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Changing the world of research based on solid measurements

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Labos 1point5: Reducing the environmental footprint of our research activities

Scientists are becoming more aware of the impact of their activities on the environment. They also want to base their analysis of the situation on measurements, leading to decisions to minimise their contribution to climate change and pollution. With this in mind, scientists in French labs started the Labos 1point5 collective in 2019, to survey what is already ongoing, to study how research is being carried out, to think about changes to promote in our teaching and research approaches, and to provide tools to measure our labs greenhouse gases emissions in a standardised way. With GES 1point5, hundreds of labs are reporting their yearly emissions from buildings, electricity, duty travel, commute and procurement. The latest addition includes emissions linked to the usage of large infrastructures such as CERN, large computing centres and astronomical observatories. The kit 1point5 and scenario 1point5 tools suggest measures and model their impact by 2030, aiming at a 50% reduction in GHG emissions.

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*Speaker

1. Labos 1point5

Inspired by the Paris Agreement and the work of climate scientists, a grassroots collective action was launched in March 2019, via an op-ed in the French leading newspaper *Le Monde* [1]. Thousands of professionals of all fields of science signed this manifesto, calling for a reduction of the environmental footprint of research activities. The Labos 1point5 collective [2] is now followed by more than 4000 individuals, in a rich network of people, labs and initiatives.

This bottom-up approach was soon recognised as a valuable asset by CNRS (the largest research institution in France, covering most fields), and a GDR (groupement de recherche) was created in November 2021 with the support of CNRS, INRAe (national research institute for agriculture, food and the environment), ADEME (French agency for ecological transition) and INRIA (national institute for research in digital science and technology). The aim is to understand and reduce the environmental footprint of research. About 250 persons are participating in this research activity along two main axes: measuring and characterising the greenhouse gas (GHG) footprint of public research, and supporting and facilitating the implementation of reduction trajectories within laboratories.

The founding principles, with an emphasis on collective action and the transformation of research practices, aim at reinventing the way we do research, such that it becomes compatible with planetary boundaries and all humans well-being on the planet. It should in particular (but not only) address the climate emergency and align with global targets to limit warming to 1.5°C. This is made possible by first quantifying and understanding the carbon footprint of our labs, its determinants, uncertainties and heterogeneity given the vast variety of activities in different research domains, as described in the next section. The second step consists in implementing solutions tailored to each lab, locally designed and followed up, as a way to re-empower our labs as decision makers.

Pushing further, this process facilitates the necessary reflexive work on the coherence, responsibility and ethics of research in relation to the low-carbon transformation of our societies (carbon emissions currently being the main but not only focus), as recently encouraged by the CNRS ethics committee [3].

2. GES 1point5

GES 1point5 [4] is a free, open source [5] and online tool [6] to measure the carbon footprint of laboratories. Rather than letting each lab use a different tool relying on different assumptions, GES 1point5 has one standardised methodology, adjusted to the specificities of research. GHG emissions are computed per lab and per year.

2.1 Emissions classification

The main emissions categories reflect our labs activities:

buildings: it takes into account emissions from the building construction, electricity consumption, heating, refrigerant fluids and water consumption.

procurement: for lack of a better proxy for the time being, monetary emission factors are used to associate emissions to all purchases not listed in another category, be it materials, machines,

hotel rooms, etc. This is done by associating each purchase to one of about 250 categories, each of which having its own monetary factor.

digital devices: specific emissions are attributed to various types of computers, servers, screens, etc., based on the EcoDiag tool from the EcoInfo CNRS group [7].

lab vehicles: cars, trucks, etc owned and used by labs, taking into account the type of vehicle and fuel.

business travels: transportation part of duty trips depending on distance and mode of transportation (also as standalone simulator [8]).

commute: survey-based accounting of emissions due to travels from home to work based on mean(s) of transportation and distance (also as standalone simulator [9]).

food: recently introduced, survey-based accounting of lunch time food consumption to evaluate impact of dietary choices.

As the tool is used by more and more labs (more than 1300 and counting), encouraged by their funding agencies, studies can be performed on this large database of more than 2700 GHG yearly inventories [10]. An early article pointed out the heterogeneity between labs [11], although recent analysis shows comparable emissions within IN2P3 labs (French particle and nuclear physics labs). In particular flight quotas [12] and the leading contribution of procurement on GHG emissions in our labs [13] have been studied.

GES 1point5 is available in French and English. Discussions are ongoing to make the tool usable in other countries, as right now it for instance relies on the specific categorisation of procurement in the French administration.

2.2 Research infrastructures

The emissions discussed in the previous section account for activities happening within each lab, while we are also users of facilities elsewhere, for computing, experiments, etc. Although emissions from these places are not directly attributable to specific users, it is important to evaluate what their usage represents as without them, part of our research would be impossible.

In the following sections, the usage of CERN and astronomical observatories is presented. Some computing facilities (high performance computing from GENCI) have also been introduced in GES 1point5, as well as emissions linked to livestock and fertilisers. More such cases will be introduced in the future.

2.2.1 CERN

CERN has been producing biennial environment reports since 2017 [14], refining scope, methodology and numbers over the years. The latest one, covering years 2021–2022, also contains updates for previous years and was used as a basis to estimate emissions linked to using the CERN infrastructures.

Given this input some assumptions have to be made in order to affect GHG emissions to users: where to affect accelerator research, how to share LHC emissions between experiments, how to evaluate and split scope 3 (mostly procurement)? It was decided to ignore emissions from LHC and tunnel construction in the calculation, not because they would be negligible but for partial

lack of information (although a rough estimation was performed) and because they represent past emissions that have no bearing on mitigating current and future emissions. Such emissions would on the other hand have to be accounted for in future projects.

Considering that physicists are the end users of the data produced at CERN, it was decided to share emissions among them only. These are well-known numbers, both to labs and CERN, on 31 December of each year [15]. Each lab using GES 1point5 only has to provide its number of PhD students, post-docs and staff working with CERN (split between LHC or non-LHC) to evaluate emissions.

Environment reports provide emissions in three scopes:

scope 1 is dominated by direct emissions from gases used in LHC experiments for particle detection and detector cooling (~ 17 tCO₂e/y attributed to LHC users). A small part goes to non-LHC experiments (~ 4 tCO₂e/y), while heating and a small “Other” category are split among all users (~ 1.3 tCO₂e/y).

scope 2 is driven by electricity consumption. Comparing consumption between years where LHC is running and during long shutdowns (LS), it was decided to attribute LS consumption equally to all users, and the extra consumption of data-taking years to LHC users only.

scope 3 is only fully available (including the main procurement contribution) for years 2021–2022. Assumptions were made for previous years: in 2017–2018 (running LHC), 2022 conditions are used for waste and water, while pre-covid conditions are used for travel, commute and catering (as behaviours have changed post-covid). For procurement in 2017–2020, the 2021–2022 average is used. Emissions are split equally among all users.

All numbers come with uncertainties. Emission factors uncertainties from GES 1point5 are used for gases (30%) and electricity (10% for the French mix mostly used by CERN). An uncertainty for methodology was derived comparing the described approach with results obtained if attributing all emissions to LHC users, leading to 30% uncertainty for LHC users and 20% for non-LHC users.

Emissions attributed per user and per year are reported in Figure 1, separately for LHC (~ 35 tCO₂e/y when the accelerator is running) and non-LHC physicists (~ 18 tCO₂e/y). When included in IN2P3 labs GHG inventories, they represent between 30% and 70% of their emissions.

2.2.2 Astronomy

Astronomical observatories, both in space and on Earth, are also sizeable GHG emitters, during construction and operation all around the world in remote places or at launch time for satellites [16]. To account for them at a single lab level a bibliometric approach was chosen, based on telescopes used in each lab’s publications. The data are extracted from ADS [17], and emissions attributed with the ratio of lab authors who published articles citing a specific infrastructure and all authors in the world who published articles citing the same infrastructure. Emissions are split by construction (with 38 years of amortisation for telescopes, 18 years for satellites) and operation. The current implementation is limited in the number of considered facilities, but will be updated soon following a more thorough survey [18].

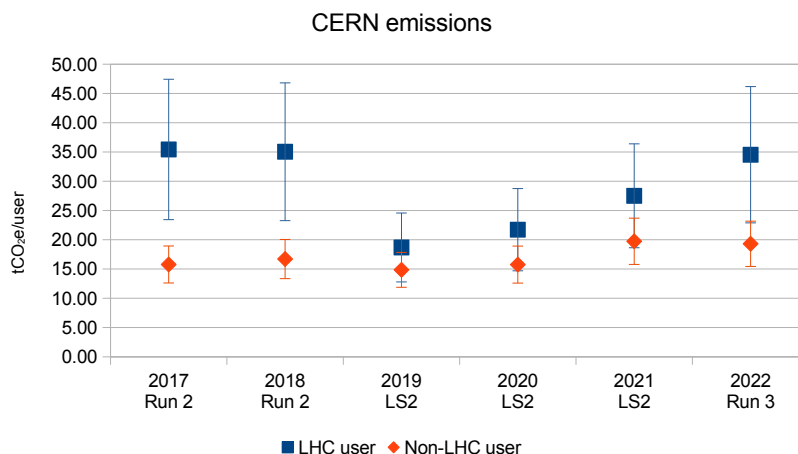


Figure 1: CERN emissions per physicist

3. Outlook

The French research community got together in Labos 1point5 to tackle climate change. All research areas are involved, and what started as a grassroots initiative is now supported officially and encouraged by hierarchy and funding agencies. The collective provides tools and methods to evaluate GHG emissions in a standardised way with GES 1point5, but also webinars and scientific papers on the subject. Having collected a large database of GHG inventories, it is already possible to analyse the structure of research emissions. Even if they vary a lot across labs of many different fields, it reveals the importance of procurement, and has allowed to evaluate the impact of various scenarios on travel emissions. It also forces to acknowledge the sizeable impact of big research infrastructures like CERN, astronomical observatories or national computing centres. This calls for action within our labs and research communities. Labs are designing GHG emission reduction plans, with a goal of -50% by 2030, helped with simulations provided by the Scénario 1point5 tool [19], and sharing their experience within the Transition 1point5 network [20], hence suggesting measures to other labs to overcome these challenges. This growing community is also an encouragement for more research institutions to join the initiative, transforming research towards a more sustainable future.

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