Considerations on sustainability

- for the German Input to the European Strategy Update for Particle Physics (ESUPP) 2025 -

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German strategy workshop in preparation of the ESUPP
Bad Honnef, 20 January 2025

Sustainability

Defined in 1987 by the United Nations as:

> “meeting the needs of the present without compromising the ability of future generations to meet their own needs”

Decision by the Federal Constitutional Court (Bundesverfassungsgericht) in 2021:

> “Art. 20a of the Basic Law obliges the state to take climate action. This includes the aim of achieving climate neutrality. [...]
>
> [F]undamental rights [...] afford protection against the greenhouse gas reduction burdens imposed by Art. 20a of the Basic Law being unilaterally offloaded onto the future”

For reference:

Article 20a
[Protection of the natural foundations of life and animals]

Mindful also of its responsibility towards future generations, the state shall protect the natural foundations of life and animals by legislation and, in accordance with law and justice, by executive and judicial action, all within the framework of the constitutional order.

Reaching climate neutrality

Paris climate agreement in 2015:

- Article 2, 1(a):

(a) Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;

Climate neutrality pathways:

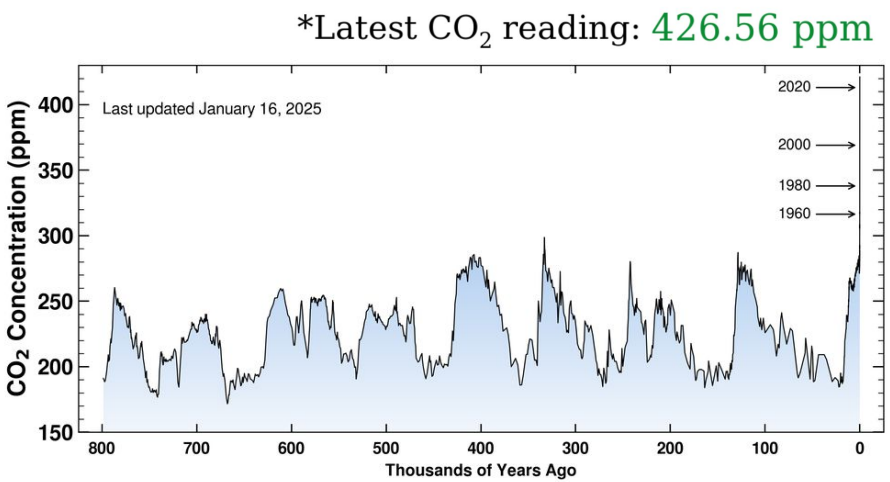
- Germany: Federal Climate Change Act in 2021
  - By 2045: net greenhouse gas (GHG) neutrality
- EU: European Green Deal in 2020
  - By 2050: No net emissions of GHGs

Time scale of the next large collider project: ~2045!

➔ Particle physics largely funded through public sources / the state
➔ Climate neutrality needs to be the aim, also in particle physics
➔ Reductions required to achieve that aim need to start now ➔ Includes any ongoing and future particle physics projects

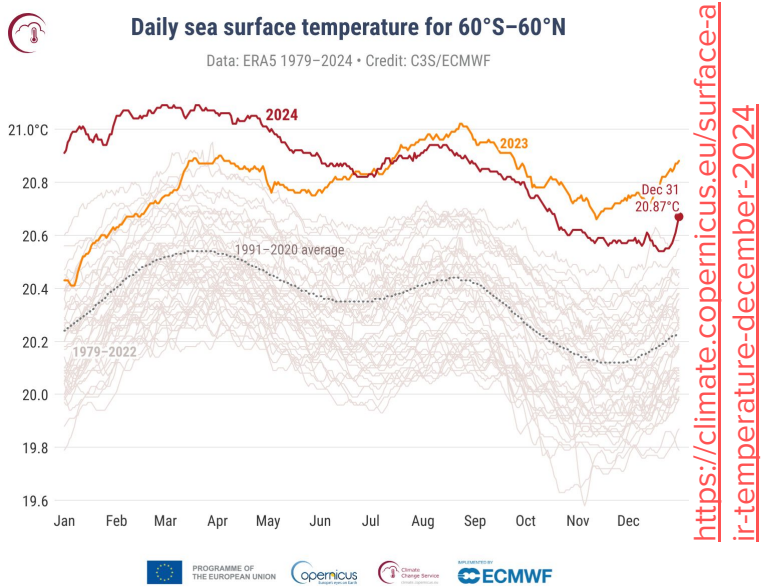
Reminder: Status of climate change

CO2 content in the atmosphere



https://keelingcurve.ucsd.edu

Sea surface temperature

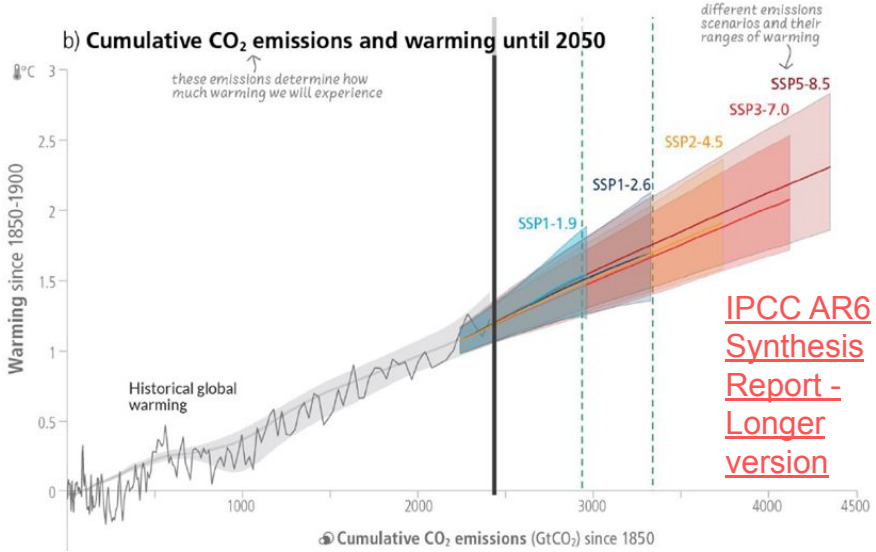


https://climate.copernicus.eu/surface-air-temperature-december-2024

- ➔ CO2 levels currently far outside of variations over last 800k years
- ➔ Temperature curve currently far outside of variations over last 45 years

Reminder: Current pathways

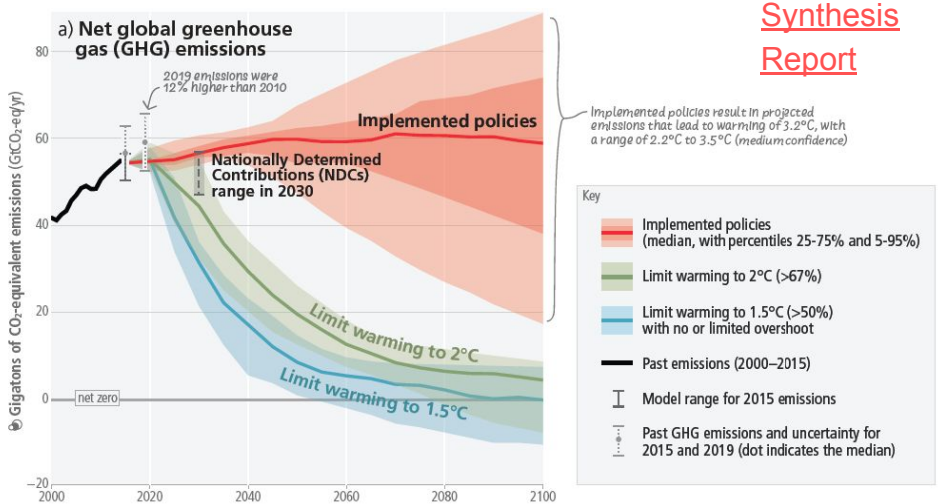
Cumulative emissions count



IPCC AR6 Synthesis Report - Longer version

Yearly emissions developments

IPCC AR6 Synthesis Report

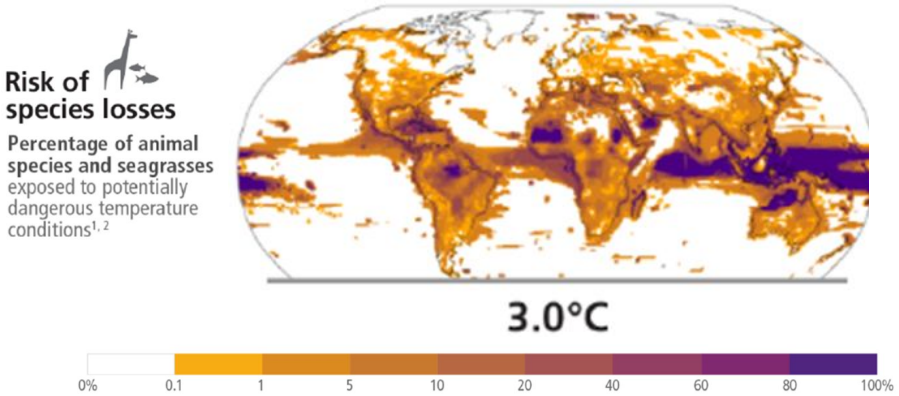


➔ Temperature rises ~linearly with cumulative emissions

➔ Need reduction to zero emissions ➔ Currently on path for 3.2°C global warming

Reminder: Some consequences of current pathway

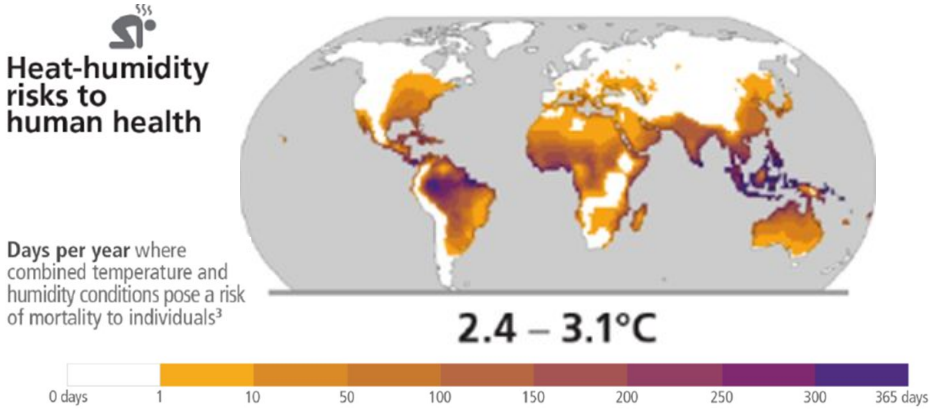
Biodiversity loss



[1]Projected temperature conditions above the estimated historical (1850-2005) maximum mean annual temperature experienced by each species, assuming no species relocation.

[2]Includes 30,652 species of birds, mammals, reptiles, amphibians, marine fish, benthic marine invertebrates, krill, cephalopods, corals, and seagrasses.

Risk of human overheating



[3]Projected regional impacts utilize a global threshold beyond which daily mean surface air temperature and relative humidity may induce hyperthermia that poses a risk of mortality. The duration and intensity of heatwaves are not presented here. Heat-related health outcomes vary by location and are highly moderated by socio-economic, occupational and other non-climatic determinants of individual health and socio-economic vulnerability. The threshold used in these maps is based on a single study that synthesized data from 783 cases to determine the relationship between heat-humidity conditions and mortality drawn largely from observations in temperate climates.

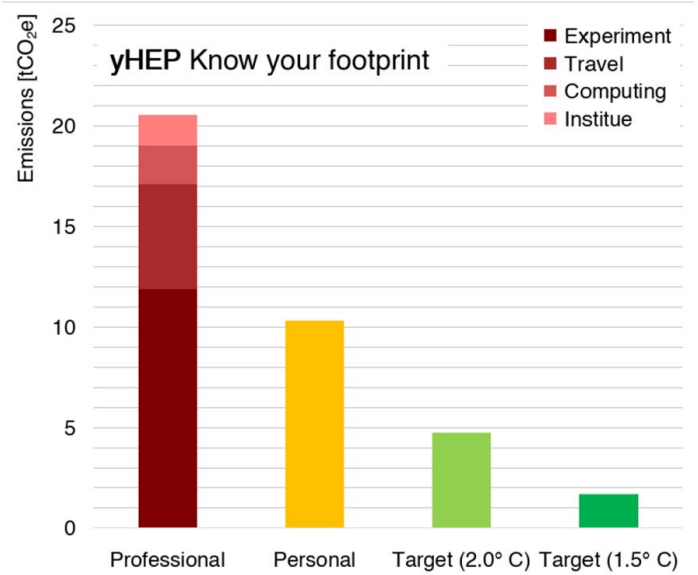
IPCC AR6 Synthesis Report - Longer version

➔ ~100% biodiversity loss in large areas around equator (=eq.)

➔ ~Full year hyperthermia risk (deadly overheating) in significant regions at eq.

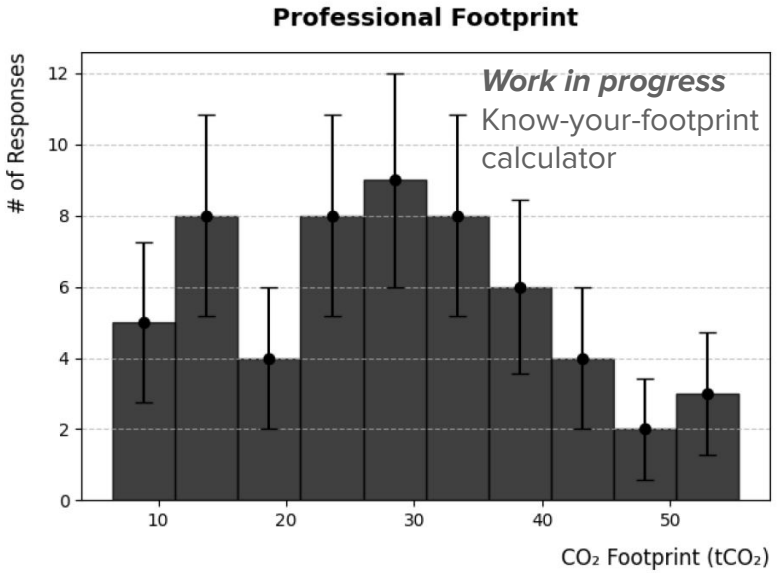
Carbon footprint of High Energy Physics (HEP)

Benchmark junior researcher in HEP



yHEP Know your footprint

Spread over researchers



➔ Significantly larger footprint than allowed for 2.0°C (1.5°C) targets!

➔ Cannot be afforded for future project ➔ Endangers rights of future generations

European Strategy Update for Particle Physics (ESUPP)

Last update in 2020:

- German statement from ESUPP 2020:
  - No explicit statement regarding sustainability included
- Final summary statement from ESUPP 2020:

7. Environmental and societal impact

a) The energy efficiency of present and future accelerators, and of computing facilities, is and should remain an area requiring constant attention. Travel also represents an environmental challenge, due to the international nature of the field. *The environmental impact of particle physics activities should continue to be carefully studied and minimised. A detailed plan for the minimisation of environmental impact and for the saving and re-use of energy should be part of the approval process for any major project. Alternatives to travel should be explored and encouraged.*

➔ Need to go beyond previous statement, given progress of climate crisis
➔ Need to get better at implementations!

Suggestion for 2025 ESUPP regarding sustainability

In general part of German statement:

- State aims of building climate neutral future also in particle physics
- Support CERN’s activities in climate research as part of the diversity program

Proposal for dedicated section on sustainability in the German statement:

➔ See next slide

Suggestion for 2025 ESUPP regarding sustainability

Sustainability of High Energy Physics Research

As scientists and as part of our society, the German HEP community is committed to building a sustainable future. Our research activities and research infrastructure must aim to minimize resource consumption and negative impacts on the environment, while exploring how research and development through our international collaborations can further contribute to the UN Sustainable Development Goals.

Any future project, while catering to the needs of the current generation, must consider the needs of future generations. In view of global climate change, this requires resolutely reducing carbon-equivalent emissions through novel and widely usable developments such as High Temperature Superconductors and bringing forward net-positive technologies like heat re-use. Future projects must perform life cycle assessments, aiming to optimize its carbon footprint. The latter implies no future use of gases with high global warming potential (if leak-tightness cannot be guaranteed), phase-out of other environmentally harmful materials such as forever chemicals (PFAS), and transitioning to carbon-neutral energy supply together with its optimized efficient use (also regarding computing). In case of new infrastructure (buildings, tunnels, etc.) being built, major effort must be undertaken to use carbon-minimized construction materials, in particular, related to concrete; existing infrastructure must be improved. Improvements extend also to institutes and research centres participating in future projects who must transition to environmentally sustainable procurement, computing, travel and hiring practices. Maintaining our international networking and personal exchange culture requires creative and flexible solutions to effectively reduce frequency and accumulated distances by air-based travel. Achieving sustainability must become an integral part of particle physics research.

Backup

Climate neutrality

Switzerland: Long-term climate strategy adopted in 2021

- By 2050: Net zero greenhouse gas emissions

France: Energy and climate law adopted in 2019

- By 2050: Carbon neutrality

F-gas policy at CERN

First policy announced in July 2024

24 JULY, 2024

CERN has recently published a Fluorinated Gases (F-Gas) Policy. This policy formalises CERN's commitment and strategy to minimise the impact on the environment of its installations containing and activities using F-Gases, thereby contributing to reducing its direct (Scope 1) greenhouse gas emissions.

Press release

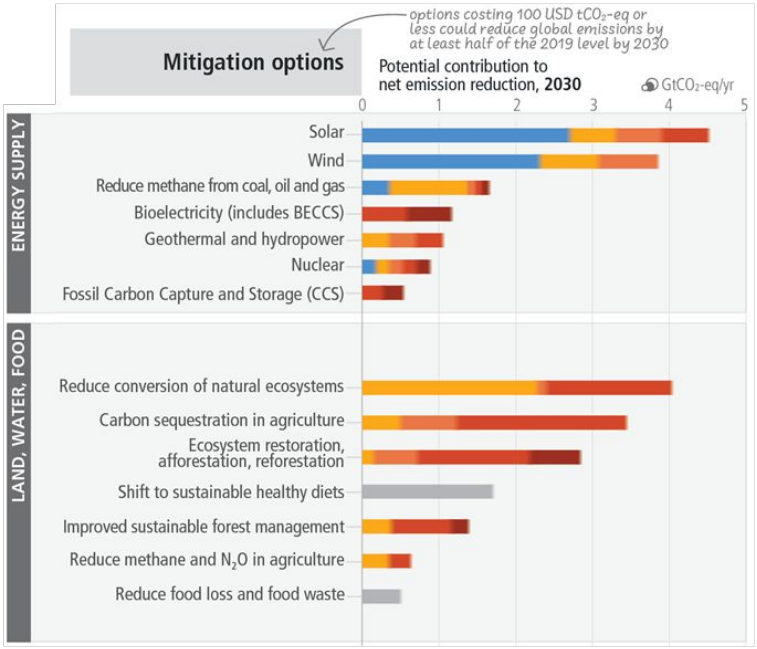
From the policy document

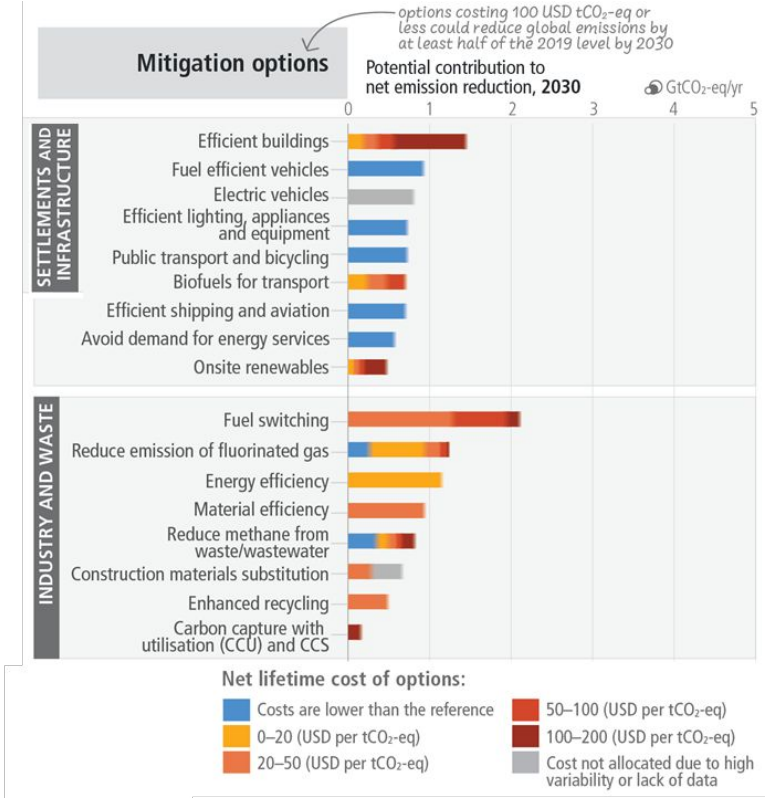
In particular, the Organization commits to:

- minimize the use of F-Gases at CERN, in particular through:
  - the promotion of research and development into F-Gas alternatives,
  - the replacement, to the extent possible, of F-Gases already used in its installations and activities with gases with no - or less impact on the environment, and
  - the minimization, to the extent possible, of the use of F-Gases in new installations and activities.
- limit its emissions of F-Gases, in particular through:
  - the prohibition of intentional releases,
  - the detection and reduction of leaks,
  - appropriate training of personnel concerned.
- monitor and manage the use and emissions of F-Gases within the Organization,
- establish and update appropriate internal procedures and regulations and monitor compliance with them,
- communicate proactively,
- collaborate with the Host States.

Policy document

Cost estimates of different mitigation options

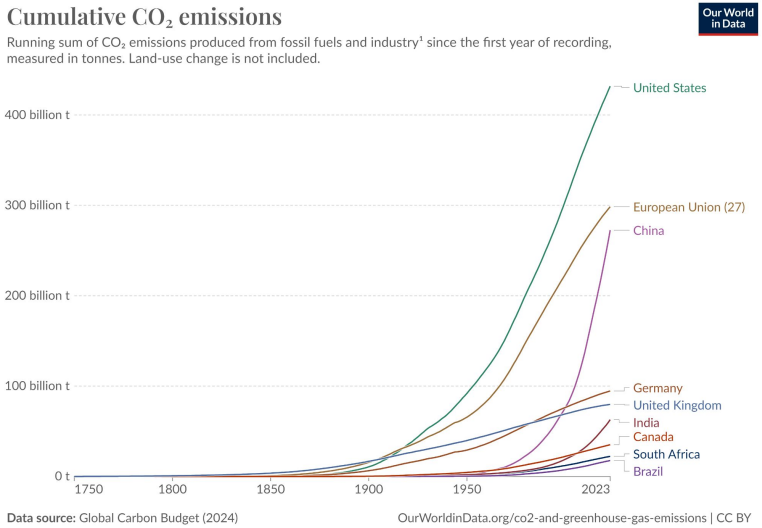




https://report.ipcc.ch/ar6syr/pdf/IPCC_AR6_SYR_LongerReport.pdf

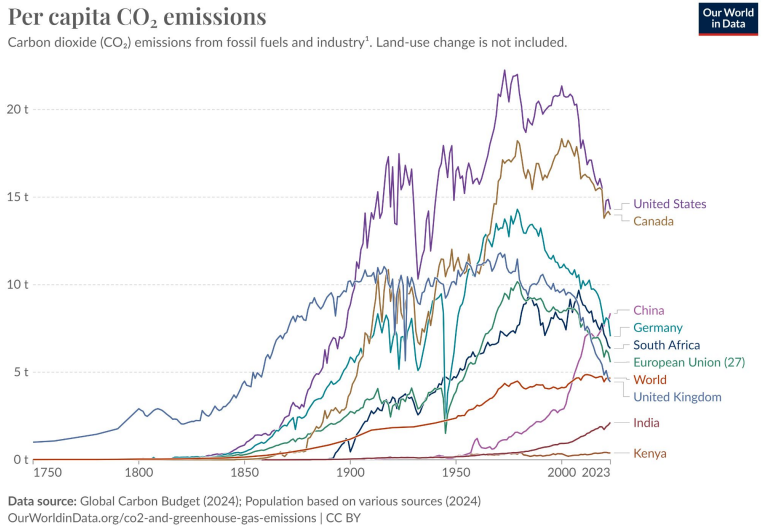
CO2 emissions worldwide

Cumulative emissions



1. Fossil emissions: Fossil emissions measure the quantity of carbon dioxide (CO_2) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO_2 includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

Yearly emissions per-capita



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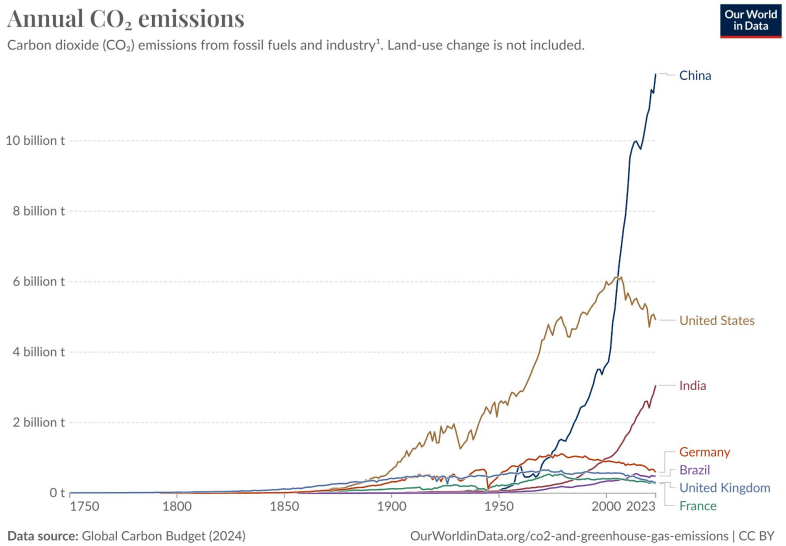
What about China?

Absolute yearly emissions



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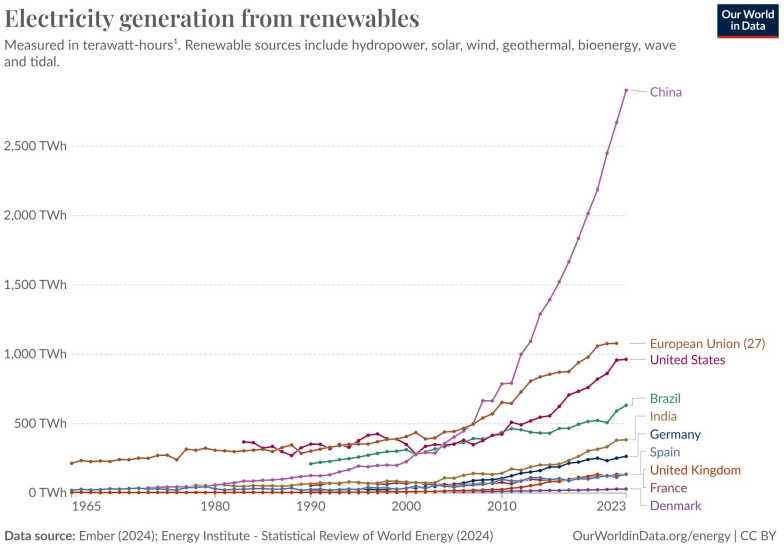
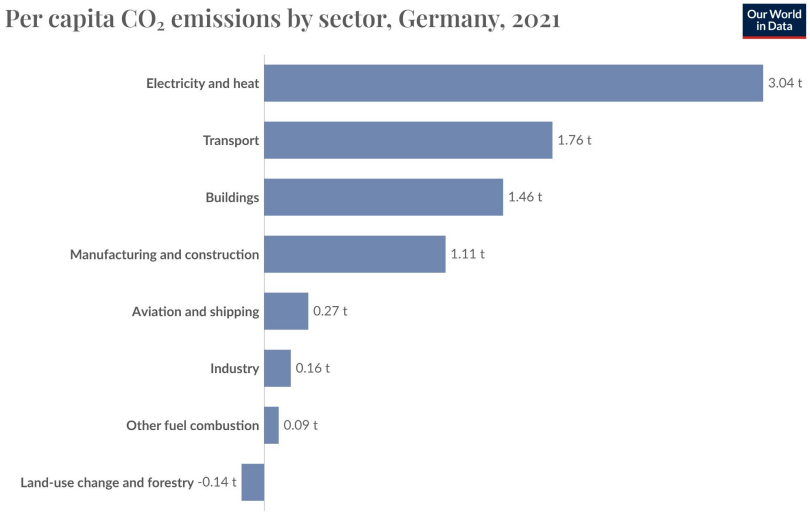
Renewable electricity generation



1. Watt-hour: A watt-hour is the energy delivered by one watt of power for one hour. Since one watt is equivalent to one joule per second, a watt-hour is equivalent to 3600 joules of energy. Metric prefixes are used for multiples of the unit, usually: - kilowatt-hours (kWh), or a thousand watt-hours. - Megawatt-hours (MWh), or a million watt-hours. - Gigawatt-hours (GWh), or a billion watt-hours. - Terawatt-hours (TWh), or a trillion watt-hours.

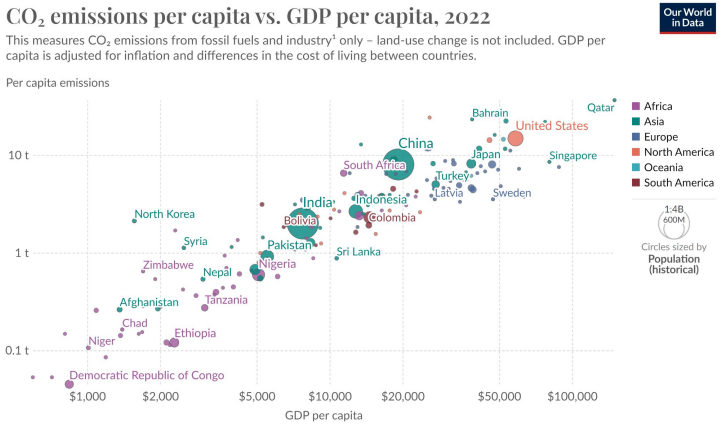
Per capita emissions for Germany

By sectors



Data source: Climate Watch (2024); Population based on various sources (2024)
OurWorldinData.org/co2-and-greenhouse-gas-emissions | CC BY

Vs. GDP



Data source: Global Carbon Budget (2024); Population based on various sources (2024); Bolt and van Zanden - Maddison Project Database 2023
Note: GDP per capita is expressed in international-$[2] at 2011 prices.
OurWorldinData.org/co2-and-greenhouse-gas-emissions | CC BY

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2. International dollars: International dollars are a hypothetical currency that is used to make meaningful comparisons of monetary indicators of living standards. Figures expressed in international dollars are adjusted for inflation within countries over time, and for differences in the cost of living between countries. The goal of such adjustments is to provide a unit whose purchasing power is held fixed over time and across countries, such that one international dollar can buy the same quantity and quality of goods and services no matter where or when it is spent. Read more in our article: What are Purchasing Power Parity adjustments and why do we need them?

Per capita emissions for Germany

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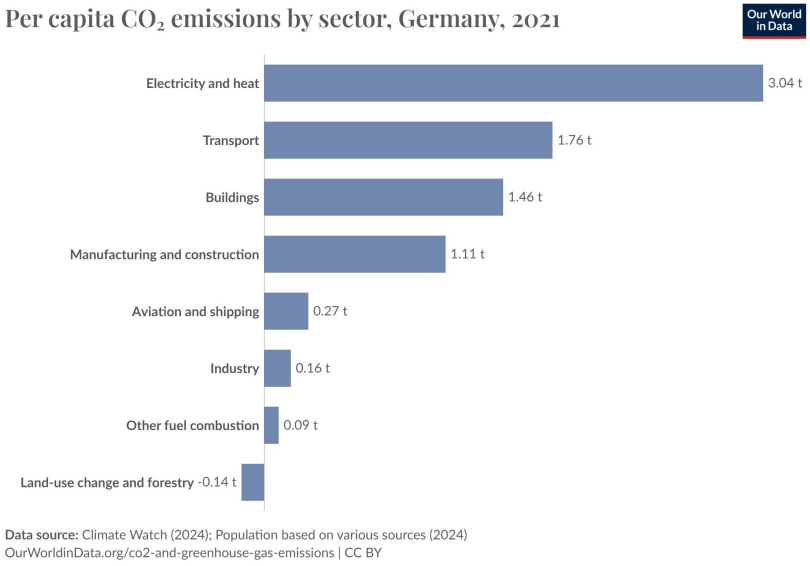

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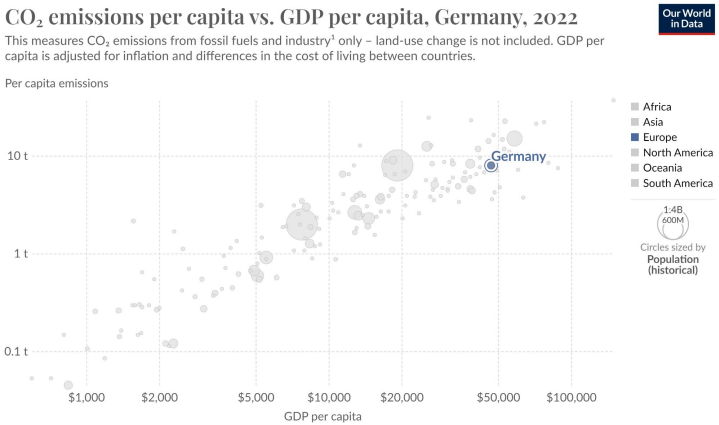

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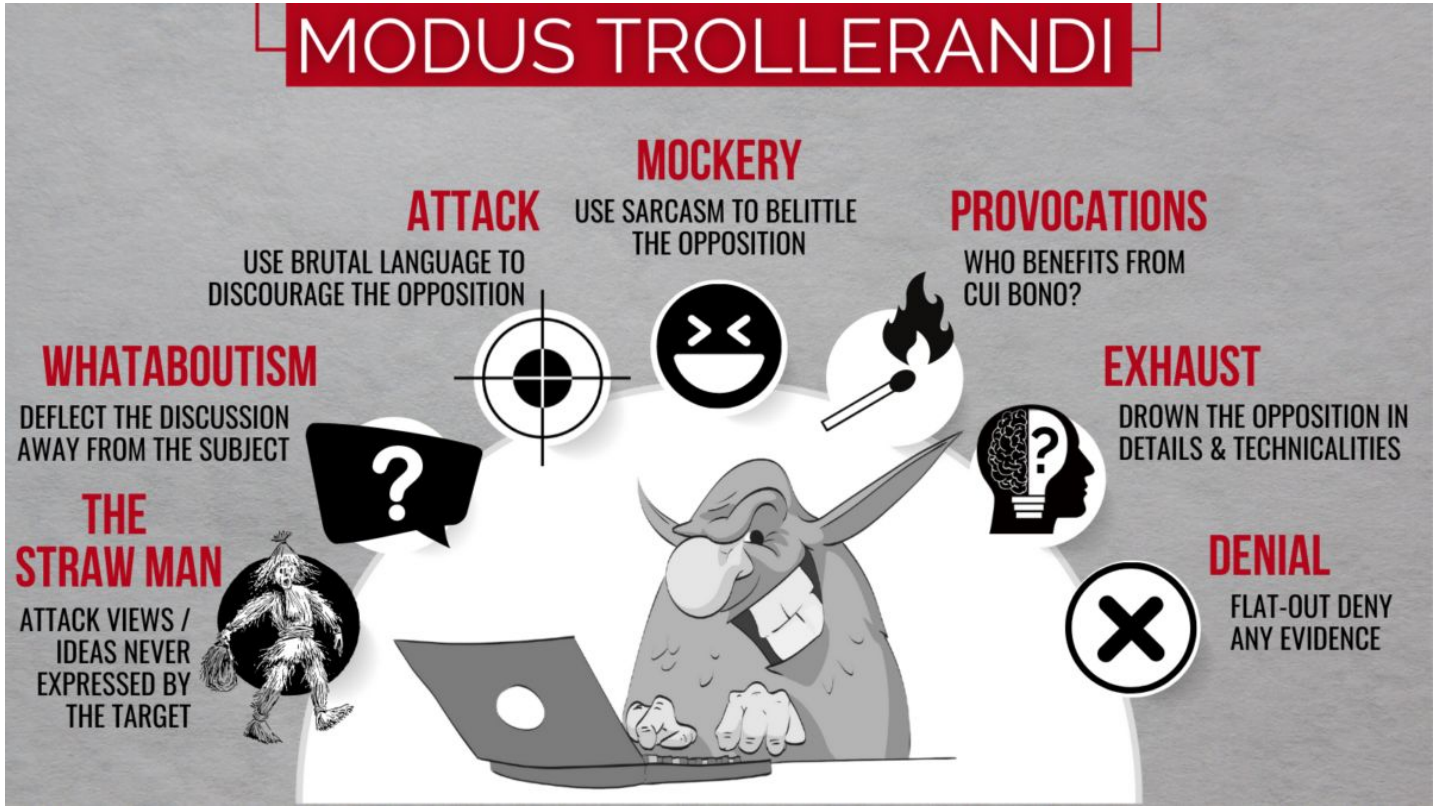
Common rhetoric tricks by populists

More populist tricks:

- False equivalency
- Whataboutism
- Derailing

https://www.zdf.de/show/mai-think-x-die-show/maithink-x-folge-31-populismus-100.html

Seven common disinformation tricks



https://euvsdisinfo.eu/modus-trollerandi-part-2-whataboutism/