ECFA ECR Meeting
Environment & sustainability Report

E. Graverini on behalf of the WG

Working group report

Meeting held on Monday 4 November. ~40 attendees.

All agreeing with each other and constructing on each other's ideas. :)

This is a summary of the discussion that happened during and after the meeting.

Disclaimers:

- summary largely centred about CERN point of view, but concepts are general to the field.
- little information. Many ideas. Inputs welcome!

Reminder:
general whiteboard for comments

LINK to WG Google Doc

1. Key issues

We discussed three main viewpoints about the sustainability of particle physics research and its inherent environmental impact.

- ➔ **Technical aspects**
  Equipment, computing resources, experiment operation, optimization of resources.
- ➔ **Financial aspects**
  This can be a bit costly. How do we finance sustainability?
- ➔ **Social aspects & awareness**
  Conferences and flights. Small actions with little impact still required to raise awareness.

What is the impact on the environment of particle physics research?

Numbers

CERN = 1.3 TWh/year

LHC ≃ ½ CERN

CERN data centre = 36 GWh/year

12'500 CERN users

??? flights to/from CERN and other laboratories...

Instrumentation

10.7 Energy management

All proposed HEP projects will consume large amounts of energy, $\mathcal{O}$(TWh) per year. On the other hand, an increasing fraction of sustainable energy sources like wind and photovoltaics in the future energy mix will result in strong variations of the supply of electrical energy. It is the HEP community's responsibility to develop sustainable models and optimized technologies in terms of energy consumption, aiming also at exporting improved technologies for other applications in the society.

One way to mitigate the impact of HEP facilities is to actively manage their energy con-
on. The aim should be to avoid high loads on the grid during low supply conditions,

and instead using preferentially "excess energy". The possibilities of energy management using dynamic operation of facilities and energy storage systems should be studied in more detail.

It is necessary to invest R&D effort into improving the energy efficiency of HEP facilities through critical technologies. In certain areas, such R&D will have an immediate impact on research and other facilities operated today, and the savings in energy consumption may be used to co-finance the investments. Certain improved technologies may also serve society directly. These relevant fields of R&D include (but are not limited to) optimized magnet design, high-efficiency RF power generation, improved cryogenics, lower loss or higher operating temperature SRF cavity technology, beam energy recovery, district heating using recovered heat, and energy storage.

Proposals for future lepton colliders include linear colliders using normal-conducting or

- Physics Briefing Book lacking...
- Attention so far mostly focussed on **energy efficiency** of equipment
  - should also carry out detailed studies of the environmental impact of **construction**, **disposal**

- ECFA sustainability WG: include the power production into the project as a whole (e.g. a power plant based on renewable sources to power our accelerator)?
- **civil engineering** has large carbon footprint too (concrete industry: ~8% worldwide)
- redesign experiment to avoid use/waste of gases with high Greenhouse Warming Potential
- improve acceleration technologies (see e.g. ERL talk here)

Operation

- Latest public figure of CERN power consumption: **1.3 TW/year**
  - LHC makes up about 53%
  - the whole accelerator complex makes up 90% of this figure
- Big labs such as CERN should leverage their high energy consumption to negotiate with the companies providing them energy. E.g. to get fed only by renewable energy sources.
- Any investment aimed at lowering energy consumption, resource usage, computing resources usage, or aimed at mitigating the environmental impact of instrumentation/facility construction and disposing, will have a **financial return** in a number of years. CERN will profit from **long term savings** after investing in energy efficiency
- If CERN and other physics labs invested in research for renewable energy and sustainability, could potentially become global leaders in the field.
  - It would positively affect the rest of society as well.
  - Diverse investment that would lead to bigger budget for physics eventually.
  - Positive attitude toward physics from the public. Could lead to favourable political decisions.

Computing

- Commercial cloud computing makes up about 2% of carbon emissions, worldwide
- At CERN this is minor with respect to accelerator operation
    - but do not forget there are several Grid sites all across the globe
    - servers / storage systems consume power
    - ...and need to be cooled
- Relatively easy gains are possible!
    - e.g.: the Green IT cube at GSI
    - economically worth to R&D in this sense
    - immediate returns for society = funding
    - rethink our computing needs in terms of "sustainable computing"

Flights to/from CERN, conferences

- Air travel amounts to ~2% of worldwide carbon emission
- Conference software and/or VR inadequate, HEP could take the lead in developing these
    - like with the WWW!
- Would institutes/researchers mind paying journeys a bit more in order to offset CO_2 footprint?
    - e.g. LHR <-> GVA = 400kg CO_2 = 1 tree's lifetime = 1-10€ to plant. See link1, link2

ECR challenges

- number of conferences = visibility of young researcher = requirement in hiring process
    - leads to unsustainable and unnecessary number of journeys
    - discriminates against ECRs with family or local commitments
    - biases towards groups with larger travel budget
- job market highly competitive → ECRs prioritize career prospects over environmental concerns
- taking a strong position can restrict career possibilities
- does one need to be 100% present at CERN to take on a **leadership / responsibility position**?

How can we improve?

Environmental impact of research centres

- Request that new projects / upgrades provide an **analysis of environmental impact**. Define **objectives to mandatorily meet** as a **requirement for approval**.
  - Requirements should be ambitious, not only in line with the IPCC.
  - CERN (or the hosting institute proposed for the experiment) should create a permanent committee to define and enforce such requirements.
  - Evaluate the climate commitment of the countries where new projects are hosted
- **Carbon free by 2030?** CERN, as a leading research centre, should have as an **ambitious vision** as possible. If there is any entity that can take a lead in changing the way we do things, it is CERN. Attract professional figures that will make these goals achievable.
  - E.g.: servers / instrumentation produce a lot of heat. Attract thermodynamics engineers that will find out what to do with all the extra heat.
- Request that **global goals** are set as part of the **European Strategy**.
- Move towards **renewable sources** for electrical power consumption.
  - e.g. CERN needs to at least complement nuclear power from French plants

Outreach / society aspects

- the Lab's public image will greatly profit from implementing an ambitious strategy for sustainability. It will in fact suffer from not doing it.
    - can expect increased research quality and financial returns from engaging in multidisciplinary studies aimed at sustainability.
    - use leverage to put (green) pressure on member states and service providers.
- Small actions are still important!
    - limited direct impact, but large induced impact from raising awareness
    - e.g.: replace / reduce climatization by adding vegetation on labs / offices roofs
    - e.g.: add solar panels
    - e.g.: hold conferences in places reachable by train by most attendees
    - e.g.: reserve budget to offset uneliminable carbon emissions
    - e.g.: promote biking (more! Need to make sure of the biker's safety)
    - e.g.: greener mensas (improve veg options), information/ training events, clubs
    - e.g.: deals with local public transport (many such deals already in place at universities)
    - e.g.: rental electric cars only, and add electric car charging stations

Examples: waste heat recovery

Waste Heat Recycling at Paul Scherrer Institute (PSI)

- Using waste heat sources above 50°C, e.g. HIPA HF, SwissFEL, He-Compressors etc.
  - Refuna: **remote heating network**, gets heat from nearby nuclear power plant.
- In 2018, **~60% of the heat** provided by waste heat recovery, 40% by Refuna.
- Project initiated in 2010 with investments below 4 MCHF. **Break-even after 10 years** in 2021. **Savings of O(450 kCHF) annually** thereafter, assuming current prices.
- **Future Plans:** include waste heat below 50°C, e.g. SLS2.0, computing. Cover **~90%** needs.

Heat up Ferney-Voltaire using LHCb's waste heat

- agreement signed between CERN and French authorities. Start operation in 2022
- waste warmed up cooling water (30°C) from P8 will be used to heat a new residential area in F-V.
- can do the same at P2 (Saint Genis Pouilly), P5 (Cessy), P1 (CERN Meyrin site).

Wasted heat can be recovered and reused. Additional wasted heat can be partially converted into electricity via stirling engine systems.

Our recommendations

1. CERN to take a lead in switching to sustainable research.
2. Set and respect goals more ambitious than the IPCC ones.
3. Projects requested to evaluate environmental impact and work on their sustainability.
4. Sustainability as a requirement for approval; threshold studied by dedicated committee.
5. Transform resource intake: switch to renewable energy, invest in low-power technologies, reuse waste heat etc.
6. Develop videoconferencing and demote air travel.
7. Raise awareness in the community.

……

……

Your input welcome! :)

> **Limiting warming to 1.5°C depends on greenhouse gas (GHG) emissions over the next decades, where lower GHG emissions in 2030 lead to a higher chance of keeping peak warming to 1.5°C (*high confidence*).** Available pathways that aim for no or limited (less than 0.1°C) overshoot of 1.5°C keep GHG emissions in 2030 to 25–30 GtCO2e yr^{-1} in 2030 (interquartile range). This contrasts with median estimates for current unconditional NDCs of 52–58 $GtCO_2e$ yr^{-1} in 2030. Pathways that aim for limiting warming to 1.5°C by 2100 after a temporary temperature overshoot rely on large-scale deployment of carbon dioxide removal (CDR) measures, which are uncertain and entail clear risks. In model pathways with no or limited overshoot of 1.5°C, global net anthropogenic CO_2 emissions decline by about 45% from 2010 levels by 2030 (40–60% interquartile range), reaching net zero around 2050 (2045–2055 interquartile range). For limiting global warming to below 2°C with at least 66% probability CO_2 emissions are projected to decline by about 25% by 2030 in most pathways (10–30% interquartile range) and reach net zero around 2070 (2065–2080 interquartile range).[1] {2.2, 2.3.3, 2.3.5, 2.5.3, Cross-Chapter Boxes 6 in Chapter 3 and 9 in Chapter 4, 4.3.7}
>
> **Limiting warming to 1.5°C implies reaching net zero CO_2 emissions globally around 2050 and concurrent deep reductions in emissions of non-CO_2 forcers, particularly methane (*high confidence*).** Such mitigation pathways are characterized by energy-demand reductions, decarbonization of electricity and other fuels, electrification of energy end use, deep reductions in agricultural emissions, and some form of CDR with carbon storage on land or sequestration in geological reservoirs. Low energy demand and low demand for land- and GHG-intensive consumption goods facilitate

Backup slides

Examples

Waste Heat Recycling at Paul Scherrer Institute (PSI)

- Using waste heat sources providing temperatures above 50°C
  e.g. HIPA HF (1.5 MW), SwissFEL(0.6 MW), He-Compressors (0.3 MW) and many more
  - Example **HIPA HF**: 4 MW electrical power in, 1.5 MW beam, 1.5 MW heat recovered, 1 MW elsewhere. (Note: HIPA uses 12 MW in total)
- In 2018, roughly **60 % of the heat needed** were provided by waste heat recovery, 40 % provided by Refuna. Need Refuna in winter, when HIPA is shut down.
- Project initiated in 2010 with investments below 4 MCHF. **Break-Even after 10 years** in 2021. **Savings of O(450 kCHF) annually** thereafter, assuming current low prices.
- **Future Plans:** Include waste heat below 50 °C. (e.g. SLS2.0 (1.5 MW), Computing (0.5 MW). **Cover O(90%) of heating** needs. To be considered once Beznau (nuclear power plant around the corner) is switched off and heat gets more expensive.

Waste heat recovery from accelerators is done economically at PSI. CERN and other institutes should do at least as much and develop a system including waste heat of lower temperatures.

Varia

- See AIDA presentation on gas for RPC systems https://indico.cern.ch/event/863154/contributions/3637353/attachments/1943925/3224784/EOI56-presentation_13_11_2019_v3.pdf

- IPCC reports: https://www.ipcc.ch/reports/
- IPCC pathways to <= 1.5°C warming: https://www.ipcc.ch/site/assets/uploads/sites/2/2019/02/SR15_Chapter2_Low_Res.pdf