CERN Must Abandon Its Mega-Collider Project

Noé21: A Report

Version 2, February 2025 (Original: French)

Contact: Jean-Bernard Billeter jb.billeter@bluewin.ch

Noé 21, acronyme de Nouvelle orientation Economique pour le 21è siècle
ONG indépendante reconnue d'intérêt public, spécialisée dans les solutions pour la transition énergétique Membre de l'Alliance climatique suisse, du Bureau européen de l'environnement et du Climate Action Network Europe Accrédité à la Convention-cadre des Nations Unies sur les changements climatiques
Noé21 - Rue des Gares 27- CH1201 Genève - Suisse
T +41 22 329 51 36 – noe21.org – info@n oe21.org

PREAMBLE

Our objective is not to question the existence of the European Organization for Nuclear Research itself. It is the largest fundamental research laboratory worldwide and its contribution to particle physics is abundant and of the highest quality. Scientists and technicians from around the globe work together at the Centre's breathtaking facilities.

What we are talking about is the appropriateness, amid the climate crisis, of the **Future Circular Collider (FCC)**, an international project that CERN is actively studying. If the FCC were built, it would require the drilling of a 91 km tunnel and would eventually triple CERN's current electricity consumption to 4 TWh. That's more than the 3.1 TWh needed to run all of Switzerland's electric public transport (trains, trams, trolleybuses, metros, funiculars, cable cars, ski lifts, etc., which carry more than 3 million passengers a day).

Worrying? Irresponsible rather at a time when *"every kilowatt-hour counts"*. Do we really have to give in to the *ever-growing, ever-more-powerful* trend, whose damages are obvious and often irreversible?

Before adjudicating on this issue, we studied the project and tried to understand its ins and outs, if not grasp all the details out of honesty, curiosity, and caution.

We published our first version of this report in the autumn of 2022, which attracted the attention of environmental associations both in Switzerland and France and alarmed the residents of the municipalities who are to be directly affected by the huge project in the making, about which they knew nothing.

In the meantime, CERN and the governments of its two host states (France and Switzerland) have continued to back the project without really agreeing to debate over the consequences its realization would entail.

We hope that this update will be useful to the political debate in the Greater Geneva region, which nee - 2 -ds to be taken to the national level.

Illustrations on pages 4, 5, 6, 7, 10, 11, 12, 13, 14, 18, 27, 28, 30, 33, 34, 40, 41 et 43 are taken from documents available on CERN and FCC project websites.

Séance d'information

Le projet du CERN? «Un grand délire!»

Tribune de Genève

En préambule à cette rencontre avec la population, les organisateurs ont détaillé le projet d'accélérateur de particules géant et ses implications.

À l'appel des associations de défense du climat, Choulex a fait salle comble mercredi soir. Le public a dit ses inquiétudes.

Cercier : les riverains et associations inquiets sur les futurs travaux du CERN

Projet pharaonique

La construction d'un tunnel de 91 km suscite d'énormes craintes

À l'heure de l'urgence climatique, le collisionneur de particules mené par nombreuses questions. Quels sont les enjeux de ce dossier hors norme, alors que l'étude de faisabilité avance?

Xavier Lafargue

24 heures

CERN SUPERCOLLIDER IN QUESTION AS TOP FUNDER CRITICIZES COST

Germany has raised doubts about the affordability of the Large Hadron Collider's planned successor.

Contents

CERN and its accelerators...

Created in 1953 after an agreement between European countries recovering from the Second World War, the aim of CERN is to provide for: *"collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto. The Organization shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available."* (1).

To this end, CERN has built a series of ever-larger and more powerful particle accelerators, which are made available to researchers, together with the necessary ancillary equipment. Its main machines are:

	Accelerator	Work	Circumference
1957	SC Synchrocyclotron (out of service)	Hall	15.7 metres
1959	PS Proton synchrotron	Covered gallery	628 metres
1976	SPS Super Proton Synchrotron	Tunnel	6.9 kilometres
1989	LEP Large electron-positron collider	Tunnel	27 kilometres
2000	LEP 2	Same tunnel	27 kilometres
2008	LHC Large Hadron collider	idem + major works	27 kilometres
2029	LHC-hl High-luminosity LHC	idem + major works	27 kilometres

The Synchrocyclotron, 1957

Cut and cover tunnel of the Proton synchrotron, 1959

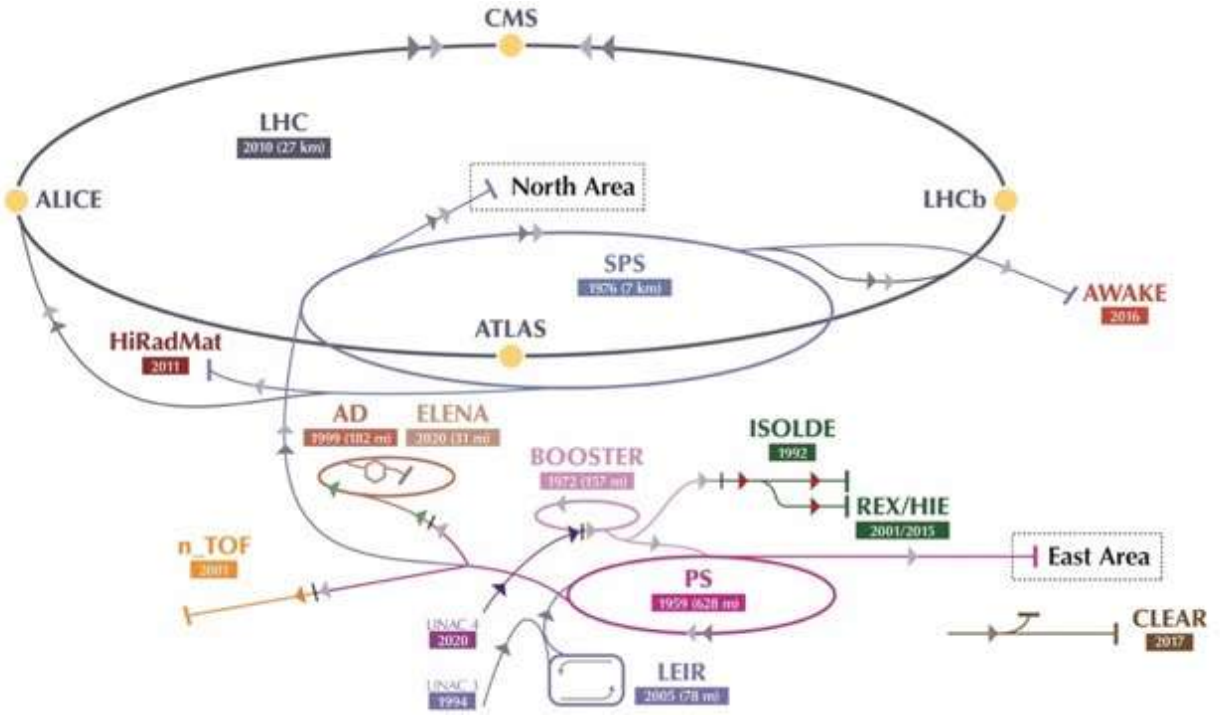
Proton Super synchrotron tunnel, 1974

Layout of the underground ring of LEP, then of the current LHC

Except for the 1957 Synchrocyclotron, all these accelerators are still operational. They are regularly upgraded and interconnected to form a powerful complex, and what is admittedly **the largest machine in the world**.

In 2013, CERN decided to boost the performance of its flagship accelerator, the LHC *(Large Hadron Collider*). This involved drilling two new shafts, a gallery, and a cavern. When it becomes operational in 2029, this upgraded LHC—now called the **High-Luminosity LHC (LHC-hl)**—will have cost almost CHF 2 billion and will run until 2041.

The interconnected network illustrated below and crowned by the LHC corresponds to **the current accelerator complex**.



(Image: CERN)

As already mentioned 40 years ago: *"CERN is a factory for building accelerators. As soon as a machine is under construction, the engineers who designed it are available again to study a new accelerator project"*. (2)

With the LHC-hl under construction, it was time to **move on**. To highlight new phenomena, the power of the beam of colliding particles needed to be increased. There are other ways of studying particles than accelerator-colliders, and if we want to stick to accelerators, there are other options to circular colliders. Once again, however, the choice fell on a circular accelerator-collider. With this technology, the increase in power implies an increase in diameter to reduce the inflection that must be imposed on the beams to keep them on their trajectory.

Choices and technical design studies...

In 2013, at the time of its ***First Update of the European Strategy for Particle Physics*** (3), the working group responsible for drafting it made **the study of a Future Circular Collider (FCC**) its priority.

"To stay at the forefront of particle physics, Europe needs to be in a position to propose an ambitious post-LHC accelerator [...] CERN should undertake design studies for accelerator projects in a global context, with emphasis on proton-proton and electron-positron high-energy frontier machines. These design studies should be coupled to a vigorous accelerator R&D programme, including high-field magnets and high-gradient accelerating structures, in collaboration with national institutes, laboratories and universities worldwide."

The proposal was accepted by the CERN Council, followed in 2014 by the official launch of the **Future Circular Collider, the FCC**.

The project we are talking about here, the FCC, is the planned successor to the LHC-hl.

Formalized in this way, the technical design studies (which actually began in 2010) bring together several 100 researchers under the auspices *of the European Committee for Future Accelerators* (ECFA).

(Image: CERN)

Five years later, the project...

The synthesis of the multiple initial technical studies was published in 2019 in four thick volumes: the **FCC Technical Design Reports (***Future Circular Collider Conceptual Design Report vol 1, 2, 3, 4.).* (4), (5), (6), (7)

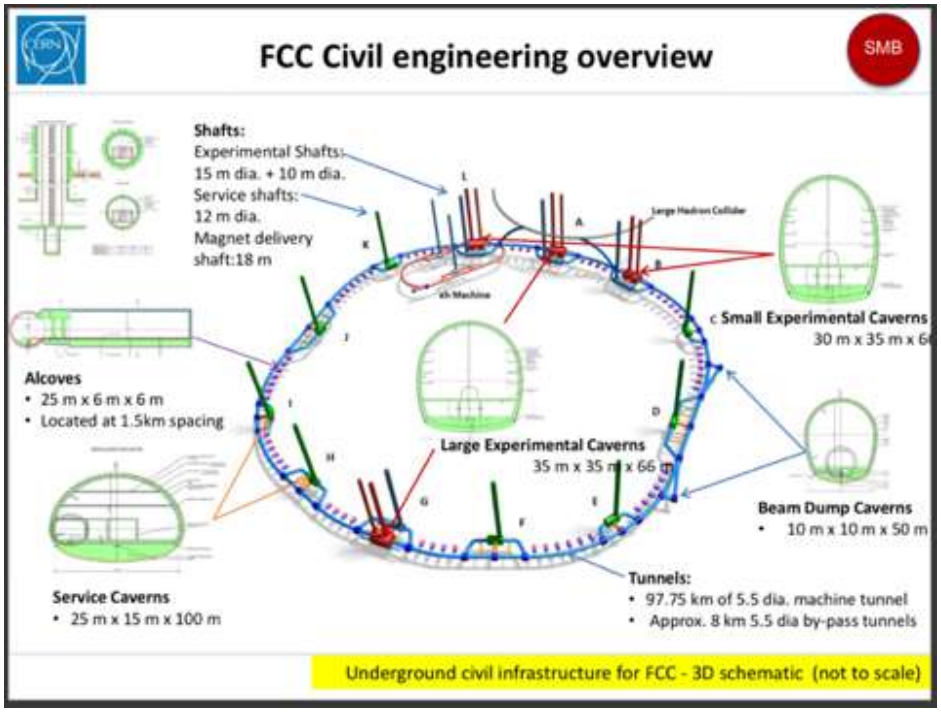
The main conclusions of these reports are that it is necessary to:

- dig a tunnel three times the size of the current LHC
- install its first machine, the FCC e-e (also known as the *Higgs Factory*),
- which is to be dismantled some fifteen years later
- to make way for FCC h-h
- which will continue to operate until the end of the century

Let's note that **the tunnel and its outbuildings are designed, from the outset, to accommodate the second accelerator, the FCC-hh**, which requires three times more energy than the FCC-ee. The FCC-hh is not to be installed directly because the necessary techniques have yet to be mastered. CERN is working on this and is betting that it will be approved and industrialized within the next 20 years.

- *"The machine tunnel will be one of the longest tunnels in the world [...]. It will be similar in scope to the recently completed Gotthard Base Tunnel (total of 151.84 km including two 57 km long tunnel tubes) in Switzerland"* (5)
- *"The underground structures that will be built to host the FCC form part of what will most probably be the biggest tunnelling project in the world when it goes for construction in 2026."* (6)
- *"... additional roads and even tunnels or bridges may be necessary."* (6)
- *"... it has been assumed a new 5 km long road is required for each surface site."* (6)
- *" It is anticipated that each site will be approximately 6 to 9 hectares in size"* (5)

The 2019 project with its 12 surface sites:

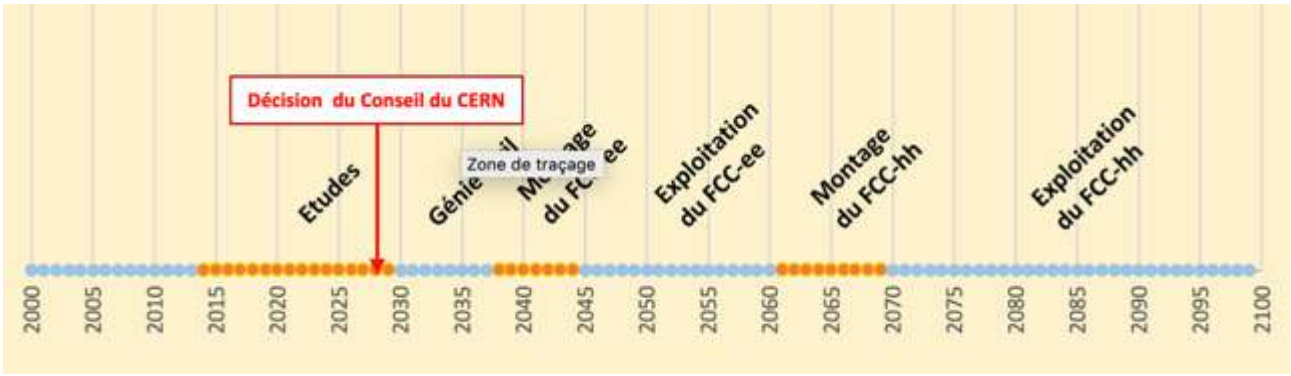


In this 97 km project (2019), 12 surface sites and 22 shafts have been scaled back a little (see below), but it clearly shows the mindset and **extraordinary ambition** of its authors. **Is this something to marvel at?** On the face of it, expanding our fundamental knowledge seems legitimate and desirable. We do not refute this, and many countries devote substantial resources to higher education and research.

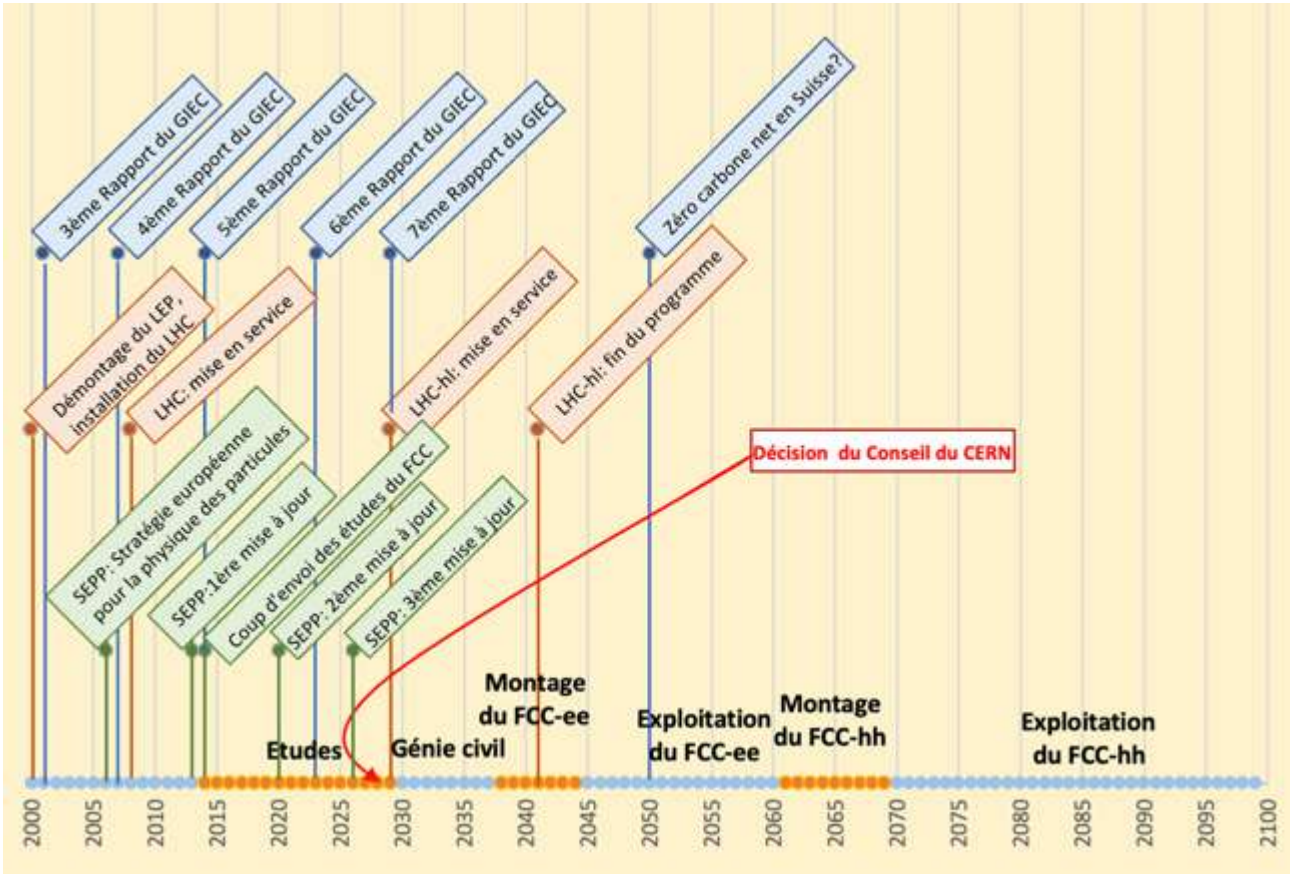
The pursuit of knowledge does not, however, mean that every project is defendable. One can't just build any laboratory anywhere, or test any product on any living creature. Whatever its purpose, a project must be subjected to scrutiny , and must respects international commitments, laws and regulations, as well the land and their inhabitants.

To fine-tune its project and obtain the green light from its Member States, in particular the host countries, CERN launched a series of **feasibility studies** in 2021, which are due to be completed in the spring of 2025. The whole project should unfold as follows:

Planning...



and its context...



Feasibility studies...

These studies, which are currently under way and costed at over **€ 100 million**, will be completed in 2025. Main objectives:

1. Optimise the location and configuration of the accelerator ring and its related infrastructure, as well as demonstrate the geological, technical, environmental and administrative feasibility of the tunnel and surface areas.

2. Complete, with the host states, all the preparatory administrative procedures required for the approval of the project, with a view to identifying and eliminating any hurdles.

3. Optimise the design of colliders and their injection chains, supported by R&D programmes (research and development) to develop the key technologies required.

4. Develop and document the main components of the technical infrastructure.

5. Develop a sustainable mode of operation for colliders and experiments in terms of energy requirements, human and financial resources, environmental aspects and energy efficiency.

6. Draw up a consolidated cost estimate, as well as financial and organisational models for the design, construction, and operation of the project.

7. Identify substantial resources outside the CERN budget for the implementation of the first phase of the possible future project.

8. Consolidate the scientific arguments and detector designs for the two colliders.

Some of these headings (3, 4, 5, 8) are technical (engineering, physics) and do not concern us initially. The other headings (1, 2, 6, 7), however, deal with regional planning, environmental protection (land, water, air, biodiversity), electricity supply, water requirements, financial arrangements and the governance of a global project which will involve the population directly. Yet, despite the study being launched over 10 years ago, almost no one in the region or in the two host countries (France and Switzerland) is aware of what is being planned. Worse, there has been no evaluation of the potential impact (duration, scale, consequences of the construction work) on human lives, or, more generally, the climate and energy transition.

Notice that the word climate doesn't appear in the list above. It is not, as one might think, tacitly included in environmental issues which, in the CERN texts, only concern the Geneva region. And yet, as we know, greenhouse gases dissipate in the (global) atmosphere.

The feasibility studies are due in 2025. At the end of 2023, CERN submitted two ***midterm reports*** (which were not made public) to the two host countries Switzerland and France. These reports concern the project as it stands today. Its circumference has been reduced from 97 to 91 km, and the total number of surface sites has dropped from 12 to 8: A, B, D, F, G, H, J, L (see illustration below). In March 2024, after reading the report, the two countries renewed their support for the project, while pointing out certain issues, such as the freedoms CERN is granting itself. We would like to thank the anonymous person who shared these documents, some excerpts of which will be presented in boxes in the text:

Remarks of the Swiss Expert Committee: "*It was noted that the methodology used to prepare the FCC Midterm Report established feasibility scenarios based on assumptions that were not verified by local authorities. As a result, the flawed assumptions and potentially unfeasible nature of some scenarios were discovered {...} when the host states reviewed the midterm report...*"

Note from the French Interministerial Committee: "*Do not put forward any decisions requiring an agreement involving France without prior validation by France*".

The 2024 current project with its 8 surface sites

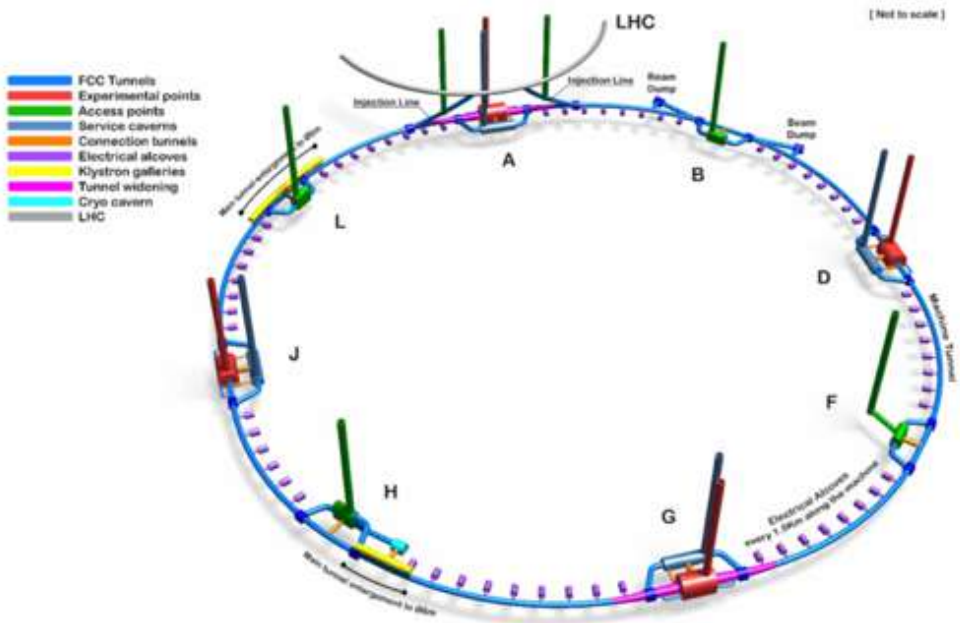
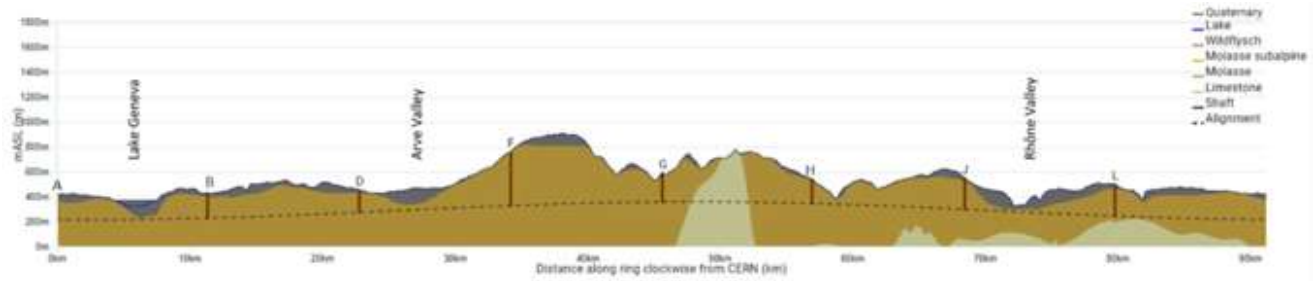
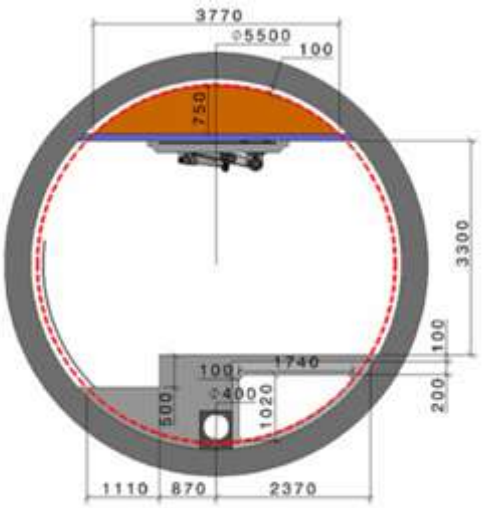


Figure 2: FCC schematic diagram. (Angel Navascues Comago, CERN).

Depending on the topography, it will be several dozen or several hundred meters underground. Average: 240 meters.

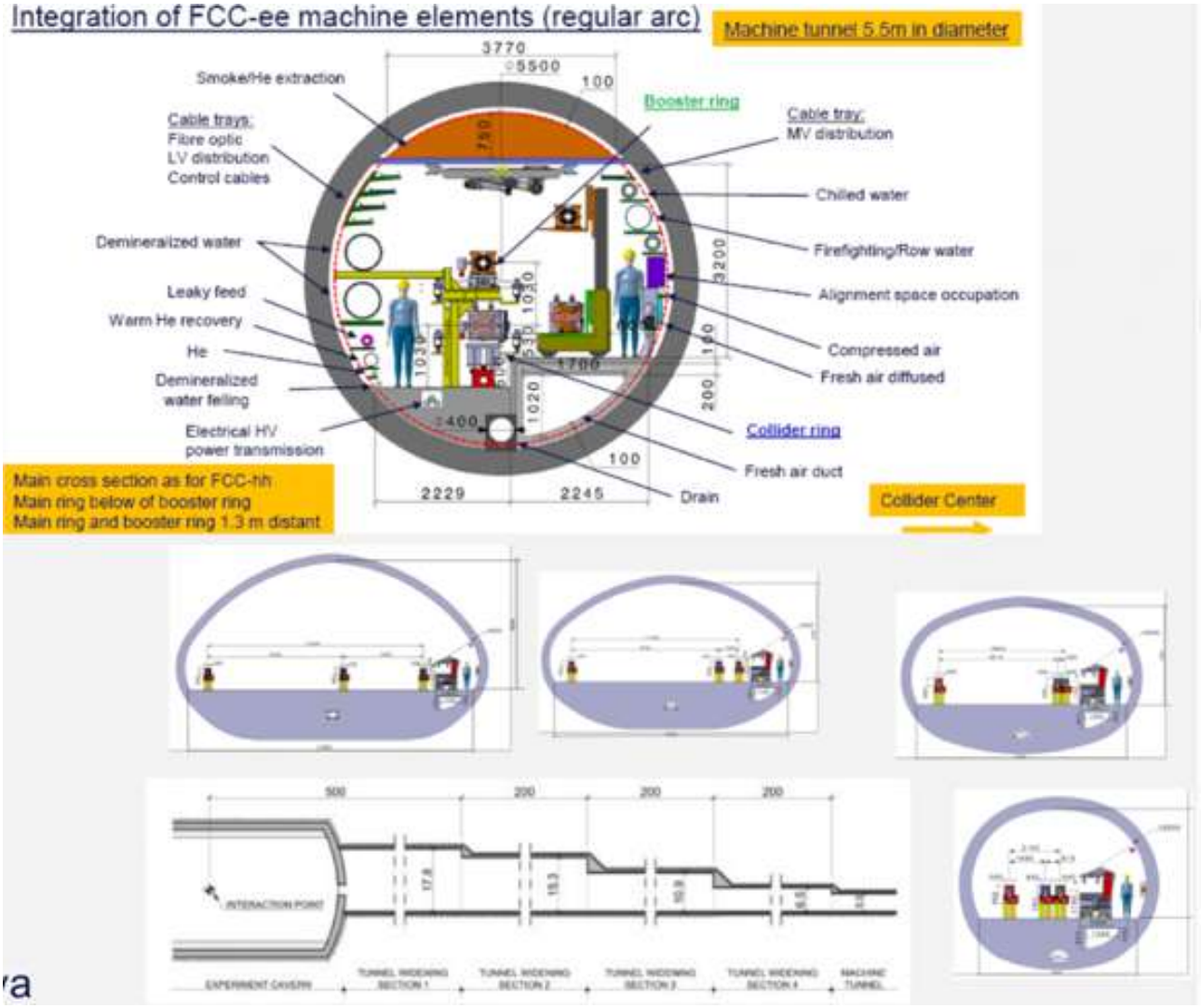




Tunneling diameter: 6,5 m
Inside diameter of tunnel: 5,5 m. (ref 190)

The machine and its annexes occupy the 91 km ring. As there are no surface entrances or exits, the 4 boring machines (TBMs) responsible for drilling will have to be lowered down and then raised via the shafts, as do the accelerator components and the detectors. The huge installations that occupy the caverns A, D, G and J, have the size of large buildings.

As it approaches the caverns beneath the eight surface sites, the tunnel widens and ovalizes:



One of the caverns in the current LHC, before the detector was installed: length 53 m, width 23 m, height 25 m.

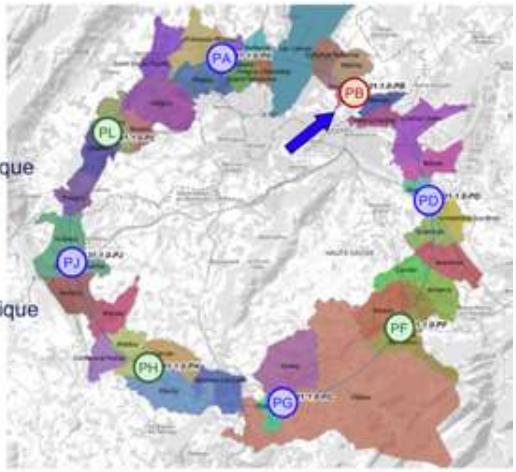
The great caverns of the FCC would be even larger:
66 m X 35 m X 25 m
or 101 m X 25 m X 15 m

The construction work...

Work on the tunnel and its underground annexes would take around eight years. It is scheduled to start in 2030. It would require between 4 tunnel boring machines. The work would be carried out simultaneously from the 8 surface sites, which would be only 12 km apart. The entire region would therefore be affected by the comings and goings of semi-trailers and exceptionally large convoys.

1. **PA – Ferney Voltaire** (FR, 01) – site scientifique
2. **PB – Choulex** (CH) – site technique
3. **PD – Nangy** (FR, 74) – site scientifique
4. **PF – Etaux/La Roche-sur-Foron** (FR, 74) – site technique
5. **PG – Charvonnex/Groisy** (FR, 74) - site scientifique
6. **PH – Cercier/Marlioz** (FR, 74) – site technique, RF
7. **PJ – Vulbens/Dingy en Vuache** (FR, 74) – site scientifique
8. **PL – Challex** (FR, 01) – site technique, booster RF

- 1 site en Suisse
- 7 sites en France



It would coincide with several other major regional projects that are already complicating the lives of residents:
- The extension of Geneva's underground railway station: 2030-2038
- The potential new underground metro from Jura to Salève: 2040-2050
- The potential A412 Thonon-Machilly motorway

Volume of excavated material...

The amount of space to be excavated is estimated at around 6.3 million m^3. The rock extracted is essentially molasse material. At 2.2 tonnes per cubic metre, this represents **13.8 million tonnes to be removed**. Once extracted, the rock takes up around 20% more volume than the rock in place (a phenomenon well known to gardeners who dig a hole and then fill it back in). The **volume to be removed** would therefore be **7.5 million cubic metres**, equivalent to three Great pyramids of Giza.

What to do with the excavated material ?

In Geneva, the "usual" waste from construction sites currently amounts to some 2.2 million m^3 per year. Part of this is recycled into new construction material, some is dumped in local gravel pits, but 1 million m^3 must be evacuated outside the canton, in the Jura canton and France. At a rate of 10 m^3 per semi-trailer, this million m^3 represents 100,000 return trips, which contribute to road congestion and a decline in the region's quality of life. The issue of the saturation of landfill sites in France, Switzerland and neighboring countries is becoming increasingly pressing and the distances travelled to get there are becoming increasingly absurd.

=> It is against this backdrop that CERN is launching its FCC project, which would massively worsen the situation.

Aware of the situation, CERN launched **the *"Mining the future" ideas* competition** in 2021, with the aim of finding *"sustainable solutions for the reuse of molasse and other excavation materials"*.

The idea - based on industrial ecology - is to consider this rubble as aressource, not a waste. No easy task! What to do with it, how to go about it, at what cost, and for which solvent users? And it must be done quickly, because *"there-use potential for excavated material is one of the factors that will contribute to the acceptability and cost effectiveness of the FCC project*.

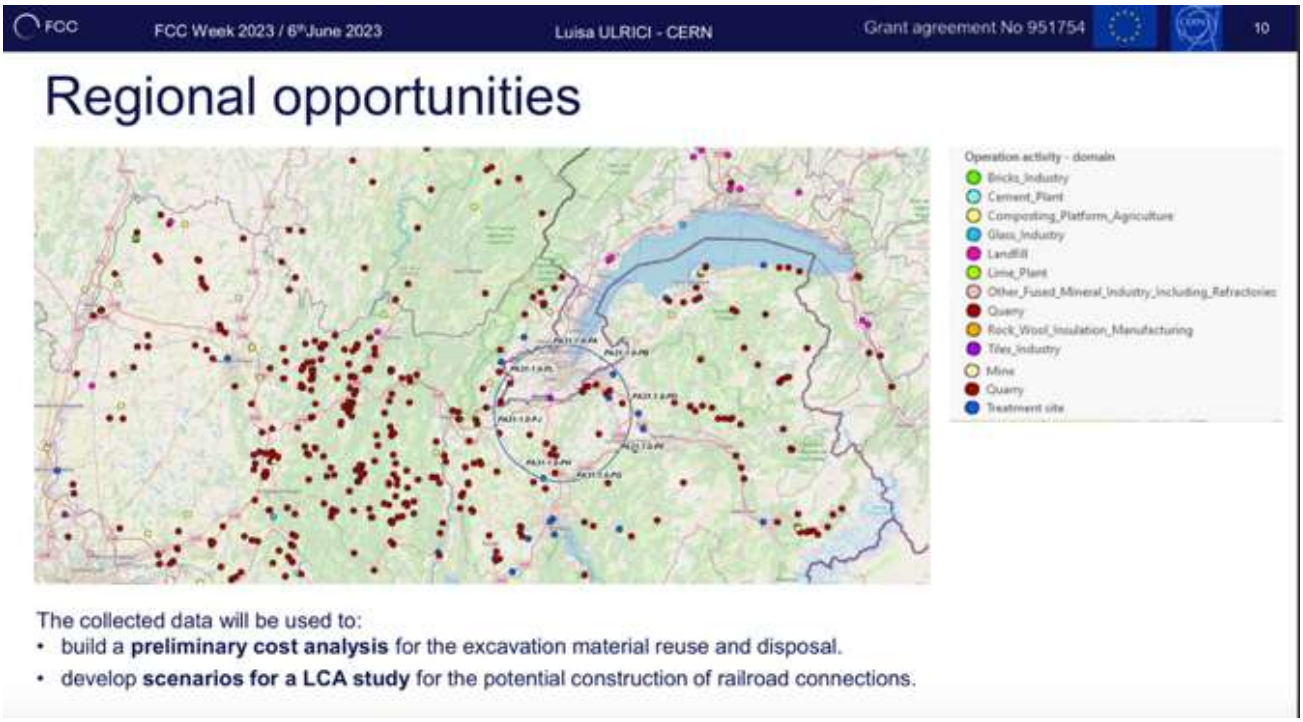
When the results of the competition were published in autumn 2022, CERN somewhat boldly declared that *"Thanks to the Mining the Future competition, there is no shortage of ideas for the sustainable re-use of excavated material produced during the construction of a new tunnel at CERN*".

However, the result did not live up to expectations. The winning project *"Molasse is the new ore"* proposes only an automated method for identifying excavated material. While this will make it easier to sort the material on conveyors, it does not solve the problem.

Where we are in 2024 ?

CERN is pursuing several avenues for using the products of shredded excavation material: construction, landscape modelling and the production of agricultural or forestry substrates by **fertilising the shredded material**. (9) Fertilization work has been started in collaboration with several higher education institutes. The project is called Open Sky: one hectare is dedicated to open-air testing near CERN. The first results are expected in June 2025.

As it is unlikely that more than modest proportion of the excavated molasse can be recycled through these various avenues, CERN is also studying ways of disposing of it in the natural environment of the two host countries, see map:



Comment from the Swiss Committee of Experts: "*We still don't know how such large volumes of excavated material will be managed in terms of transport and intermediate storage*".

Remarks of the Swiss Committee of Experts: "*Switzerland expects CERN to assume full responsibility for the project and to refrain from considering the need for enhanced and inclusive collaboration with the host States as an opportunity to abdicate certain project-related responsibilities. For example, digging the tunnel is closely linked to the logistical strategy for extracting excavated material, including the establishment of disposal areas and transport arrangements. (...) these two aspects are the responsibility of CERN, and responsibility for one of them cannot be delegated to the host states.*

CO_2 emissions linked to the construction of the civil engineering work...

In 2022, in the absence of data supplied by CERN, we have made the following calculation (adjusted here to take account of the shorter tunnel):

An initial assessment of CO_2 emissions linked to the construction of the tunnel and its shafts, galleries, caverns, and alcoves should at least consider emissions from the following activities:

1. Excavation (tunnel boring machine, blasting, etc.)
2. Evacuation of excavation debris (7.5 million m^3 or 16.5 million tonnes) at the site gates
3. Evacuation of the material to its final repository or recovery points
4. Production of concrete
5. Production of reinforcing steel
6. Laying concrete
7. Site operations (lighting, ventilation, water treatment, etc.)

This type of calculation has already been the subject of publications and standards in several countries. In 2022, CERN had not commented on the issue. The fact that the terms of reference for the feasibility studies (5) did not mention it and that nowhere did the word 'climate' appear suggests that CERN would only provide this essential figure if the authorities of the member countries demanded it. We will see below that it has since published its first calculations of CO_2 emissions.

We attempted to make an estimate based on the work of Julia Sauer: *"Ökologische Betrachtungen zur Nachhaltigkeit von Tunnelbauwerken der Verkehrsinfrastruktur"* (12). Her method consists of taking an inventory of the volume of the different materials used and the consumption of the different energy carriers, multiplying them by their respective CO emission factors and adding them up. Julia Sauer's work takes as an example the current construction of the **Brenner base tunnel** between Italy and Austria. Her calculations produce (among other things) two figures:

a) an emission factor per metre of tunnel: 30 $teqCO_2$ / m (p96, ill. 4.1)
b) an emission factor per m^3 of excavation: 0.16 $teqCO_2$ / m^3 (p96) $teqCO_2$ = equivalent in tonnes of CO_2

Applied to the FCC project, these factors give two quite different values:

a) 91'000 m - 30 $teqCO_2$ /m = 2,730,000 $teqCO_2$
b) 7,500,000 m^3 - 0.16 teqCO /m_2^3 = 1,200,000 $teqCO_2$

The similarities between the Brenner and FCC structures are sufficient to refer to these results. However, it should be noted that:

• The cross-section of the FCC tunnel is smaller than that of a rail tunnel. Figure a) should therefore be reduced.
• The debris from the Brenner excavation is evacuated through the portals, while the 14 million tonnes of debris from the FCC should be brought up through the wells, which requires considerably more energy.
• The FCC has several huge caverns, a dozen shafts and its tunnel widens in several places.

For the sake of clarity, we will continue with a **conservative figure of 1,400,000 tCO_2** (14):

In their article entitled *"The carbon footprint of proposed e+e- Higgs factories"* (11), Patrick Janot and Alain Blondel, both physicists at CERN, propose a much lower figure: 250,000 to 300,000 $teqCO_2$. They refer, however, to the method of R. Rodriguez and F. Perez (13) which, when applied, leads us to the very different result of 1,125,000 $teqCO_2$.

Janot and Blondel back up their estimate by quoting the figure of 221,000 $tCO2_2$ put forward by eight physicists in *"Climate impacts of particle physics"* (13). Without explanation, the authors reduce the volume of excavations from 9 (CERN's figure in the year the article was published) to 7 million m^3 and specify that their figure (237,000 $teqCO_2$) only considers the CO_2 attributed to the cement used in the structure. Referring to the Rodriguez study, they estimate without calculation that, if the other factors involved (iron, fuel, electricity) were considered, the CO_2 emissions linked to the structure would be about 0.5 to 1 million tonnes.
A more recent study by a major engineering firm (14) concludes, after drawing up a more detailed list of the materials used, that building the structure would emit 1,170,800 teqCO2. The authors add that by following *"optimisation strategies"* consisting essentially of using recycled materials and lightening the structures, it is possible to reduce this figure... by half! Which would be providential! Pending further details, we're sticking to our figure.

=> CO emissions $_2$ linked to the construction of the civil engineering works (site work, drilling, concreting): 1,400,000 $teqCO_2$

Graph 1 teqCO2: equivalent in tonnes of CO_2

Emissions linked to manufacturing and installing the 1st collider: FCC-ee...

The *"Conceptual Design Report Volume 2"* (5) classifies the elements of the FCC-ee technical system as follows:

The machine itself:

1. Main magnet system
2. Vacuum system and electron could mitigation
3. Radiofrequency system
4. Beam transfer systems
5. Combined polarimeter and spectrometer
6. Hallo collimators
7. Machine protection
8. Controls requirements and concepts
9. Detectors

Added to this are the technical infrastructures, most of which are external:

10. Piped utilities
11. Heating, ventilation, air conditioning
12. Electricity distribution
13. Emergency power
14. Cryogenic system
15. Equipment transport and handling
16. Transport staff
17. Geodesy, survey and alignment
18. Communication, computing and data services
19. Safety and access management systems

Based on the information available, it is impossible to calculate the CO_2 footprint of the manufacture and assembly of this equipment. We can, however make rough estimates to discern orders of magnitude.

• Magnets...

It is planned (2) to equip the FCC-ee with, among other things:
- 2,900 bending dipole magnets which force particles to follow a circular path rather than a straight line, each magnet containing 5,000 kg of iron or steel, 440 kg of aluminium, and measuring approximately 25 m in length,
- 2,900 quadrupole focusing **magnets** (keeping the particle beam tightly grouped), each containing 4,400 kg of iron or steel, 820 kg of copper, measuring approximately 3 m in length.

Together, these magnets occupy (2,900 - 25) + (2,900 - 3) = ~ 84 km, or most of the tunnel.
Total weight of magnets: **~31,000 tonnes**, broken down into 27,260 t of iron, 1,334 t of aluminium and 2,378 t of copper.
If we take the respective emission factors for these 3 materials to be 2.4, 0.5 and 7.1 $teqCO_2$ /t (17), we obtain the following minimum estimate (minimum because these magnets include other materials):

=> CO_2 equivalent : $(27{,}600 \cdot 2.4)_{steel} + (1{,}334 \cdot 0.5)_{alu} + (2{,}378 \cdot 7.1)_{copper}$: ~ <u>80,000 $teqCO_2$</u>

• Detectors...

Preliminary studies for the selection of the 2 or 4 FCC-ee detectors are underway. Some information to illustrate the size of these installations:

Size of the 2 or 4 caverns that will house them: 66 metres x 35 metres x 35 metres.

As for their weight, let's take the 4 detectors of the current LHC as a reference:

Atlas: 7,000 tonnes, CMS: 14,000 tonnes, Alice: 10,000 tonnes, LHCb: 5,600 tonnes,

This represents a total of 36,600 tonnes without auxiliary equipment (the Eiffel Tower weighs 7,000 tonnes).

Assumed total weight of the FCC-ee detectors: <u>35,000 tonnes</u>.

The material is much more varied than that of magnets. Let's give them a $teqCO_2$ emission factor of 5.

CO_2 equivalent: $35{,}000 \cdot 5$ = **175,000 $teqCO_2$**

So together (magnets plus detectors) we would have 31,000 + 35,000 = 66,000 tonnes of equipment, to which we can attribute 80,000 + 175,000 = 255,000 $tCO2_2$ emissions. To this, we must add 5 years of work on site to assemble the equipment. Estimate: **500,000 $teqCO_2$**

CO_2 emissions linked to the construction and assembly of this FCC-ee equipment exceed 255,000 + 500,000 = 755,000 t CO_2 eq as the FCC-ee includes many other elements, we have rounded off this figure conservatively:

=> Emissions linked to the construction and installation of FCC-ee equipment: 1,000,000 $teqCO_2$

Graph 2 teqCO2: equivalent in tonnes of CO_2

Fluorinated gas emissions from FCC-ee

CERN's current LHC already uses large quantities of fluorinated greenhouse gases known as F-gases, and 90% of these gas emissions come from the **"experiments"** i.e., the 4 enormous detectors housed in the caverns. The experiments *"use a wide range of gas mixtures for particle detection and detector cooling, including fluorinated gases, which have a high global warming potential and account for about 78% of the Organisation's direct emissions."* (16)

Cryogenics (extreme cold) is necessary for the **superconductivity** of the FCC-hh beam bending magnets and the FCC-ee and FCC-hh accelerator cavities, as well as for the **air conditioning** and **insulation** of the power supply systems. (Readers who want to understand these terms should google them them together with the word CERN). Like those used in car air conditioning, these gases must be recharged regularly, which automatically triggers emissions.

The current accelerator, the LHC, is ***"the largest cryogenic system in the world*** *and one of the coldest places on Earth. The operating temperature of the LHC's main magnets, 1.9K (-271.3°C), is lower than that of interstellar space, 2.7K (270.5°C). [...] The system [...] requires 40,000 watertight pipe joints, a power supply of 40 MW (10 times the power needed by a locomotive), and 120 tonnes of helium to maintain the magnets at 1.9 K."* (17)

This is impressive and, on the backdrop of climate change, frightening. Fluorinated gases have a greenhouse effect several hundred or thousand times greater than that of CO_2 per molecule and that they can also be harmful to the ozone layer.

In 2022, CERN's facilities dissipated some 185,000 $teqCO_2$ of fluorinated gases ($teqCO_2$: tonnes of CO_2 equivalent). (16)
"The gases responsible for about 80% of CERN's Scope 1 direct annual GHG emissions are perfluorocarbons (PFC), les hydrofluorocarbons (HFC) and sulphur hexafluoride (SF6) in particle detection, and HFCs and PFCs for detector cooling. To put the emissions into context, CERN's PFC emissions are roughly of the same size as the Swiss emissions and only reduce by about 30% when there is no LHC run." ***(18)***

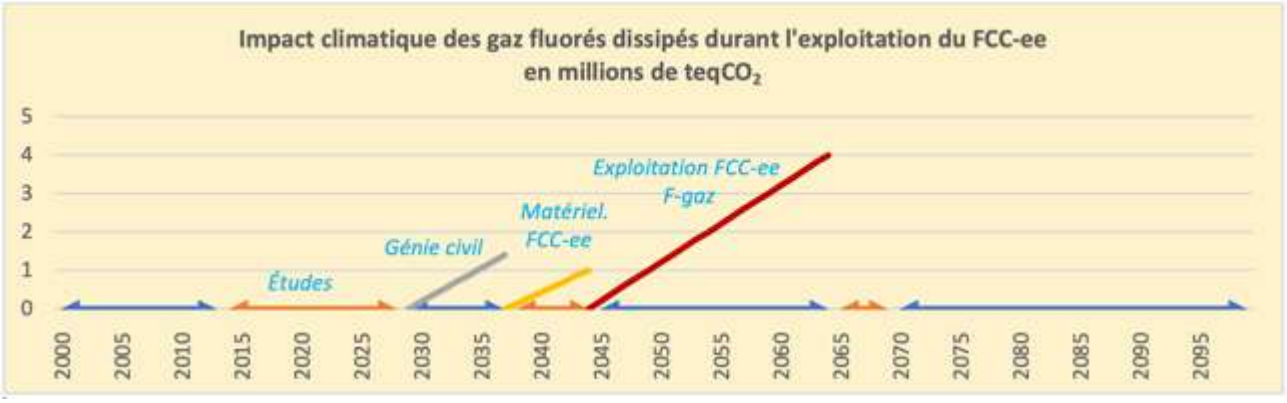
It may come as a surprise that CERN should be allowed to use and, inevitably, release such large quantities of fluorinated gases, given the efforts made at municipal, national and international level to prevent their use (see Vienna Convention, Montreal Protocol). The fact is these restrictions do not apply to major scientific experiments, such as those conducted by CERN.

Two large helium tanks for the High-Luminosity LHC were installed at Point 1 in June. (Image: CERN)

One of the 8 groups of refrigeration compressors used by the current LHC (Image: CERN)

It is difficult to estimate the extent of the emissions the FCC-ee would produce which, unlike the current LHC and the future FCC-hh, would use non-superconducting magnets that are less harmful in this respect. Leak prevention techniques will certainly have progressed, but regardless of whatever efforts and progress will have been made, adding installations the size of the FCC-ee to the existing complex would result in a net increase in greenhouse gas emissions. Let's propose 200,000 teqCO_2 based on current emissions from the LHC which, as we saw above, are 185,000 teqCO_2.

=> Annual GHG emissions linked to FCC-ee gas leaks: 200,000 tonnes teqCO_2 /year



Graph 3 teqCO2: equivalent in tonnes of CO_2

CO_2 emissions linked to the FCC-ee's electricity consumption

With the entry into service of FCC-ee, CERN's average annual energy consumption would rise from 1,400 GWh to 1,900 GWh (2). These figures will be explained below but it must be noted that CERN's main supplier, *Électricité de France (EDF), "uses low-carbon electricity, mainly of nuclear origin."*

The term "*low emissions*" reflects the fact that 75% of French electricity is nuclear-generated, and that its **emissions factor** is only 0.1. This means that producing 1 MWh of electricity in France would emit just 0.1 $teqCO_2$ (26), compared with the figure of 1 $teqCO_2$ produced by coal-fired power stations.

If we are to believe this figure (which does not include the decommissioning of power plants, the construction of deep-seated caverns, the conditioning of waste, the transport to the caverns and their monitoring over more than 100,000 years), the emissions attributable to the electricity consumption of CERN/FCC-ee (i.e., of the whole of CERN when it has the FCC-ee) would amount to 190,000 $teqCO_2$ per year. (1 MWh -> 0.1 t; 1 GWh -> 100 t; 1 TWh 100,000 t; 1.9 TWh -> 190,000 t)

However, two factors suggest that this figure will in fact be much higher:
1) In electrical terms, CERN is not an island. It is connected to the European grid.

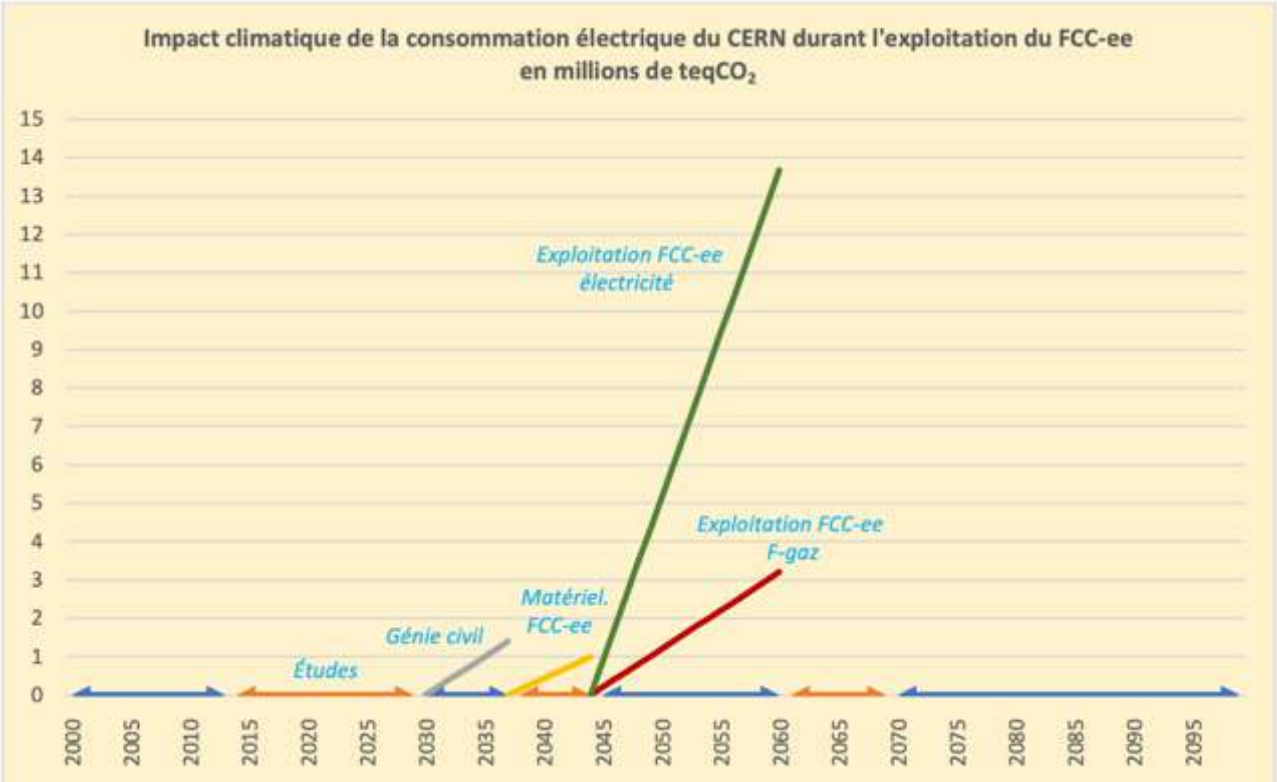
Unified European electricity grid

The electricity consumed by a user at a given point and at a given time is the result of bidirectional exchanges that are constantly rebalanced between national producers. So, while we can say that the emission factor for French production is 0.1 (and that French production is very clean in this respect), *"French energy production is part of the common EU market [...] it would therefore be more appropriate to use a conversion factor for an EU mix, which is about a factor of five higher than that for France"*.

The average emission factor for European electricity is 0.45 $teqCO_2$ per MWh of electricity, which would mean:

=> CO_2 emissions linked to CERN-FCC-ee's electricity consumption: 855,000 $teqCO_2$ /year

2) However, his factor of 0.45 is too low. In fact, it applies to the standard user, i.e., one that has no appreciable influence on the market. But when CERN withdraws the enormous amount of electricity it needs from the interconnected European grid, electricity suppliers, who have to meet demand from other customers, switch on the back-up power stations, including fossil-fired power stations.



Graph 4 [17x11] $teqCO_2$: equivalent in tonnes of CO_2

Nevertheless, it is possible that the carbon footprint of electricity will gradually improve as the proportion of renewable electricity increases. Let's hope so! However, the production of renewable electricity in turn requires the construction of facilities (wind turbines, solar panels, etc.) and distribution networks, which inevitably have a carbon impact. This is particularly true of the new nuclear power stations that France plans to build as part of its energy transition. And by always betting on and investing in new infrastructures and technologies, we are crushing what would be **the primary tool in the fight against global warming: managing energy demand with energy efficient appliances and conscious energy consumption by end-users, i.e., sobriety**.

Nor can we absolve ourselves—as the FCC project manager did in an interview with Noé21—by claiming that there is no problem, since our countries have undertaken to consume only carbon-free electricity as of 2050, i.e., shortly after the FCC-ee comes into service! It is true that if the FCC's energy production and consumption cycle were already clean today, the climate issue would be scaled down and F-gases would take the lead. But we are not there yet. For the record: in December 2023, the energy ministers of the *Pentalateral Energy Forum* (Belgium, the Netherlands, Luxembourg, Germany, France, Austria and Switzerland) declared that they would "*strive*" to decarbonize their interconnected electricity grids by 2035 (ref 255). But their declaration, which is purely formal, **says nothing about sobriety or the need to avoid megaprojects** that serve only a minor part of the population while heavily contributing to greenhouse gas emissions.

We could invoke the grail of technophile mythology, namely the industrial exploitation of nuclear fusion. Pending its advent, we'll stick to what we see: the European average is 0.45 $teqCO_2$. If CERN deems this conversion coefficient to be wrong, it should show us how it will change between 2030 and 2100, considering the series of 'difficulties' that our infrastructures will have to face as a result of global warming (including, not far from CERN, the forced closure of nuclear power stations because of the warming of the Rhône).

Emissions linked to the dismantling of the FCC-ee and the manufacture and assembly of the second collider, the FCC-hh.....

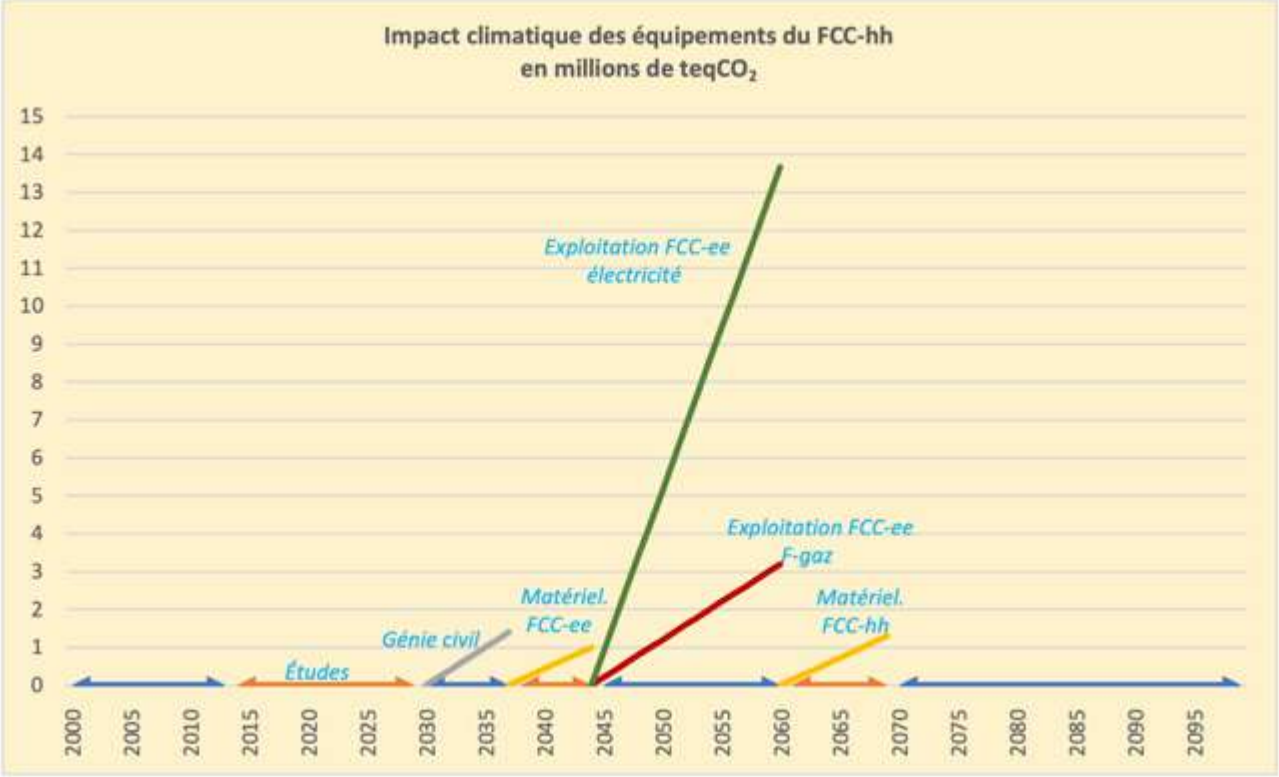
At the end of the FCC-ee research program in 2060, the accelerator-collider will be dismantled, removed and replaced by the FCC-hh. Part of the infrastructure used for FCC-ee will be maintained. More powerful and more voluminous, FCC-hh will use superconducting magnets that must be maintained at 1.9 K (-271°C).

To risk an initial assessment of the emissions linked to the manufacturing of the second accelerator, we have a figure of 230,000 tonnes (21) for the *cold mass*, the sum of the material maintained close to absolute zero. To this we can add 10% for the cryostats. This means that an accelerator-collider of this size weighs around 250,000 tonnes, without the annexes.

So, let's assume that the FCC-hh and its immediate annexes weigh 300,000 tonnes. The average emission factor for this machine is probably more than 2 teqCO_2 / t, which adds up to some 600,000 teqCO_2 for its construction. The FCC-hh will also require new detectors. The model currently being studied would have a diameter of 20 m and be 50 m long. What CO_2 emissions are associated with their construction and installation? Let's suggest 200,000 teqCO_2.

In addition, there will be 5 years of dismantling the FCC-ee and installing the new equipment. Estimate: 500,000 teqCO_2.

=> The CO_2 emissions linked to the construction and assembly of FCC-hh equipment amount to 1,300,000 tonnes.

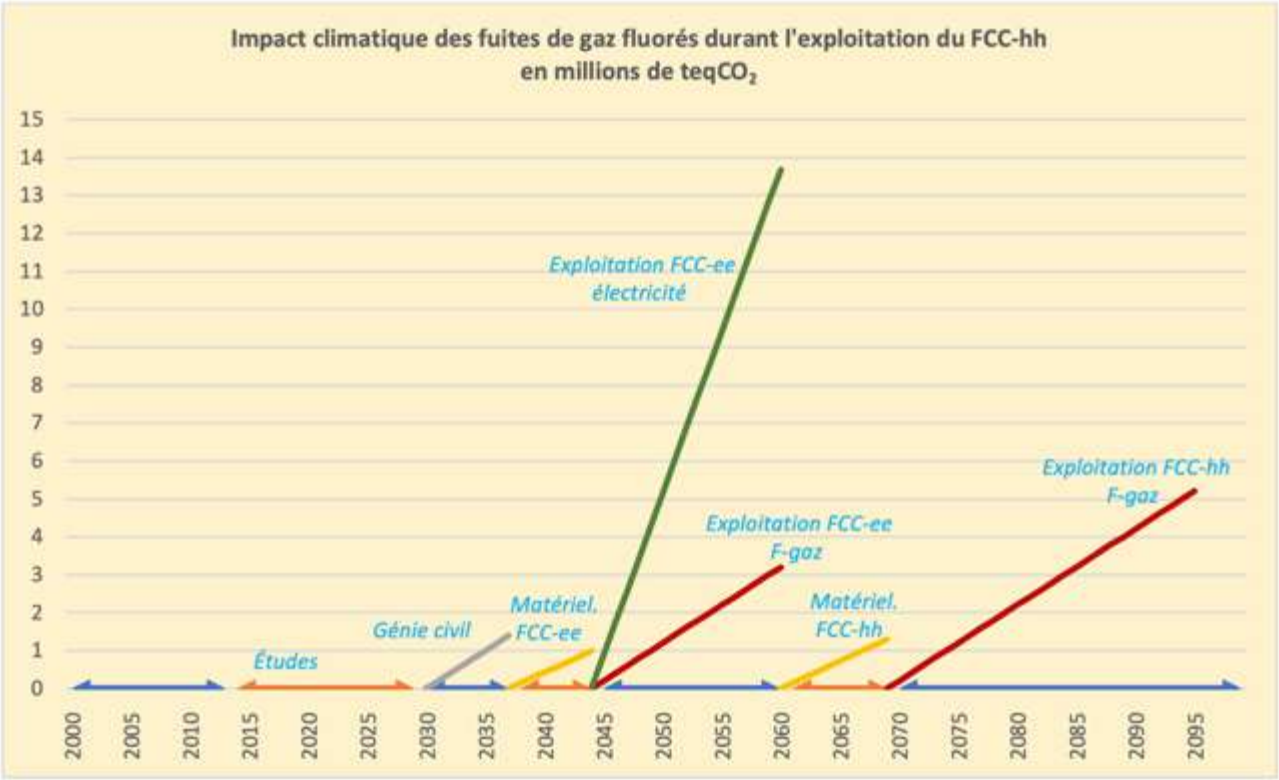


Graph 5 teqCO2: equivalent in tonnes of CO_2

Fluorinated gas emissions from FCC-hh...

We mentioned earlier that around 90% of these gas emissions come from the "experiments", i.e., the enormous detectors lodged in the caverns. Similarly to the LHC, the FCC-hh will have four of these. The cryogenic requirements of all the superconducting magnets will be about three times greater than those of the LHC, given that the circumference of the tunnel is triple the size. Should we expect a reduction in greenhouse gas losses compared with the FCC-ee? CERN will have to prove it. To set the scene carefully, let's go back to the FCC-ee figures:

=> Emissions of teqCO_2 linked to FCC-hh gas leaks amount to 200,000 teqCO_2 / year



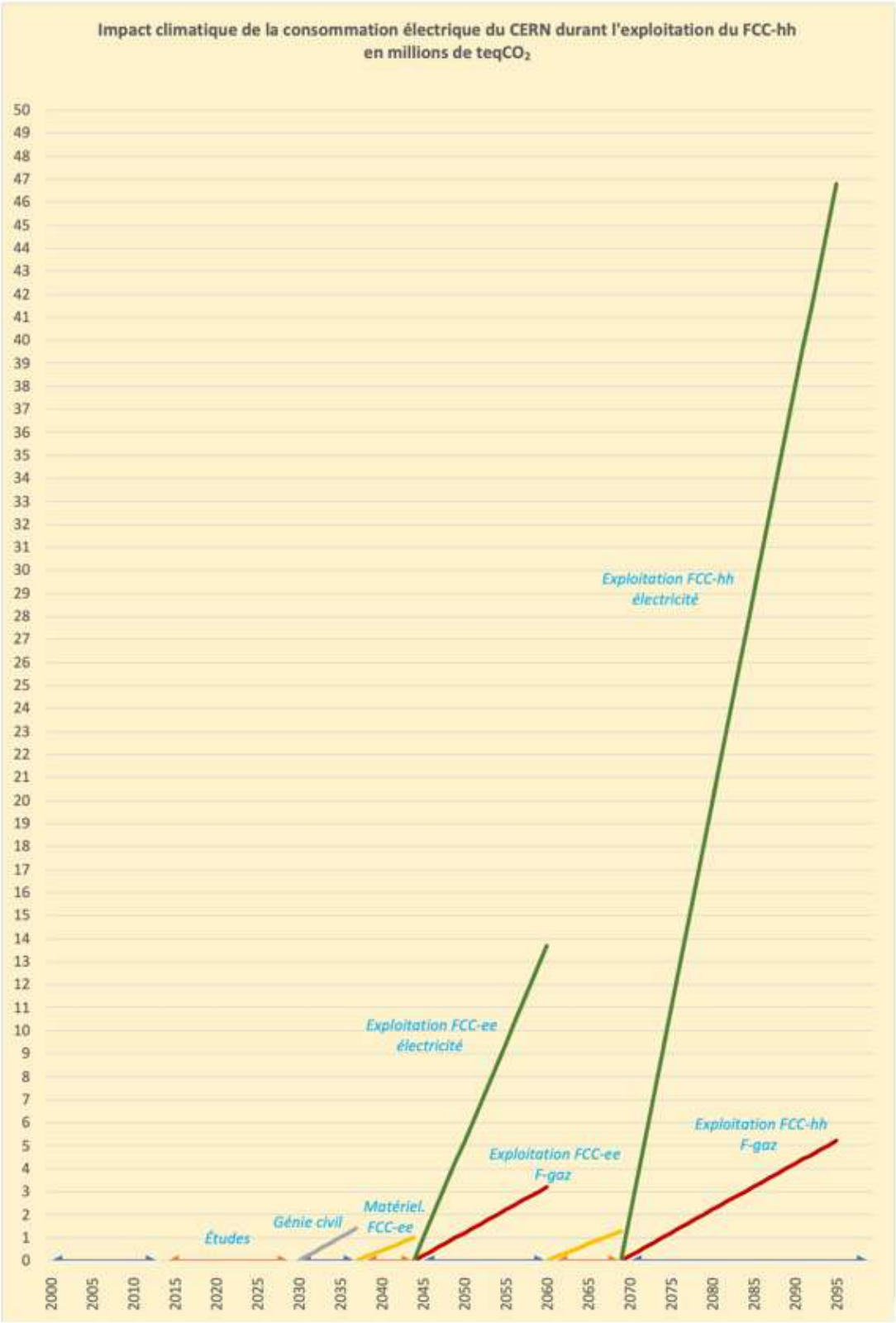
Graph 6 teqCO2: equivalent in tonnes of CO_2

CO_2 emissions linked to the FCC-hh's electricity consumption...

According to the Conceptual Design Report, with FCC-hh, CERN's consumption would increase to 4,000 GWh per year. Using the coefficient of 0.45 teqCO_2 per MWh, or 450 teqCO_2 per GWh introduced, we obtain

=> The CO_2 emissions linked to CERN-FCC-hh's electricity consumption: 1,800,000 teqCO_2 / year

To include these emissions in our graph and keep the graph on one page, we need to reduce the scale slightly



Graph 7 teqCO2: equivalent in tonnes of CO_2

For the **sum of greenhouse gases** produced by civil engineering works, equipment, F-gases and the carbon impact of electricity consumption, see below. Given the slow decomposition of greenhouse gases, we can, as a first approximation, consider that the four sources of emissions represented in this graph add up: once again, we need to reduce the scale.

Climate impact assessment to 2095...

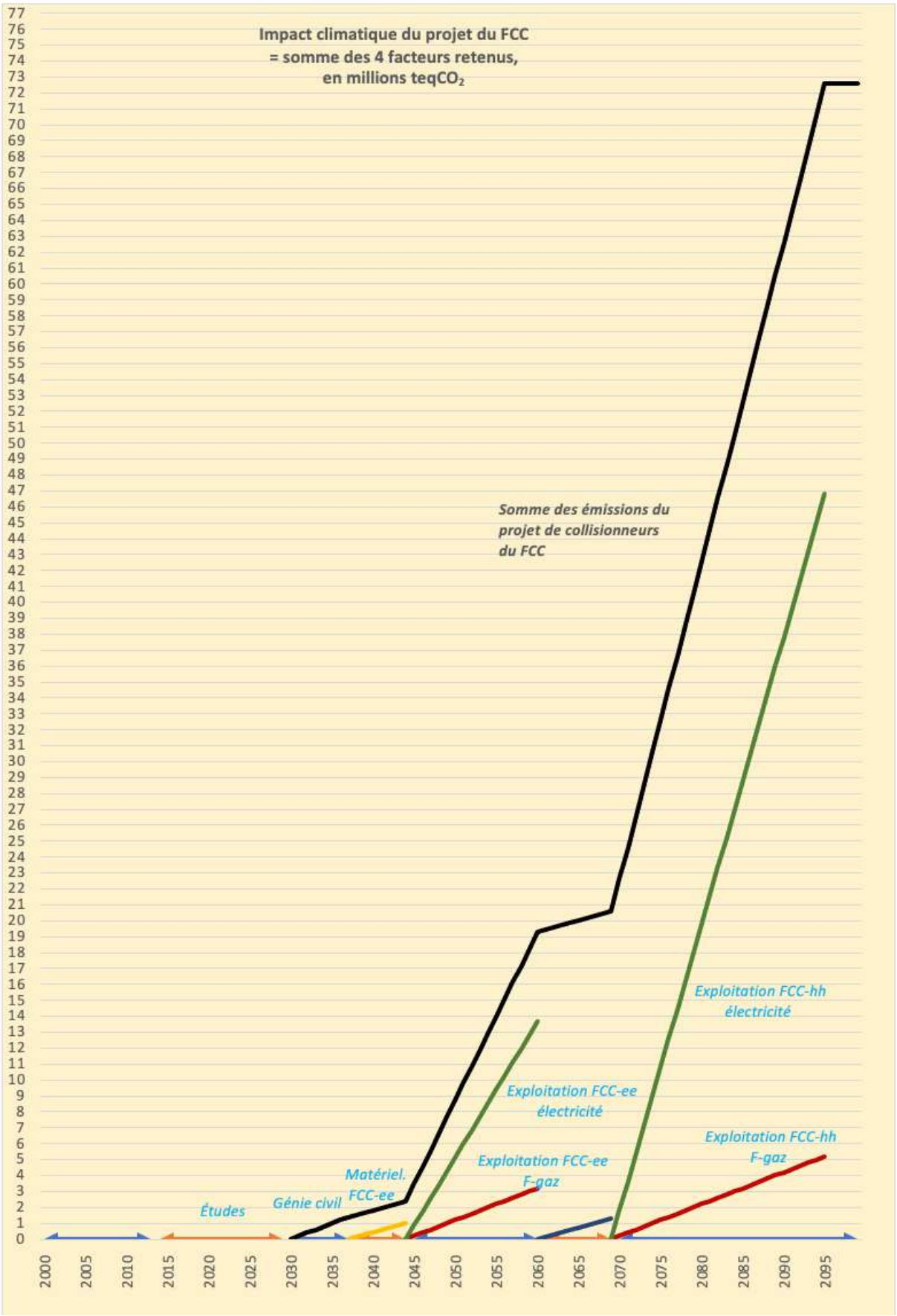


Chart 8 teqCO2: equivalent in tonnes of CO_2

"In 2022, Switzerland emitted 41.6 million tonnes of CO_2 equivalent into the atmosphere (not including international air and sea transport), equivalent to 5 tonnes of CO_2 equivalent per inhabitant (including 4 tonnes of CO_2 per inhabitant). (21)

The 72 million teq CO_2 that the FCC project would emit over 66 years (2030 - 2095) correspond to an average emission of 72 million teqCO_2 / 66 years = 1.1 million teqCO2 / year. This equals the greenhouse gas emissions of 1.1 million / 5 = **220,000 inhabitants** of Switzerland!

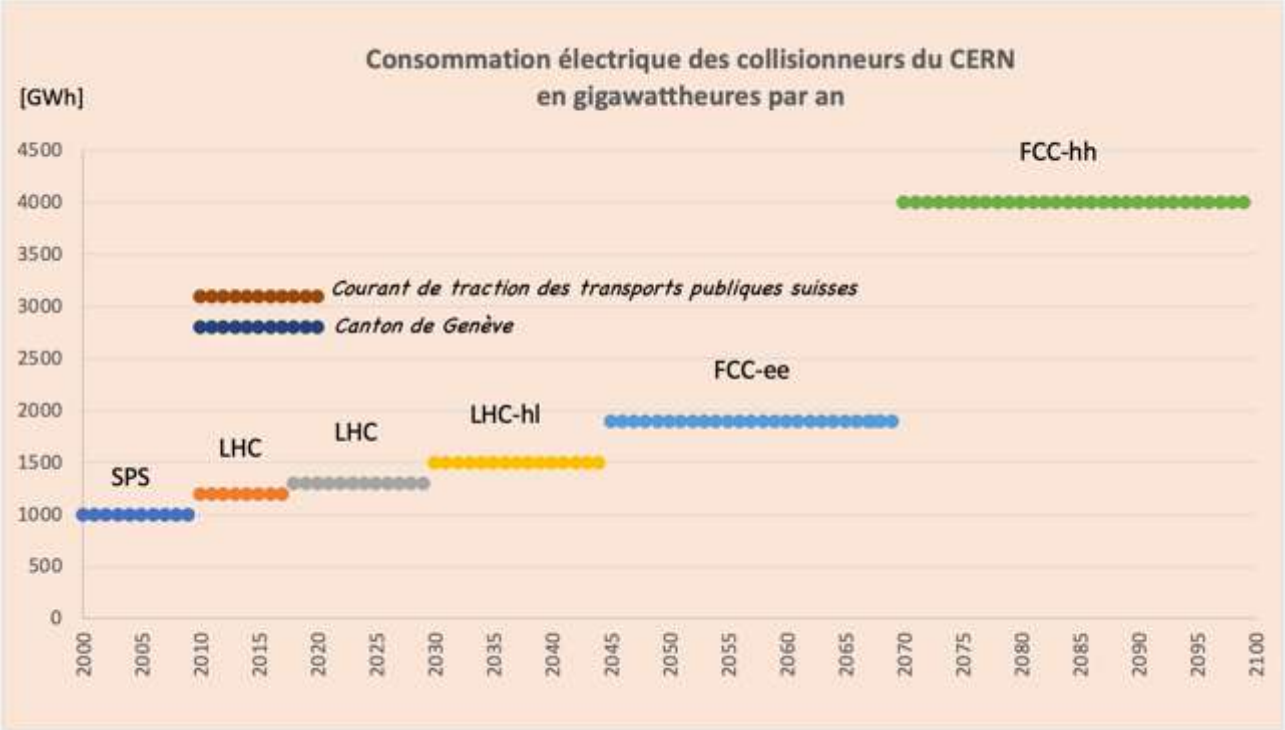
In the absence of data officially validated by CERN, the staggering figures revealed by our cautious assessments should open the discussion.

However, it is up to CERN to calculate the CO_2 equivalent of the emissions linked to its FCC-ee and FCC-hh projects. It is up to CERN to provide the figures for comparison with efforts being made elsewhere to reduce carbon footprint. It is hard to understand why the CHF 100 million plus allocated to the feasibility studies for this mega-project have not yet made it possible to provide the public with these figures.

Collider power consumption

=> With FCC-ee, CERN would consume 1,900 GWh / year

=> With FCC-hh, CERN would consume 4,000 GWh / year (21)



CERN's consumption figures are averaged over the operational timeframe of the main accelerator, including technical shutdowns. This explains why they are shown in plateaus.

The FCC-hh's consumption of 4,000 GWh is equivalent to that of a Swiss city of 700,000 inhabitants, all activities included, and to that of a city of 1 or 2 million inhabitants in a less energy-intensive country.

It would clearly exceed the Swiss electric public transport network's current traction, all vehicles combined (trains, trolleybuses trams, etc.), which carry millions of people and thousands of tonnes of goods every day.

Researchers have not overlooked the extravagant power consumption of accelerators, if only because of the cost. The contradiction between the programmed increase in consumption and the energy-saving policies advocated by governments has occasionally triggered reactions. At a symposium on the *European Strategy for Particle Physics*, one speaker concluded:

"This puts accelerators into the range where they become relevant for society and public discussion. (22)

Jorgen D'Hondt of the European Committee on Future Accelerators (ECFA), made a statement regarding the FCC:

"The big elephant is power consumption" (23)

In addition, CERN already operates **the world's largest calculating network, the WLCG**, the *World Computing Grid for the LHC*, with 1.4 million processor cores and 1.5 exabytes of storage, mobilizing more than 170 sites in 42 countries. Today, CERN provides around 20% of the Grid's resources. It does not account for the electricity consumption for the remaining 80%, which is nevertheless used to interpret the data from the experiments carried out using its equipment. With the FCC, the computing resources required would be 5 to 10 times greater. Given the development of computer hardware, it is difficult to know to what extent the Grid's power consumption will increase as a result.

Consequences for the energy transition

The aim of the energy transition is to **move away from fossil fuels**, mainly because of their greenhouse gas emissions. To achieve this, countries need to secure their supplies of clean energy, essentially renewable electricity. In the long term, the electricity currently produced by thermal power stations (most of the world's electricity) will have to be replaced by new, clean installations. This means that demand for electricity will only increase, even if our standard of living is steady.

The aim of the transition is to achieve a **decent balance** between the needs of society and its capacity to produce clean, undamaging energy. This implies we make an initial effort to **reduce the** staggering **waste of** material and energy to which we have become accustomed. Most of Europe's inhabitants could save 10, 20 or 30% in one, two or all of the consumer sectors (food, transport, clothing, furniture, cleaning products, etc.) without any perceptible change in their quality of life.

Beyond this common-sense reduction, we will obviously not achieve the desired balance unless we also make a general effort to be more **energy-sober**. Whatever our attitude to the issue**, we must avoid launching new titanic projects that do nothing to protect us from the worst of the climate, but in fact make the situation worse.** The arrival of mega-consumers such as FCC-ee and FCC-hh on the rapidly restructuring electricity market will delay the closure of thermal power stations. Obsessed by its corporatist concerns, CERN has simply decided to disregard the potential delay in the energy transition. Even so, CERN is aware of the problematic nature of this decision, so it relies on a few sophisms to explain that, on the contrary, since it will need a lot of electricity and that this electricity will have to be essentially renewable, it will invest heavily in renewables, which will make it one of the major players and pioneers of the transition.

Radiation and radioactivity from the FCC-ee...

In many areas of CERN, staff are at risk of exposure to ionizing radiation. This is reflected in the fact that dosimeters are worn all the time.

"The potential sources for environmental radiological impact are identical to those for the LHC:

1) dose from stray radiation emitted during beam operation,
2) dose from radiation emitted by radioactive materials and waste,
3) operation of sources and X ray emitting devices and
4) the dose from release of activated water and air
5) radioactive waste regularly extracted from underground installations or removed when installations are dismantled
6) the use of X-ray sources and equipment

	Very low-level radioactive waste	**Medium and low-level radioac. waste**
Waste from construction sites	0	0
Operational waste		
Injectors	< 250 m /year^3	< 10 m /year^3
Collider	< 1450 m /year^3	< 70 m /year^3

Source (5)

Radiation and radioactivity from the FCC-hh

	Very low-level waste	**Medium- and low-level waste**
Waste from construction sites	5000 m^3	200 m^3 (conversion from SPS to injector)
	300 m^3	900 m^3 (conversion of the LHC into an injector)
Operational waste		
Injectors (incl. LHC)	650 m /year^3	30 m /year^3
Colliders	< 1450 m /year^3	70 m /year^3

Source (5)

To put these figures into perspective (which do not include all the irradiated materials), it must be remembered that CERN's current capacity for receiving, processing, and disposing of radioactive waste is around 400 m^3 per year. The FCC-ee will produce 1,700 m^3 per year, and the FCC-hh 2,100 m^3 per year. To this we add the 6400 m^3 of waste from the FCC-ee dismantling site when it gives way to FCC-hh (21) although there is currently no mention of the dismantling of FCC-hh.

Comment from the French Interministerial Committee: "*Develop aspects related to radiation protection and nuclear safety issues, which are not directly addressed in the midterm document".*

The issue of cooling water...

"Most of the electrical energy consumed by this research infrastructure [the FCC] will be converted into heat"

To dissipate this heat, the current solution, and the one that will probably prevail in future installations, is to circulate cold water, lots of cold water:

" CERN consumes a considerable quantity of water to cool its accelerator complex. At the same time, the Organization also releases water into the neighbouring watercourses, many of which are small and thus sensitive to the quality of the water they receive. In 2018, the last year of accelerator operation before LS2, CERN consumed some 3.5 million cubic metres of water, which corresponds to around 1400 Olympic-sized swimming pools. The majority of this water comes from Lake Geneva. In the same year, CERN discharged 5.1 million cubic metres of water (this figure includes infiltration water pumped from the tunnels and release of precipitation run-off) into watercourses and wastewater treatment plants". (25)

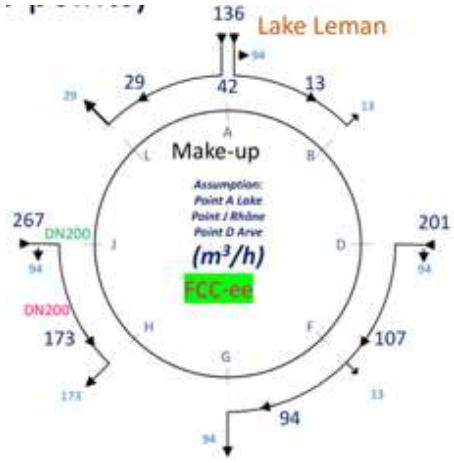
" The water used at CERN is mainly supplied by the Services Industriels de Genève (SIG). The raw water is pumped from Lake Geneva (CH), processed to drinking water quality [...] and then delivered to CERN.." (26)

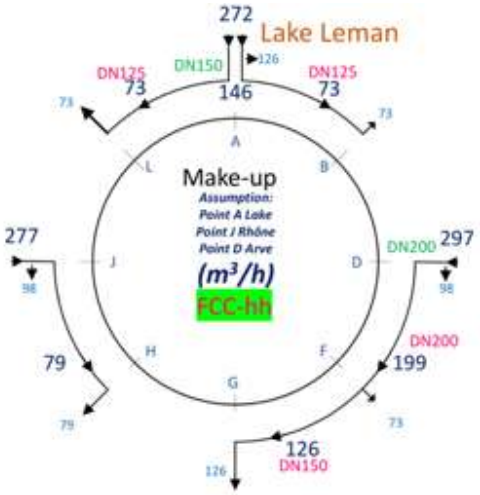
CERN has launched several projects to reduce water consumption and in its *Environmental Report 2020 - 2022* (16)committed not to increase consumption by more than 5% by the end of 2025, despite the commissioning of its new computing centre. In 2029, when the LHC-hl (LHC upgrade) comes on stream, consumption is likely to increase again.

But what if the FCC-ee and its successor, the FCC-hh, were to be built? Current studies (27) suggest pumping water from three points: the Léman, the Rhône and the Arve. Points A, B, D, F, G, H, I, J, K inside the circles below correspond to the underground technical and scientific sites and the corresponding surface sites.

• For the FCC-ee (on the left), 136 m³ / h could be taken from the lake and shared between sites A (Ferney-Voltaire), L (Challex) and B (Choulex/Presinge); 267 m³ / h could be extracted from the Rhône and shared between sites H (Cercier/Marlioz) and J (Vulbens/Dingy en Vuache); 201 m³ / h could be extracted from the Arve and shared between sites PD (Nangy), PF (Etaux/La Roche sur Foron) and PG (Cercier/Marlioz).

• For FCC-hh (right), the three pumping volumes would increase to 272, 267 and 297 m³ / h respectively.





The water heated by the facilities would be cooled by groups of 2, 6 or 8 cooling towers of the type illustrated opposite (group of 4 towers) from where it would return to cool the facilities (reduced by the proportion released or evaporated in the plume).

Currently, CERN consumes some 3 to 3.5 million m³ of (drinking) water per year, or around 5% of the 58 million m³ distributed by SIG in the canton. And it remains confident in optimization with what the future and research have in store for it:

*"A thorough re-assessment revealed that the maximum water requirement during the operation of the FCC-ee at the highest collision energy can be kept below **3 million m3 per year**, which approximately corresponds to **the present water use for the LHC**."* (28)

As for FCC-hh, we have no forecasts of its water requirements.

> Comment from the French Interministerial Committee: "*Make projections on the evolution of the flow of the Rhône and the Arve rivers for the coming decades, taking into account the recurrence of periods of drought and the melting of glaciers, and describe the withdrawals from the Rhône and the Arve in order to verify that the withdrawal for the FCC remains marginal*".

Project cost...

Physicist Sabine Hossenfelder doesn't beat about the bush:

"The projected construction cost for the two stages is around 20 billion euros. That doesn't include the running costs, which are probably around 1 billion dollars a year [...] I think particle physicists need to wake up. They seem to think that they are entitled to tens of billions of dollars in exchange for nothing in particular while the world is leaning towards hell." (ref 29)

The figures derived from the conceptual design reports and our conservative estimates of operating costs are slightly different. The financial package for the project is part of the feasibility studies currently under way, the results of which will be released in 2025 and will serve as the basis for the decision as to whether or not to build, in 2027 or 2028.

Estimated cost of FCC-ee in 2018			Billions CHF
Civil engineering	5,4		
Technical infrastructure	2,0	Total:	10,5
Collider and its injectors	3,1		
+ "tt working point" option			1,1
Operating cost over 15 years*)**)			20

*) Based on the LHC precedent: *"The direct and indirect costs of the LHC in action represent around 80% of CERN's annual budget for operation, maintenance, technical shutdowns, repairs, and consolidation work, covering both staff and facility (for the machine, injectors, information, and equipment)"*. CERN's current budget is around CHF 1.3 billion per year.

**) Update 2024: according to the German Ministry of Education and Research (BMBF), the operating costs of the FCC-ee would exceed CHF 1.3 billion per year. (30). We have adopted this figure

Estimated cost of FCC-hh in 2018			
Civil engineering	0,6		
Technical infrastructure	2,8	Total:	17
Collider and its injectors	13,6		
Operating cost over 25 years *)			35
FCC-ee and FCC-hh		**Gd total**	**84**

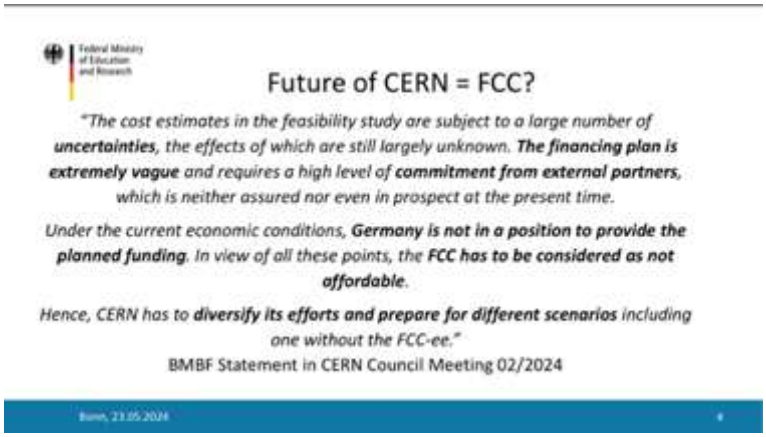
*) If the FCC-ee has been previously built

Expenditure will be shared between the 24 member countries and other international partners. The host countries (Switzerland and France) will probably be asked to make a special effort. Surprises can be expected given that the project is based on unconfirmed technological advances. It should be remembered that the construction of the LHC, initially budgeted at CHF 2.6 billion, ended up costing CHF 10 billion.

Halfway through the feasibility studies, the host countries are finding that these calculations leave plenty of room for uncertainty:

> Remark by the French Interministerial Committee: "... *the current weaknesses of the technical, financial risks and contingencies analysis, and the associated blind spots, mean that it is impossible to make an exhaustive estimate of the items involved, or to put a precise figure on the costs and margins for contingencies. In fact, it is still necessary to consider the cost of detectors and the future operating cost of the installation.*

However prestigious CERN may be, the issue of cost is proving to be a very sensitive one. At a meeting of German researchers in 2024, a representative of the Ministry of Research somewhat sobered the participants up by saying: *"Under the current economic conditions, Germany is not in a position to provide the planned funding "*.



It should be noted, however, that the wording leaves room for another strategy: skipping the FCC-ee stage and going straight to FCC-hh. This option is also unacceptable, as explained in section "Plan B".

Will scientific breakthroughs be achieved ?

• What do the initiators of the project think ?

The main aim of the FCC is to...

• Further the study of the Higgs boson;
• Possibly find new particles or new phenomena linked to dark matter;
• Carry out much more precise measurements which, with the new calculation methods, will enable the extraction of an over-proportional amount of information.

However, the initiators are not certain that they even know what they are looking for, let alone find what they are looking for in the energy range that the FCC will open up: *"Having answered the question 'Where is the Higgs hiding?', thanks to the LHC, particle physicists now face an even more difficult question: 'What is the next thing to look for, and where can we find it?"* (6)

They rely partly on the discovery of *"unknown things of an unknown nature"* . In other words, the theory proposes nothing, but let's go for it anyway!

They also note that, according to the current theoretical model, there is nothing interesting to be found at this energy level. There is unanimity on this point. This is the first time that one of these machines will have been built without a well-defined idea of what it should enable us to discover: "*[…] no clear theoretical guidance on the direction this exploration might take, which is a first since Fermi's theory (1933)*".

• What do CERN staff think ?

It is difficult to know. CERN's communications department is unwavering in its enthusiasm and makes no mention of any debate within the organization. Some teams of researchers who have studied projects other than the FCC continue to defend them at various particle physics conferences.

• What do physicists outside CERN think ?

Professionals are not unanimous. The main objections are as follows:

- Money is mostly be spent on civil engineering and equipment; it's more a project for civil engineers than physicists.
- As for scientific breakthroughs, we'll see....
- CERN is going off track.

Physicist Sabine Hossenfelder has courageously expressed her views on the subject in the articles and video referenced below. She is particularly critical of the sensational promises that CERN had already exaggerated previously with the LHC:

"The Uncertain Future of Particle Physics / Ten years in, the Large Hadron Collider has failed to deliver the exciting discoveries that scientists promised." New York Times (31)

"The World Doesn't Need a New Gigantic Particle Collider." Scientific American (32)

"Particle Physicists Continue Empty Promises." youtube.com (33)

"No one in physics dares say so, but the race to invent new particles is pointless." The Guardian (34)

In the mentioned above video (33), she states and insists that:

"According to [CERN Director] Fabiola Gianotti, we need the FCC because the discovery of dark matter particles would lead to a new and more complete theory of how the Universe works. […] It is true that the discovery of dark particles, if they exist, would lead to a more complete theory of how the universe works, but there is no reason to think that the FCC would contribute to this.

To be honest, I find it distressing that CERN physicists are still trying to mislead the public about the prospects of their experiments. Let me remind you that they also told you that the LHC (the current 27 km accelerator) would find dark matter. This was not the case, nor was it ever likely to happen.

The first time they did this, I was prepared to believe that they themselves were unclear on the matter. But now I can no longer accept that excuse. At this stage, it's deliberate misinformation."

Other renowned specialists share her scepticism:

Adrien Chao: *"Ten years after the Higgs, physicists face the nightmare of finding nothing else."* Science (35)

Others think that the FCC is not the best option:

Chandrashekbar Joshi: *"These gargantuan and costly machines are not the only options."* Scientific American (36)

Tom Hartsfield: *"Please, don't build another Large Hadron Collider. A next-generation LHC++ could cost $100 billion."* bigthink.com (37)

Carlo Rubbia, former director of CERN and winner of the Nobel Prize in Physics, considers the size, cost and timetable for the FCC to be unrealistic and proposes another option, the muon collider. (38)

• What do Swiss research bodies think ?

The first organizations concerned are:

• SEFRI, the State Secretariat for Education, Research and Innovation, oversees the CERN dossier for Switzerland.
• ETH Zurich, through its Rector Günther Dissertori
• PSI, Paul Scherrer Institut, Villigen ~~home to CHART~~
• EPF Lausanne, Laboratory for Particle Accelerator Physics
• University of Geneva
• CHART (Swiss Accelerator Research and Technology) created in 2016; brings together CERN, PSI, EPFZ, EPFL and UNIGE

They all seem to be behind the project. If not, nothing betrays it. Here again, the official communication is unwaveringly enthusiastic, makes no mention of any debate, and remains silent about the climate issue.

• What do we think ?

In the previous version of this text, we responded as follows*: "The question of expected results is beyond our remit. However, it appears that it has not been clarified to our satisfaction, even though the project is being vigorously pursued. Hence the feeling that CERN is practising a fait accompli strategy."*

Since then, reading the exchanges between physicists on the issue, listening to them on YouTube, or chatting with former CERN collaborators, it is difficult not to feel that the FCC's scientific dossier is oversold.

Practical applications of programmed research...

None is known or even anticipated at this time.

Technological spin-offs...

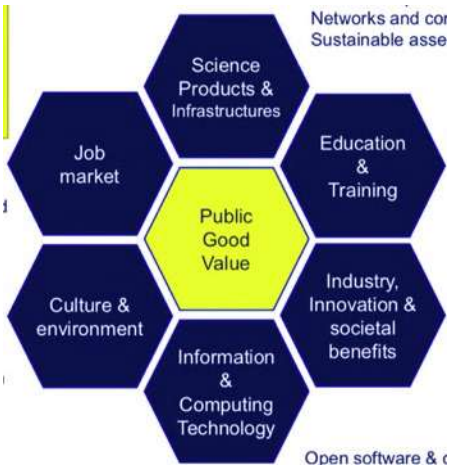
The construction and operation of CERN's accelerators has led to advances in several technologies. The most frequently cited are:
• Cryogenics: necessary for superconductivity (superconducting magnets, radiofrequency cryomodules, etc.).
• Ultra-high vacuum: particles circulate in cavities with a vacuum comparable to that of interplanetary space, also used as a thermal insulator in cryogenics.
• Superconducting magnets: the current LHC uses more than a thousand of these, each measures 15 metres and weighs 35 tonnes.
• Computing: a huge global computing grid; Tim Berners-Lee came up with the idea for the Web while working at CERN.

But any techno-scientific project with a comparable budget would generate technological spin-offs of the same order. And above all: spin-offs are not the intended target.
"…. all these benefits are certainly very important […] but they are nonetheless secondary in justifying the funding of particle physics: the scientific argument must take precedence." Christopher Llewellyn Smith, Director of CERN 1994-98

Socio-economic assessment of the venture...

Nobody expects CERN to finance its operations. It practically doesn't sell anynothing and follows a policy of making the results of its work free and accessible. It is financed mainly by contributions from Member States. But the continuity of public funding for activities which the public and most elected representatives know little about is more precarious than that for indispensable public infrastructure, such as a hospital or a public transport. This is one of the reasons why CERN regularly highlights the socio-economic benefits of its activities.

In addition, French law and the European Community require from the promoters of projects they fund to submit a socio-economic assessment beforehand. CERN commissioned economists to carry out this work and provide the following diagram of the various socio-economic aspects of FCC-ee: (ref. 242):



Each of these aspects is in turn broken down into numerous items which are the subject of complex calculations (40). They are not yet complete because **the following elements have yet to be included**:

1. **Cost of carbon (global warming potential)**
2. **Loss of land**
3. **Forest losses**
4. **Biodiversity loss**

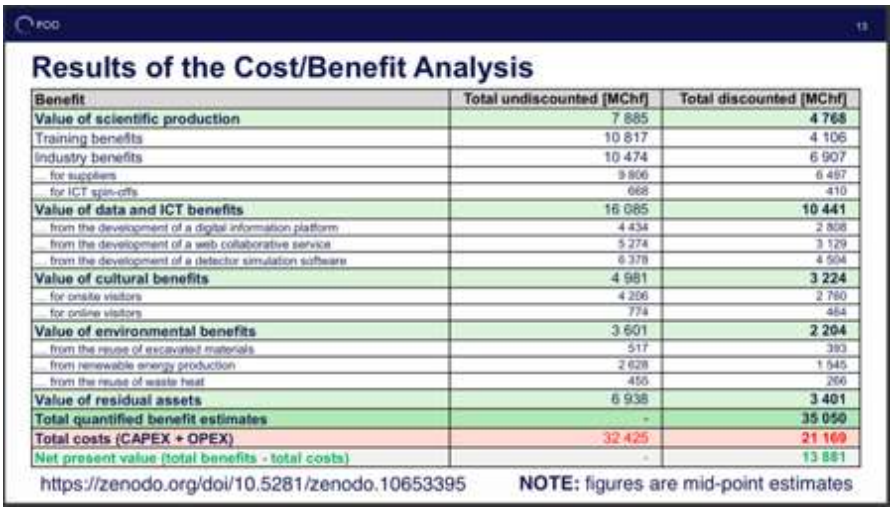
That's no mean feat! Along with the delay imposed on the energy transition, these issues are at the heart of our objections!

These major omissions do not prevent the authors from concluding that every €1.00 invested in the project will return €1.66 (average between €1.44 for the pessimistic scenario and €1.87 for the optimistic scenario)**.**

To which they add that *"a more detailed socio-economic analysis [...] could reveal other positive impacts".* It is unacceptable to list every conceivable positive aspect, derive a result that is accurate to the second decimal place, and widely disseminate it in public communications **while postponing the consideration of the negative externalities**.

Questioning a project's social benefit is legitimate. To benefit who or what? The socio-economic assessments of the CFC focus so much on *added value* and *employment* that they forget about the biosphere: the living world around us, with its land, water, atmosphere, vegetation and wildlife. The one and only biosphere that can provide us human beings with the conditions for a decent life. It is up to us to avoid irretrievably undermining its fundamental balance.

For example, what are we to make of the figures below on the value in francs of the environmental benefits of three items in the FCC project: the recovery of excavation material, the production of renewable energy, and the reuse of heat dissipated by the installations? (under the heading *Value of environmental benefits* in the following table) (39).



Results of the Cost/Benefit Analysis

Benefit	Total undiscounted [MChf]	Total discounted [MChf]
Value of scientific production	7 885	**4 768**
Training benefits	10 817	4 106
Industry benefits	10 474	6 907
... for suppliers	9 806	6 497
... for ICT spin-offs	668	410
Value of data and ICT benefits	16 085	**10 441**
... from the development of a digital information platform	4 434	2 808
... from the development of a web collaborative service	5 274	3 129
... from the development of a detector simulation software	6 378	4 504
Value of cultural benefits	4 981	**3 224**
... for onsite visitors	4 206	2 760
... for online visitors	774	464
Value of environmental benefits	3 601	**2 204**
... from the reuse of excavated materials	517	393
... from renewable energy production	2 628	1 545
... from the reuse of waste heat	455	266
Value of residual assets	6 938	**3 401**
Total quantified benefit estimates	-	**35 050**
Total costs (CAPEX + OPEX)	32 425	**21 169**
Net present value (total benefits - total costs)	-	13 881

https://zenodo.org/doi/10.5281/zenodo.10653395 **NOTE:** figures are mid-point estimates

This table suggests that digging up the ground for five years and then managing to sell the excavated material after hauling it off is an environmental benefit!

Equally incredible is the claim that the GWh of renewable energy reserved for the sole use of the FCC-ee represents an environmental benefit for society as a whole quantified at several billion francs, when compared with the status quo.

> Remarks by the Swiss Confederation, March 2024: *"Overall, the analysis of the socio-economic benefits currently seems over-optimistic (...) Several items appear to be overestimated, such as the cultural value of visits to the site (CHF 4,206 million) (...) or "the environmental benefits associated with the reuse of excavation materials and the strengthening of renewable energy capacities"*.

> Comment from the French Interministerial Committee: "The *identification of territorial benefits (...) will have to be completed (...)* ***by comparing the FCC scenario with the absence of a project*** *or a comparable private project (NB: the region is rich and densely populated; the population often has the feeling that major projects are a constraint for the region)*".

It should also be noted that, by only looking at the FCC-ee, the calculations leave out the main stage of the project, the FCC-hh. The March 2024 CERN Courier questions (41).

Acceptability...

The first fact is that the construction site would disrupt life in the regions surrounding the eight surface sites. As the latter are only 11 km apart, the whole of Haute-Savoie, Ain and Geneva would be affected by the comings and goings of thousands of additional structural workers over a period of seven years, and then by those who would install the 91 km machine and its ancillary equipment by lowering the lot down the shafts for another five years.

Several local associations organized presentations and debates in the locations where CERN plans to set up its drilling and future surface sites (https://co-cernes.com ; https://co-cernes.ch). All the events were fully booked. Audiences showed great interest in the historical and technical presentations, which helped them understand the whys and wherefores of the project, the impact it would have and, finally, the ways in which citizens could make their voices heard. The first reaction during the question-and-answer sessions was generally astonishment and incomprehension that a project of this scale has been under study for ten years (since 2014) without either the government or CERN having thought to consult the population concerned. Some people defended the project mainly in the name of science and employment, but the prevailing opinion can be summed up as follows:

We do not wish to be impacted by:

- seven years of civil engineering work,
- five years of equipment installation,
- surface sites being taken from nature or agriculture,
- planned road and rail developments,
- the transport of millions of tonnes of excavated material,
- a real estate price increase,

Nor do we need advice on how to organize our future.

MJC de Reignier le 27.02.2024 ©Camille Content

La Tribune

Futur collisionneur circulaire : ce gigantesque chantier du CERN qui inquiète en Haute-Savoie

Le Dauphiné Libéré
Lundi 14 octobre 2024

Actu locale Chéran -

Marlioz

Le futur collisionneur du Cern suscite des inquiétudes

Près de 300 personnes étaient réunies dans la salle des fêtes de Marlioz vendredi 11 octobre afin d'assister à une réunion organisée par le collectif CO-CERNes, "Information" était le maître mot de la soirée puisque depuis le début de son action, ce collectif déplore le manque d'explications sur un projet qui pourrait être validé en 2027 : le futur collisionneur du Cern.

Brigitte Pépin Donat, directrice de recherche au CNRS, a plaidé ce projet.

How do you go about launching a project of this magnitude ?

The 1953 **Convention** that created CERN entrusted the new organization with the construction of *"one or more accelerators"* (1).

Since then, once CERN completes a new accelerator, it tackles the next one.

CERN does not work in a vacuum; it collaborates with dozens of universities and laboratories in Europe and around the world. It is closely linked to the particle physics community that defines the profile of the next accelerator.

Every five years, the **CERN Council** appoints a **European Strategy Group (ESG)** which submits an update of the **European Strategy for Particle Physics**. The FCC study was launched in response to the 2013 update. (42]

The ESG is assisted by the **Physics Preparatory Group (PPG)**, which generates and collects scientific proposals from all the stakeholders in the strategy (hundreds of universities and laboratories).

A **Strategic Secretariat** assisted the two groups, drafted the strategy update and submitted it to the **Board**. The current update was approved in 2020.

Everything then hinged on this **European Strategy**, which is *"the cornerstone of Europe's decision-making process for the long-term future of the field",* or, as FCC project director Michael Benedikt puts it: *"serves as the objective and provides the* ***legitimacy for*** *our efforts"*. (43) (44) (45)

Following this report, CERN Council stated that it had been given the task of fullfilling these wishes and set to work: *" In response to the 2013 Update of the European Strategy for Particle Physics, the Future Circular Collider (FCC) study was launched.* (5)

The results of the study are then **discussed by the Member States** on the basis of information supplied mainly by CERN.

The project is then put to the **vote of the CERN Council**, which is made up of representatives from the member countries (two per member country, usually including one physicist and one diplomat, or two physicists). However, a large majority of the hundred or so people directly involved in the decision-making structure described above **(ESG, PPG, Strategic Secretariat, Council)** work or worked at CERN.

=> **The principal and the agent are practically the same people, leading to a decision making in-groupå**

There's nothing bold about acknowledging this fact. Forty years ago, shortly before work began on the current 27 km tunnel, *Éditions d'en bas* (Lausanne) published a collective work entitled *"La Quadrature du CERN".* The following long extract is ever so relevant:

"The Organization is managed by a Council. It meets several times a year. In principle, it is the Council that "determines the scientific, technical and administrative policies of the Organization" and exercises primary control over its operations. The Council is made up of government representatives. There are two representatives per country, one from the Ministry of Foreign Affairs [...] and one from the Ministry of Research [...]. As far as the representative from the Ministry of Foreign Affairs is concerned, this official is generally responsible for following several international organizations and numerous conferences in various parts of the world and is by nature incompetent in particle physics. The officials who represent their governments on research matters are generally researchers who have been associated with CERN for previous research and therefore have ties with CERN. This encourages them to promote CERN to their government rather than defend the interests of the citizens and monitor CERN objectively.

It should be noted that the government representatives are appointed by the executive and are not politicians. The governments have made no provision for giving them the time and resources they need to provide real leadership for the organization. Their debate is based on documents prepared for them by the CERN administration, among others, and they have little opportunity to check the actual accuracy or timeliness of what is contained in these reports. The Council has enormous power. Article II, point 4 [of the Convention for the Establishment of a European Organization for Nuclear Research] allows it to define "any supplementary program of activities" by a two thirds majority vote, even if this program has nothing to do with particle physics.

The national members of Parliaments who voted for the initial institutional framework are hardly involved in CERN's management anymore, especially as questions concerning international organizations seem to be too specific and should be managed by experts". (2)

An observation made by a CERN executive 15 years ago points in the same direction:

"If the delegates (of the Member States) receive instructions from their ministries as to the line to be followed, the CERN Council retains the authority to negotiate and take decisions in the interests of the organisation, largely without permanent consultation with the governments". (46)

We are in the same situation today. As the time for a decision approaches, the host countries are showing signs of irritation with CERN, which sometimes tends to confine them to the role of facilitators:

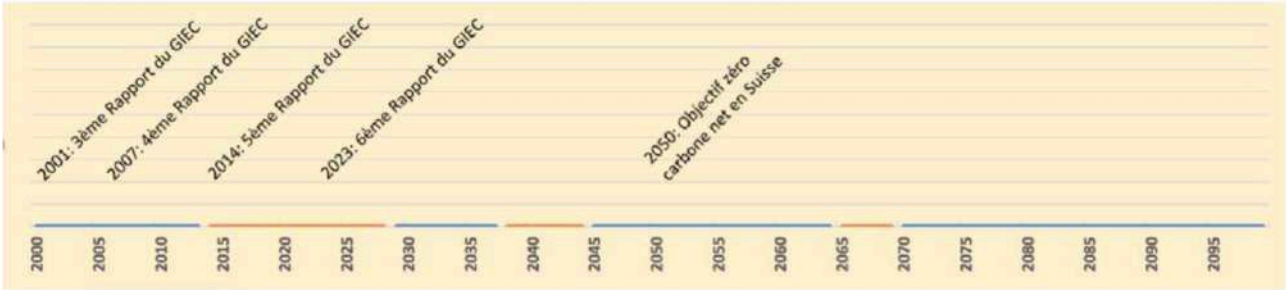
> French Interministerial Committee: "*Transfer the FCC study documents directly to the CERN-FRANCE-SWITZERLAND Tripartite Committee in the same way as is done for the members of the CERN Council...*".

> French Interministerial Committee: "*Some of the assumptions in the feasibility study are based on changes in French government policy (on energy and mobility infrastructure, for example). This raises several questions: (...)*
> *- If such statements are brought to the attention of political activists, doesn't CERN run the risk of triggering political debates that are internal to France?*

Avoiding the climate issue...

In line with developments in the principles of good governance, CERN has been publishing fairly detailed environmental reports since 2017, incorporating certain elements of internationally agreed standard, the *Global Reporting Initiative* (GRI) (47, 48, 16). The reports show that the organization already has a heavy impact on the climate and that it is committed to reducing its emissions by the end of 2025.

What is not mentioned is that, beyond this date, the organization proposes to launch a project for colliders (FCCs) that would triple its electricity consumption and increase its fluorinated gas emissions. It is astonishing that high-level scientists who will not have missed the seriousness of global warming should scoff at the warnings and alarm signals sent by their colleagues in the IPCC (Intergovernmental Panel on Climate Change).



It cannot be a case of negligence or misunderstanding. Nowhere in the hundreds of publications available to the curious on CERN's websites is the question debated head-on. It is sometimes mentioned in a polite preamble that commits no one, and fails to reappear in the body of the text. Another strategy – because that's what it's all about – is to organize seminars on sustainability in particle physics. They talk about how to reduce the energy voracity and emissions of future installations, concerns that are in any case part of the technicians' specifications, if only to reduce the insane electricity bills of the upcoming machines. But there is never any question of abandoning a project because of its carbon footprint.

CERN's communication on the FCC...

An element of the feasibility study (to be delivered by the end of 2025) concerns **Communication and Public Work**:

"To ensure a bright future for CERN and for high-energy physics in Europe, it is essential that governments and the general public understand through convincing, effective, and simple communication, the importance of CERN's scientific mission, of curiosity-driven research and the development of knowledge as an end in itself, and of the prospects that a post-LHC collider would open up in this context". (49)

To this end, CERN has adopted a **communication strategy** presented in a 37-page document that was previously available on the web (50). The target audience is broad:

"The global high-energy experimental particle physics community.
The global theoretical physics community.
Other science communities in fields related to the study and beyond.
French and Swiss authorities and notified bodies.
French and Swiss local communities.
Science & technology decision-makers, funding agencies and opinion leaders.
Media representatives.
Citizens in CERN Member States and Associate Member States.
Citizens and voters in selected CERN Non-Member States.
Educators and educational/academic institutions.
Students in higher education.
Industry executives and collaborator."

The strategy specifies that, in these groups, a distinction must be made between supporters, sceptics, and critics/opponents. Supporters are encouraged to spread the good word, while **sceptics** are told that they are ill-informed *("with an FCC-related information deficit")*. As for the **critics/opponents**, dealing with them proactively is to be avoided, for the sake of efficiency and to maintain a positive tone. Critics/opponents of the project have observed that CERN has implemented this policy as it has systematically declined to send scientific speakers to public presentations.

One of the instructions given in this document makes you smile:

"Position the FCC among the large number of priorities perceived as urgent by the world today (Covid, climate change, economic inequalities, access to drinking water, medical care, migration...)"

Is it revealing to put the FCC on the list of calamities that beset us? Note that in these 37 pages, **this is the only passage where the word *"climate"* appears.** The term '*sustainable'* is generously used in the *key messages,* but its relevance in this context is unclear:

"Lasting peace is born of collaboration" "SCIENCE FOR A NEW ERA: global, collaborative, sustainable". "The FCC collaboration is committed to the pursuit of sustainable development and is working hard to provide a truly 'green' research infrastructure.

This rhetoric does not seem to convince the French Interministerial Committee, which insists:

> French Interministerial Committee: "*Devote part of the study to sustainable development and include a discussion of technical adaptation to climate change".*

An example of creative communication: excavation materials...

Major headache for the FCC project: the removal of 8 to 9 million m^3 of molasse material from the tunnel and its annexes. From an environmental point of view and in terms of the nuisance imposed on the region, **it's a bomb**. So, in 2020, CERN launched an international ideas competition *entitled "Mining the Future",* in collaboration with Montanuniversität, an Austrian university...
"... with a clear challenge: to identify credible solutions for the innovative re-use and sustainable management of the large quantities of molasse material extracted during the construction of the new FCC infrastructure". (51)

The challenge is huge, the objective ambitious: *"The 'Mining the Future' competition [...] aims to encourage technologies which can integrate these materials into the future circular economy".* (52)

Here the molasse mountains are associated with a desirable but elusive circular economy while the results of the competition were not yet known. It was even suggested that the competition would help achieve the climate targets:

"By keeping excavated material in the circuit, circular economy models clear a path towards our collective climate objectives, the reduction of greenhouse gases linked to the extraction, processing, manufacture, and burial of natural resources". (51)

Defused and rehabilitated in this way, the environmental bomb can be integrated into the *"suggested narratives"* and the *"story factory"* being developed around the project. The Strategy suggests that the priority that the FCC would give to sustainability should be underpinned by initiatives such as *Mining the Future*:

"Make it clear that the FCC is putting sustainability first by talking about its initiatives such as Mining the Future". (50)

An awakening of the particle physics community ?

In the article already quoted previously, *"Climate impacts of particle physics"* (53), eight particle physics researchers address the question of the general impact of their discipline on the climate:

"Current and future activities in particle physics need to be considered in this context [la crise climatique], either on the moral ground that we have a responsibility to leave a habitable planet to future generations, or on the more practical ground that, because of their scale, particle physics projects and activities will be under scrutiny for their impact on the climate."

They note that, professionally, the carbon footprint of researchers in their discipline is much higher than that of the average citizen, while it is impossible for them to specify how society will benefit from their work. They are particularly concerned about the following four areas:
- The construction of very large experimental facilities
- The design and operation of detectors, which use greatly harmful greenhouse gases (f-gases)
- The enormous computing power required to exploit the results
- The way researchers work involves many intercontinental flights

Their advise: to be transparent about the figures, to make efforts in all sectors and to communicate these efforts well. That's all very fine**, but they never mention the possibility of abandoning new mega-projects because of the climate crisis!**

This position is dominant in the industry: one acknowledges the existence of the problem but avoids mentioning the decision that needs to be taken i.e., not to make the situation worse, not **to build the accelerator of global warming which is exactly what the FCC would be**.

The same attitude is expressed in the "*2020 Update of the European Strategy for Particle Physics*", which calls on CERN to make the FCC one of its priority initiatives:

"The environmental impact of particle physics activities should continue to be carefully studied and minimized. A detailed plan for the minimization of environmental impact and for the saving and re-use of energy should be part of the approval process for any major project". (54)

Here, *"minimzed"* and *"minimization"* leave CERN free to drill a 91 km tunnel, use massive quantities of fluorinated refrigerants and triple its electricity consumption, all of which have a clear impact on climate.

The same attitude was expressed in a presentation by the EPFL's Laboratory for Particle Accelerator Physics (57). It begins with the inevitable observation flanked by wishful thinking...

"Climate change causes critical reflections on non-sustainable energy carriers and irresponsible consumption of energy and resources. With our research we must contribute to solutions and should not be part of the problem."

... and then goes on to look at the various ways of optimising accelerator performance without jeopardising current megaprojects. It concluded with a skillfully presented optimistic message that is not backed by any concrete examples:

"Our community can contribute to the solution of the global energy problem through spin-offs, our R&D (research and development) programmes and international networking."

The same attitude was expressed in an interview published in the local daily *Le Temps* (ref 209). To the question *"In the midst of a climate crisis, can we still launch projects [...] such as CERN's Future Circular Collider?",* the brilliant physicist Astrid Eichhorn, known for her actions in favor of climate (see Wikipedia), seems unable to take the plunge. The article reads as follows, in good order:

1. *"...Everyone must reduce their carbon footprint..."*
2. *"... The position of researchers confers on us a special responsibility"*
3. *"… Giving up certain projects because of their environmental impact would have negative repercussions on the quality of scientific results: I don't think that's desirable."*
4. *"Individual scientists can take measures to reduce their air travel..."*
5. *"An organisation like CERN, for its part, could become a platform for reflection on sustainability in particles physics."*

Plan B...

In 2023, CERN Director Fabiola Gianotti stated: *"Extremely positive feedback so far [...] No showstopper found at this stage".*

However, the possibility cannot be ruled out that the FCC project will fall victim to one of the potential showstoppers that have long been identified, such as cost, excavation materials, land use issues, electricity consumption, local opposition, climate crisis, population's lack of interest in scientific research, or even an international crisis changing Member States' investment priorities...

Here are a few warning signs:

• In their midterm remarks, CERN's Swiss counterparts returned to a nagging subject:

> Comment by the Swiss Expert Committee: "*Excavation materials have been identified as being of critical importance, presenting a major risk potential for the FCC project".*

• In June 2024, the German Research Ministry announced that Germany would probably not be able to take part in the financing of the FCC beyond its annual contribution to the CERN budget.

• In September 2024, Karl Jakobs, secretary of the next update of the *European Strategy for the Physics of particles*, the key document for the 2028 decision, told the *CERN Courier: "That we should discuss alternatives to the chosen baseline is important to this strategy update,"*.

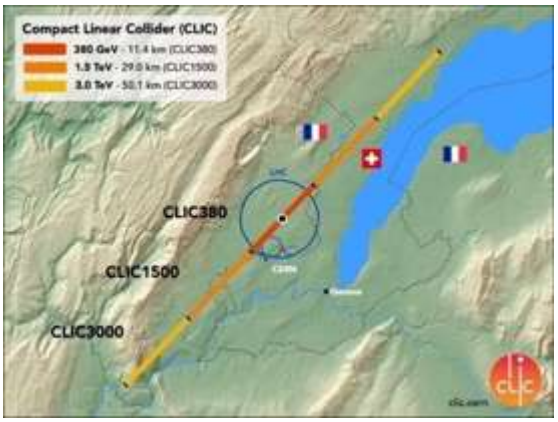
• In a recent presentation (57), two senior FCC project managers clearly illustrate their position:

What are these alternatives which some people deny exist but which an organization the size of CERN cannot do without? The ones most often mentioned are the following:

• Skip the FCC-ee stage, speed up the development of superconducting magnets, and then build the FCC-hh directly

• Launch the FCC-hh directly with conventional, non-superconducting magnets

• The CLIC project (Compact Linear Collider)



• The muon collider

• Equipping the LHC with ERL (Energy Recovery Linac) technology

• Laser acceleration of particles in plasma (wakefield)

What would happen if the FCC project were to be abandoned? Member States that rejected the FCC might be tempted to award CERN one of the less ambitious B projects by way of consolation. That would be a **huge mistake**, the like of which History is replete.

Indeed, **before** paving the way for a new project, it is important to specify the **red lines** that its greenhouse gas emissions, electricity consumption and territorial impact must not cross. These limits should have been set when the technical design studies were launched in 2014. Whether for the FCC or for a B project, it is important to be rigorous, to abandon the **subterfuge** of declaring projects to be of "public utility" or "national importance" to exempt them from regulations, procedures, and being opportunities for public opposition. Yet this is what Canton of Geneva has chosen to do in a letter (see below) to the Swiss Confederation asking it to take the lead of the project specifically to (top of page 2) "*reduce possibilities for opposition*".

RÉPUBLIQUE ET CANTON DE GENÈVE

6370-2020

Genève, le 9 décembre2020

Le Conseil d'Etat

6370-2020

Département fédéral de l'économie, de la formation et de la recherche (DEFR)
Monsieur Guy PARMELIN
Conseiller fédéral
Palais fédéral Est
3003 Berne

Concerne : développements territoriaux du CERN

Monsieur le Conseiller fédéral,

L'Organisation Européenne pour la Recherche Nucléaire (CERN) est implantée dans le canton de Genève depuis 65 ans.

Le plus grand centre de recherche au monde en physique fondamentale situé à la fois en France et en Suisse a permis des découvertes importantes ces dernières années. Comme vous le savez, le recours à de nouvelles infrastructures est nécessaire afin d'anticiper l'obsolescence du Large Hadron Collider (LHC) d'ici 2040.

La perspective d'accueillir le "Future Circular Collider" (FCC), d'une emprise quatre fois supérieure à l'installation actuelle, requiert d'examiner à nouveau les conditions des développements territoriaux du CERN, notamment pour les terrains identifiés dans le contrat de superficie de 1998 signé avec l'Etat hôte.

Ceux-ci sont grevés d'une non constructibilité en raison du caractère agricole et inscrits en surfaces d'assolement (SDA). Le canton a pu, avec l'aide de la Mission Suisse, accompagner le CERN dans une planification décennale de ses besoins en identifiant des principes d'optimisation et de rationalisation du sol. Ce schéma directeur en cours de finalisation prévoit des besoins à hauteur de 5 hectares pour la partie Suisse.

Dès 2030, la construction possible du FCC pourrait multiplier cette emprise par 10 sur des terrains privés actuellement situés en zone agricole et pour lesquels des contraintes environnementales existent.

Ce cumul des besoins présente un fort impact pour le canton compte tenu du quota de surfaces d'assolement d'une part et de la recherche du souci de préserver la zone agricole. De plus, la spécificité de cet ambitieux projet impose une anticipation et un accompagnement à la hauteur des enjeux pour notre territoire. Le déclassement des futurs terrains nécessaires au développement du CERN devra pouvoir se faire selon un calendrier contraint avec un portage fort au sein de l'Etat hôte et en employant des processus innovants.

Afin de permettre à l'organisation internationale d'envisager une croissance attendue, l'élaboration d'un plan sectoriel centré sur les développements du CERN permettrait d'ancrer cette stratégie au niveau fédéral, de faciliter la coordination et serait en outre de nature à diminuer les procédures de recours.

C'est pour cette raison que le canton propose de recourir à cet outil qui offrirait un cadre de référence adapté pour répondre aux besoins de développement du CERN, et pour accompagner les procédures d'aménagement du territoire et d'autorisations de construire. Dans cette perspective, l'office de l'urbanisme du canton de Genève serait le répondant technique pour l'élaboration du plan sectoriel.

En cas d'accord de votre part, nous travaillerons dès 2021 à la mise en place de cette stratégie, en associant le CERN et les offices fédéraux.

Nous vous prions de croire, Monsieur le Conseiller fédéral, à l'assurance de notre haute considération.

AU NOM DU CONSEIL D'ÉTAT

La chancelière :

Michèle Righetti

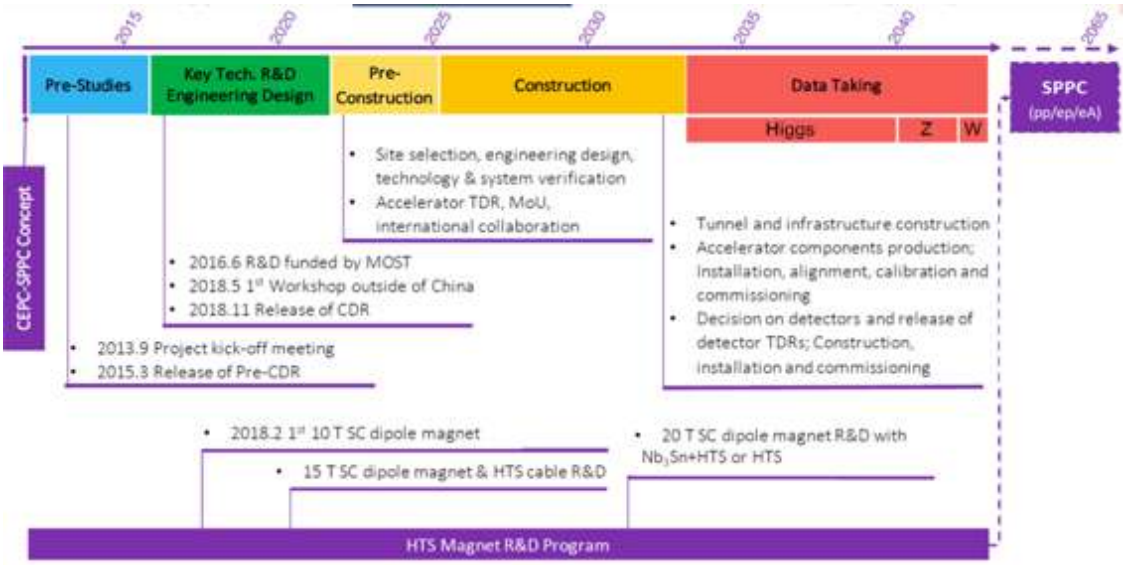
La présidente :

Anne Emery-Torracinta

Copie à : Mme Simonetta Sommaruga, conseillère fédérale chargée du département fédéral de l'environnement, des transports, de l'énergie et de la communication

"If it's not us, it' China"

During public discussions on the FCC, we inevitably hear the following argument*: "If we don't build this machine, the Chinese will."* An argument that often hits the nail on the head. This is not the place to try and distinguish between European combativeness and mistrust of the Chinese regime. Suffice to say that the People's Republic of China has a project equivalent to the FCC, the CEPC (*Circular Electron Positron Collider*) and has never indicated that it would drop it if Europe went ahead with its own! On the contrary, it recently published the technical design report for the machine (58, 59). The decision on whether to go ahead should be taken in 2025 by the People's National Assembly during the 15th Five-Year Plan (2026-2030) discussion.



During a recent interview, CERN Director Fabiola Gianotti statted: *"If China manages to build this collider, which is the equivalent of our FCC, if it manages to build it before us, Europe will lose its leadership not only in particle physics, but also in all the technologies that go with it."* (60).

Is it an exaggeration? Will China, as announced, open its construction site in 2027? Who knows! Whatever the case may be, it is embarrassing and painful to see CERN – which readily recalls its historic mission of uniting researchers across borders – playing its part in terms of geopolitical *soft power*. "Soft" because let us not forget, no practical application of this research has yet been identified.

Is it not first and foremost up to the famous *World Particle Physics Community,* also known as *the World High Energy Physics Community*, to agree on **the essential issue: not accelerating global warming?**

This Community, both an epistemic community and a corporation defending its interests tooth and nail, brings together some 40,000 people from all over the world. They are well connected, they collaborate. The names of several Chinese institutes appear in the FCC's technical design studies, and the names of many European institutes and research centers appear in the Chinese project's technical design studies.

If these cosmopolitan scientists, with their unparalleled level of training, don't come to their senses and finally take their climate responsibilities seriously, who can we count on? Using selfish arguments to evade the collective duty is unworthy.

Is it premature to intervene ?

CERN claims that it has not yet decided between the various post-LHC collider projects under study. This allows CERN, and by extension the authorities, to avoid responding to the concerns of associations and the public. However, given the difference between the resources committed to the FCC and the other projects under consideration, and given the number of publications, collaboration agreements, conferences, seminars, web pages, etc., it is hard not to see that the FCC is clearly the favorite.

Another reason given for declining to discuss the project's impact is that we need to wait for the feasibility studies to be submitted, i.e., by 2025. But the longer we wait, the more difficult it will be to stop the project. Moreover, the figures we already know are sufficient to disqualify it. And so it is:

• The FCC project is not really discussed by the elected representatives.

• CERN has involved more than 170 laboratories in its studies and, on the day of the decision, will have invested far more than the 100 million Euros initially devoted to the current feasibility studies.

• Those concerned are accomplishing their public relations work so that, when the time comes to chosse, making the FCC will seem obvious and abandon it unthinkable. The longer we wait to reassess the project in the light of its impact, the harder it will be to stop it.

The time to take a hard look at the issue is **now**.

Those who support the project would prefer not to rush the discussion:

"A specific challenge will be to avoid media hype, particularly in the Geneva region, with shortcuts or simplifications suggesting that the Member States have already taken the decision to fund and build the FCC (or any other alternative project, the CLIC linear collider for example)". (61)

Noé21 point of view...

In Geneva, **CERN has been known as a voracious consumer of energy for decades**. Its annual electricity consumption is 1,250 GWh, almost half that of the entire canton (2,700 GWh for all sectors combined, excluding CERN).

However, as the electricity comes from the French grid, this figure is not relevant to the Geneva energy debate. And as CERN is an international organization with the usual immunities and privileges, the canton does not intervene. What's more, CERN is a source of pride for the locals and is regarded internationally as an exceptional institution. So even though we've known for years that CERN is energy-hungry, **silence remains the order of the day**.

The belated recognition of the reality of **climate disruption**, with its mind-blowing weather episodes and the programmed suffocation of millions of people, forces us to react. But how?

One of the necessary measures is to **save energy so as to close fossil-fuelled power stations as quickly as possible**. Which is proving difficult to achieve. Some households and corporations are trying to adapt their consumption habits, others are changing their daily habit, while others are passive, sometimes taking refuge in denial.

It was against this backdrop that CERN announced its intention to build an accelerator around 100 km long, **tripling its electricity consumption to 4 TWh per year.** Astonishing! For comparison:

Electric public transport throughout Switzerland (railways, trams, trolleybuses, etc.) consumes **3 TWh of traction current per year.** They transport several million people and 200,000 tonnes of goods a day, and its usefulness cannot be doubted. On the other hand, CERN and its planned FCCs would consume a third more electricity for the needs of some thousands of scientists who see their discipline as a race against time on which all of science depends and which will benefit society as a whole. But this is not the case.

Yes, scientific research must continue. But let's imagine the existence of the Higgs boson had not been confirmed in 2012 and would have needed an extra 20 years to be pinpointed. In what respect would people's lives be different?

The question inevitably arises as to the appropriateness of such a huge project in the context of climate change.

To fully understand the ins and outs of the project, we studied it from various angles and found that **the following points were sufficient to disqualify it**:

1. Its enormous power consumption
   Why should CERN have such a large share of the electricity while every kWh must be saved?

2. Its impact on the climate
   Why does CERN think it is exempt from taking the climate issue into account?

3. The impact of the project on the region
   What gives CERN the right to: impose 12 years of work, some 60 km of roads to build, retrieve hundreds of acres for surface sites and molasse material storage areas, dig out the equivalent of three Cheops pyramids of debris to evacuate, add swarms of additional trucks on roads, to residents who don't want any of this?

Our conclusion is that CFCs are indefensible in the current context and that the project should have been abandoned as soon as the conceptual design report had been submitted.

The project is incompatible with our climate policies, makes a mockery of all our efforts to save energy and discourages households and corporations who strive to reduce their energy consumption.

We call on CERN to abandon this project and any other excessive projects.
If CERN does not do so spontaneously, we call on the Federal Council to shoulder its responsibilities...

... by quickly announcing that its representatives on the CERN Council would vote against the FCC project
... by contacting other Member States to encourage them to do the same
... and capping CERN's energy consumption.

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