Nachhaltigkeit in der Teilchenphysik

Will our civilisation survive the next 30 years?

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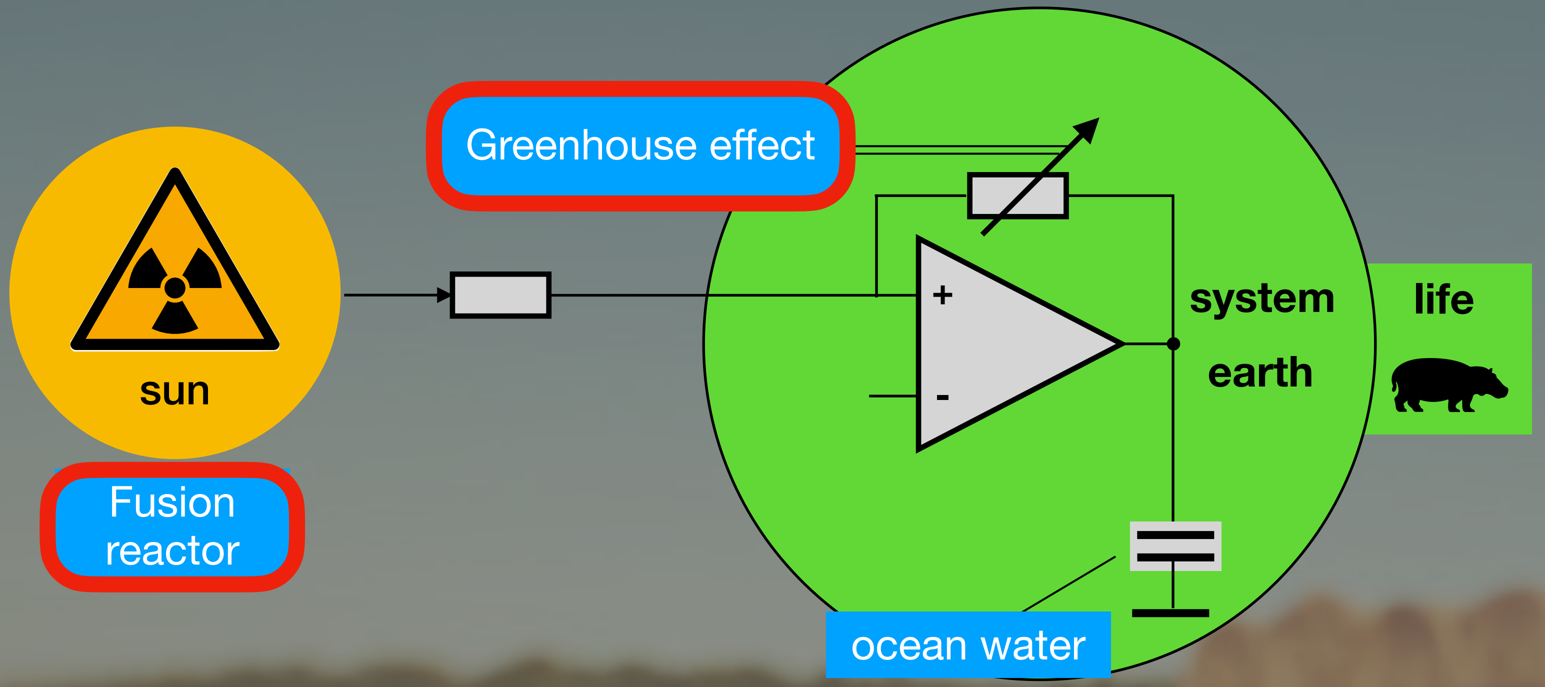
II. Phys. Institut der JLU Giessen

Zentrum für internationale Entwicklungs- und Umweltforschung

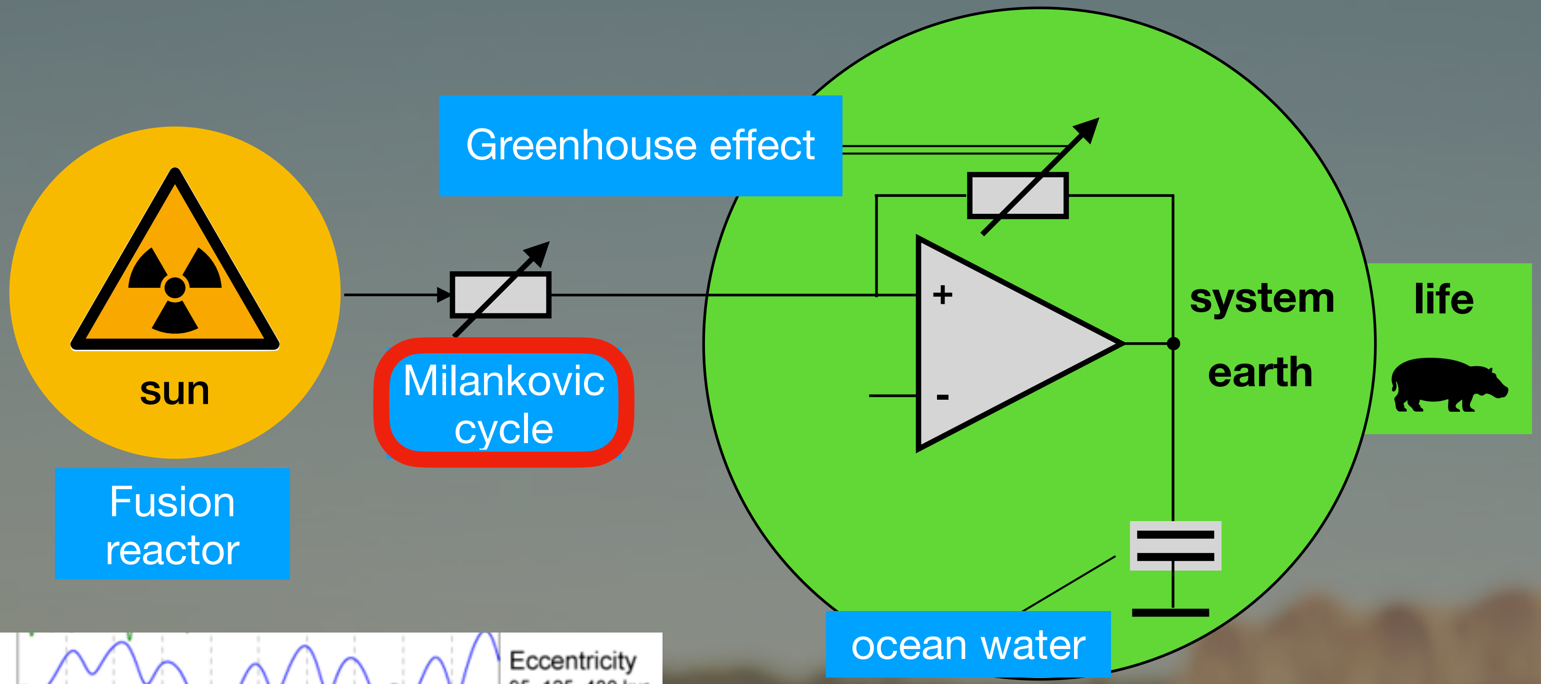
Arbeitskreis Energie der DPG

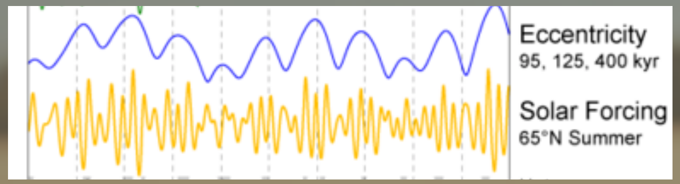
24.11.23



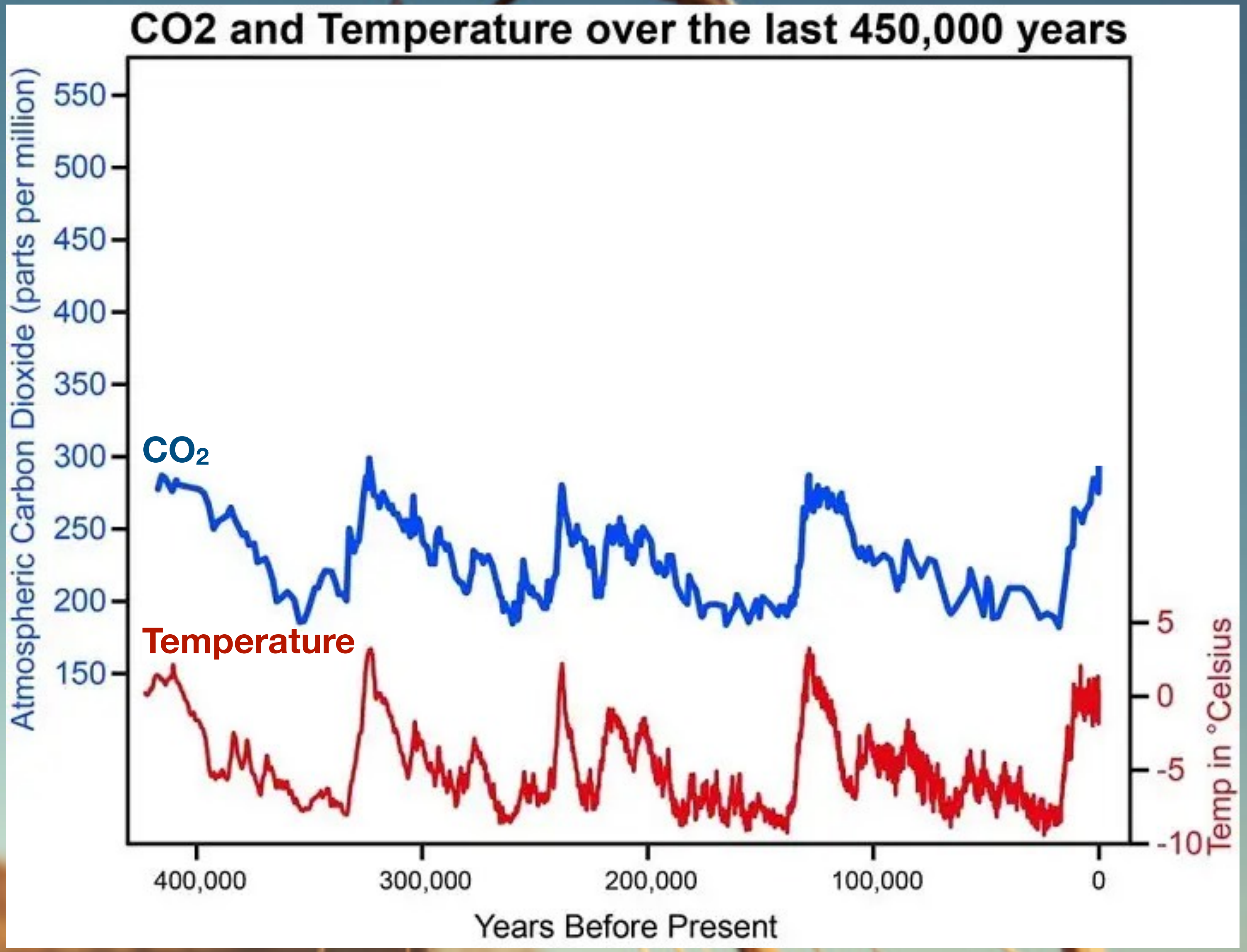
Hothouse Earth

Michael Düren, Univ. Giessen



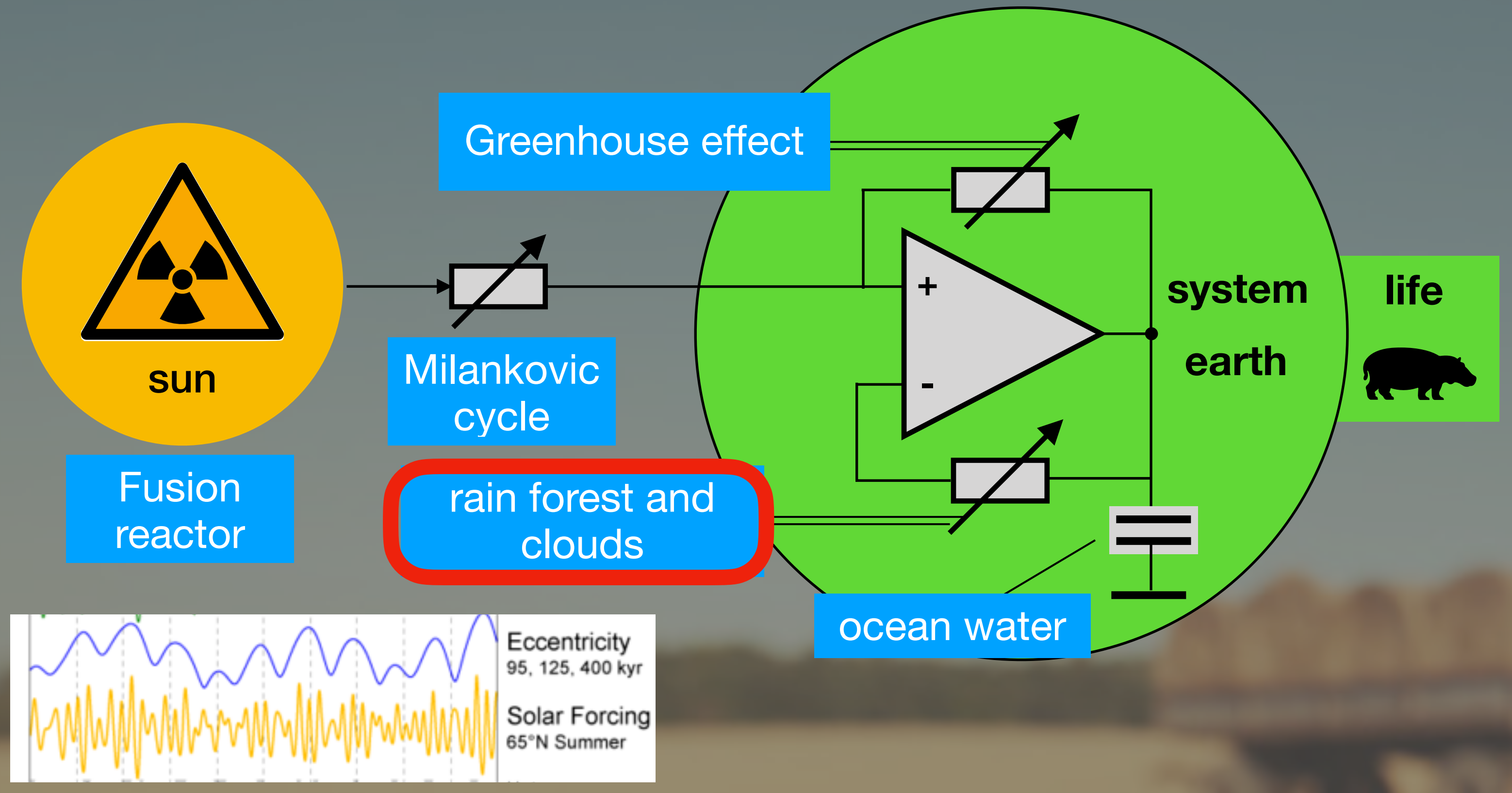


1 million years

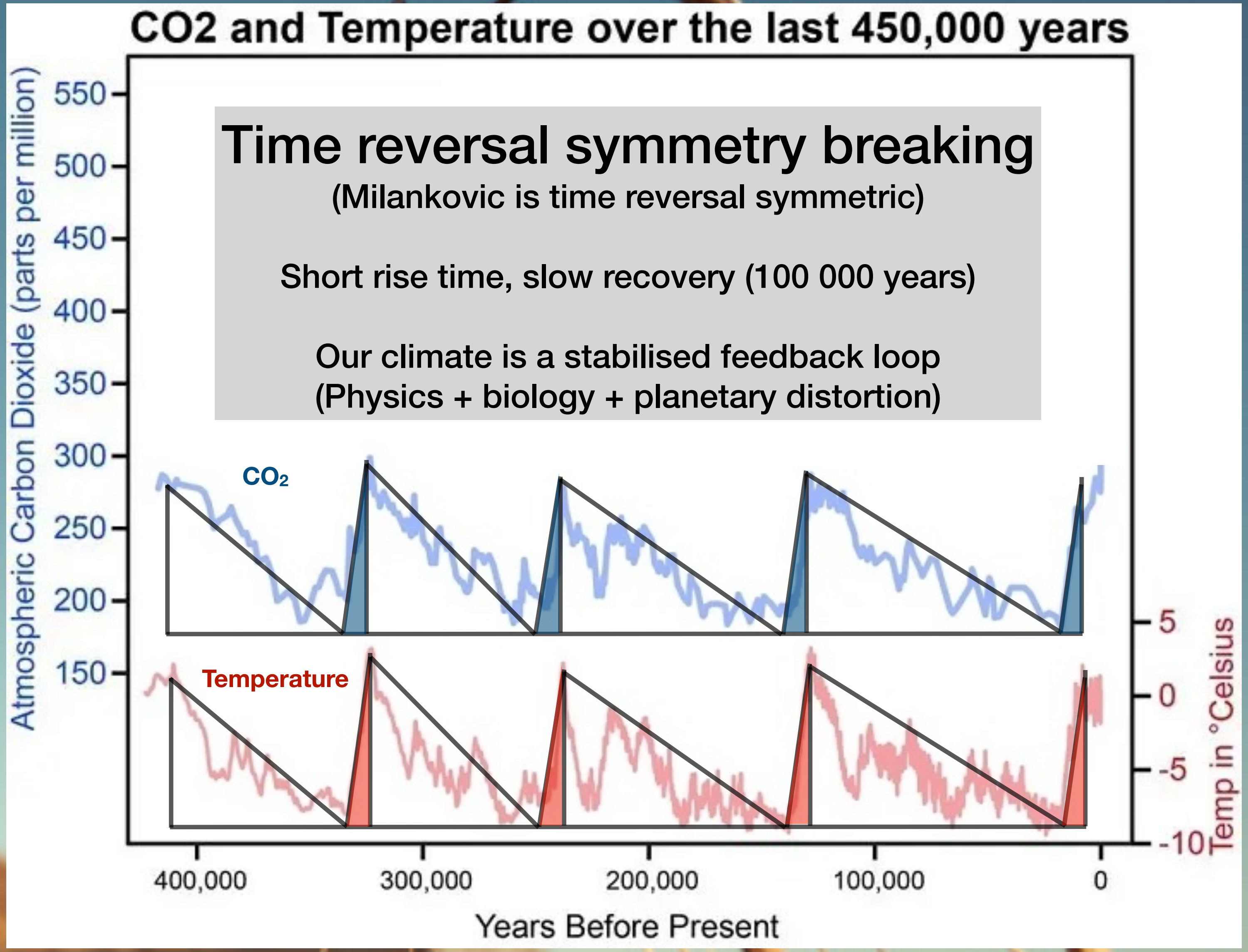


Hothouse Earth

Temperature on Earth is controlled by a Stable Feedback System



1 million years



Hothouse Earth

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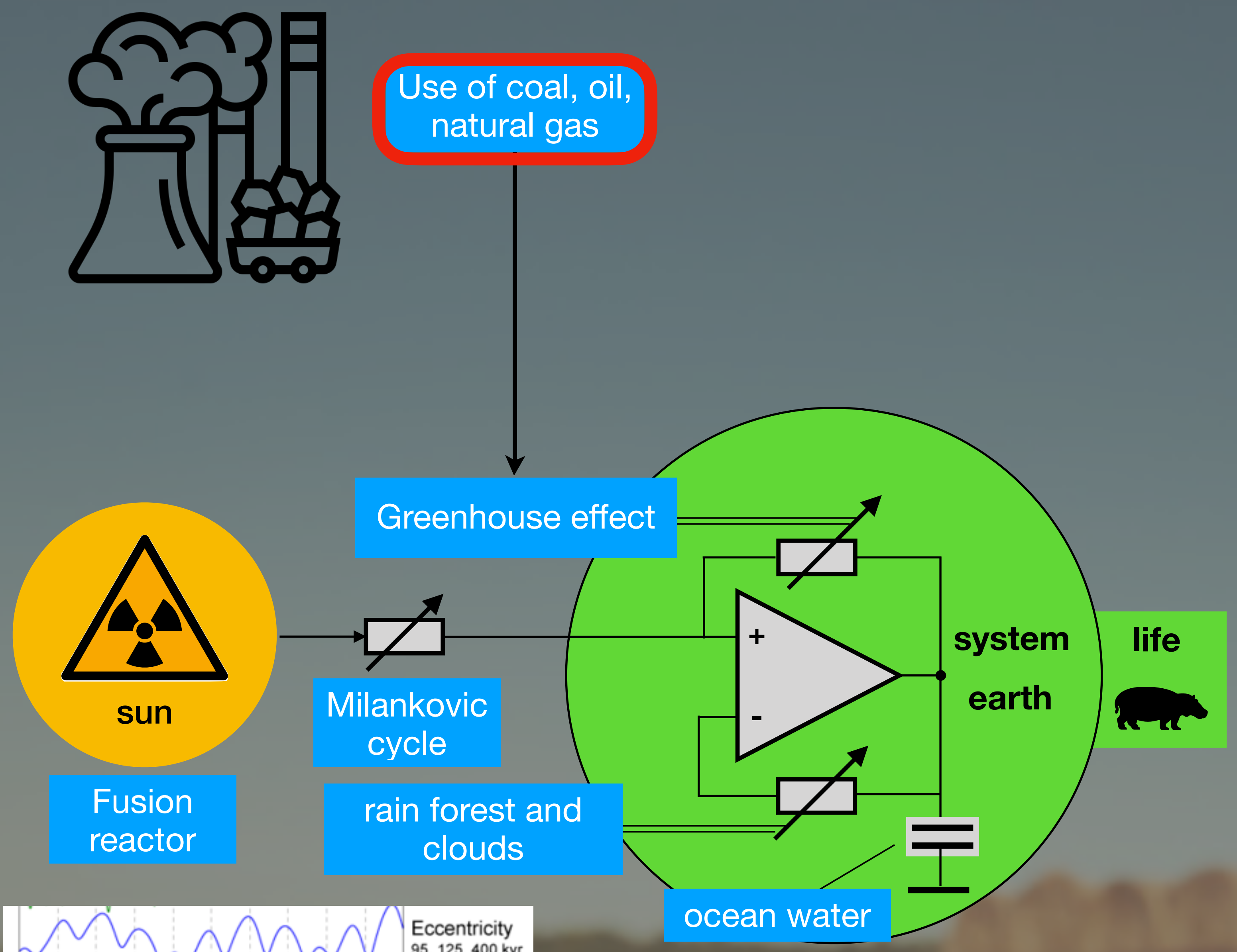
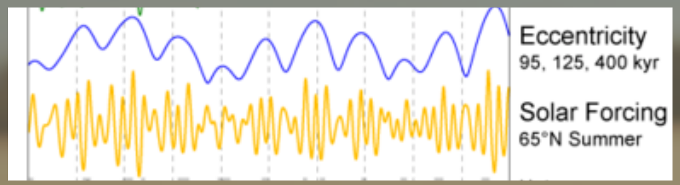
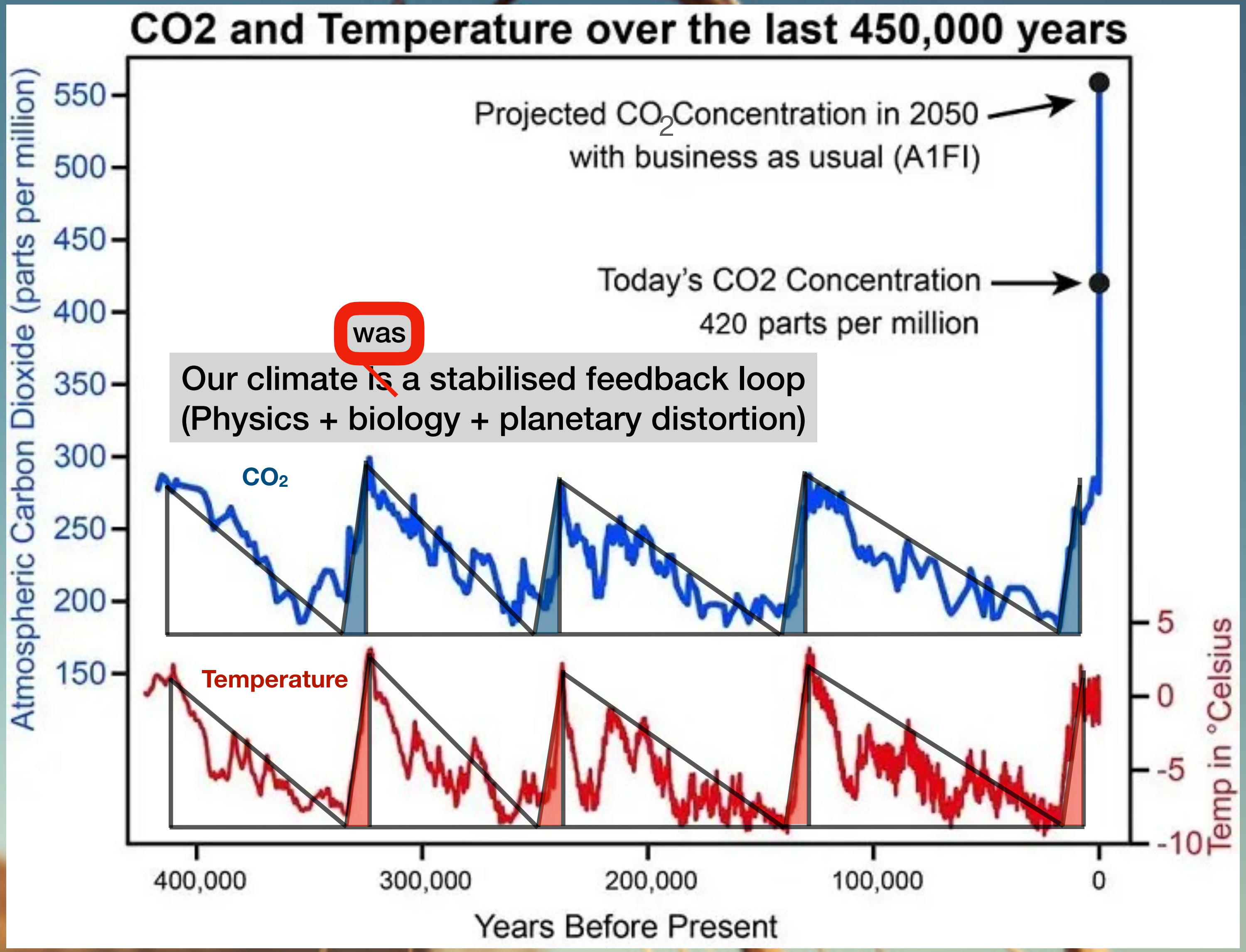
Anthropogenic Climate Change since ~100 Years



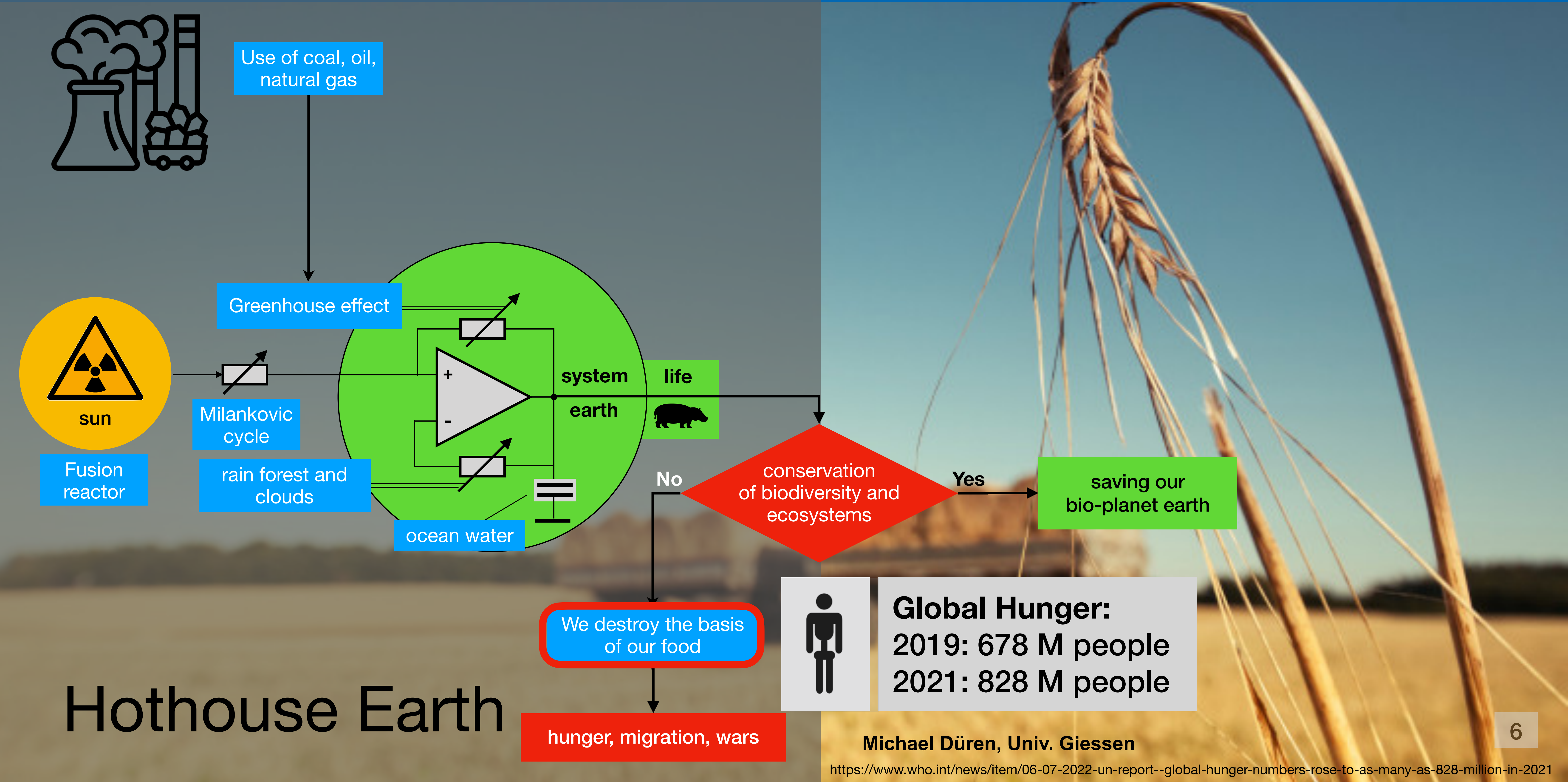


1 million years

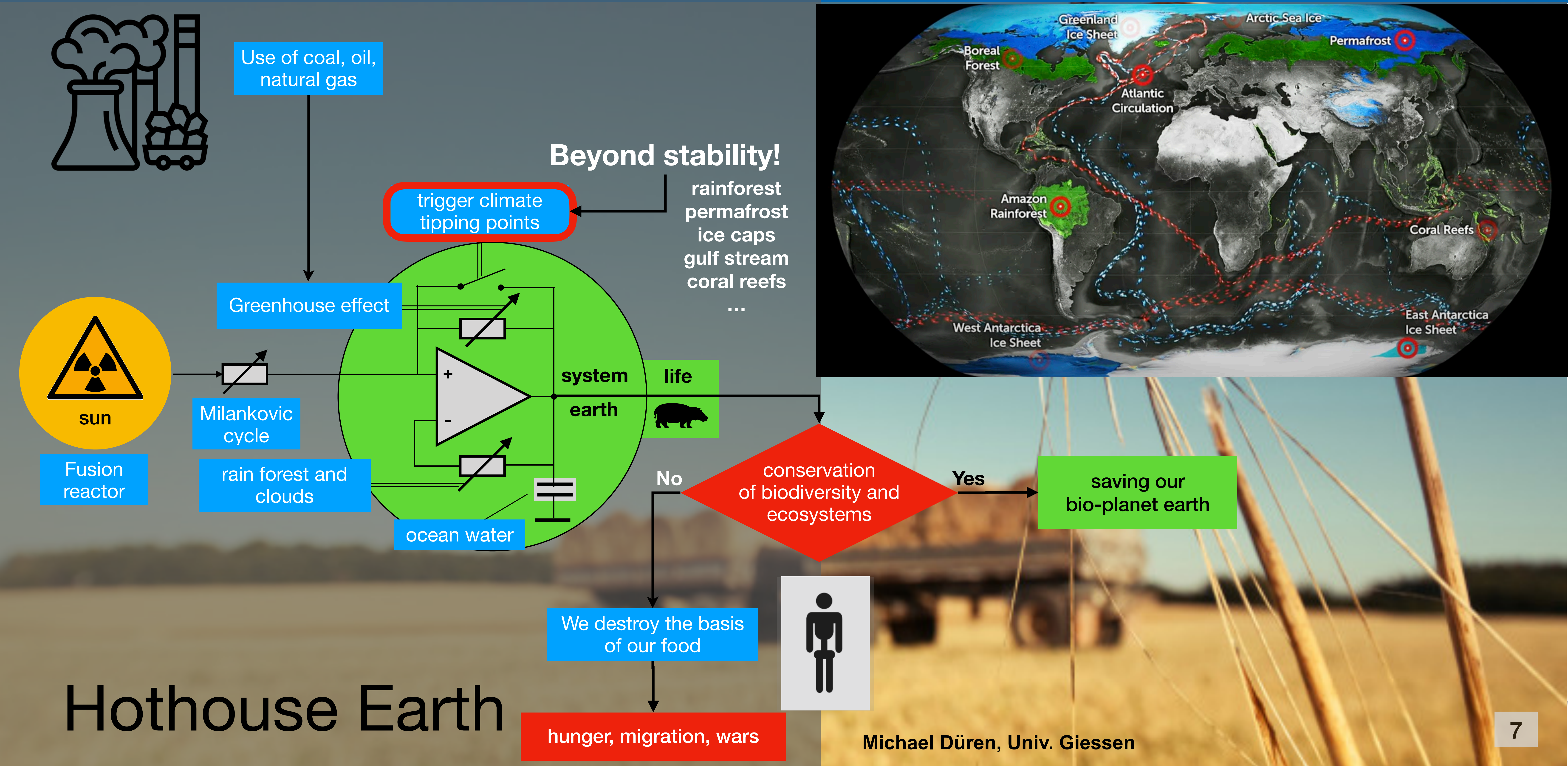


Hothouse Earth

Food production for 7.5 Billion People will decline drastically



CO_2 -Emissions will Trigger Tipping Points: Irreversible!



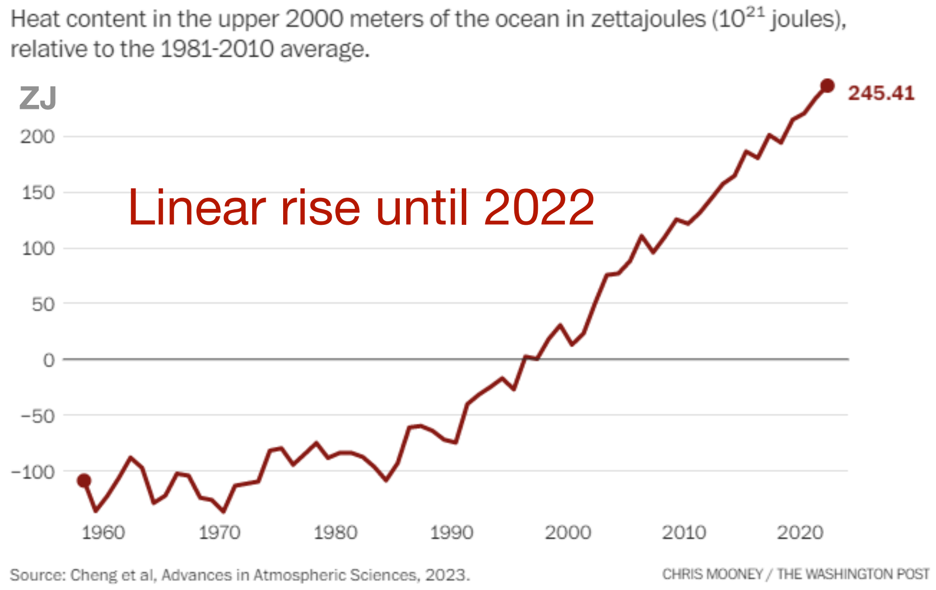
Unexpected climate effects in 2023

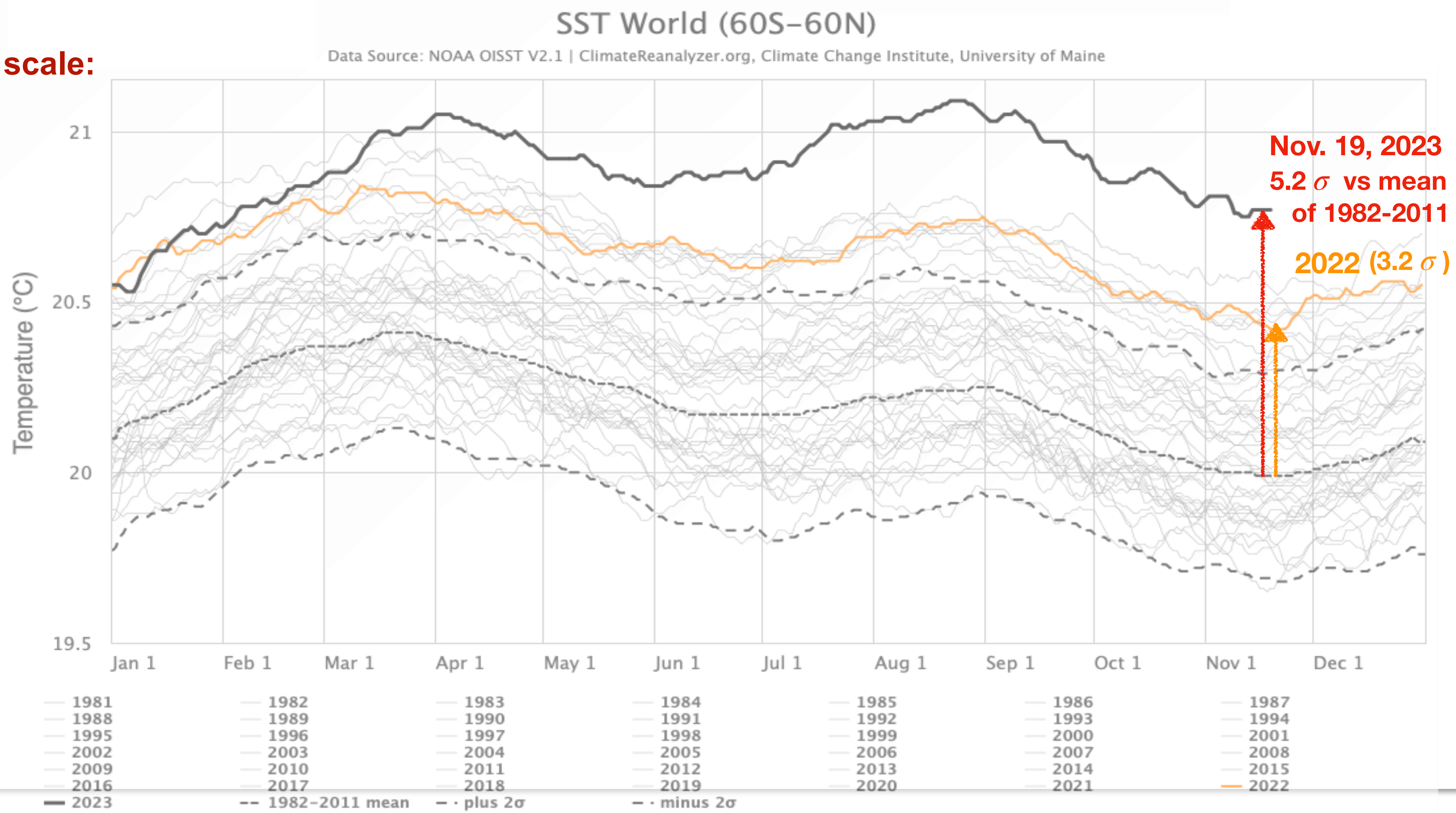
Global Sea Surface Temperature

Nature's power is beyond the human scale:

Heat stored in upper ocean since 2000:

250 Zetta Joule = 70 Billion GWh

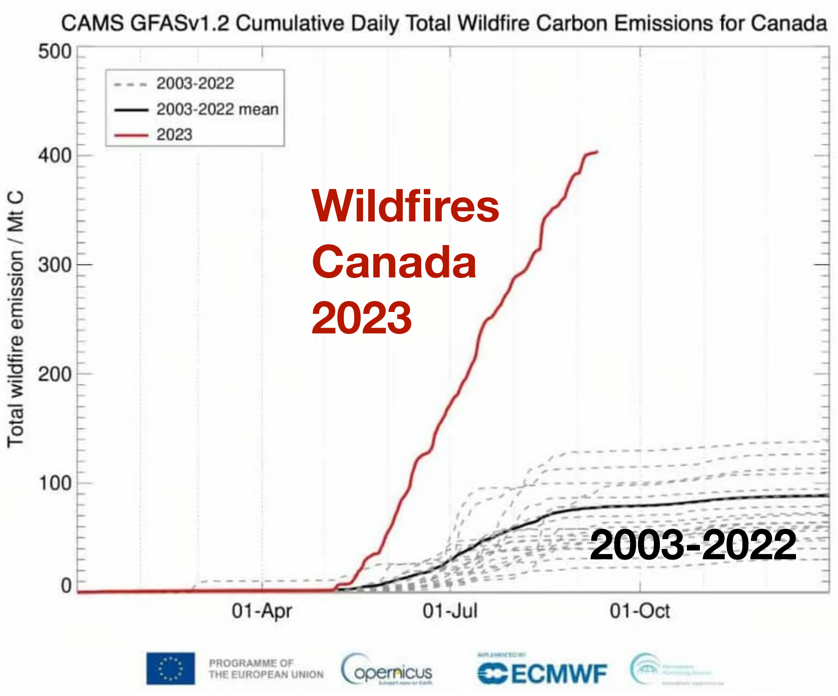




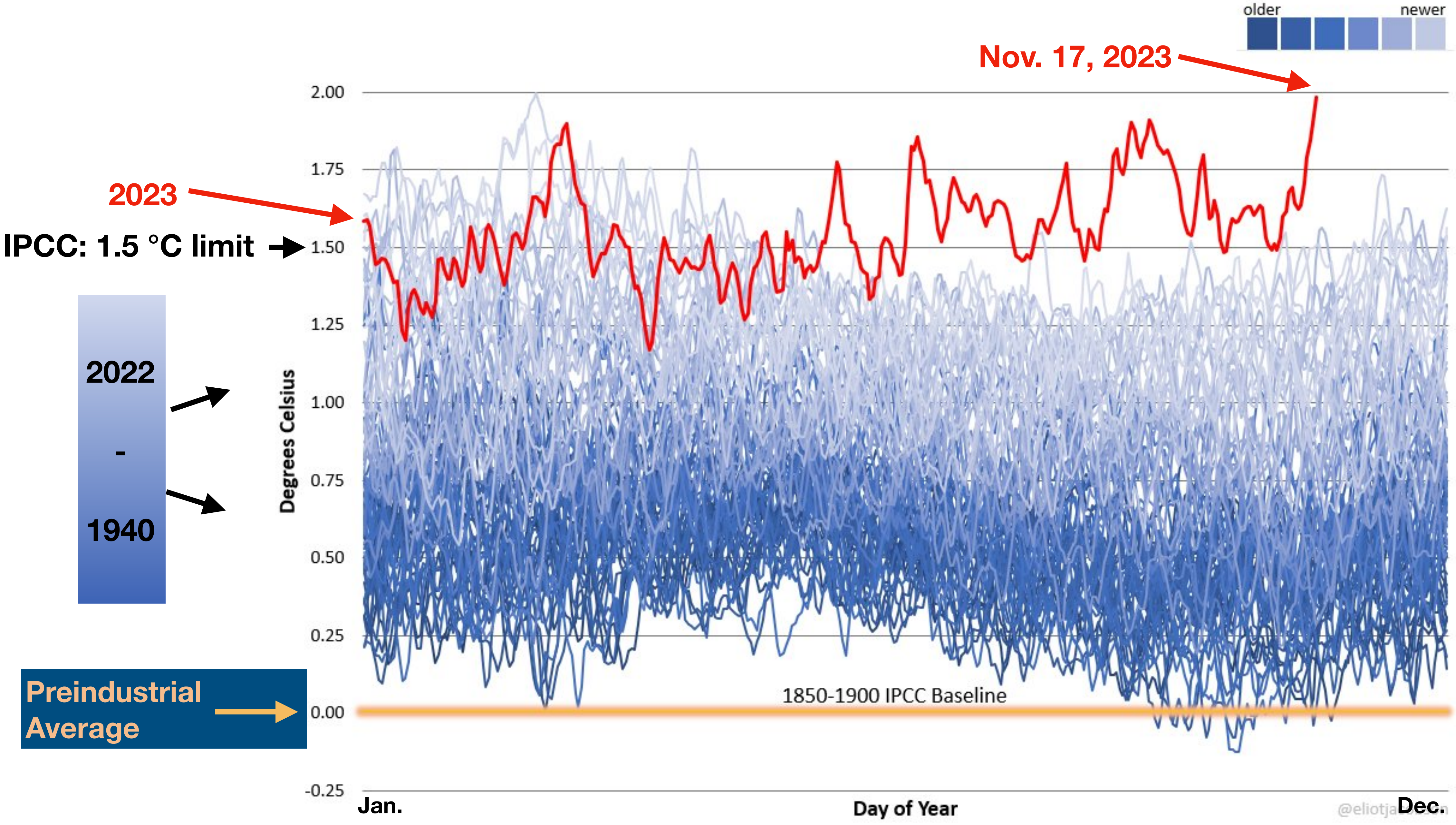
https://climatereanalyzer.org/clim/sst_daily/

Unexpected climate effects in 2023

2023:
Many wildfires
and floods and droughts
all over the planet earth

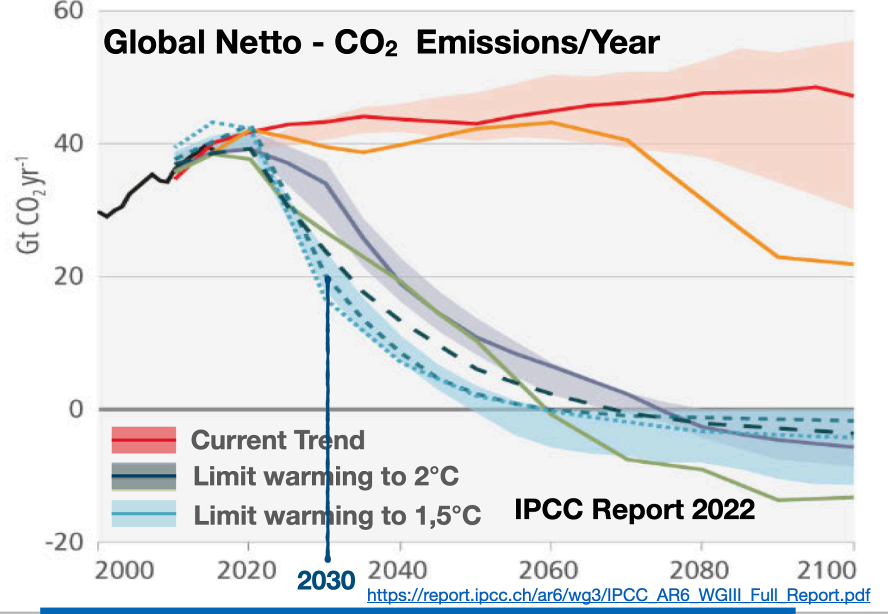


Global 2m Air Temperature

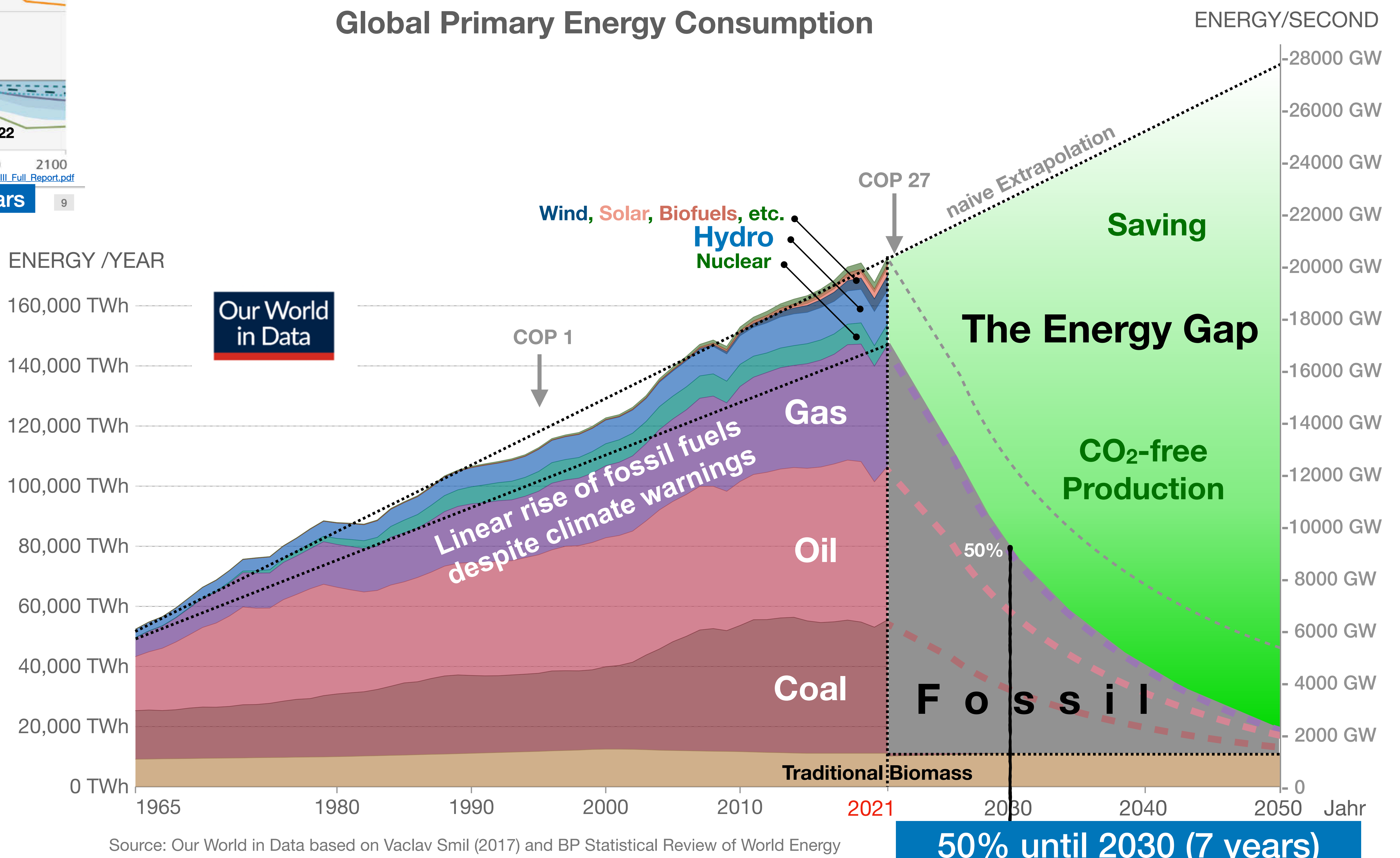


https://climatereanalyzer.org/clim/t2_daily/

The global energy gap



Required reduction: 50% in ~7 years



50% until 2030 (7 years)

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Personally, I think:
The next 10 years will be a step by step breakdown of our civilisation

HECAP+ paper: Environmental sustainability in basic research

(High Energy Physics, Cosmology, Astroparticle Physics, and Hadron and Nuclear Physics)

Environmental sustainability in basic research

A perspective from HECAP+

Sustainable HECAP+ Initiative

arXiv:2306.02837v2 [physics.soc-ph] 18 Aug 2023

Abstract
The climate crisis and the degradation of the world's ecosystems require humanity to take immediate action. The international scientific community has a responsibility to limit the negative environmental impacts of basic research. The **HECAP+ communities** (**High Energy Physics, Cosmology, Astroparticle Physics, and Hadron and Nuclear Physics**) make use of common and similar experimental infrastructure, such as accelerators and observatories, and rely similarly on the processing of big data. Our communities therefore face similar challenges to improving the sustainability of our research. This document aims to reflect on the environmental impacts of our work practices and research infrastructure, to highlight best practice, to make recommendations for positive changes, and to identify the opportunities and challenges that such changes present for wider aspects of social responsibility.

Version 2.0, 18 August 2023

Please read this document in electronic format where possible and refrain from printing it unless absolutely necessary. Thank you.

Moral reason to act:

We have the responsibility to limit negative impacts on climate and ecosystems

We have abilities to contribute to solutions (e.g. by being a role model for a global transition)

Pragmatic reason to act:

Our research activities will be under increasing scrutiny from the public, governments and funders

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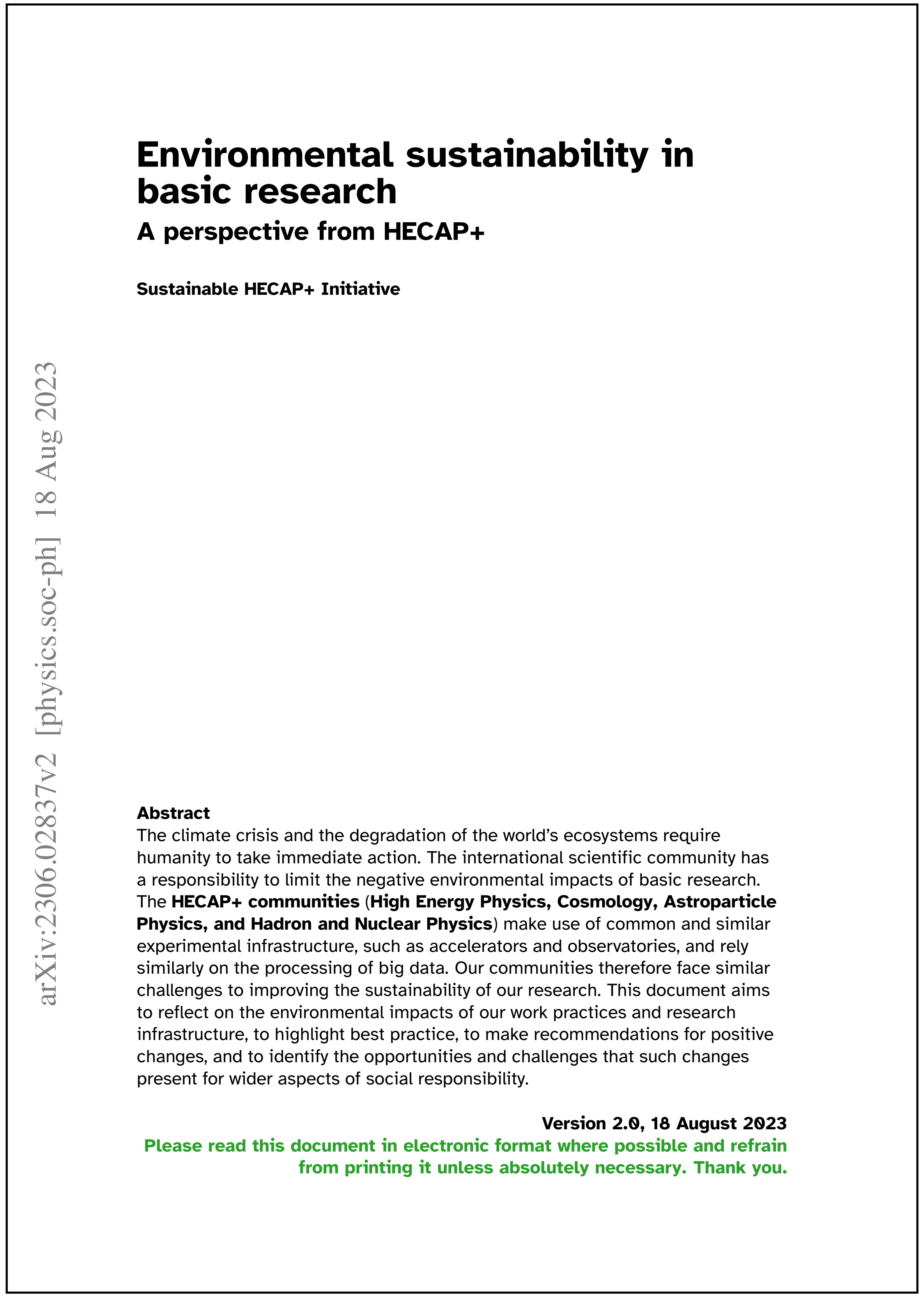
The HECAP+ paper is only one example of an increasing number of activities in HEP to improve the environmental sustainability.

Chapters

- Introduction
- Energy
- Mobility
- Food
- Computing
- Research Infrastructure and Technology
- Resources and Waste

180 endorsers at https://sustainable-hecap.github.io

HECAP+ paper: Environmental sustainability in basic research



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Recommendations — Impelling Positive Change

Individual actions: „You and me“

-

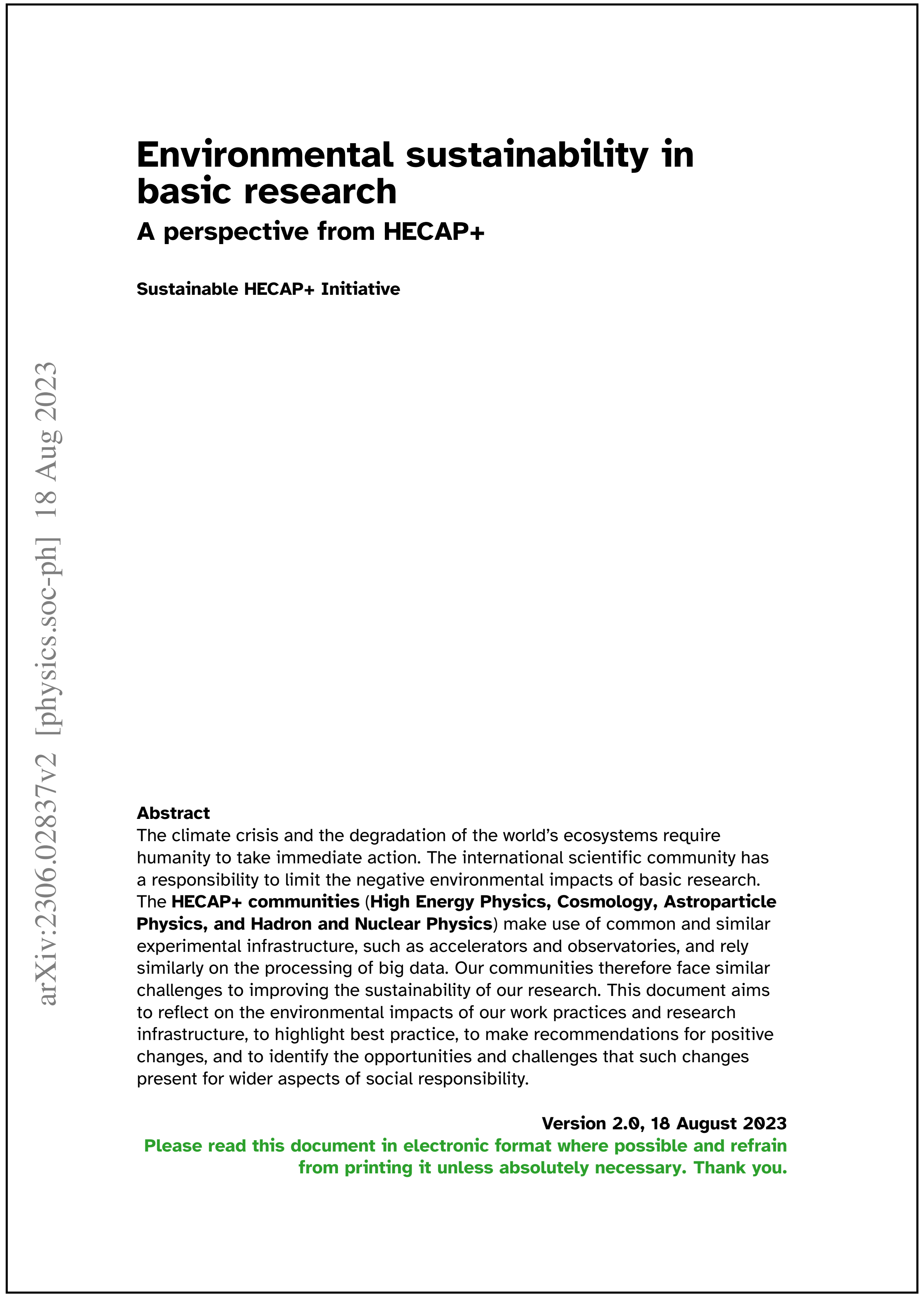
Further group actions: „Collaborations and projects“

-

Further institutional actions: „Universities, CERN, …“

-

HECAP+ paper: Environmental sustainability in basic research



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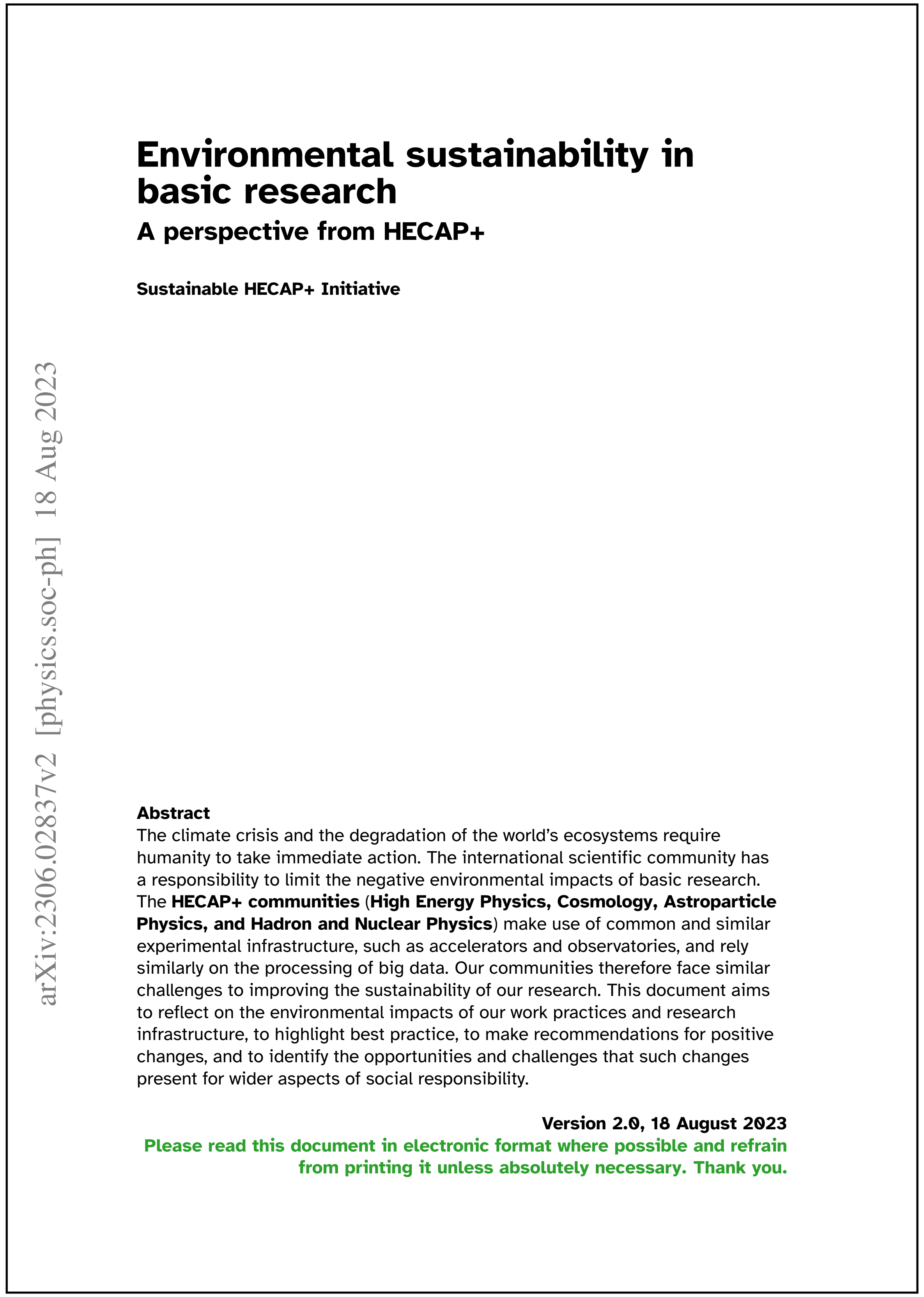
Recommendations — Impelling Positive Change

Individual actions:

- Consider the environmental impact of work practices.
- Be proactive in seeking best practice.
- Make and model positive change in research activities.
- Drive positive group and institutional actions.

HECAP+ paper: Environmental sustainability in basic research



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Recommendations — Impelling Positive Change

Further group actions:

- Include critical assessment of the environmental impact of all activities during planning stages.
- Monitor, assess, report on and set targets in relation to the environmental impacts of research activities.
- Drive institutional actions, and encourage, support and incentivise individual actions, e.g., through training.

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A perspective from HECAP+

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Recommendations — Impelling Positive Change

Further institutional actions:

- Require funding applications to outline plans for monitoring, reporting and minimising adverse environmental impacts, and for ensuring that research is undertaken in line with principles of social justice.
- Allow flexibility in policies and procedures e.g., budget allocation, that enable environmentally sustainable choices to be made.
- Ensure that degree programmes include a focus on global citizenship, encompassing environmental sustainability and associated social justice implications.
- Acknowledge focus on environmental sustainability and social justice in the accreditation of degrees by governments and professional bodies.
- Encourage, support and incentivise individual and group actions, e.g., by considering them in professional development and appraisal processes.

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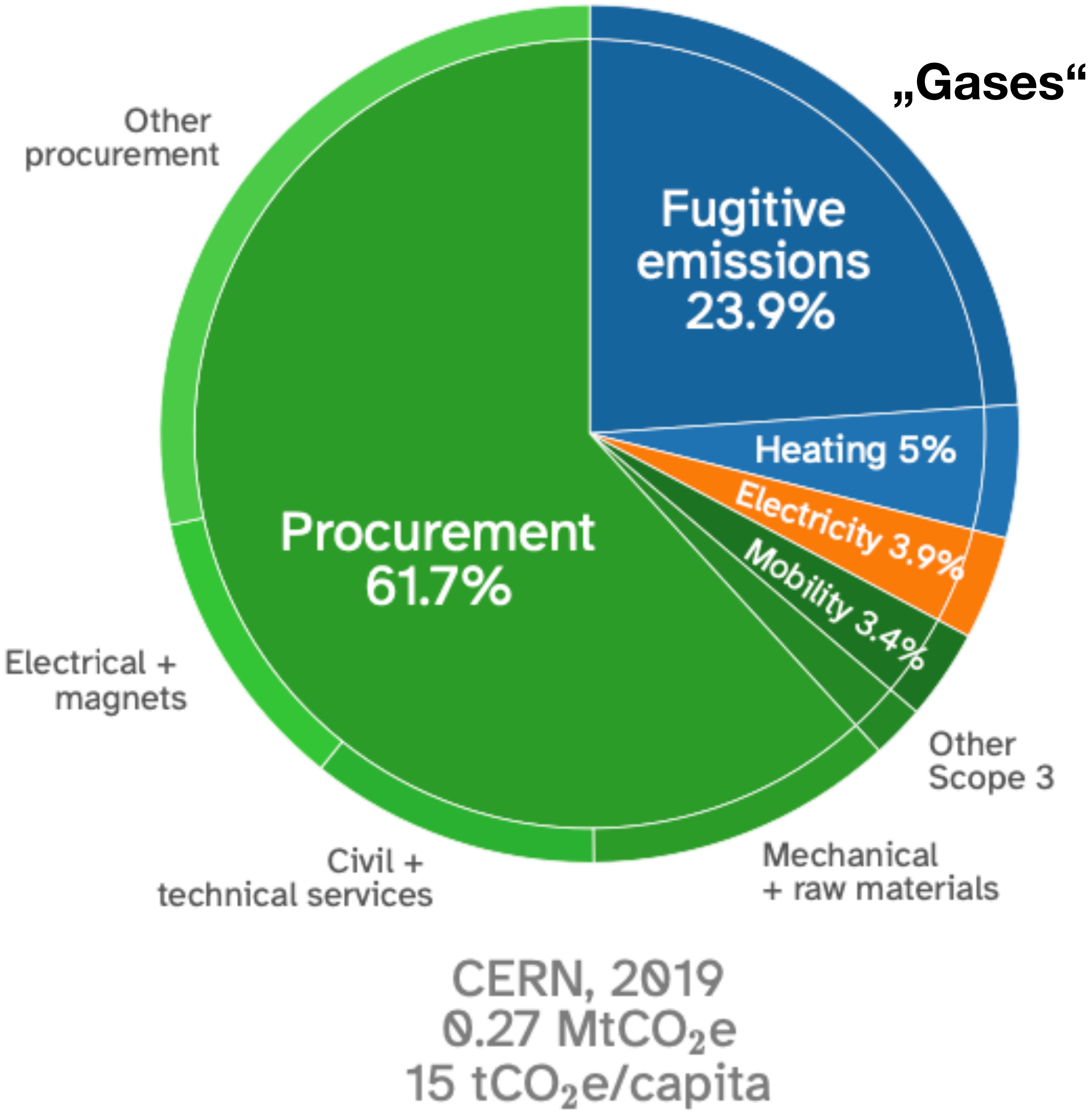


„CERN“ emissions

CO_2-equivalence

during LHC shut-down (2019)

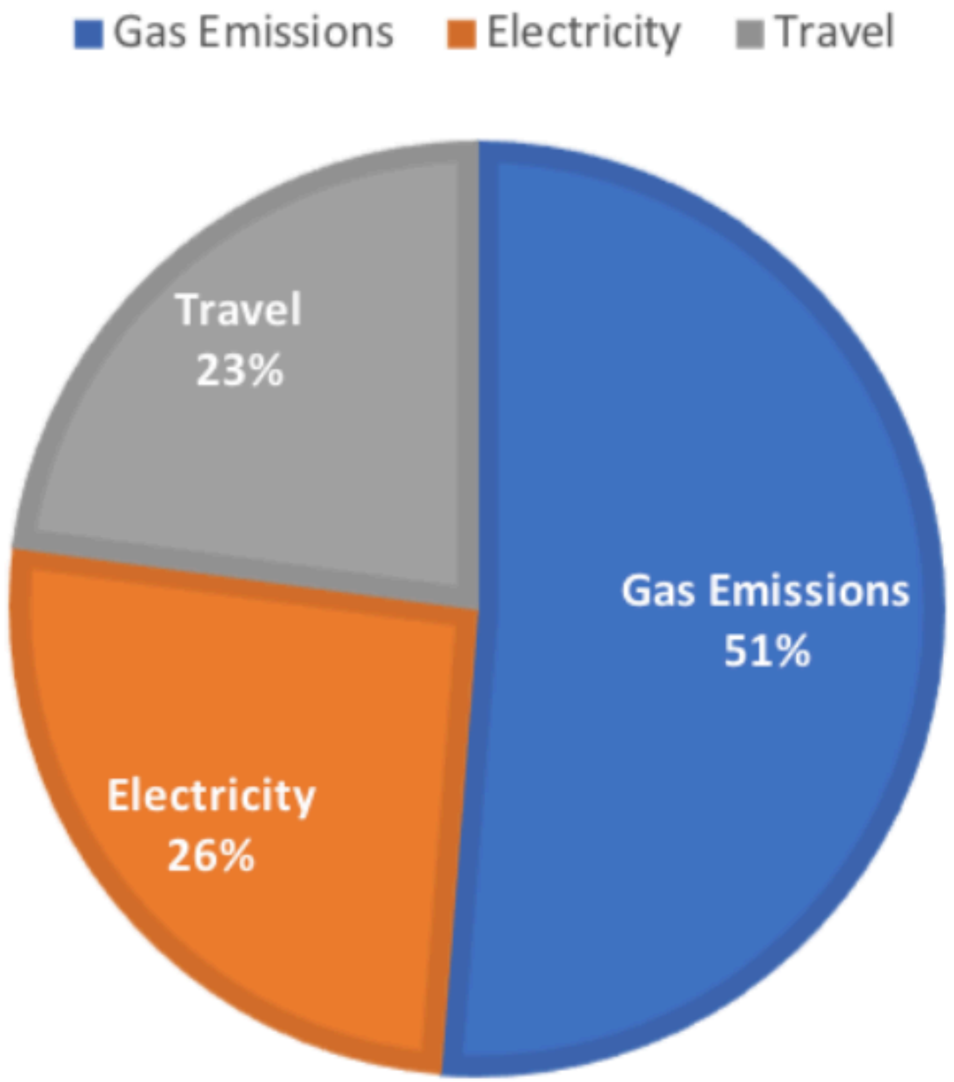
Carbon footprint:

Scope 1 = direct emission (e.g. fossil heating)

Scope 2 = indirect emission (electricity)

Scope 3 = purchase materials, services, …

HECAP+ paper: Environmental sustainability in basic research



LHCb: Run 3 emissions

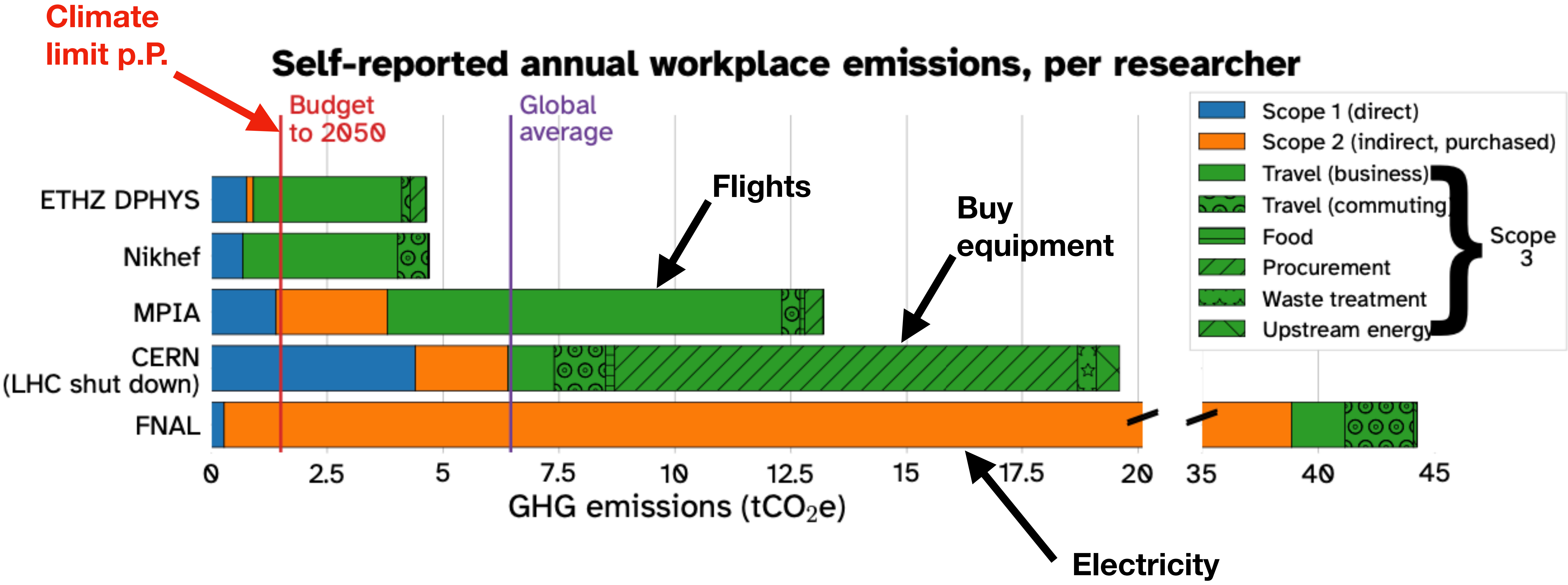
leaking gases from RICHs and muon chambers, …

Global warming potential of greenhouse gases

Name	Chemical Formula	Lifetime [years]	Global warming potential (GWP) [100-yr time horizon]
Carbon dioxide	CO_2	–	1
Dimethylether	CH_3OCH_3	0.015	1
Methane	CH_4	12	25
Sulphur hexafluoride	SF_6	3,200	22,800
Hydrofluorocarbons (HFCs)			
HFC-23	CHF_3	270	14,800
HFC-134a	$C_2H_2F_4$	14	1,430
Perfluorocarbons (PFCs)			
PFC-14	CF_4	50,000	7,390
PFC-116	C_2F_6	10,000	12,200
PFC-218	C_3F_8	2,600	8,830
PFC-3-1-10	C_4F_{10}	2,600	8,860
PFC-5-1-14	C_6F_{14}	3,200	9,300

Table 6.2: Environmental impact associated with GHGs, from Ref. [218], which also forms the source for the calculations in the CERN environmental report and the EU regulations described in Ref. [219].

HECAP+ paper: Environmental sustainability in basic research



Physicist's emissions

Personal Emissions

(Plot deleted from HECAP+ paper v2 as it can easily be misinterpreted)

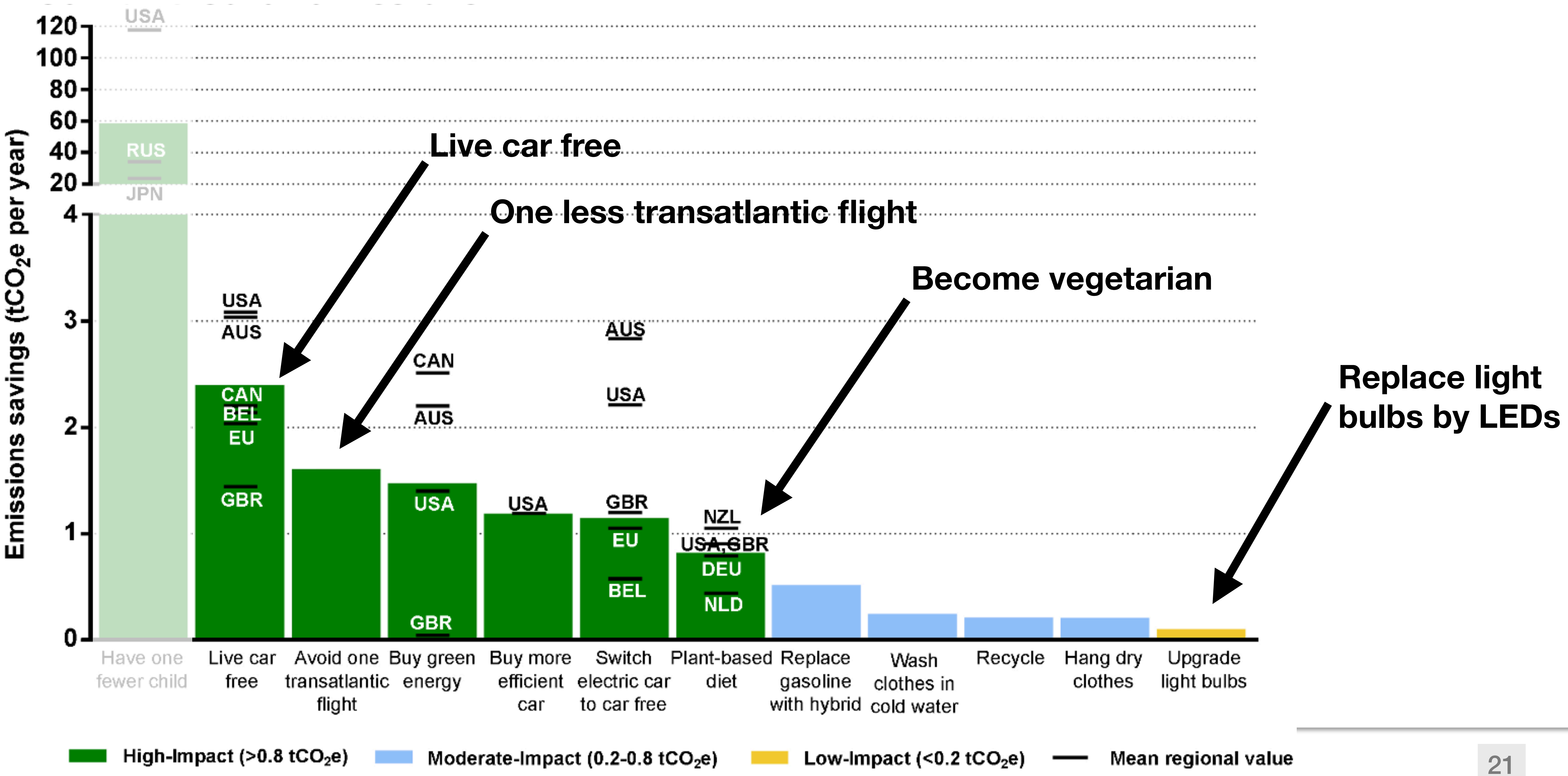


Figure from https://doi.org/10.1088/1748-9326/aa7541

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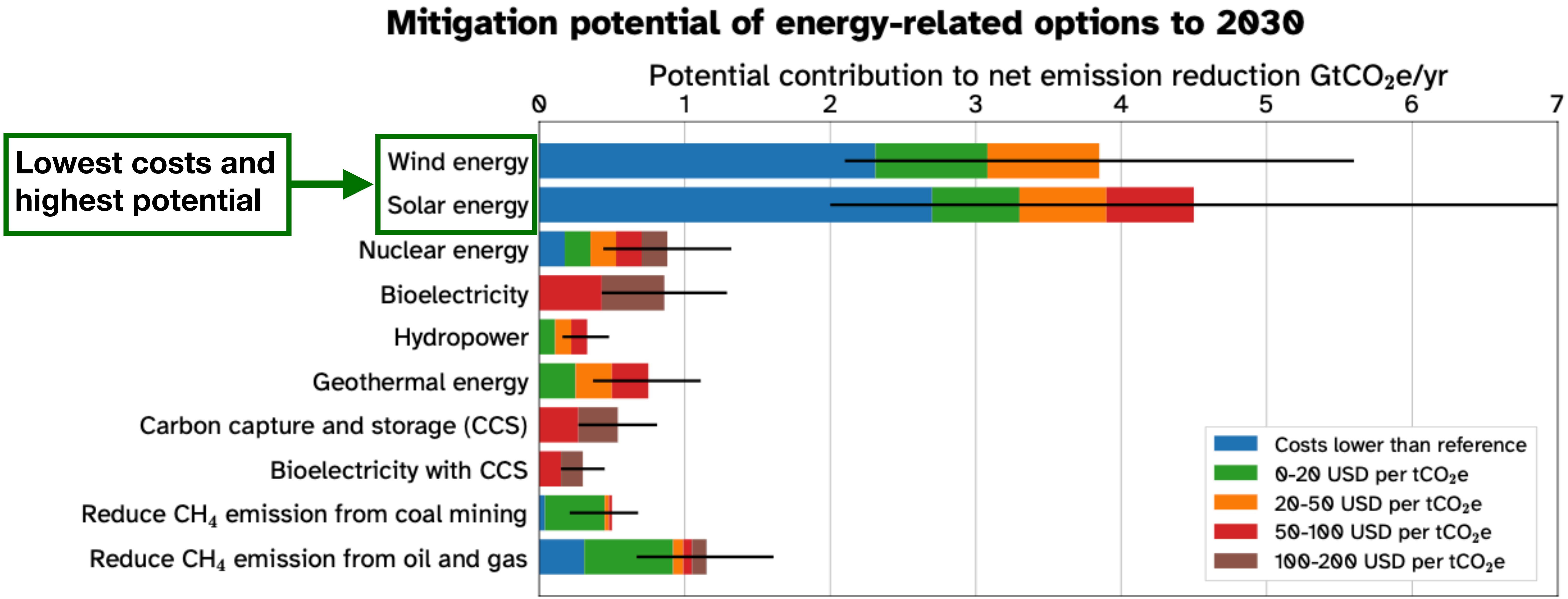
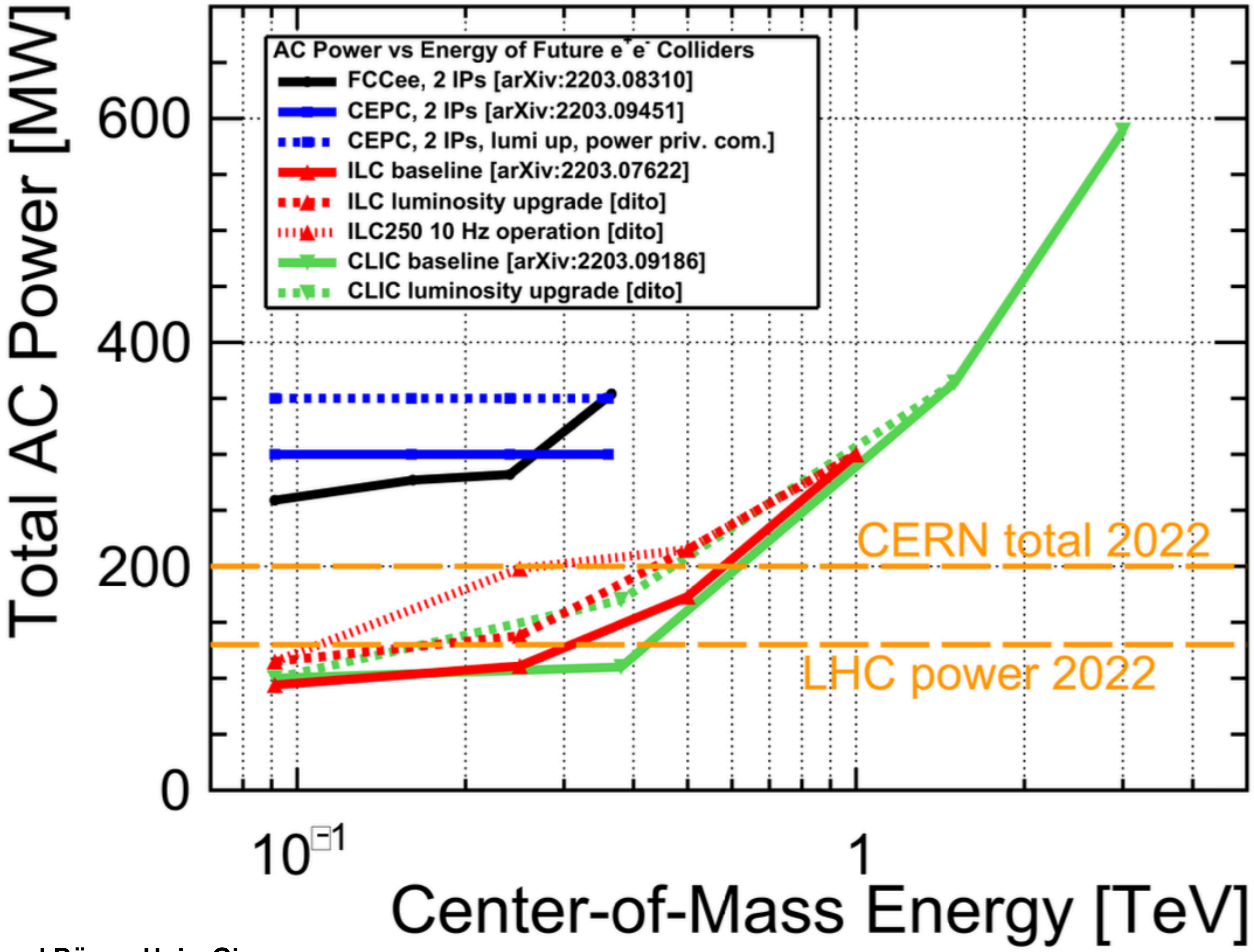


Costs calculated with respect to conventional power generation; mitigation potential assessed with respect to current policy reference scenarios. For all measures save emissions reductions, the cost categories are indicative, and estimates depend heavily on factors such as geographical location, resource availability and regional circumstances. Relative potentials and costs will vary across countries and in the longer term.

IPCC analysis

HECAP+ paper: Environmental sustainability in basic research



Power consumption of CERN, LHC and future colliders

CERN-Link

<u>Proposal:</u>
Power line exclusively for international research:

3.6 GW (day)
2.2 GW (night)

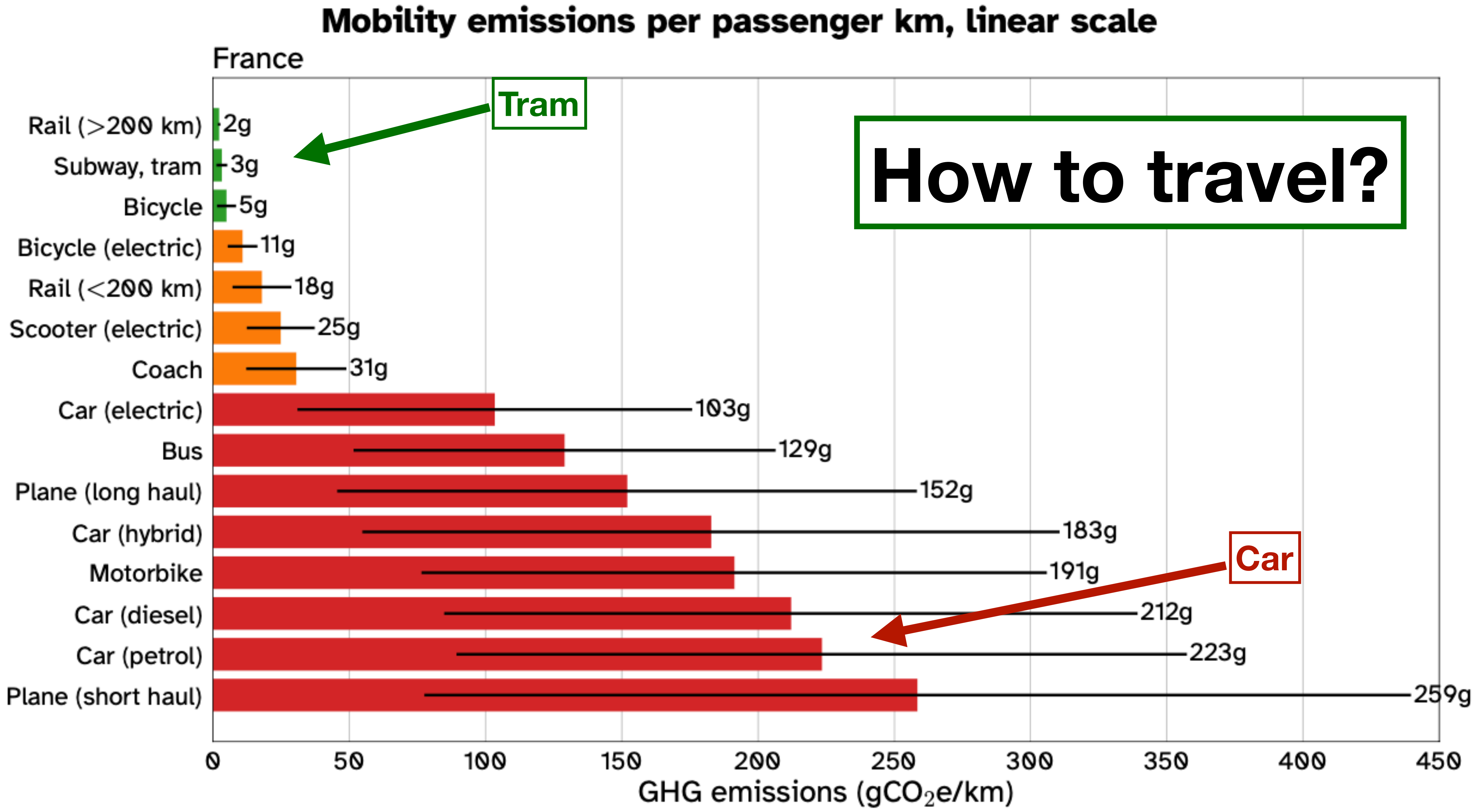
6-7 ct/kWh
Stable & low costs!

Ref: Thesis J. Hampp

Power from hydrogen has 2-3 x higher costs!

To be initiated by
CERN, HGF, Universities, … ?

What to do and what to avoid?



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Source: Labos1.5 database. Estimates include production emissions, and may vary slightly based on occupancy of public transport, and between countries.

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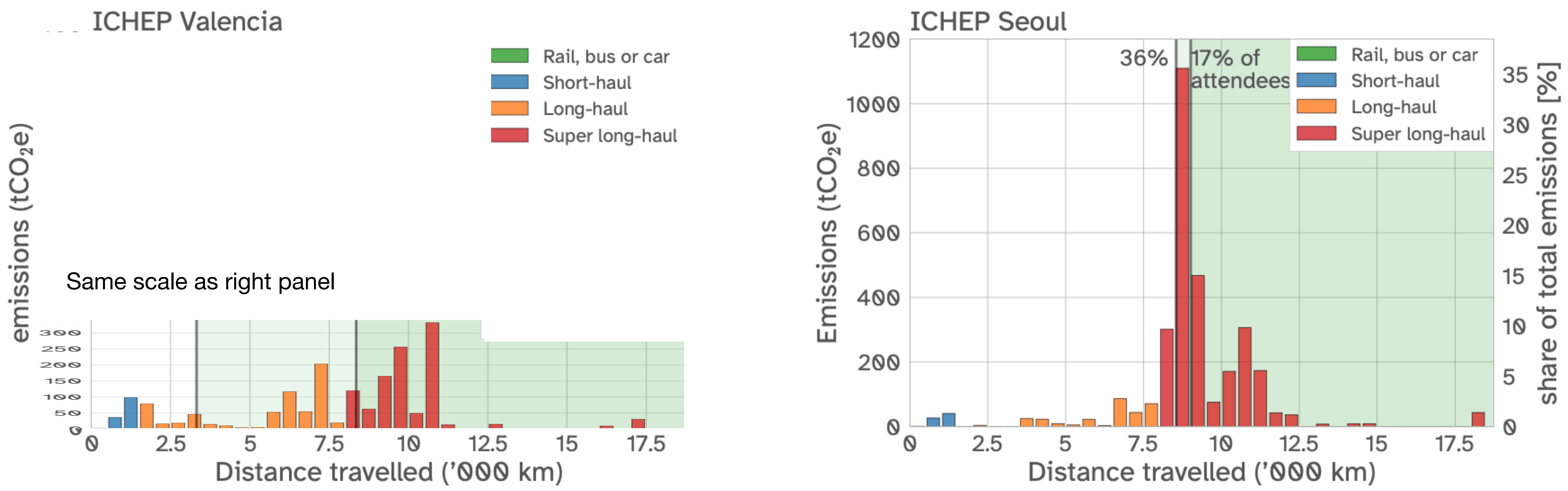

Where to make conferences?

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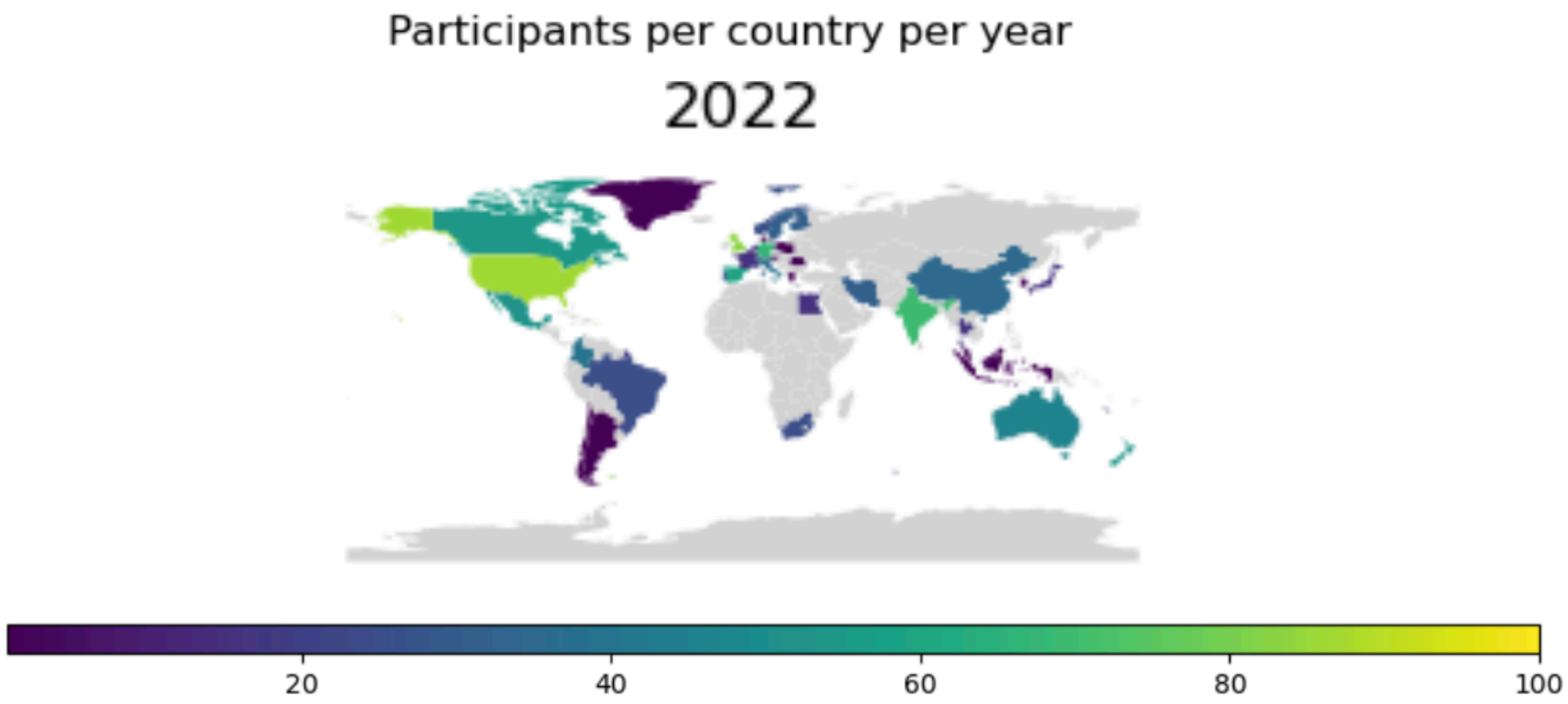

Figure 5.4: Geographical distribution of Cosmology from Home participants for each of the installments by year.

„Cosmology from Home“:
an online conference that includes all researchers

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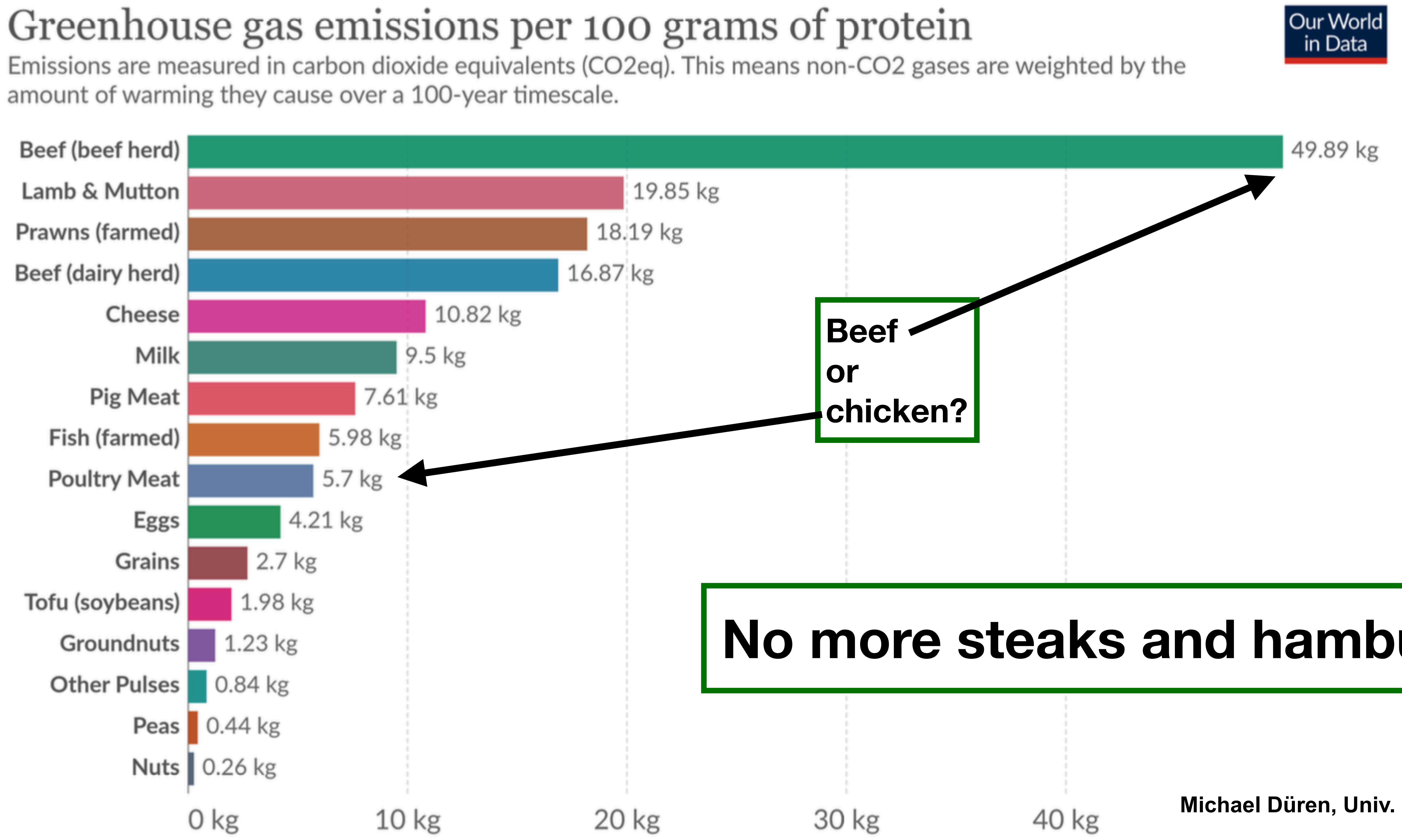

No more steaks and hamburgers?

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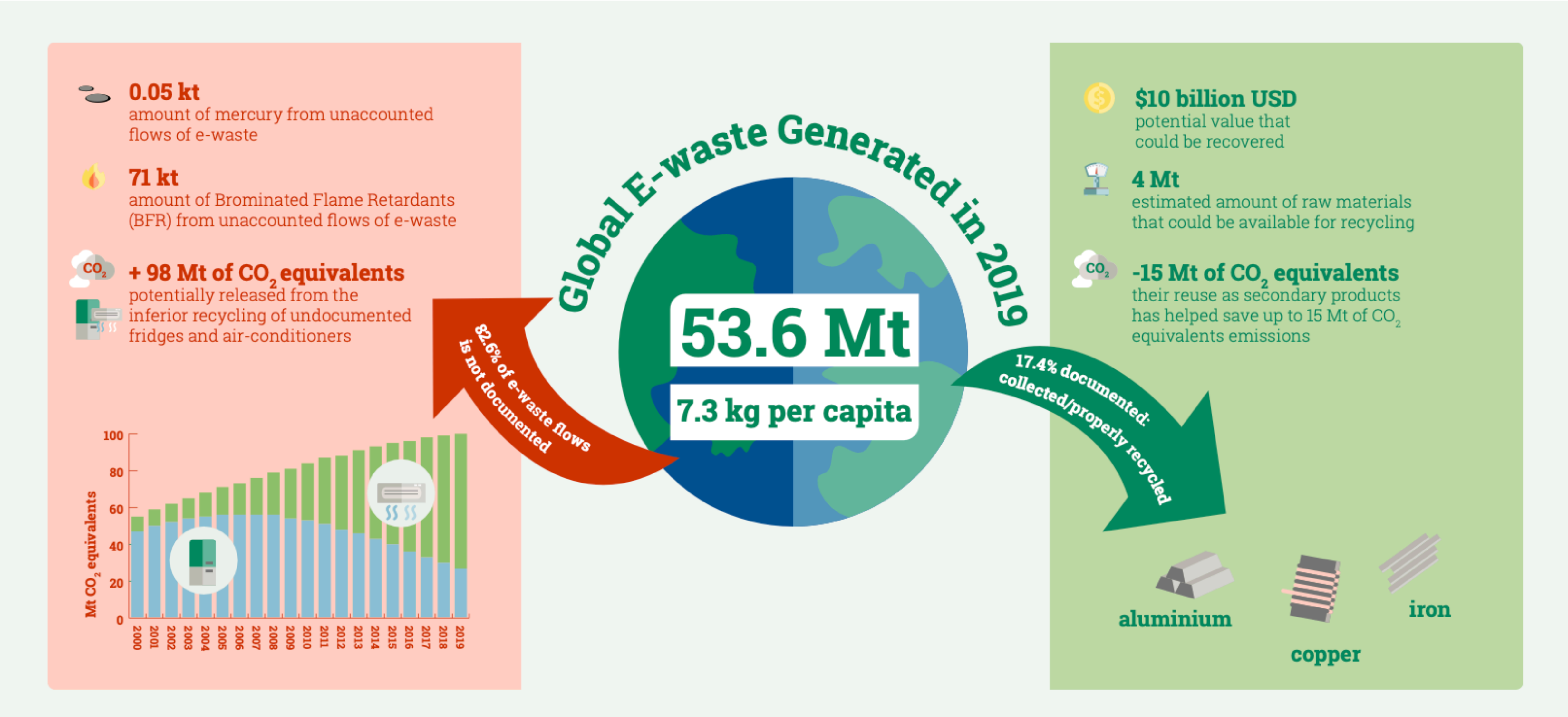

Importance of
Reduce
Re-use
Re-pair
Re-cycle

Manufacturers:
Build devices from standardised modules that can be repaired easily

Research institutions:
Have a pool of devices that can be used by many groups

Personally, I think:
If our planet would be a HEP experiment, we would manage to overcome its climate crisis

The HEP community has skills that can help to solve the global crises

e.g.

Sensors and monitoring

Big data

Complex systems

Detailed simulations

Machine learning

Goal oriented individual motivation

Intercultural, diverse, open and democratic management

THANK YOU FOR YOUR UNDERSTANDING