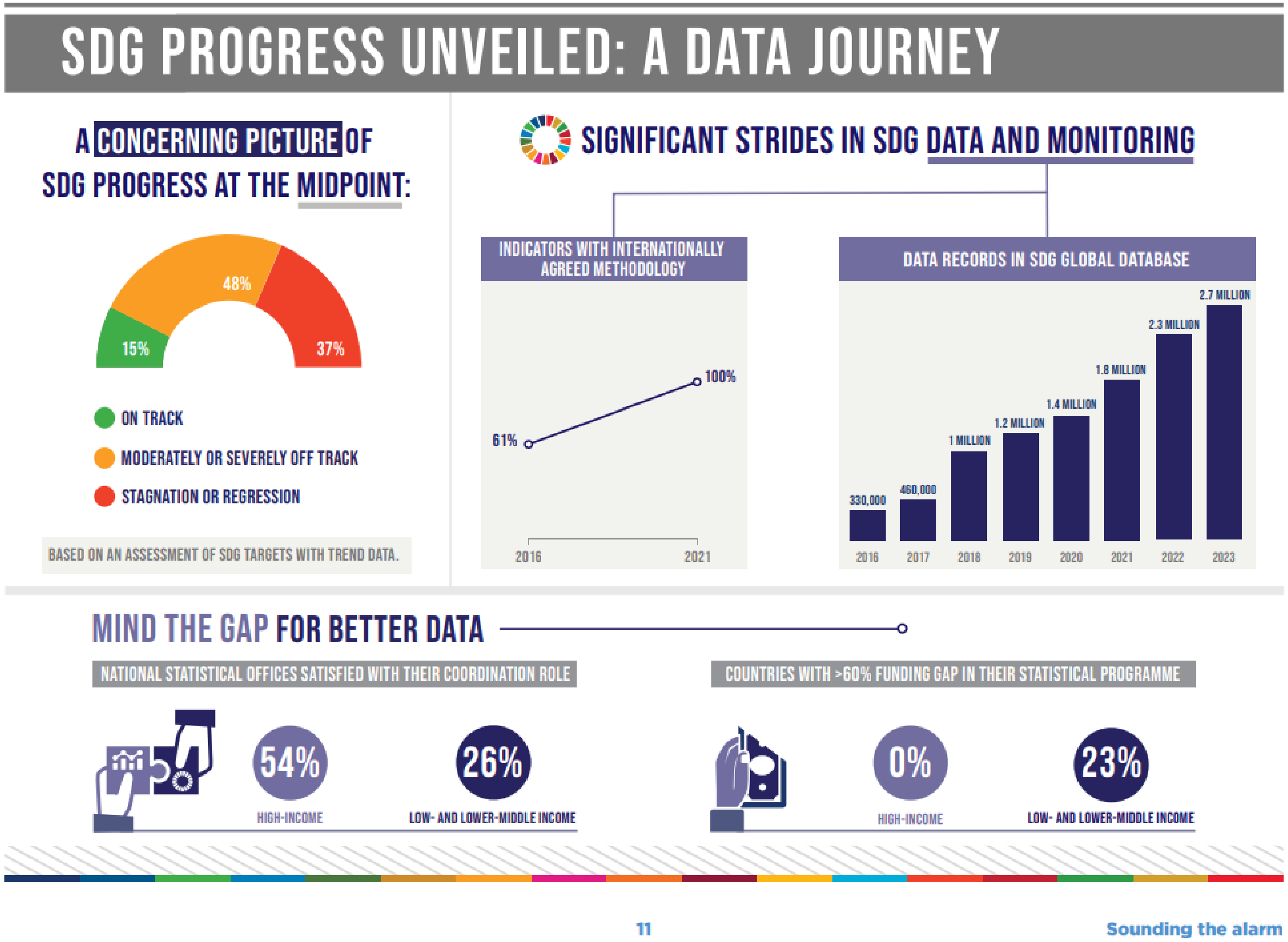


Sustainable Development Goals
The basics

- 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.

UN Report on SDGs 2023



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

Buildings sector


BREAKTHROUGH AGENDA

THE BREAKTHROUGH AGENDA REPORT 2023

Accelerating Sector Transitions Through Stronger International Collaboration

iea

IRENA International Renewable Energy Agency

UN Climate Change High-Level Champions in collaboration with:

Marrakech Partnership

A vision and milestones for the sector's transition are set out in the UN Climate Action Pathway and 2030 Breakthroughs, which require the sector to halve its emissions by 2030 (relative to 2021), with 100% of new buildings having net zero operating emissions by 2030, and widespread deep renovations of existing assets well underway. Embodied carbon must be reduced by at least 40%, with leading projects achieving at least 50% reductions.

Breakthrough Agenda report 2023

In order to control you need to measure…

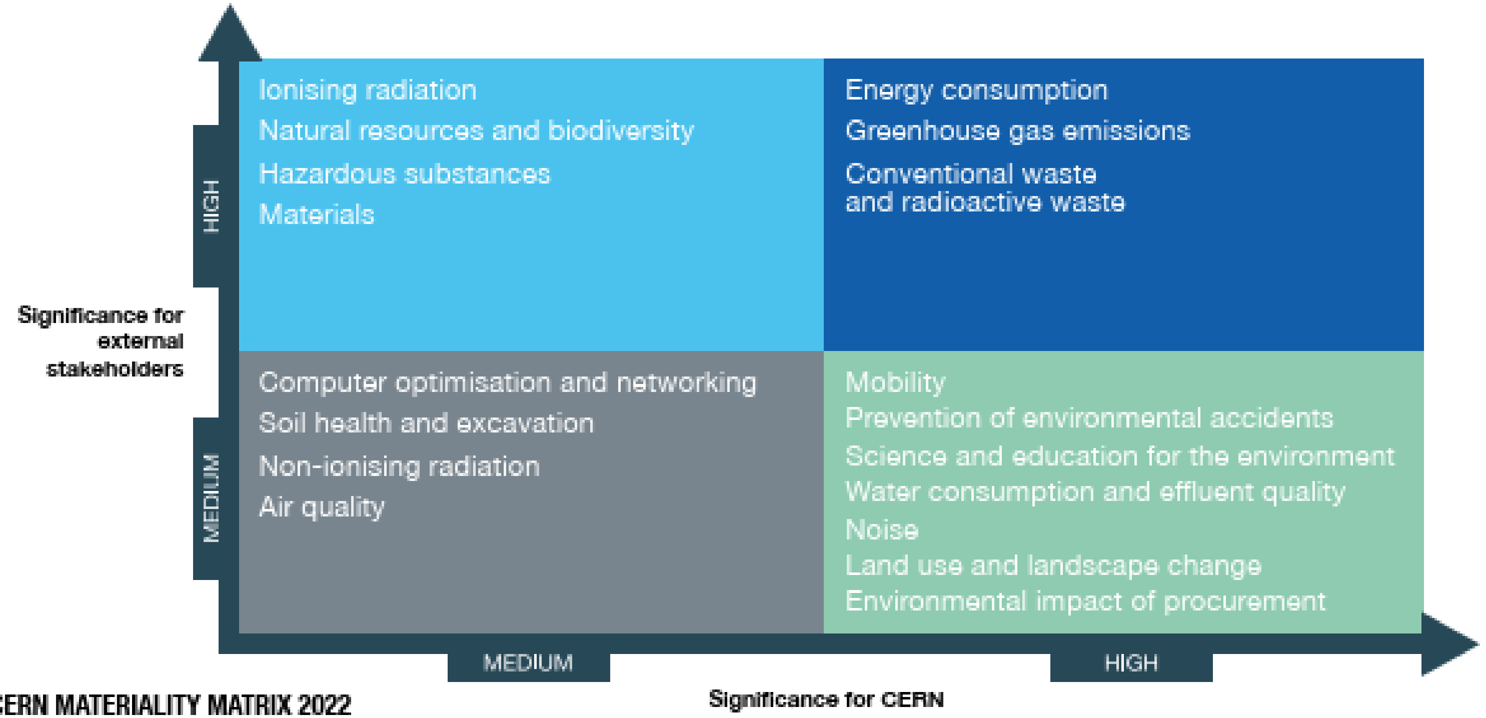
- CERN publishes since 2017 environmental reports based on the **GRI (Global Reporting Initiative)** standards

- 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.

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.

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.

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.

BIODIVERSITY
18 species of orchids

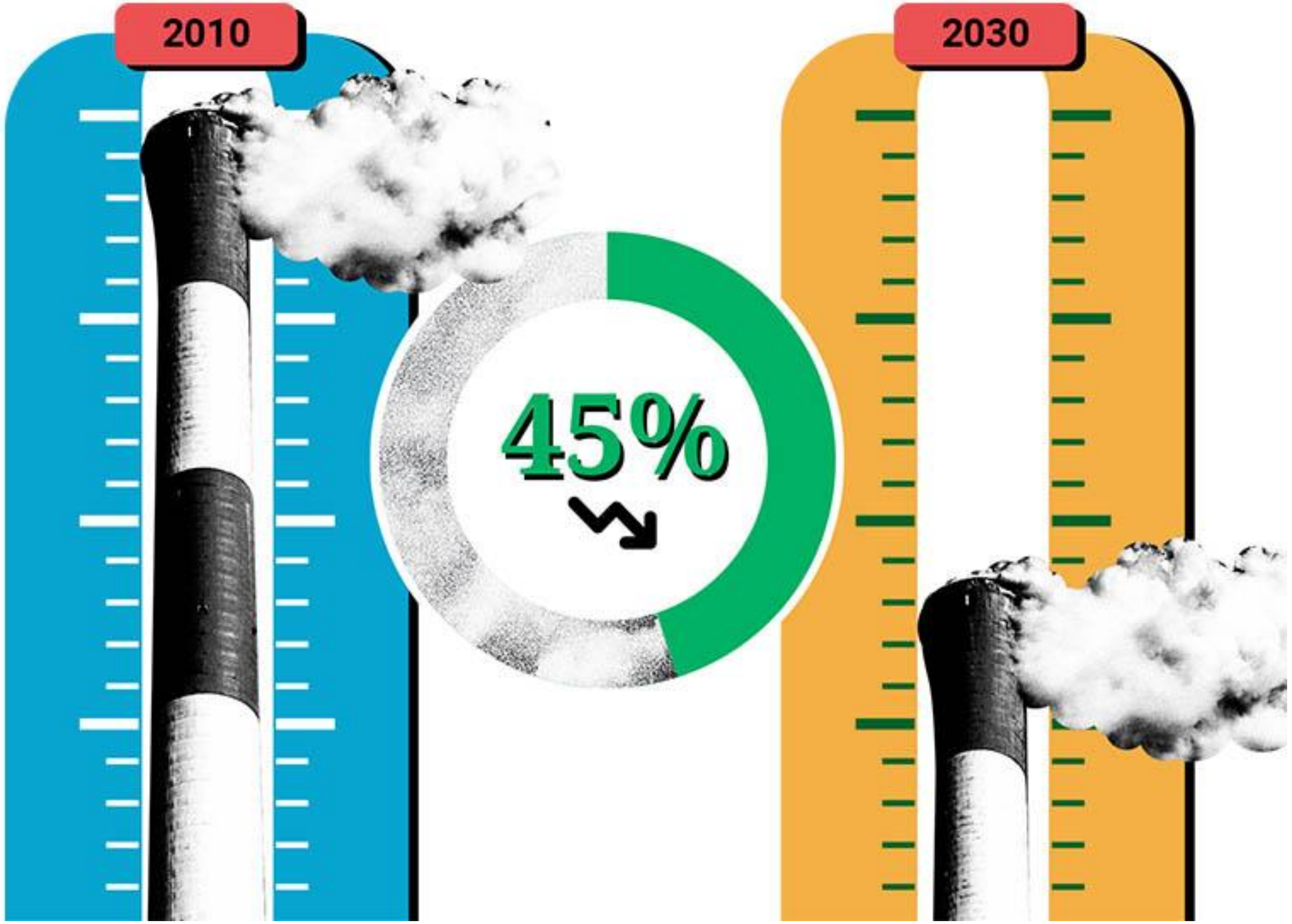
Inventories of flora and fauna were conducted in 2022. A further two species of orchid were identified, bringing the total on the CERN sites to 18, as well as 62 species of Lepidoptera and 32 species of Orthoptera.

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.

UN Climate Roadmap (Paris Agreements)



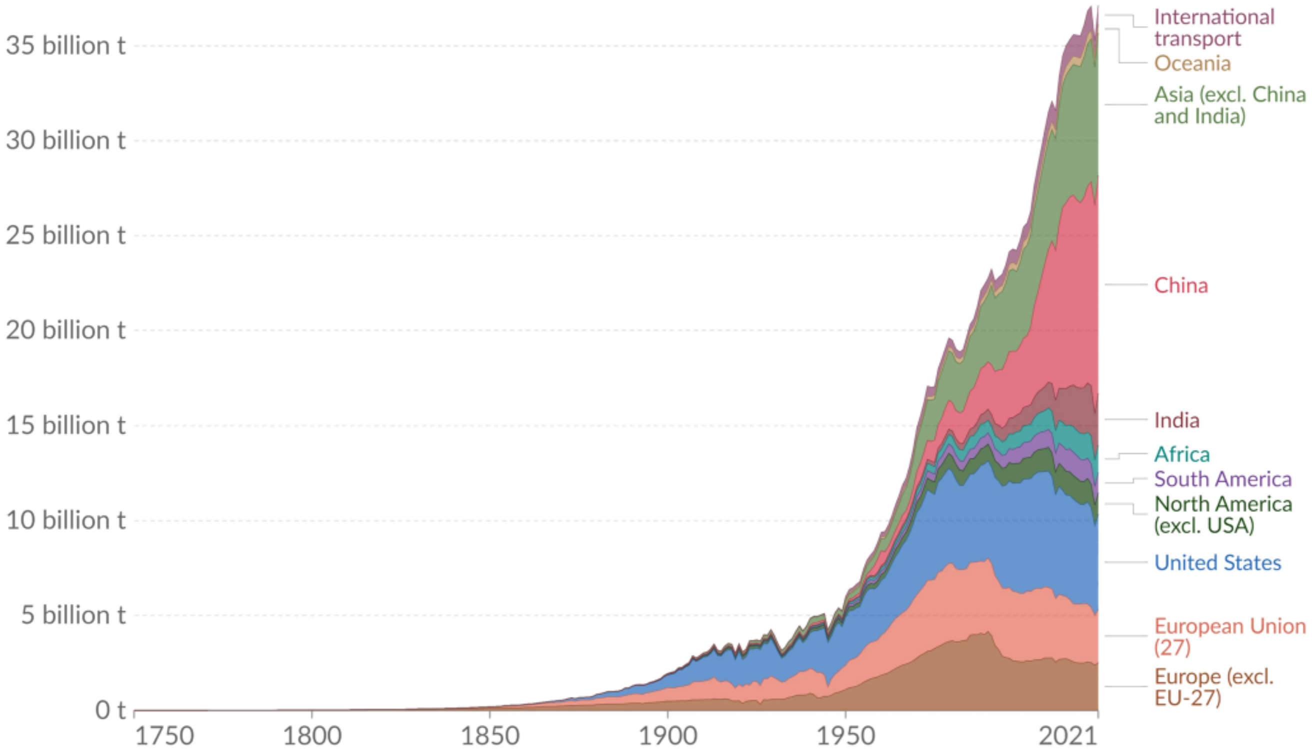
UN Climate Roadmap (Paris Agreements)

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

Global GHG Emissions (tCO_2e)

ARUP

To limit global warming to 1.5°C (relative to 1900), the estimated remaining carbon budget from the beginning of 2020 is **< 300 billion t** https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf



Data source: Global Carbon Budget (2022) OurWorldInData.org/co2-and-greenhouse-gas-emissions | CC BY

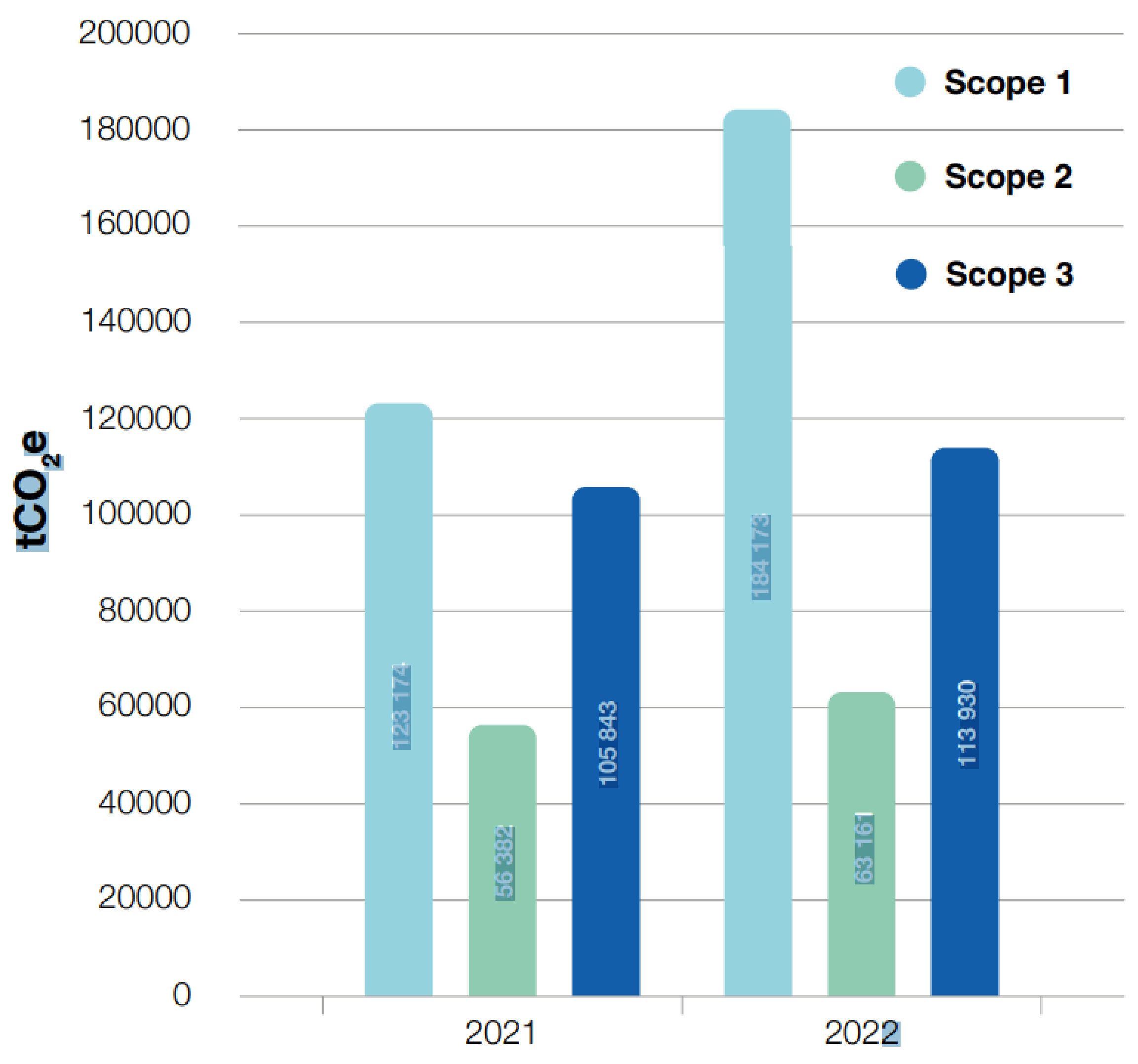
CERN decarbonisation seminar. 24 November 2023

9

ARUP Seminar: https://indico.cern.ch/event/1334547/

Where are the main drivers of CO2 emissions?

- 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…



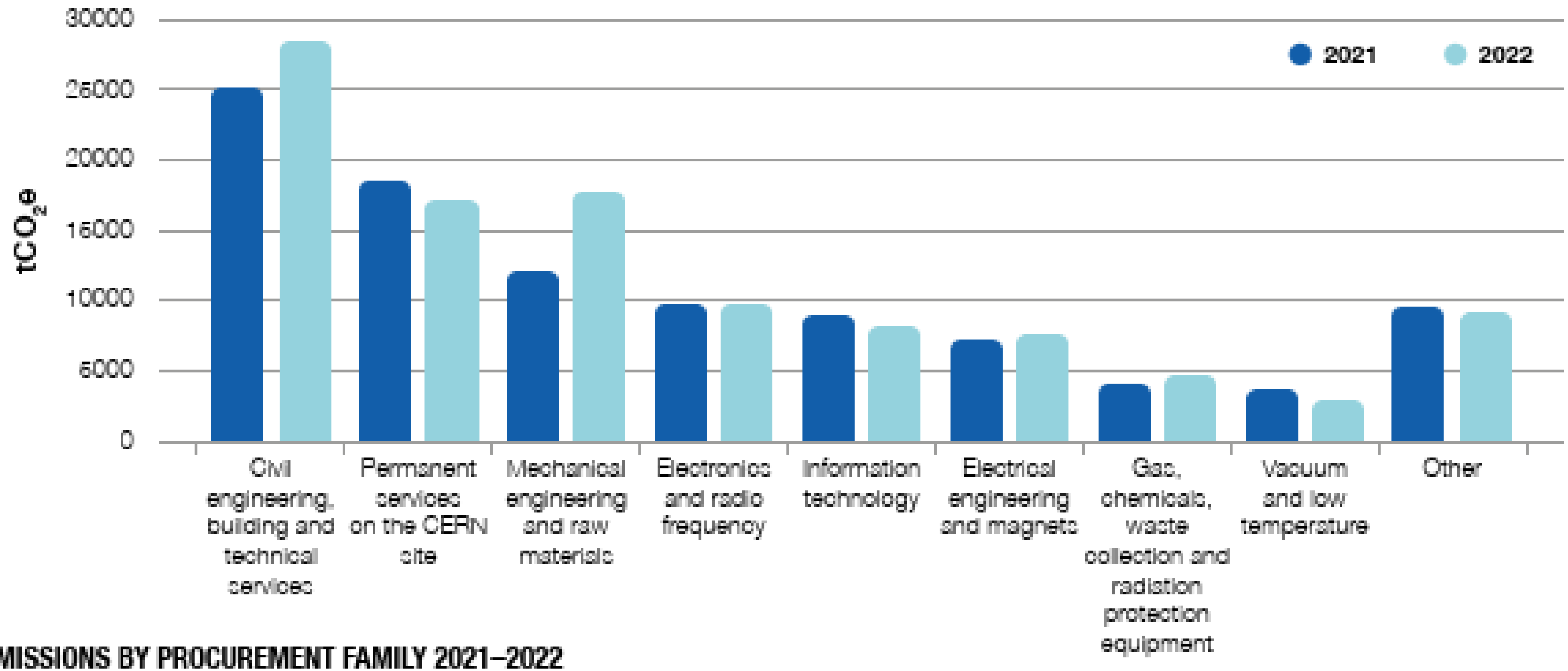
CERN'S TOTAL SCOPE 1, 2 AND 3 EMISSIONS 2021–2022

Scope 1

Detectors and cooling circuits

CANNOT use GHG gases

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.

Life Cycle Assessment

Context

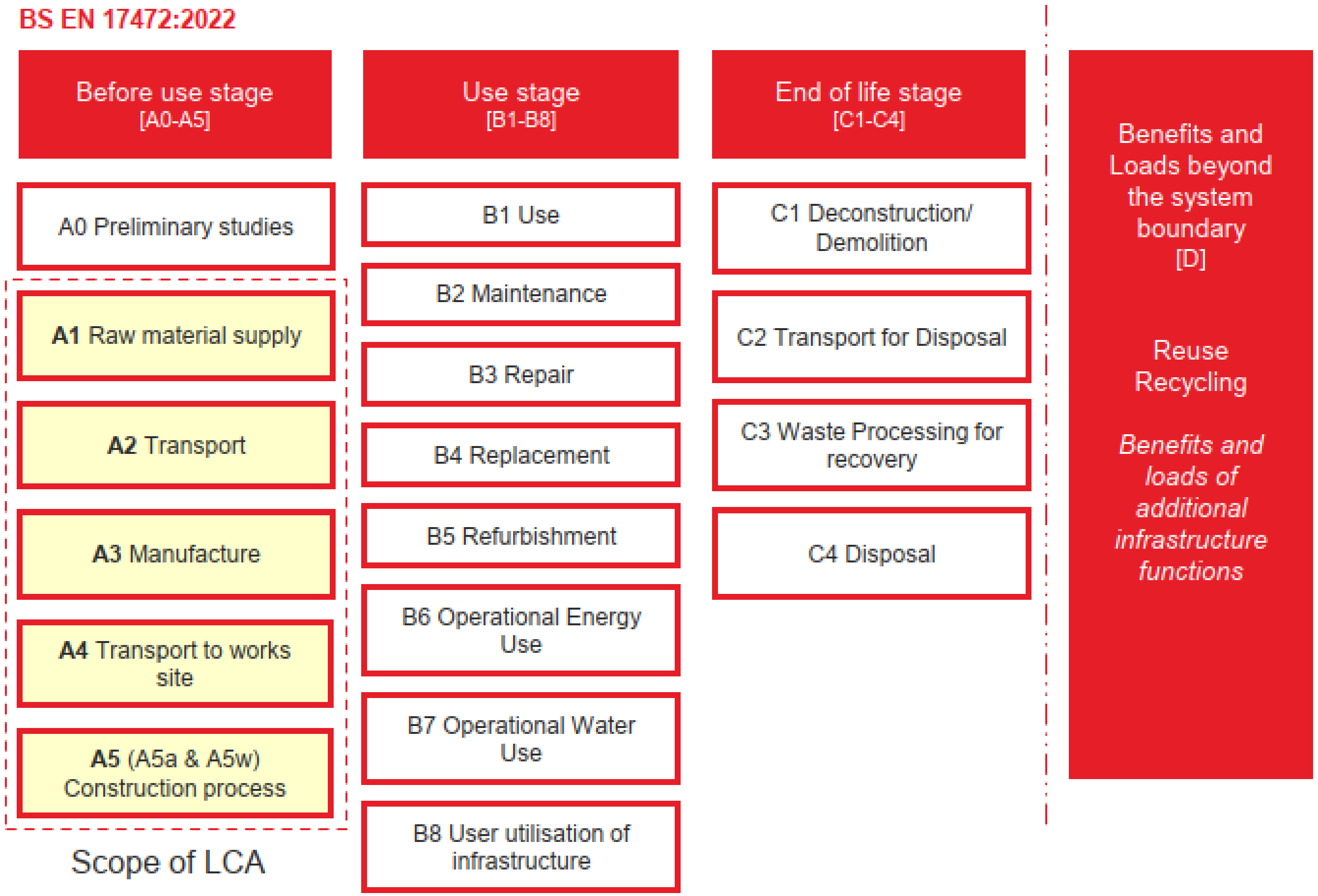
A Life Cycle Assessment (LCA) systematically assesses the environmental impact of a product or asset throughout its life cycle. The purpose of this LCA is to inform a baseline indication of the environmental impact of the underground construction of CLIC and ILC, and to identify opportunities where reductions in environmental impact can be made to help inform decision makers and future design optimisation.

The life cycle is broken down into life cycle modules, as outlined in BS EN 17472:2022.

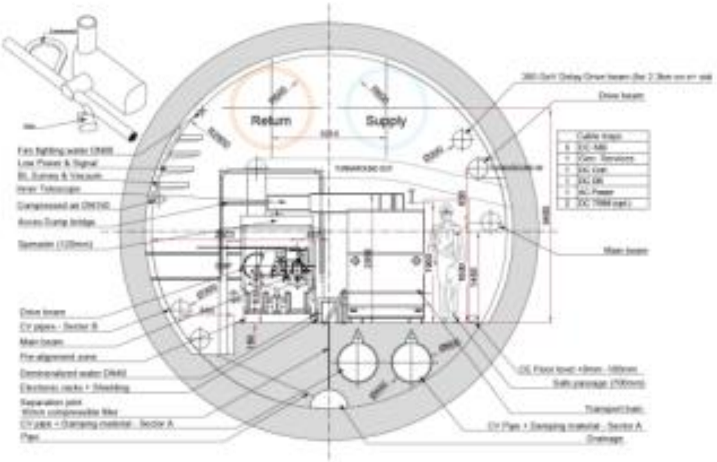
A LCA can be completed for different parts of the life cycle, most common being A1-A3, A1-A5, and A-C modules.

The scope of this LCA is A1-A5, which includes the raw material extraction to construction activities on site. A5 is split into A5a and A5w, construction activities and material wasted on site, respectively.

This final report evaluates A1-A5 for the three proposed linear colliders as highlighted in section 1.1.



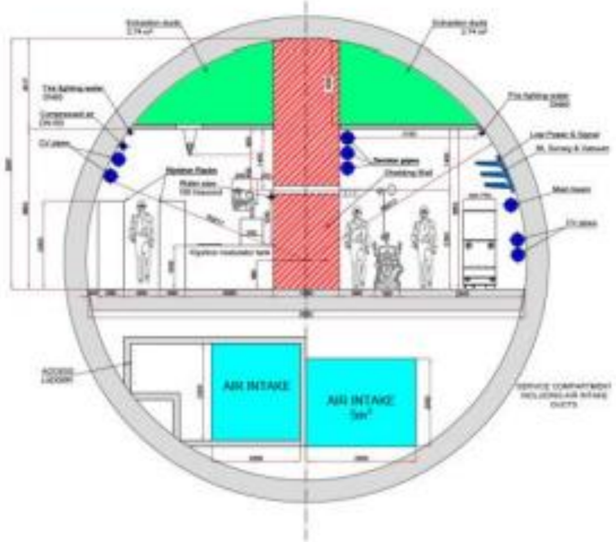
LifeCycle Assessment: CLIC & ILC



CLIC Drive beam, 5.6m dia.

Geneva

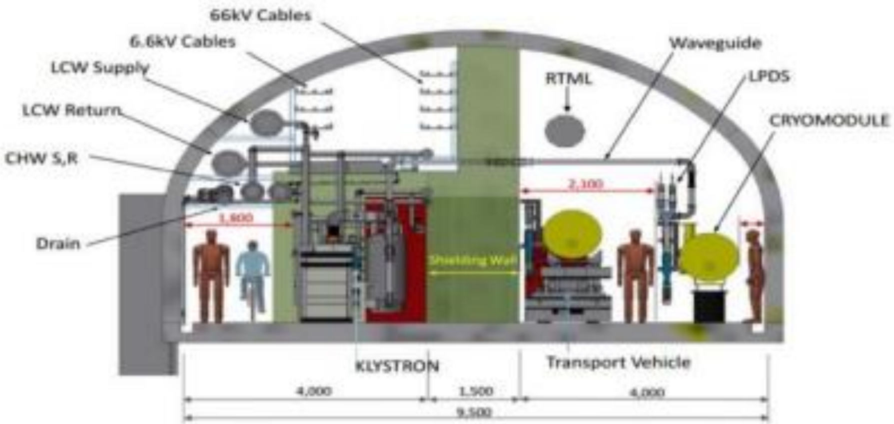
Energies: 380GeV, 1.5TeV, 3TeV.



CLIC Klystron, 10m dia.

Geneva

Energies: 380GeV

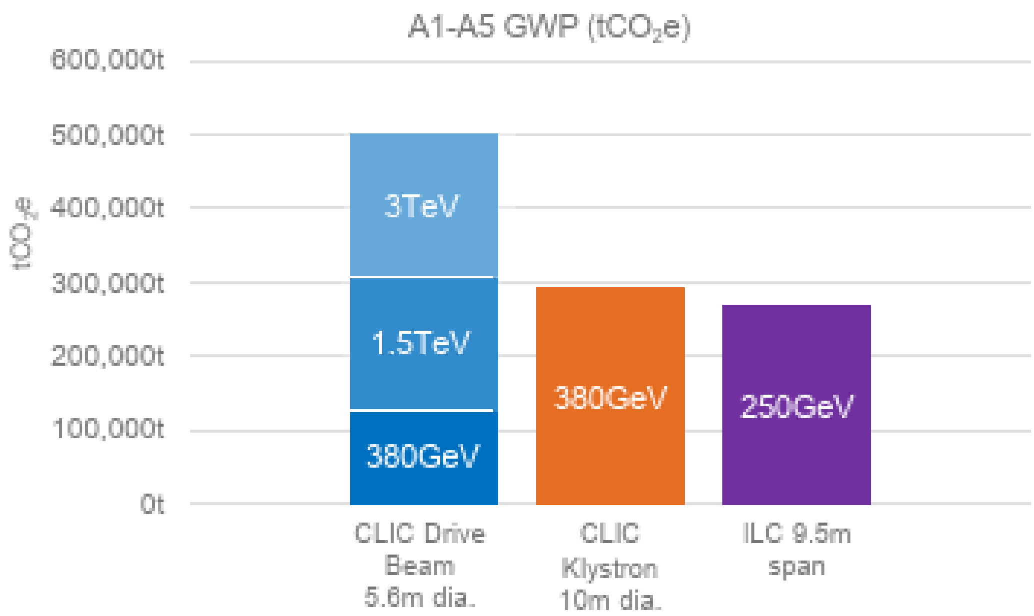


ILC, 9.5m span

Tohoku Region, Japan

Energies: 250GeV

LifeCycle Assessment: CLIC & ILC



UN Breakthrough Outcomes for 2030

For the built environment sector, the UN breakthrough outcomes for 2030 detail that 100% of projects due to be completed in 2030 or after are net zero carbon in operation, with at least 40% less embodied carbon compared to current practice. This has been set to make sure the sector is on track for 100% projects to be net zero carbon across the whole life cycle by 2050.

https://climatechampions.unfccc.int/system/breakthroughs/

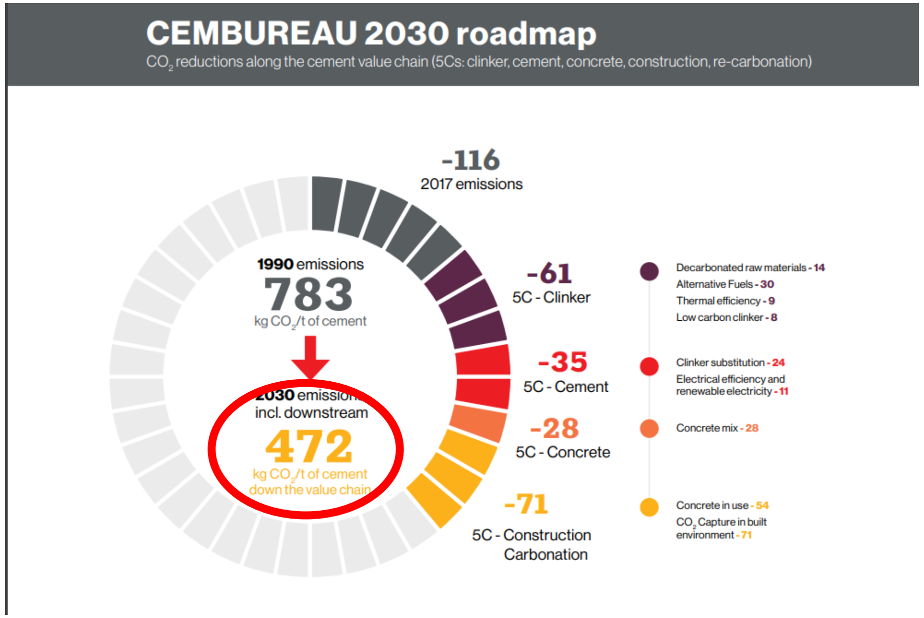
- **We need to consider how to get to net zero carbon operation and 40% less impacting construction for our future projects….**

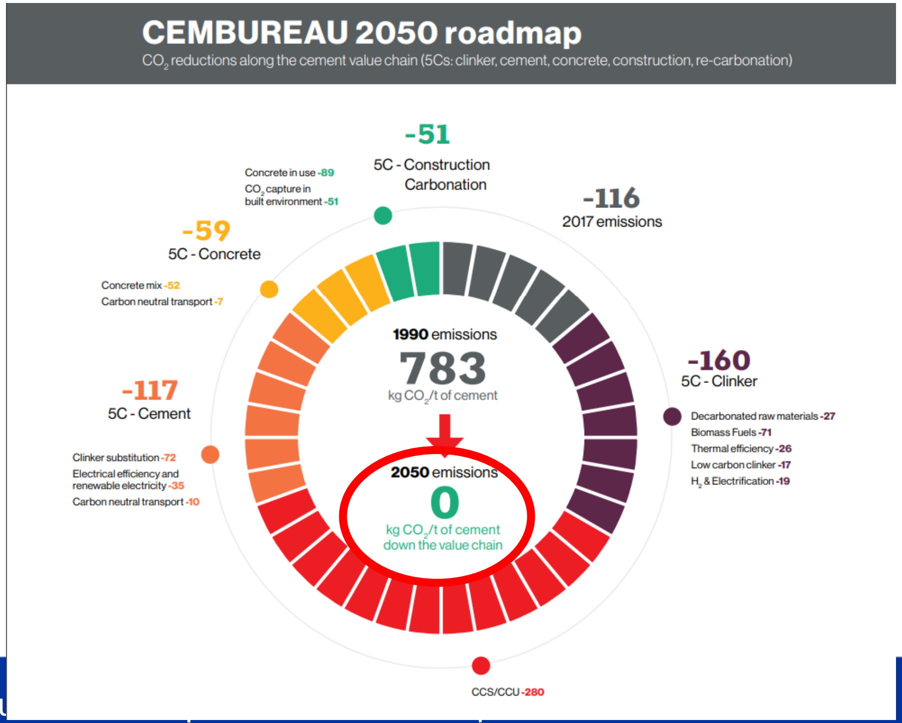
Concrete

- 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):
- $CaCO_3 \rightarrow CaO + CO_2$
- 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?





Context for future projects: Energy

(SDG7: Affordable and Clean Energy)

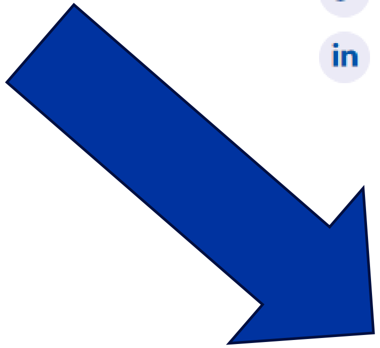
CERNCOURIER
Reporting on international high-energy physics

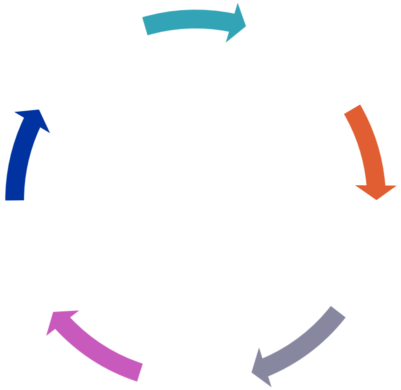
Physics ▾ | Technology ▾ | Community ▾ | In focus | Magazine

POLICY | OPINION

Less, better, recover

25 May 2022

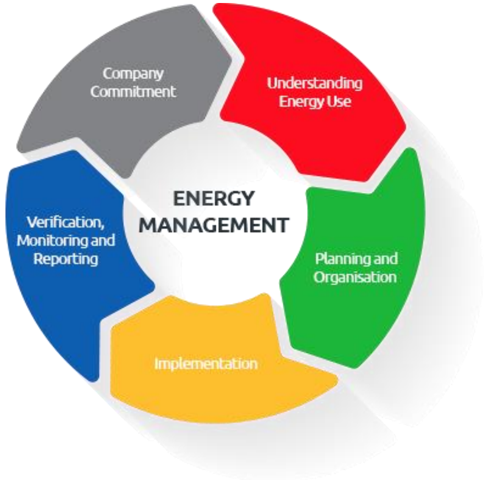




LESS BETTER RECOVER

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) *This certificate is valid from (year/month/day)* 2023-02-02 Jusqu'au *until* 2026-02-01

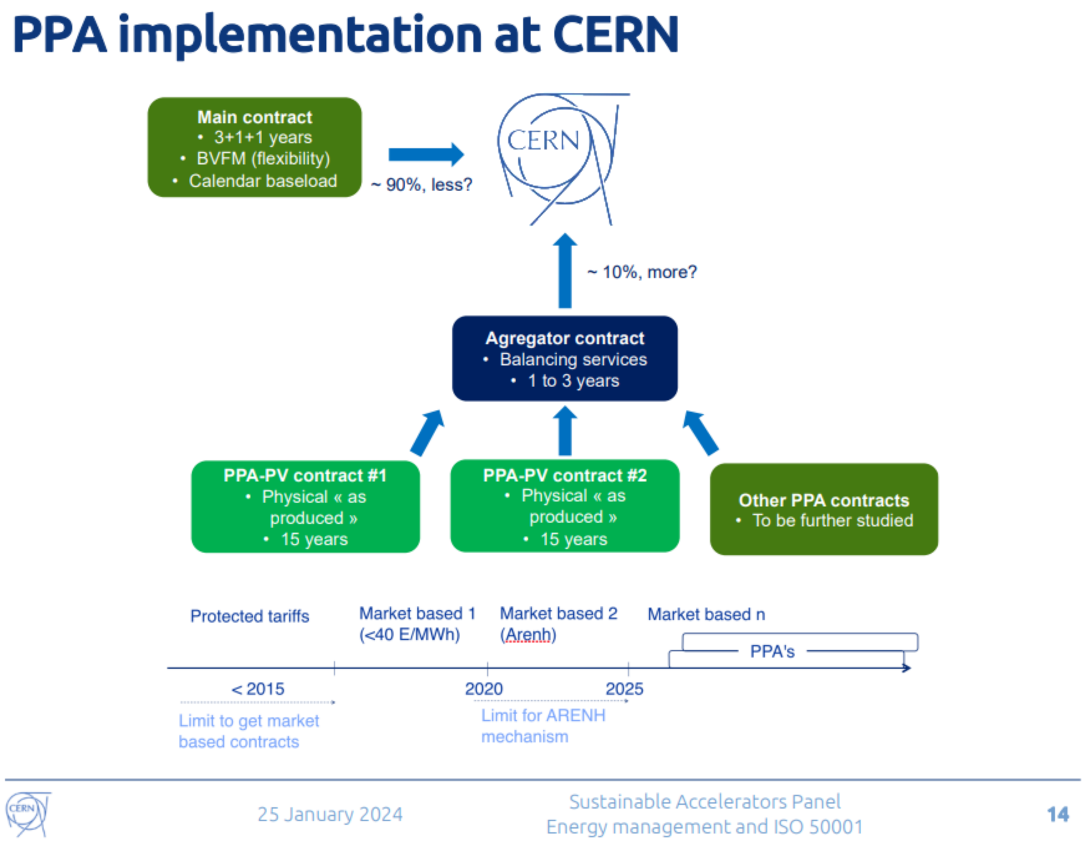
Julien NIZRI
Directeur Général d'AFNOR Certification
Managing Director of AFNOR Certification

Flashez ce QR Code pour vérifier la validité du certificat

Area needed to generate 1.3 TWh/y

(no contingency, no distribution, no storage…)

Electricity in FRANCE for CERN



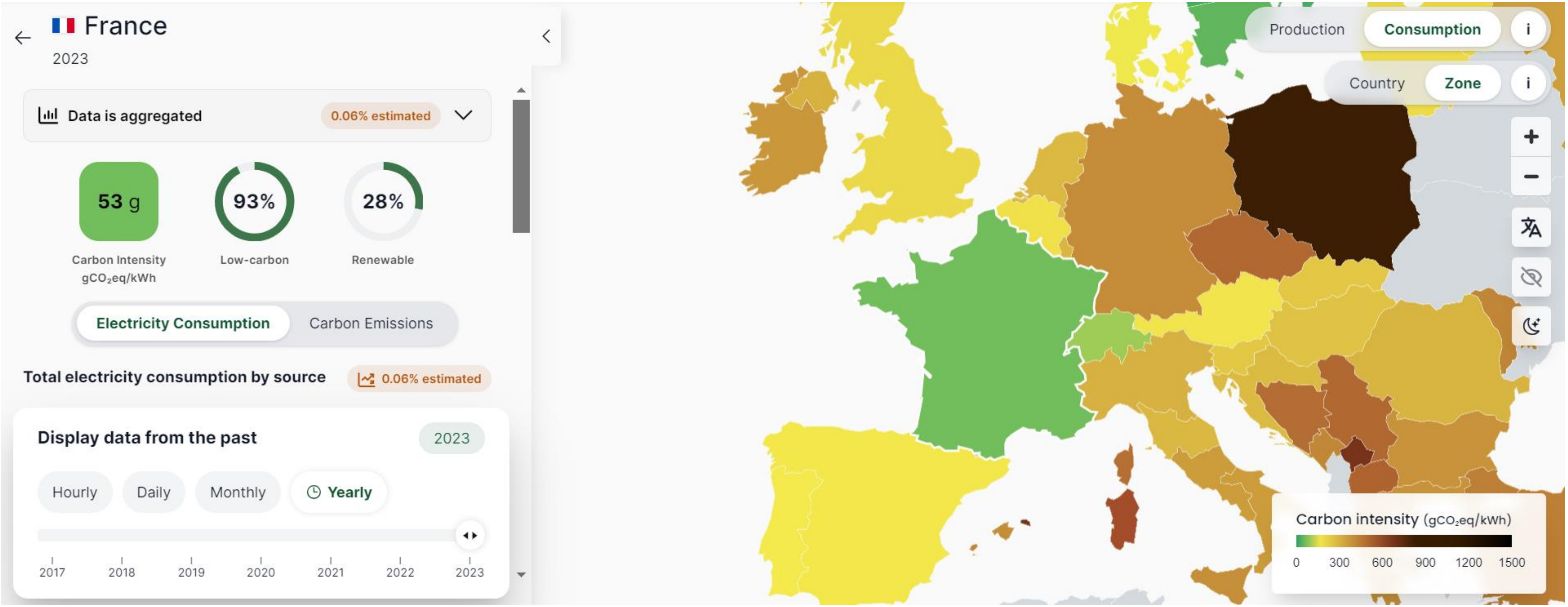
Courtesy of N. Bellegarde

- **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**

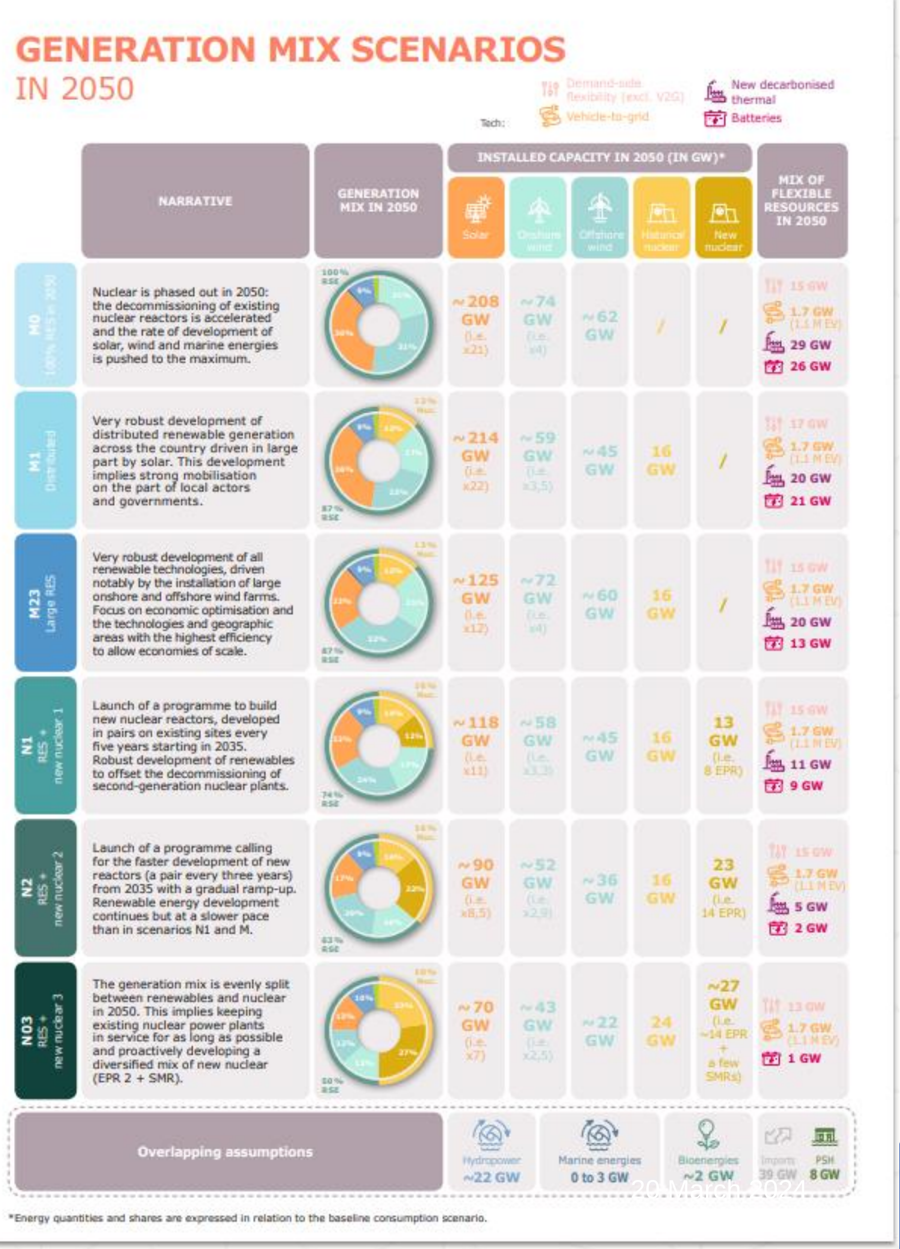
ISO 50001 Action plan

	Energy saved
Cooling and ventilation consolidation projects	6 GWh/year
75 consolidation projects for buildings	10 GWh/year
Science Gateway	200+ MWh/year
Optimisation of Cryo operations mode	25 GWh/year
Heat recovery projects	
Meyrin and Prévessin	30+GWh/year
Ferney-Voltaire	20 GWh/year (for the neighbors)

Electricity in FRANCE Today



Electricity in FRANCE in 2050



GENERATION MIX SCENARIOS
IN 2050

Tech: Demand-side flexibility (excl. V2G) · Vehicle-to-grid · New decarbonised thermal · Batteries

	NARRATIVE	GENERATION MIX IN 2050	Solar	Onshore wind	Offshore wind	Historical nuclear	New nuclear	MIX OF FLEXIBLE RESOURCES IN 2050
M0 100% RES in 2050	Nuclear is phased out in 2050: the decommissioning of existing nuclear reactors is accelerated and the rate of development of solar, wind and marine energies is pushed to the maximum.	100% RSE	~208 GW (i.e. x21)	~74 GW (i.e. x4)	~62 GW	/	/	15 GW; 1.7 GW (1.1 M EV); 29 GW; 26 GW
M1 Distributed	Very robust development of distributed renewable generation across the country driven in large part by solar. This development implies strong mobilisation on the part of local actors and governments.	87% RSE	~214 GW (i.e. x22)	~59 GW (i.e. x3,5)	~45 GW	16 GW	/	17 GW; 1.7 GW (1.1 M EV); 20 GW; 21 GW
M23 Large RES	Very robust development of all renewable technologies, driven notably by the installation of large onshore and offshore wind farms. Focus on economic optimisation and the technologies and geographic areas with the highest efficiency to allow economies of scale.	87% RSE	~125 GW (i.e. x12)	~72 GW (i.e. x4)	~60 GW	16 GW	/	15 GW; 1.7 GW (1.1 M EV); 20 GW; 13 GW
N1 RES + new nuclear 1	Launch of a programme to build new nuclear reactors, developed in pairs on existing sites every five years starting in 2035. Robust development of renewables to offset the decommissioning of second-generation nuclear plants.	74% RSE	~118 GW (i.e. x11)	~58 GW (i.e. x3,3)	~45 GW	16 GW	13 GW (i.e. 8 EPR)	15 GW; 1.7 GW (1.1 M EV); 11 GW; 9 GW
N2 RES + new nuclear 2	Launch of a programme calling for the faster development of new reactors (a pair every three years) from 2035 with a gradual ramp-up. Renewable energy development continues but at a slower pace than in scenarios N1 and M.	63% RSE	~90 GW (i.e. x8,5)	~52 GW (i.e. x2,9)	~36 GW	16 GW	23 GW (i.e. 14 EPR)	15 GW; 1.7 GW (1.1 M EV); 5 GW; 2 GW
N03 RES + new nuclear 3	The generation mix is evenly split between renewables and nuclear in 2050. This implies keeping existing nuclear power plants in service for as long as possible and proactively developing a diversified mix of new nuclear (EPR 2 + SMR).	50% RSE	~70 GW (i.e. x7)	~43 GW (i.e. x2,5)	~22 GW	24 GW	~27 GW (i.e. ~14 EPR + a few SMRs)	13 GW; 1.7 GW (1.1 M EV); 1 GW

Overlapping assumptions	Hydropower	Marine energies	Bioenergies	Imports	PSH
	~22 GW	0 to 3 GW	~2 GW	39 GW	8 GW

*Energy quantities and shares are expressed in relation to the baseline consumption scenario.

- **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…
  - The rate of installation of new renewable plants needs to increase dramatically wrt today…
- **Net-zero Impact in 2050: ~15÷25 gCO_2eq/kWh**
  - ~30÷50 kT CO_2/year for a 2 TWH/year class of collider: small but not zero
  - Important to optimize the design, develop technologies such as High Efficiency Klystrons, HTS for magnets, A15 for SCRF…

Running on renewables and when electricity is cheap

Two studies in 2017:

- Supply the annual electricity demand of the CLIC-380 by installing local wind and PV generators (this could be e.g. achieved by 330 MW-peak PV and 220 MW-peak wind generators) at a cost of slightly more than 10% of the CLIC 380 GeV cost.
  - Study done for 200 MW, in reality only ~110 MW are needed
- Self-sufficiency during all times can not be reached but 54% of the time CLIC could run independently from public electricity supply with the portfolio simulated.

- Can one run an accelerator as CLIC in a mode where one turn "on" and "off" depending prices (fluctuating with weather, demand, availability etc) ?
- Specify transition times (relatively fast for a LC) and the annual luminosity goal
- Significant savings – but the largest saving is the obvious one, not running in the winter.
- Flexibility to adjust the power demand is expected to become increasingly important and in demand by energy companies.

More information (link)

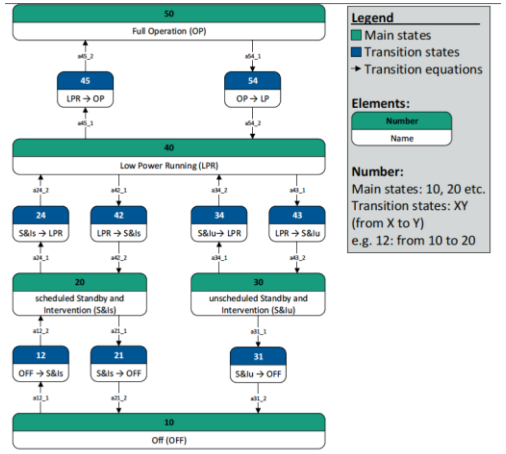
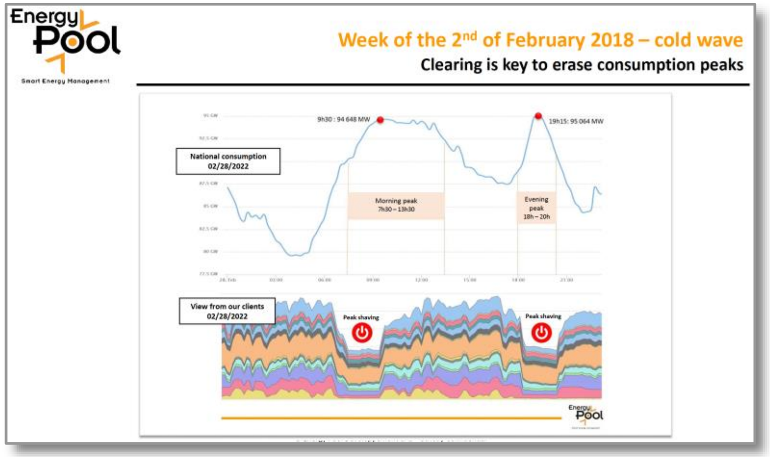


Figure 1-1: Schematic representation of the finite state machine

(Regenerative) Power availability varies
Linear accelerators have no stored beam -> ideal for flexible operation

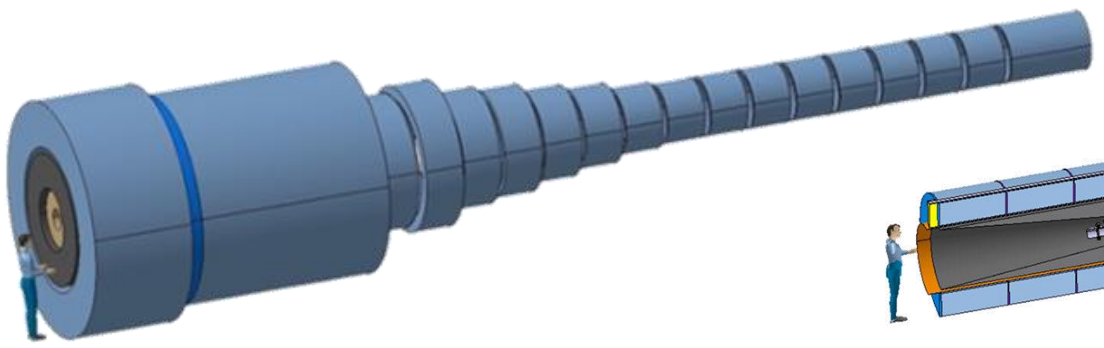
Study by Fraunhofer institute considered running
on renewables and participating in **demand side flexibility**

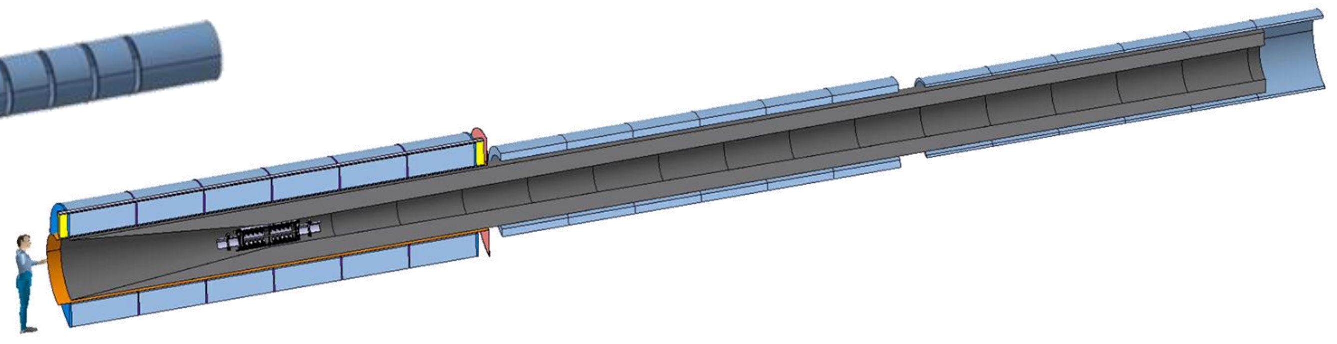


Courtesy S. Stapnes

Technology: HTS

Target & Capture Solenoids for the Muon Collider





US-MAP
Proposal
(<2016)

E_M = 2.9 GJ
T_{op} = 4.2 K
M_{coils} = 200 tons
M_{shield} = 300 tons
P = 12 MW

EM = 1 GJ
Top = 10…20 K
Mcoils = 110 tons
Mshield = 196 tons
P = 1 MW

IMCC
Proposal
(2023)

Superconductivity: RF

Objectives for WP9
Innovative superconducting cavities

To improve performance and reduce cost of SRF acceleration systems

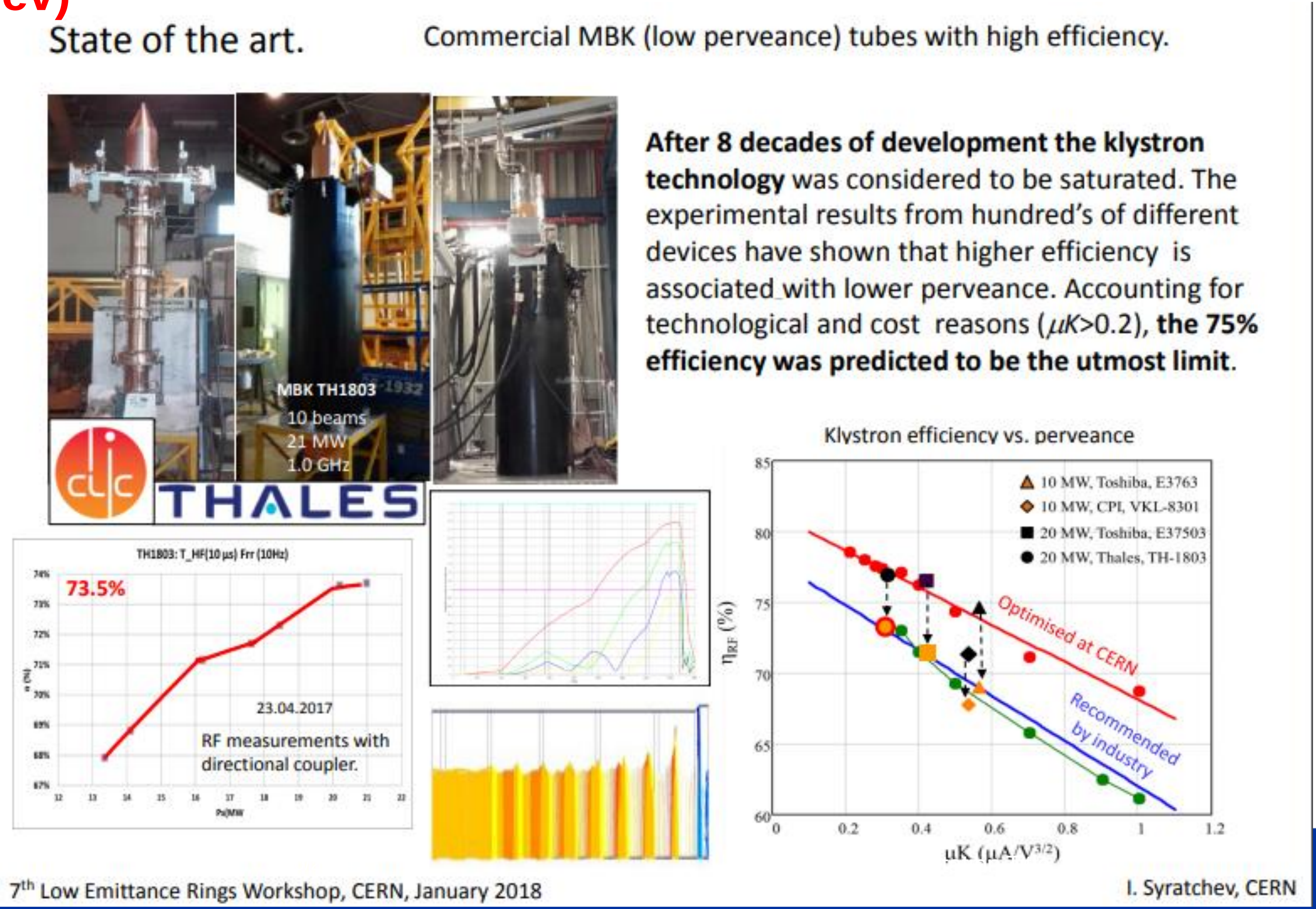
Small community

- We built together a global strategy to be able to produce Superconducting RF (SRF) cavities coated with a superconducting film. Not only IFAST, (informal) WW collaboration
- It includes pursuing the optimisation and the industrialisation:
  - Substrates preparation (Nb, Cu), e.g. PEP, metallographic polishing
    - Pre-and post treatment (laser)
    - The production of seamless copper cavities
  - The optimization deposition techniques: MS, PVD, ALD… to get Nb, NbN, Nb_3Sn, V_3Si… thick films (μm) and/or SIS Multilayers (nm)
- Produce and RF test prototypes of SRF cavities at 6 & 1.3 GHz Easier to handle, fabricate, dissect to provide fast feedback
- Produce accelerator type 1.3 GHz cavities (feasibility assessment).

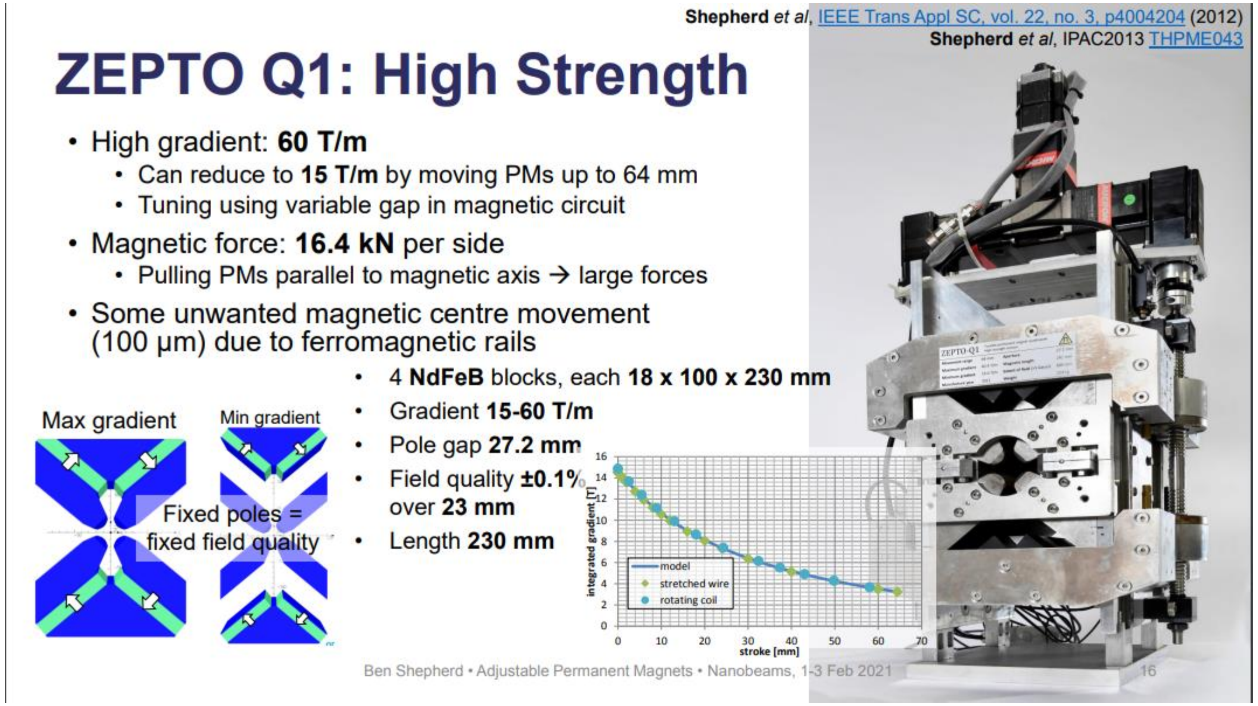
IFAST

O.B. Malyshev | WP9 | 2nd I.FAST Annual meeting | 18-21 April 2023 5

High Efficiency Klystrons
(I. Syratchev)



Permanent Magnets



Rare earths for permanent magnets: blessing or curse?

Although permanent magnets can significantly reduce the energy consumption of accelerators, their use of rare earths requires best practices, as discussed by experts at the latest I.FAST workshop.

13 APRIL, 2023 | By Denise Völker (DESY), Andrea Klumpp (DESY) & Mike Seidel (PSI/EPFL)

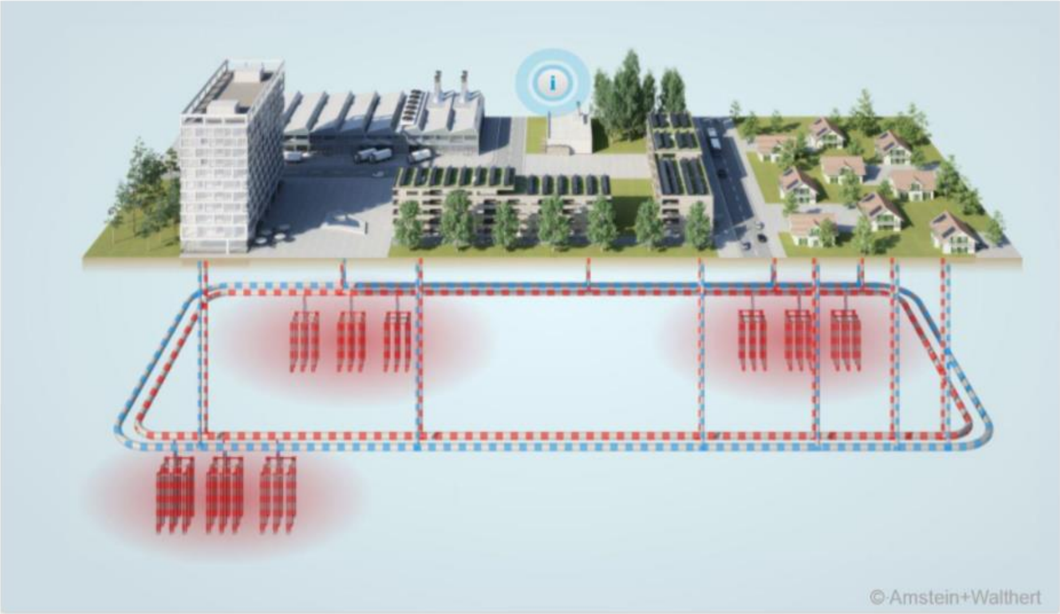
Permanent magnets require large amount of rare earths, often mined in precarious conditions for both the workers and the environment. (Credit: Sebastian Pichler/Unsplash)

RECOVER

Comment réchauffer un quartier en refroidissant le LHC

L'eau chaude issue du système de refroidissement du LHC au point 8 va être récupérée pour chauffer un nouveau quartier de la commune avoisinante de Ferney-Voltaire

23 JUILLET, 2019 | Par Anaïs Schaeffer



Des sondes géothermiques implantées dans le sol sous le nouveau quartier (les 9 « grappes » rouges sur l'image) permettent de stocker de la chaleur.

uvelle Zone d'aménagement concerté (ZAC) actuellement en construction à Ferney-Voltaire. En rouge, le réseau de récupération de chaleur qui reliera le point 8 à ce nouveau quartier (Image : Territoire d'Innovation)

Establishing a Working Group on "Sustainability Assessment of Accelerators"

- We have been commissioned by LDG Chair to draft a charge for a new working group that will develop guidelines and a minimum set of key indicators pertaining to the methodology and scope of the reporting of sustainability aspects for future HEP projects
- This group will effectively define to all new infrastructure proposals what they should quantify and report upon so that fair comparisons can be made between these proposals
- Having clear and common indicators will ensure that projects are not accused of cherry picking only their most favourable sustainability numbers

Open Meeting of the European Laboratory Directors Group

J. Clarcke (STFC), B. Heinemann (DESY & U. Freiburg), M. Seidl (PSI)

Jul 10 – 11, 2023
INFN - Frascati National Laboratories
Europe/Rome timezone

Enter your search term

Can we compare different colliders based on sustainability?

- ***A sustainable accelerator needs to minimize its impact on the Environment and on the available resources, while maximizing the value returned to society***

- **Need to compare not only what is consumed, but also what is produced!**
  - Scientific case
  - Training of people
  - Innovation potential

- **While it is "easy" to evaluate the resources consumed, evaluating the advantages looks more subjective…**

- **Therefore, scientific approaches are developed to assess the socio-economic impact of Scientific Projects:**

M. Florio, G. Catalano, FCC week 2022:

FCC

TO SUM UP

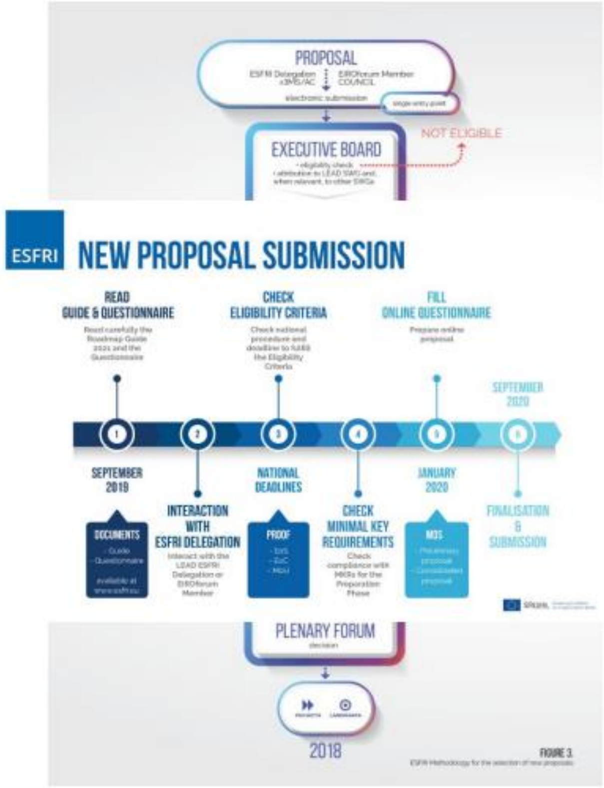
- Economists have convinced governments that **investing in science** is the best option for long term sustainable **economic growth**
- But governments still need to be convinced project by project that funding of a **specific project** will have a positive socio-economic impact
- This is why **microeconomic analysis** (for example CBA) and other evaluation methods are increasingly applied to science
- **Socio-economic impact studies increasingly required** by international and national institutions to fund large scale research infrastructures
- **The scientific case comes first, the socio-economic impact case second, along with technical, environmental, legal, political considerations: winning the game on the different dimensions of decision making**

M. Florio, G. Catalano, FCC week 2022:

FCC May 31, 2022/ FCC Week 2022 Massimo Florio (University of Milan) 14

EUROPEAN STRATEGY FORUM ON RESEARCH INFRASTRUCTURES

ESFRI engages in well-defined roadmapping processes with publicly available rules and procedures. **Socio-economic impact** has become one of important considerations in the road-mapping process that identifies European investment priorities in Research Infrastructures, as it has been formally considered as one of the **evaluation criteria since ESFRI Roadmap 2016**



CONCLUSIONS

- **Building and operating a CO_2-free Accelerator is not easy**
- **Assumptions to get to “net-zero” in 2050 imply large uncertainties, since several technologies will need to be developed at paces that we don’t see today**
- **Large Laboratories need to undergo a profound change of culture:**
  - Less, better, Recover
- **Training to Lifecycle assessment must become common practice**
- **A large contribution to the CO2 footprint across the lifetime of a new collider will come from its construction:**
  - Mainly from Concrete: CO2 free production are starting to appear, but costs will probably be much higher…
- **Socioeconomic Impact assessment will be a must (and is anyway required by ESFRI…)**