Workshop Introduction
Setting the Stage

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Sustainable HEP - 2nd Edition

5th September, 2022

Acknowledgements

We thank **Elena Gianolio** for her constant support on the technical side.

We also thank **Gian Giudice, Marko Simonovic, Valerie Domcke, Michelle Connor** and the **CERN TH** department for helping us organise this workshop.

Historical context

- First **Sustainable HEP** workshop series held between **June 28-30, 2021** successfully organised by **Niklas Beisert**, **Valerie Domcke**, **Astrid Eichhorn**, and **Kai Schmitz** **https://indico.cern.ch/event/1004432/**

- The workshop started several interesting discussions within the **High-energy, Cosmology, Astro(Particle) Physics (HECAP)** community which continues till today.

- Follow-up **one-day mini-workshop** held on **18.01.2022**

- Existing Mattermost Channel: https://mattermost.web.cern.ch/sustainable-hep/channels/town-square

- New Mattermost sub-channel: https://mattermost.web.cern.ch/sustainable-hep/channels/sustainable-hep-second-edition

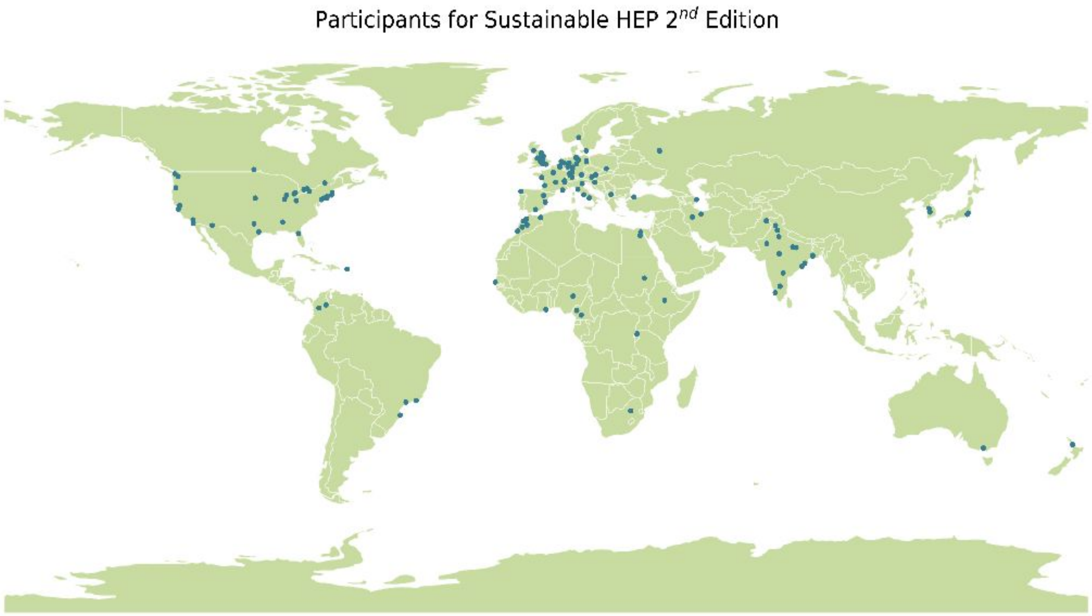
- Mattermost channels for the various initiatives and special interest groups from the last meeting still exist for anyone who wants to join.

About this workshop

Participants

- **254** registered participants
- **30** speakers + panelists

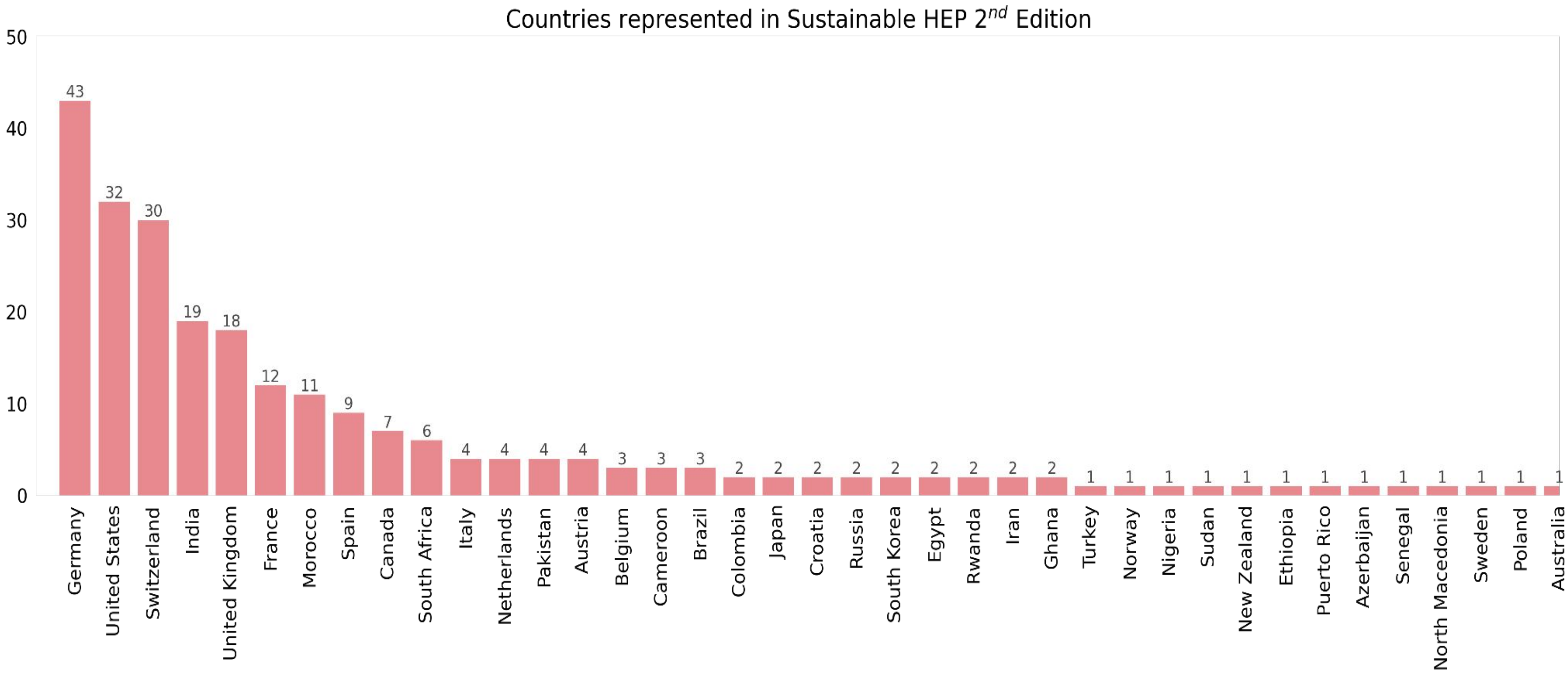
Members from 39 countries covering 5 continents



A fully online format helped us reaching out to scientists motivated towards this common cause from different countries and different backgrounds. We also required minimal financial support and received logistical support from the CERN TH department.

Building on last year's successful 1st edition, the plan is to build a sustainable HECAP community.

Participation by institution’s country



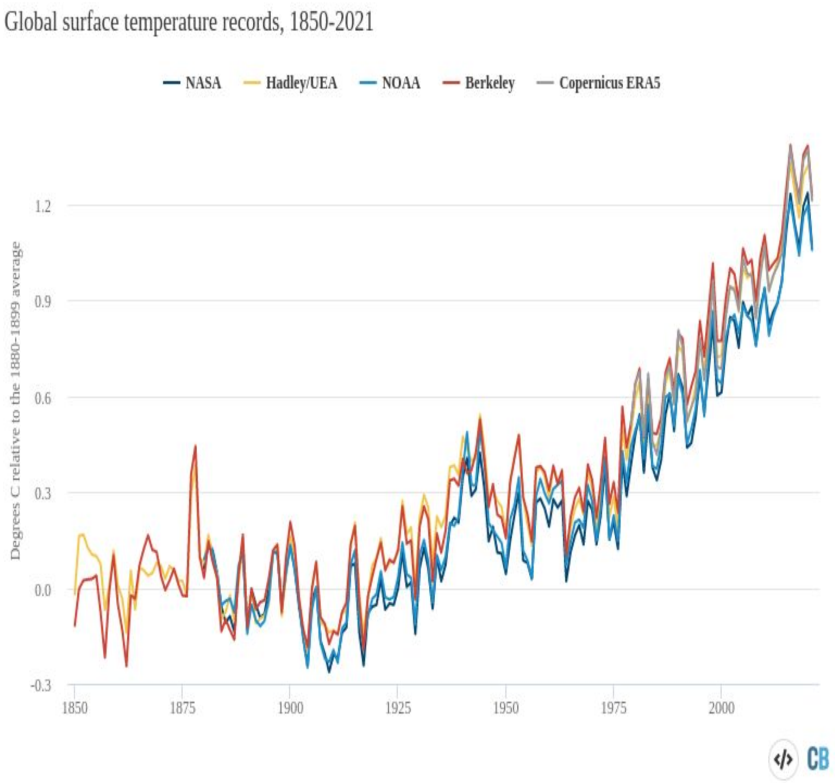
Disclaimer and Code of Conduct

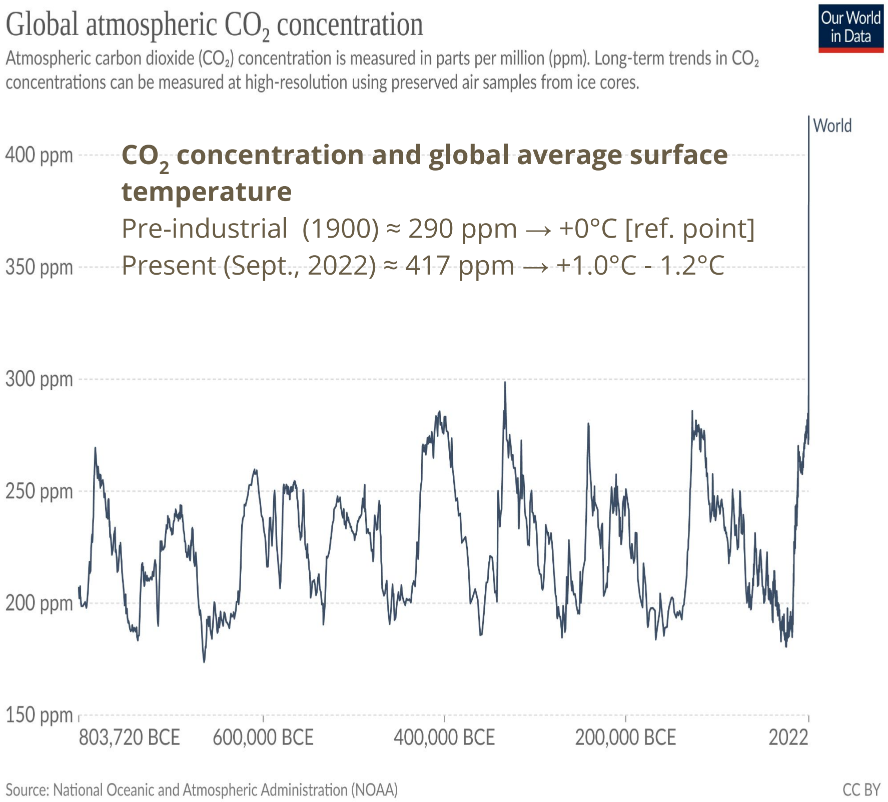
- Most of us are not climate scientists — Please treat any error on our part with courtesy.
- Please maintain courtesy during discussions and in the Mattermost channels. We are all here to learn.
- For questions or comments please  raise hand. Chair or technical support person will ask you to speak when your turn comes.
- If you aren't speaking, please keep yourself muted during sessions.
- Please keep your video off except for speakers and panelists (great if you can have your camera on) and for persons asking questions (would be nice for the speakers to have some personal impression).

Global warming and climate change

- Long-term heating of Earth's surface observed since pre-industrial era (1850-1900) due to human activities. Mechanism well understood.
- Caused by the anthropogenic greenhouse gases (GHGs) which give rise to greenhouse effect
  - GHGs: CO_2 (stable), methane (25 times more potent than CO_2 and short lived), nitrous oxide, water vapor, and synthetic fluorinated gases
  - Trap the sunlight on earth. Tips the balance of the radiation escaping into space.
  - Earth gets hotter
- Pollutants (GHGs) can stay in atmosphere for years and up to centuries.
- Human activities, e.g. burning of fossil fuels (**coal**, oil, gasoline etc), generating power, deforestation, agriculture, transport, etc are direct contributors of GHGs
  - Change in atmospheric concentration by **> 115 (23) ppm in the last 100 (10) years**. [Source: Our World In Data]
  - **> +1° C increase in the average surface temperature**

Surface temperature and atmospheric CO2 concentration change





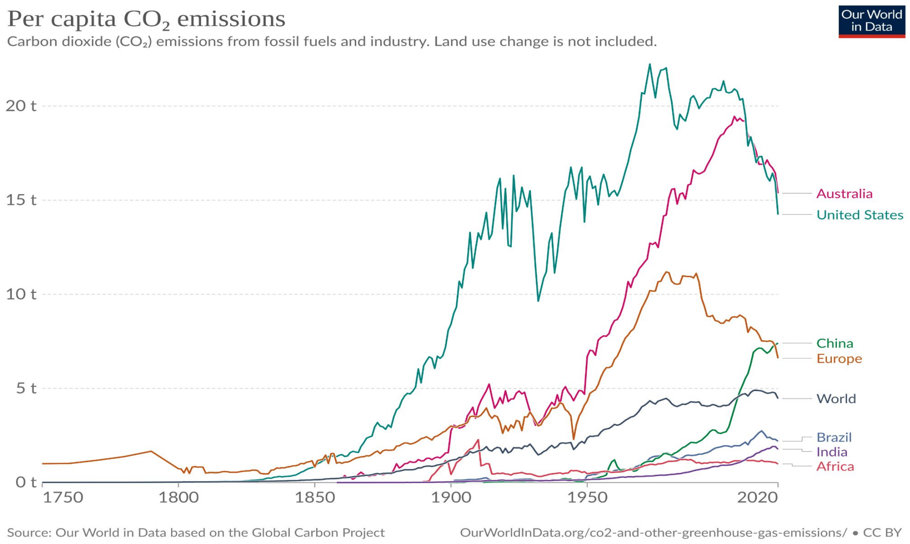
CO_2 concentration and global average surface temperature

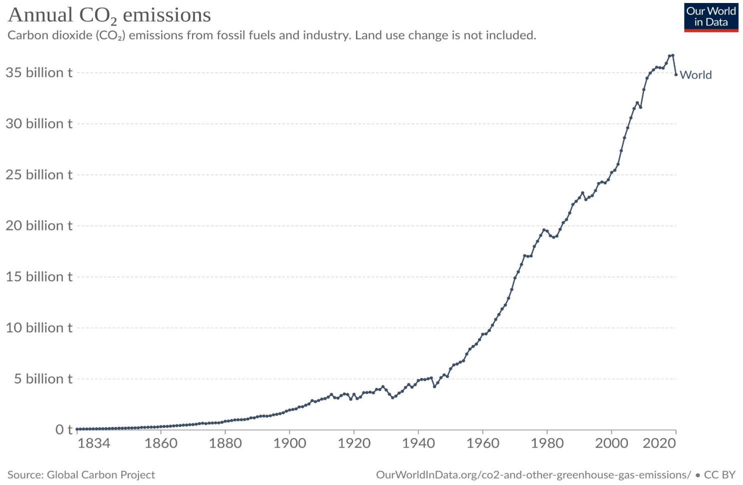
Pre-industrial (1900) ≈ 290 ppm → +0°C [ref. point]

Present (Sept., 2022) ≈ 417 ppm → +1.0°C - 1.2°C

Sources: CarbonBrief, and Our World in Data

Global CO_2 emission rates and per capita rate





Per capita average emissions in 2020 by region.

World average:	**≈ 4.5 t**
Australia:	**≈ 15.4 t**
United States:	**≈ 14.2 t**
China:	**≈ 7.4 t**
Europe:	**≈ 6.6 t**
South America:	**≈ 2.3 t**
Brazil:	**≈ 2.2 t**
India:	**≈ 1.8 t**
Africa:	**≈ 1 t**

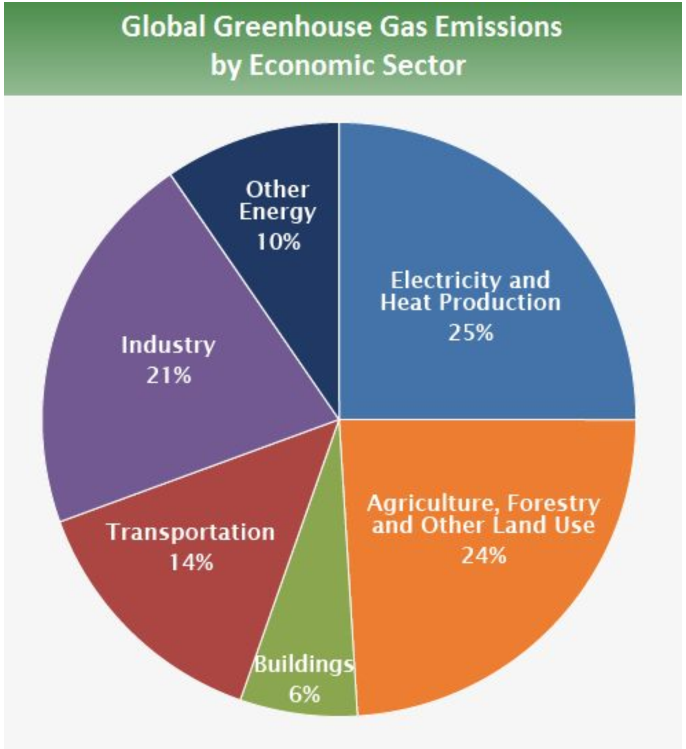
Per capita emissions unequally distributed across the world.

Source: Our World in Data

Global emissions by economic sector

- **Electricity and heat production:**
  Burning of coal, natural gas, and oil
- **Industry:**
  Fossil fuel burning, chemical, metallurgical, and mineral transformation
- **Agriculture, forestry, and other land use:**
  Animals and crops, deforestation
- **Transportation:**
  Fossil fuel burning
- **Buildings:**
  Burning fuel for heat and cooking
- **Other Energy:**
  Fuel extraction, refining, processing, and transportation

Source: [EPA]



International Agreements/Conventions

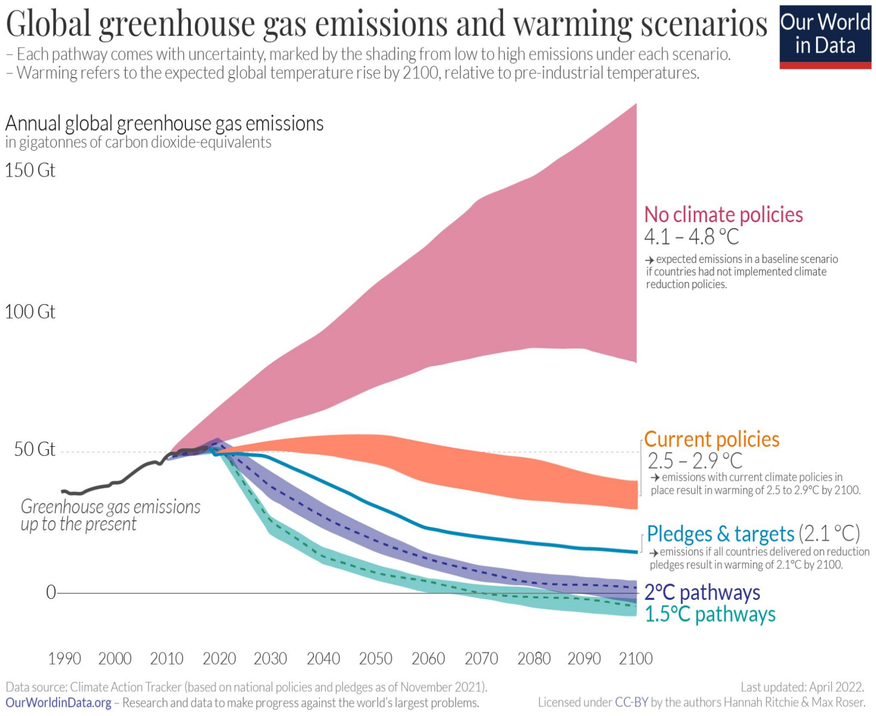
United Nations Framework Convention on Climate Change (UNFCCC) [1992], Kyoto Protocol [1997]

Paris Agreement (December, 2015)

- Limit global surface temperature well below 2.0°C.
- Strive towards limiting below 1.5°C.
- Help poorer nations have access to sustainable energy.
- Carbon neutrality by 2050.
- All 197 UNFCCC members have either signed or acceded to the Paris Agreement.

Status and Projections

- Currently between 1.0°C - 1.2°C
- Without policy agreements between 4.1°C - 4.8°C

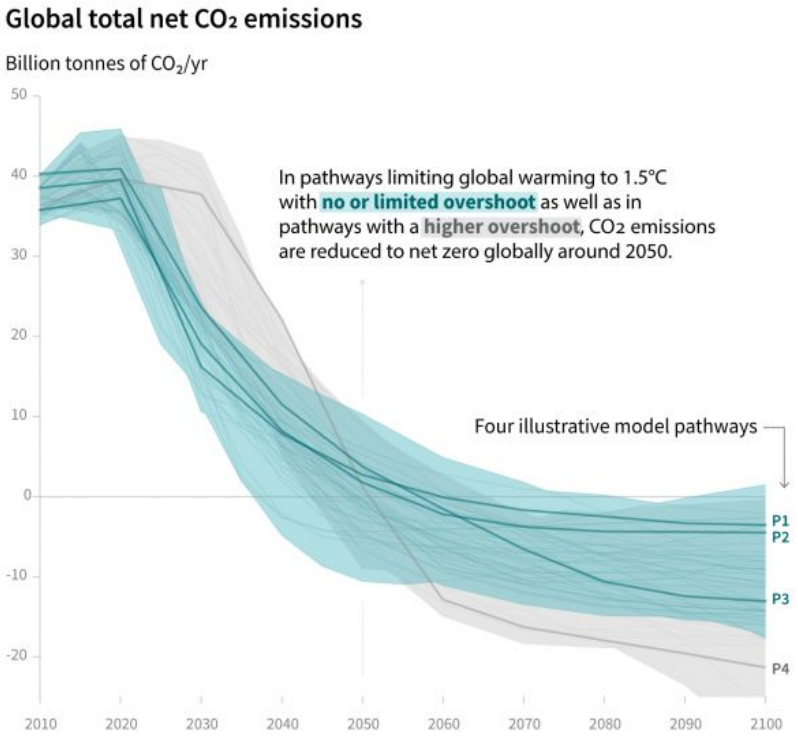


Source: Our World in Data

Towards global net zero

Requirements:

- Reduce emissions by half by 2035. Steep descent
- Net zero emissions by 2060 for all model pathways.
- P1, P2, P3, and P4 are model pathways for **Low Energy Demand** (LED), and **Shared Socioeconomic Pathways** (SSP) S1, S2, and S5, respectively.



Source: IPCC Chapter SR 1.5

Reduction sectors:

- Fossil fuels (limiting coal)
- Nutrition (reducing meat, dairy, fishing)
- Transportation (reducing air travel, cars)
- Buildings (concrete, heating/cooling)
- Unnecessary consumption (e.g. fast fashion)
- CO2 capture and sequestration (reforestation, negative emission technologies (e.g. DACCS))

Emissions in Research Institutes

Scopes:

- Scope 1 (Direct): own heating, cooling, leaked gases
- Scope 2 (Indirect): purchased electricity, heating, cooling
- Scope 3 (value chain): goods, construction, value, equipment, services

~ 10 t CO_2e emissions per person per year (US + Europe averaged).

Fermilab, a case study [Climate impacts of particle physics; Bloom et al, FNAL Environmental Reports, FNAL Sustainability Plans]

Tevatron shutdown, Sept. 2011

	2008	2018	2019	2020	2021
Scope 1+2	384,666	128,304	144,013	106,961	163,818
Scope 3	29,503	16,495	14,468	6,516	17,456

Table 1. Summary of Fermilab GHG emission data from 2008 (reference year) and 2018 - 2021. Emissions are divided into the three scope areas and given in CO2e metric tons [42].

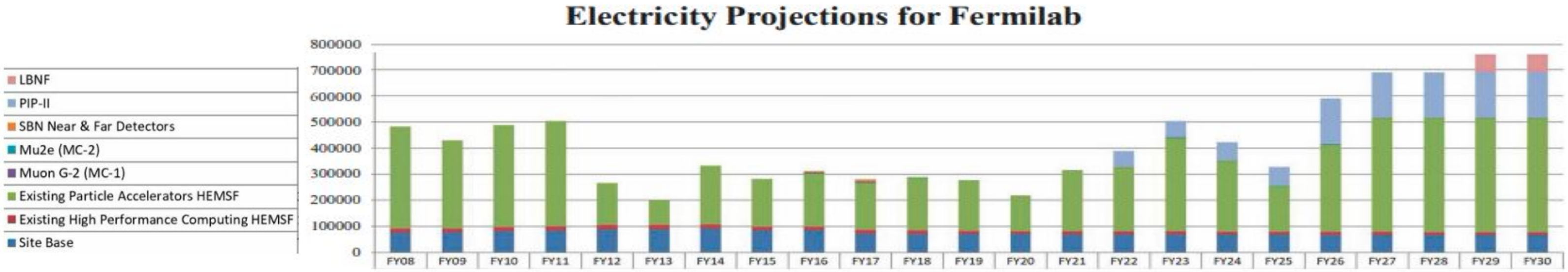
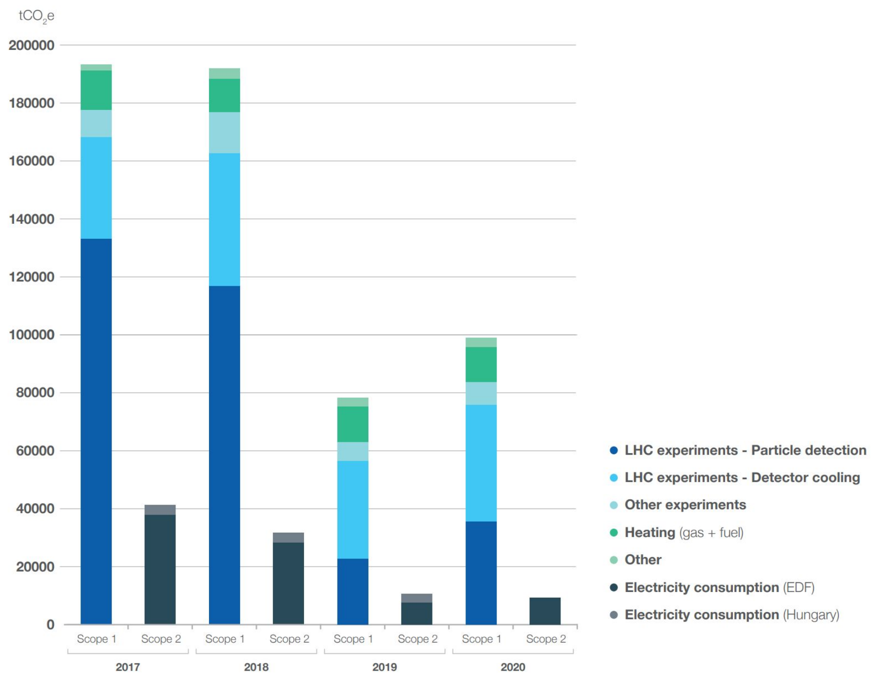
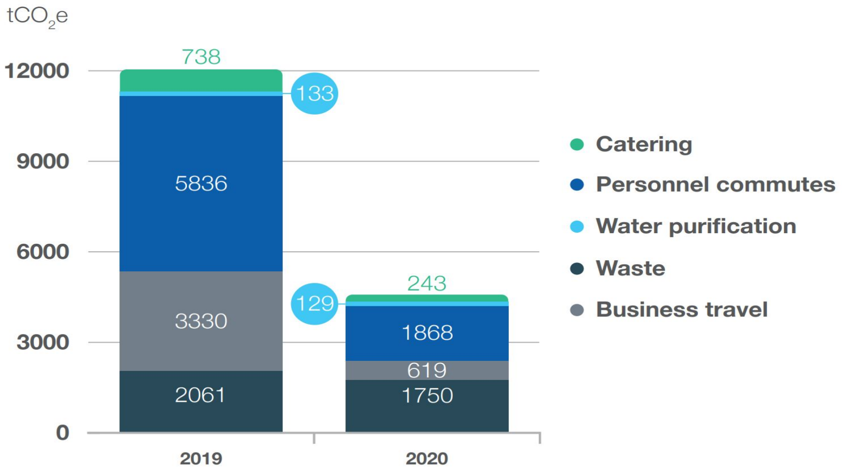


Figure 4. Past and projected future electricity consumption at Fermilab split by the different accelerator projects, computing and site base operation, adapted from [47].

Emissions in HEP (CERN, a case study)



GROUP	GASES	tCO_2e 2019	tCO_2e 2020
PFC	CF_4, C_2F_6, C_3F_8, C_4F_{10}, C_6F_{14}	43277	45678
HFC	CHF_3 (HFC-23), $C_2H_2F_4$ (HFC-134a), HFC-404a, HFC-407c, HFC-410a, HFC R-422D, HFC-507	17540	34899
Other F-gases	SF_6, NOVEC, R1234ze	3840	5377
CO_2	CO_2	13512	13046
TOTAL SCOPE 1		78169	98997



Source: CERN HSE

Agenda for this workshop

- Impulse talk on **Summary of IPCC report**
- **Best-practice examples** including scale back compute, air quality monitoring, sustainable software training, optimising computational footprint, and energy efficient computing
- Impulse talk on **Sustainability and HEP**
- Panel discussion: Preparing a Sustainable Future for HEP
- Impulse talk and discussions on the **17 Sustainable Development Goals** (SDGs)
- **Best-practice examples** including Slow Science, Sustainable Catering Practices in HEP, Climate impacts of particle physics (Snowmass), Sustainable Social Justice, Environmental impact of future colliders and Higgs studies, Particle-Bites - a blog based journal club, grassroots initiative of Sustainable HECAP
- Impulse talk on **sustainability in the scientific information industry**
- Talk on making **HEP and APP a truly global effort** (case study of Ghanaian girls in Mathematical Sciences)
- **Sustainability initiatives** including Webfest, food at work, environment @ CERN, and bike infrastructure
- Summary of SDG Breakout rooms' discussion sessions
- A few future directions including Sustainability Platforms needing humanpower, and "**HEP from Home**" conferences
- Plus, a lot of time for discussions in open forums, and on our dedicated Mattermost channels

Mattermost links for today's sessions

Impulse talk 1:
https://mattermost.web.cern.ch/sustainable-hep/channels/2022-day-1---impulse-talk-verdolini

Best practice examples:
https://mattermost.web.cern.ch/sustainable-hep/channels/2022-day-1---best-practise-examples

Impulse talk 2:
https://mattermost.web.cern.ch/sustainable-hep/channels/2022-day-1---impulse-talk-grimshaw

Panel discussion:
https://mattermost.web.cern.ch/sustainable-hep/channels/2022-day-1---panel-discussion

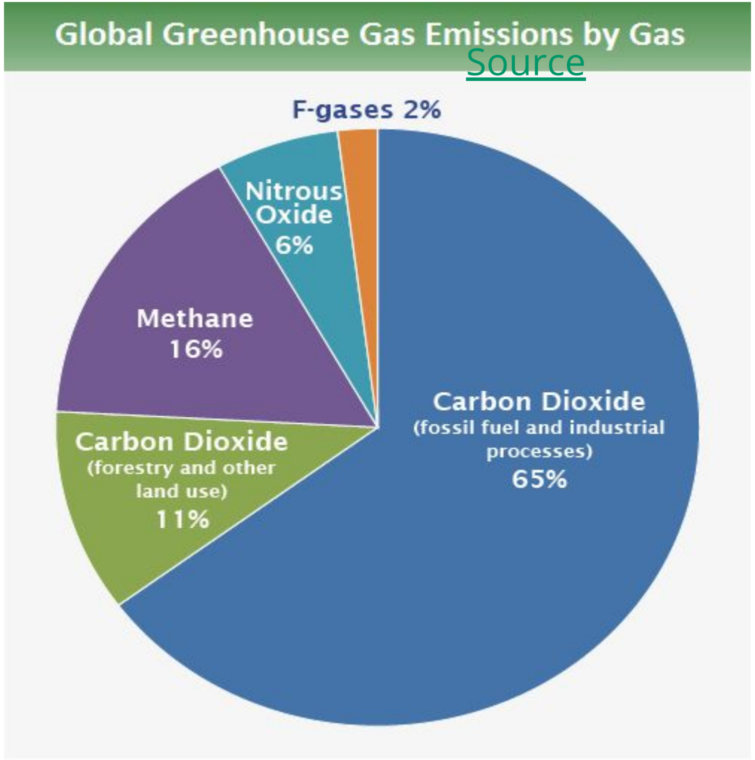
Thank you for contributing!

Let’s have a fun and educational workshop.

Backup slides!

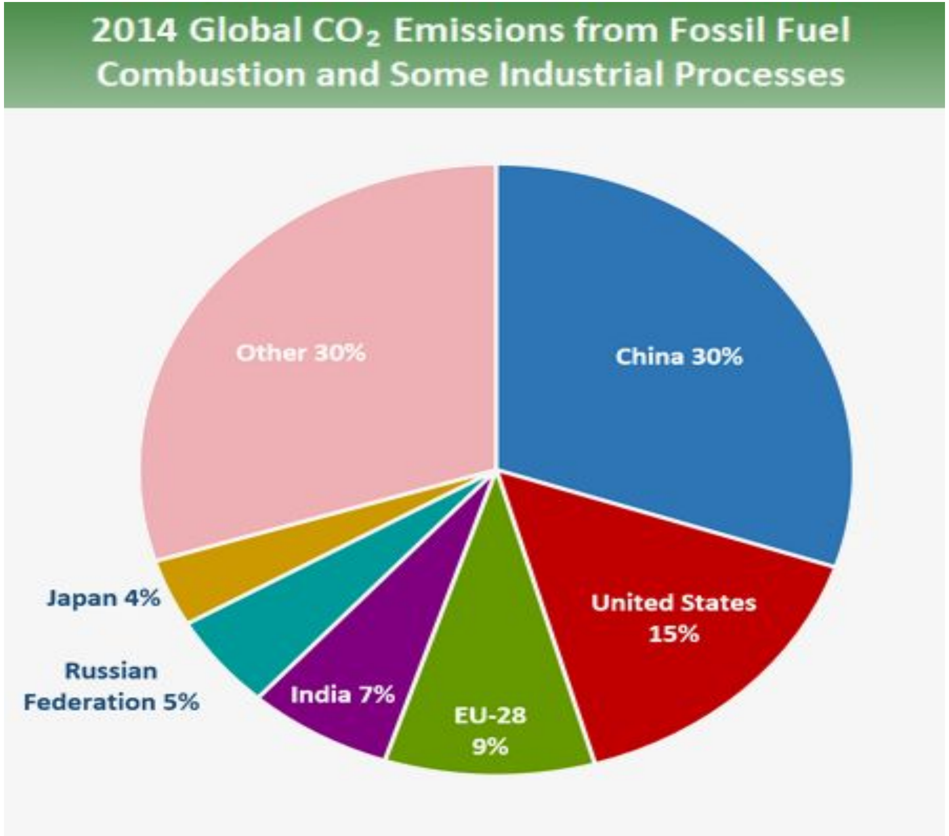
Global GHGs emission

- Key green house gases from human activities
    - CO_2: Fossil fuel, land use
    - CH_4: Agricultural activities, waste management
    - Nitrous oxide (N2O): Usage of fertilizers, fossil fuel
    - Flourinated gases (F-gases): Industrial processes, refrigeration,

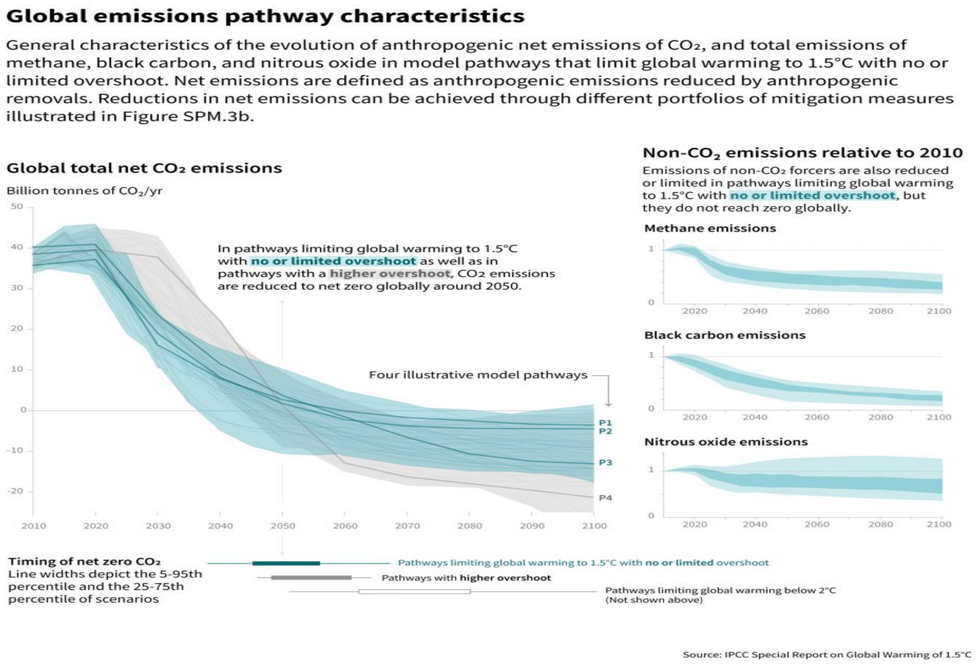


Source

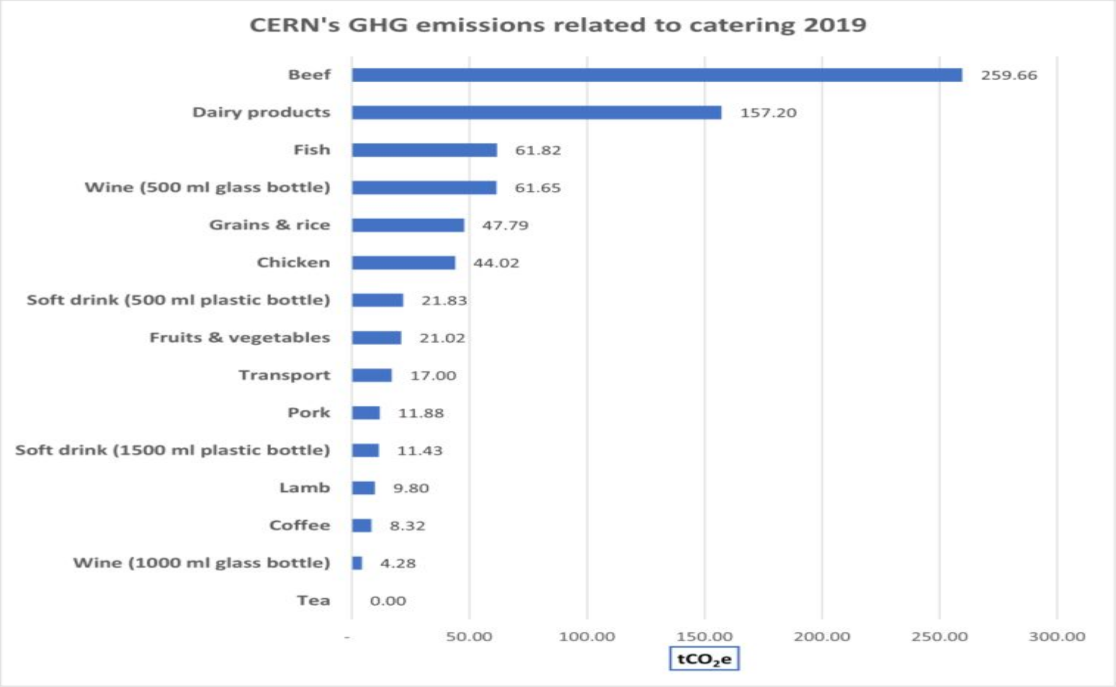
Emissions by country



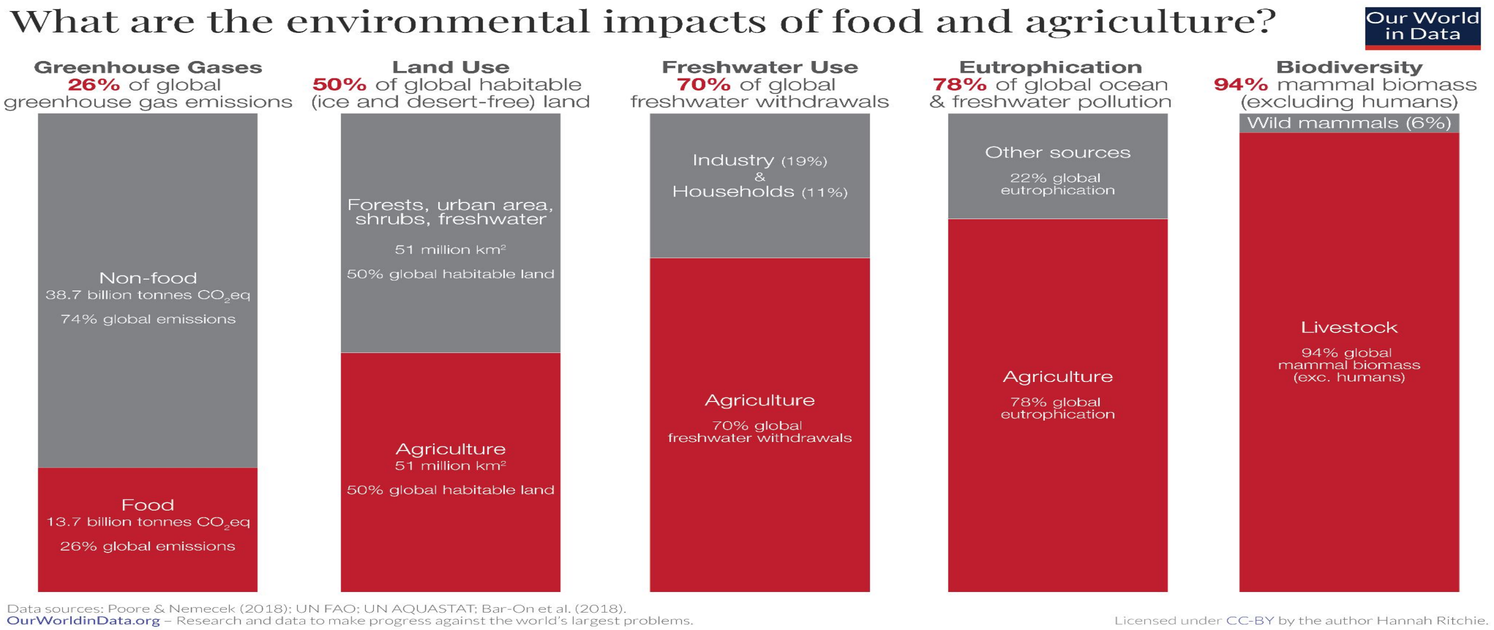
Towards global net zero (comparison of GHG sources)



Emissions from Catering (CERN, a case study)



Climate change isn't just GHG emissions (E.g., Agriculture)



Source: [Our World in Data]