

# Global trend for the policies toward carbon-neutral world

ALPS International Symposium, Tokyo, 4 February 2025, For achieving the carbon neutral and green economy policies in the major countries, region; 

**Nebojsa Nakicenovic**

**Vice Chair, Group of Chief Scientific Advisers**



**Distinguished Emeritus and Honorary Scholar**



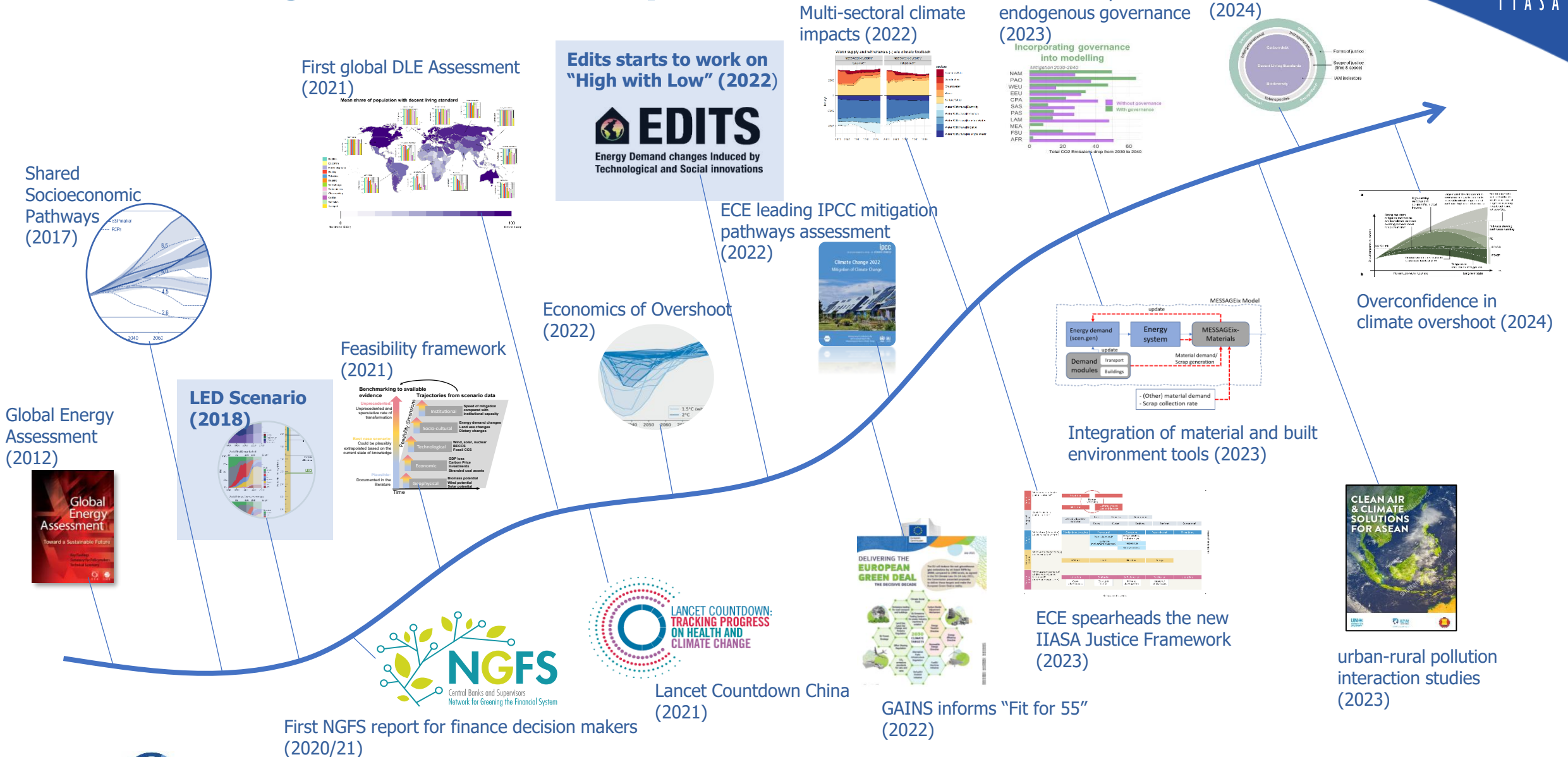
**Emeritus Professor of Energy Economics**



**Earth Commission Ambassador**



# Evolutionary progress of ECE towards a better understanding of the solution space







**Astronaut Sunita Williams**



# Two Faces of the Anthropocene

*“One can see from space how the human race has changed the Earth. Nearly all of the available land has been cleared of forest and is now used for agriculture or urban development. The polar icecaps are shrinking and the desert areas are increasing. At night, the Earth is no longer dark, but large areas are lit up. All of this is evidence that human exploitation of the planet is reaching a critical limit. But human demands and expectations are ever-increasing. We cannot continue to pollute the atmosphere, poison the ocean and exhaust the land. There isn’t any more available.”*

**Stephen Hawking**

# Is there (intelligent) life elsewhere, how do we know, and do we prepare to interact?

- ➡ Is life on Earth unique in the universe? Are we “alone”?
- ➡ There are 200 billion to 2 trillion galaxies in the observable infinite universe
- ➡ Milky Way has some 100-200 billion stars and 800 billion to a trillion planets
- ➡ Fermi paradox: Interstellar travel might be easy given enough time, so we should have been already visited by aliens
- ➡ But space-time limits reaching other Earth-like worlds
- ➡ Are (neutron) stars habitable (Ernst Julius Öpik, 1965)?



# How are we as humans having an impact on and beyond planet Earth, and what are the implications?

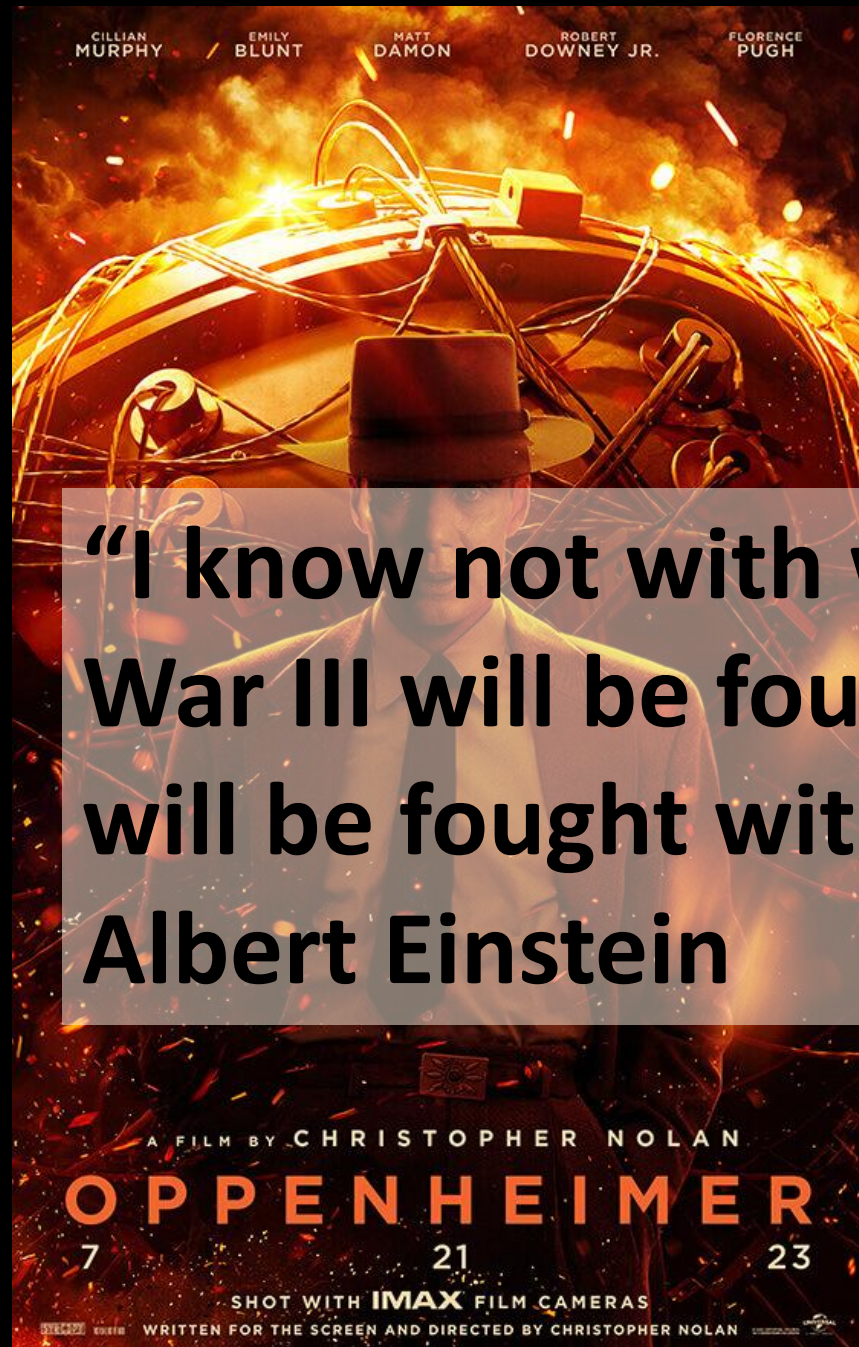
- ➡ Humans have and are changing the planet at a vigorous pace especially since the onset of the Great Acceleration
- ➡ This is visible from space as the atmosphere and surface have changed
- ➡ We are emitting electromagnetic radiation also in the visible spectrum, have overcrowded the orbit ...
- ➡ In toto, we have left the Holocene and are now a single species that is changing the Earth system, thus we are in the Anthropocene



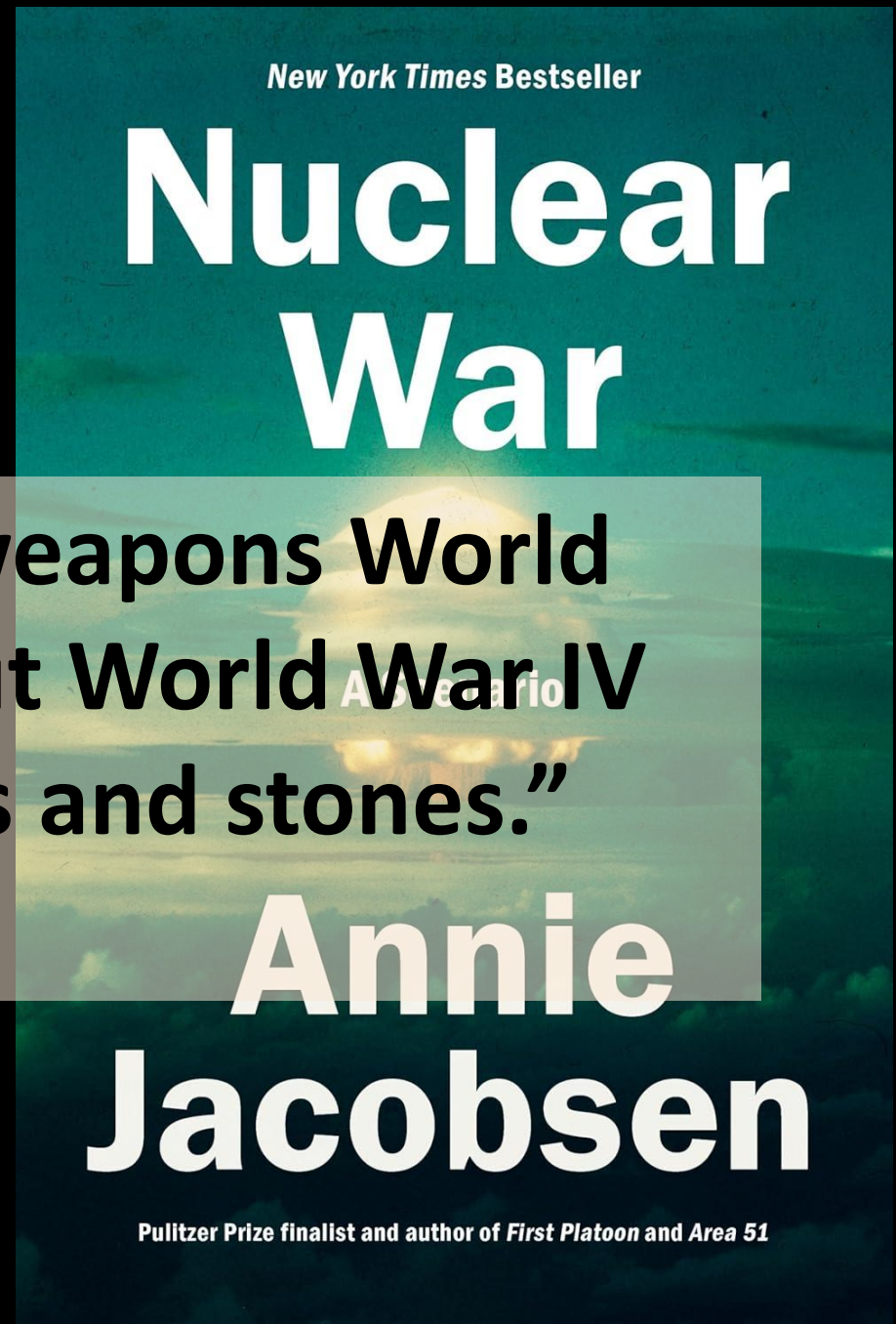
***“The Earth is a fine place and worth fighting for.”***  
**Ernest Hemingway**







**“I know not with what weapons World War III will be fought, but World War IV will be fought with sticks and stones.”**  
**Albert Einstein**





# Transformational Change

## Dynamic, Cumulative, Systemic and Uncertain

- ➡ Incremental – gradual (continuous) and cumulative improvements
- ➡ Abrupt – radical, discontinuous and disruptive as “gales of creative destruction”
- ➡ Add as many mail-coaches as you please, you will never get a railroad by so doing. [Schumpeter, 1935/1951, 136]



# Disruptive Change and Tipping

Easter Parade on Fifth Avenue, New York, 13 years apart

1900: where's the car?



1913: where's the horse?



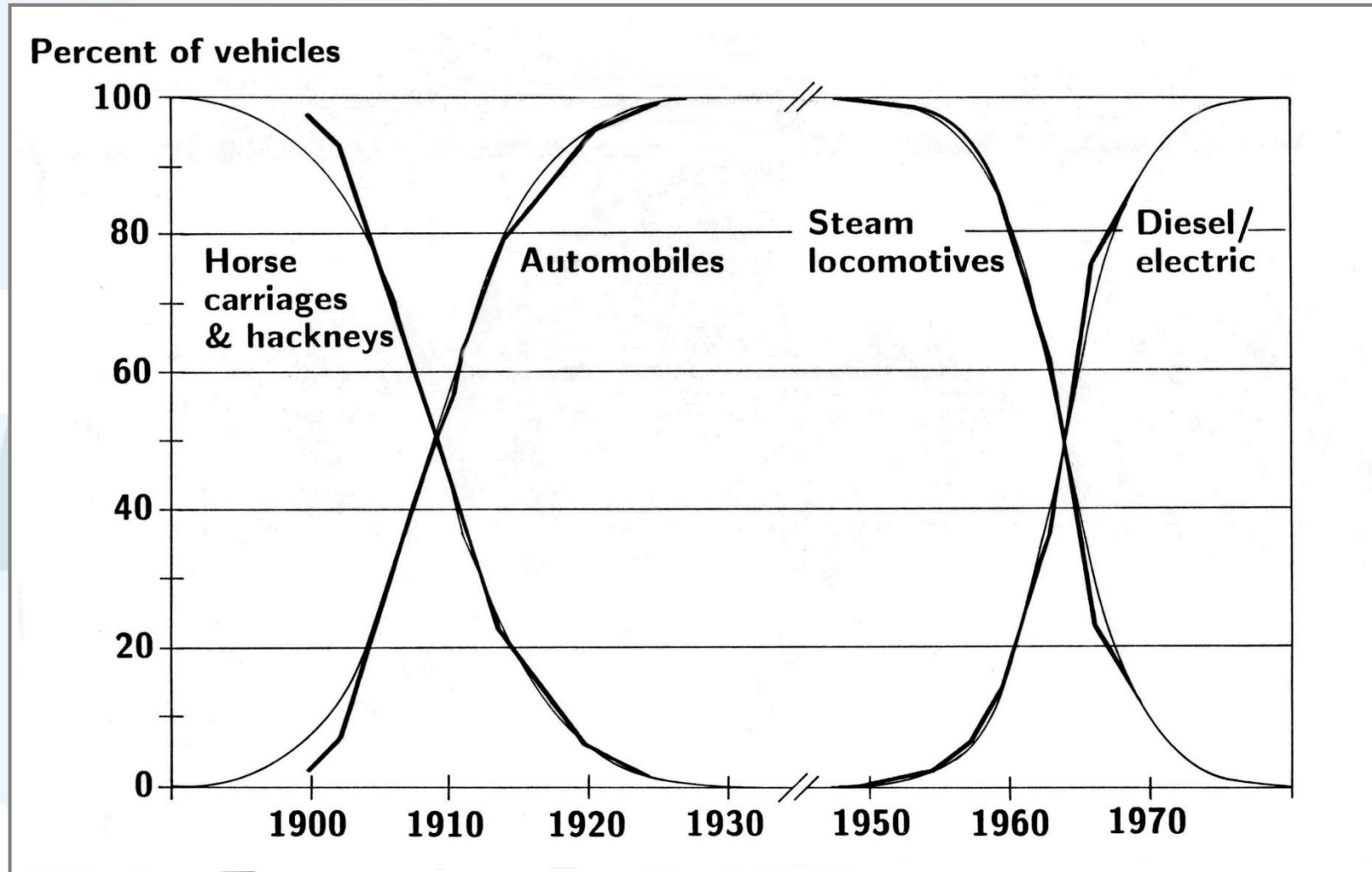
Images: L, National Archive, [www.archives.gov/research/american-cities/images/american-cities-101.jpg](http://www.archives.gov/research/american-cities/images/american-cities-101.jpg)

R, [shorpy.com/node/204](http://shorpy.com/node/204).

Inspiration: Tona Seba's keynote lecture at AltCar, Santa Monica CA, 28 Oct 2014,  
<http://tonyseba.com/keynote-at-altcar-expo-100-electric-transportation-100-solar-by-2030/>



# UK – Disruptive Change and Tipping Vehicle Fleets



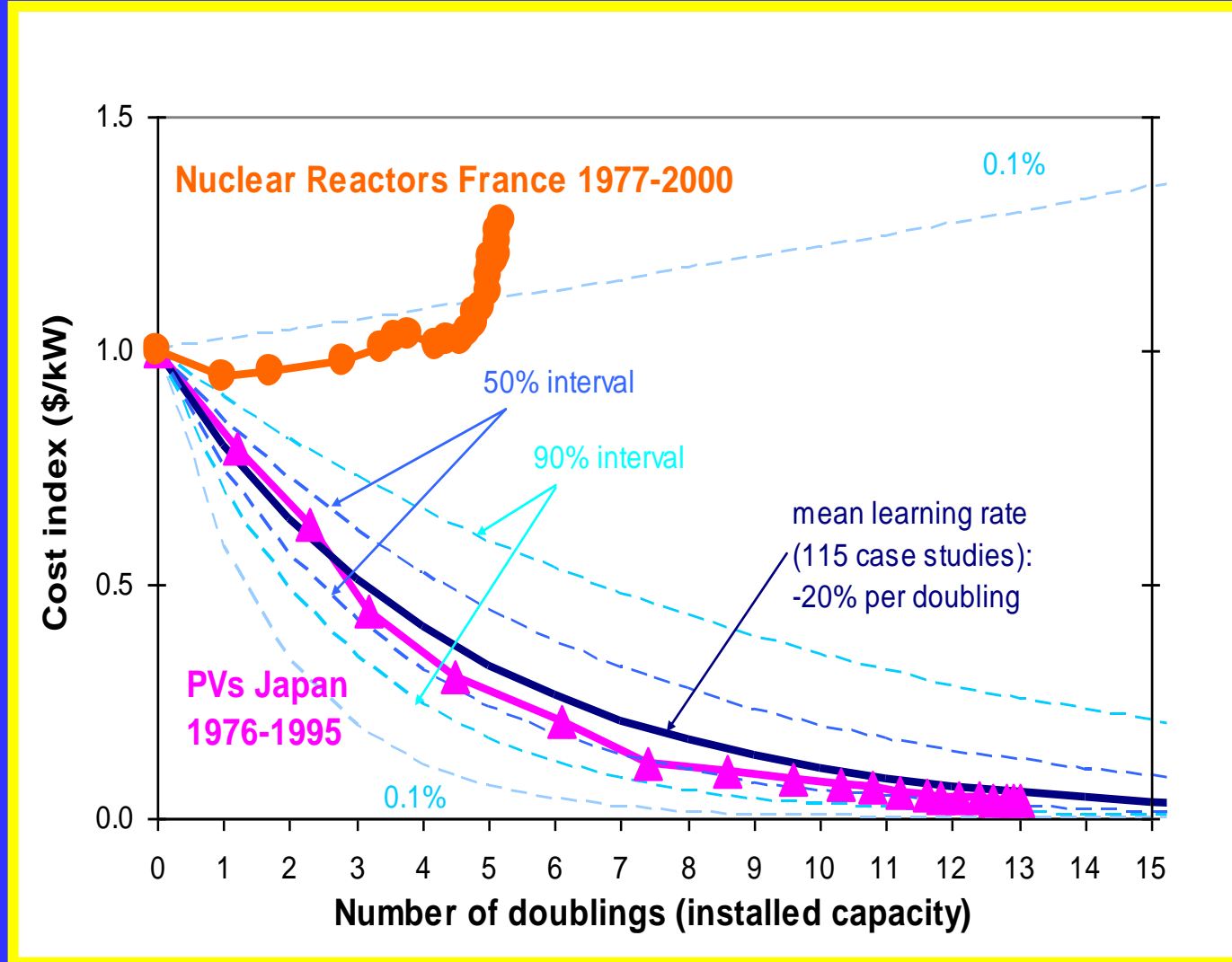
# Uncertainty of Transformational Change

- ➡ Future characteristics (e.g. costs) not a function of time, but dependent on intervening actions (R&D and investments)
- ➡ Improvements through accumulation of experience (learning + knowledge appreciation)
- ➡ Interactive rather than linear model: Learning by doing and using; supply push and demand pull



# Deep Uncertainties and Tipping

## Learning rates (push) and market growth (pull)



# The World is at a “Crossroads”

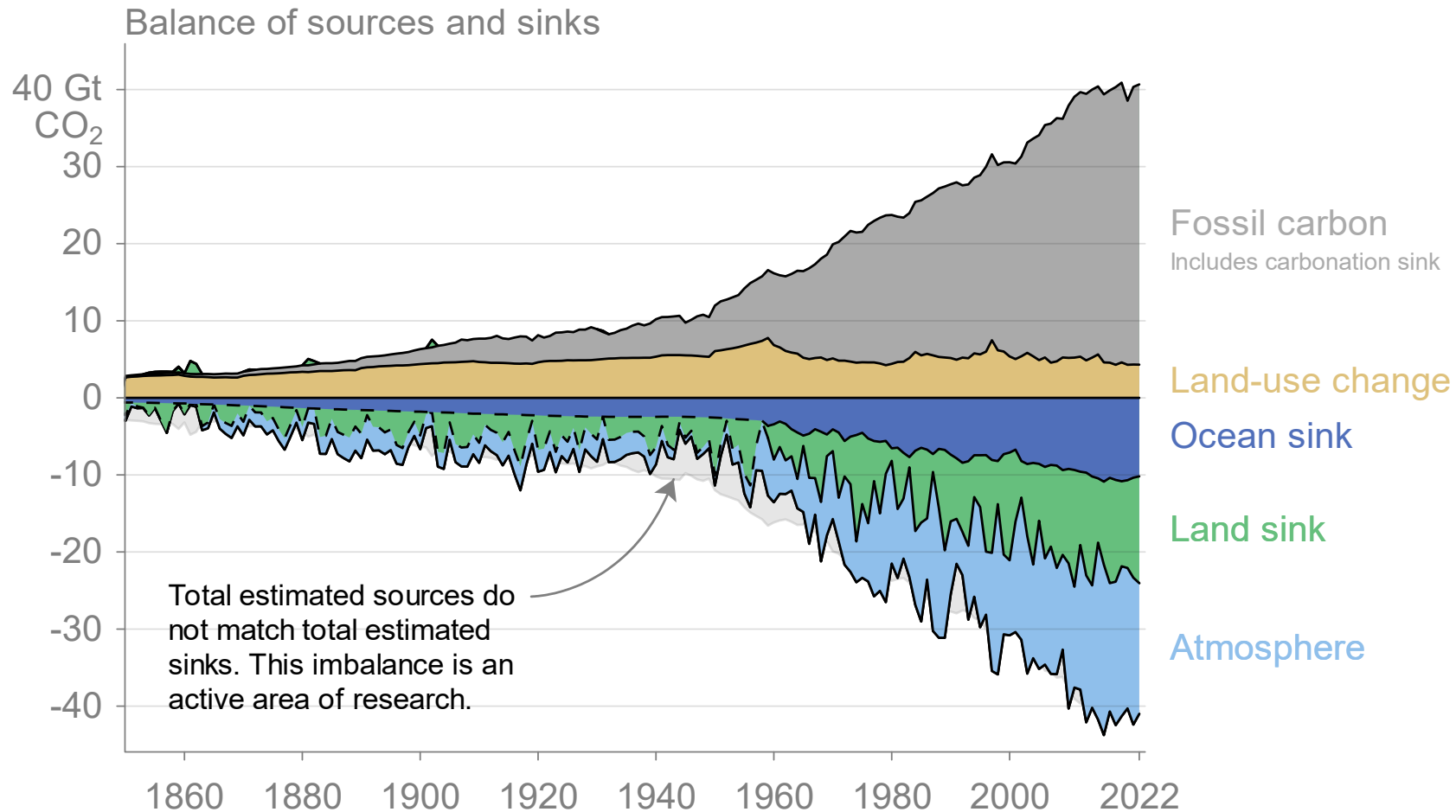
**Enormous challenges and opportunities are facing humanity from multiple crises to achieving a safe and just future for all**

- ➡ Since 1800 global economy increased 100-fold, energy 50 times and CO<sub>2</sub> 30 times bringing multiple benefits
- ➡ During the same period temperature increased over 1.5°C and about 8 million die annually due to air pollution
- ➡ Explosive development also led to transgressing Earth-system boundaries while billions are left behind in poverty
- ➡ Achievement of 2030 Agenda, **Paris Agreement**, and EGD would bring multiple co-benefits for people and the planet



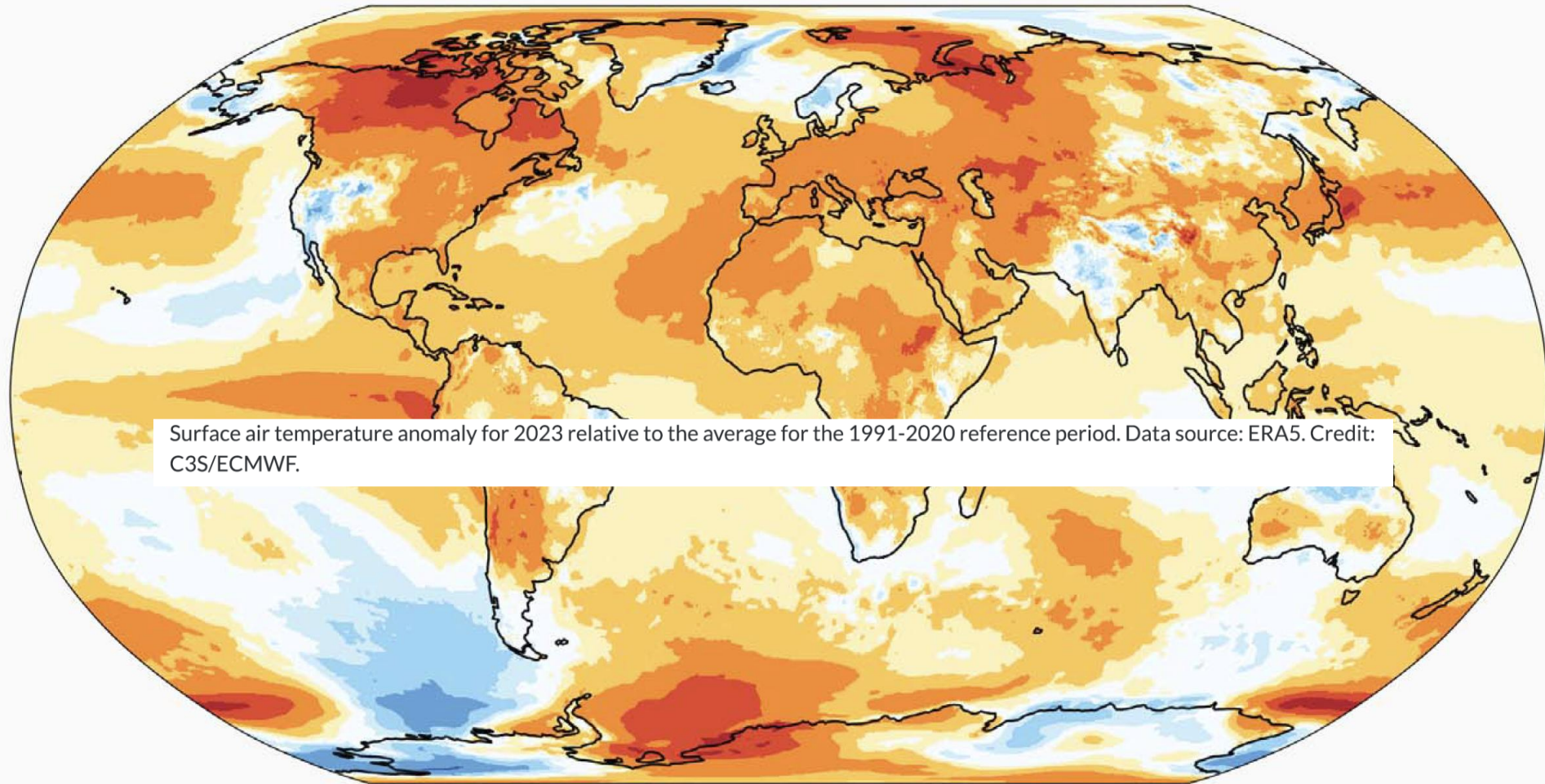
# Global carbon budget

Carbon emissions are partitioned among the atmosphere and carbon sinks on land and in the ocean  
The “imbalance” between total emissions and total sinks is an active area of research



# SURFACE AIR TEMPERATURE ANOMALY • 2023

Reference period: 1991–2020 • Data: ERA5 • Credit: C3S/ECMWF

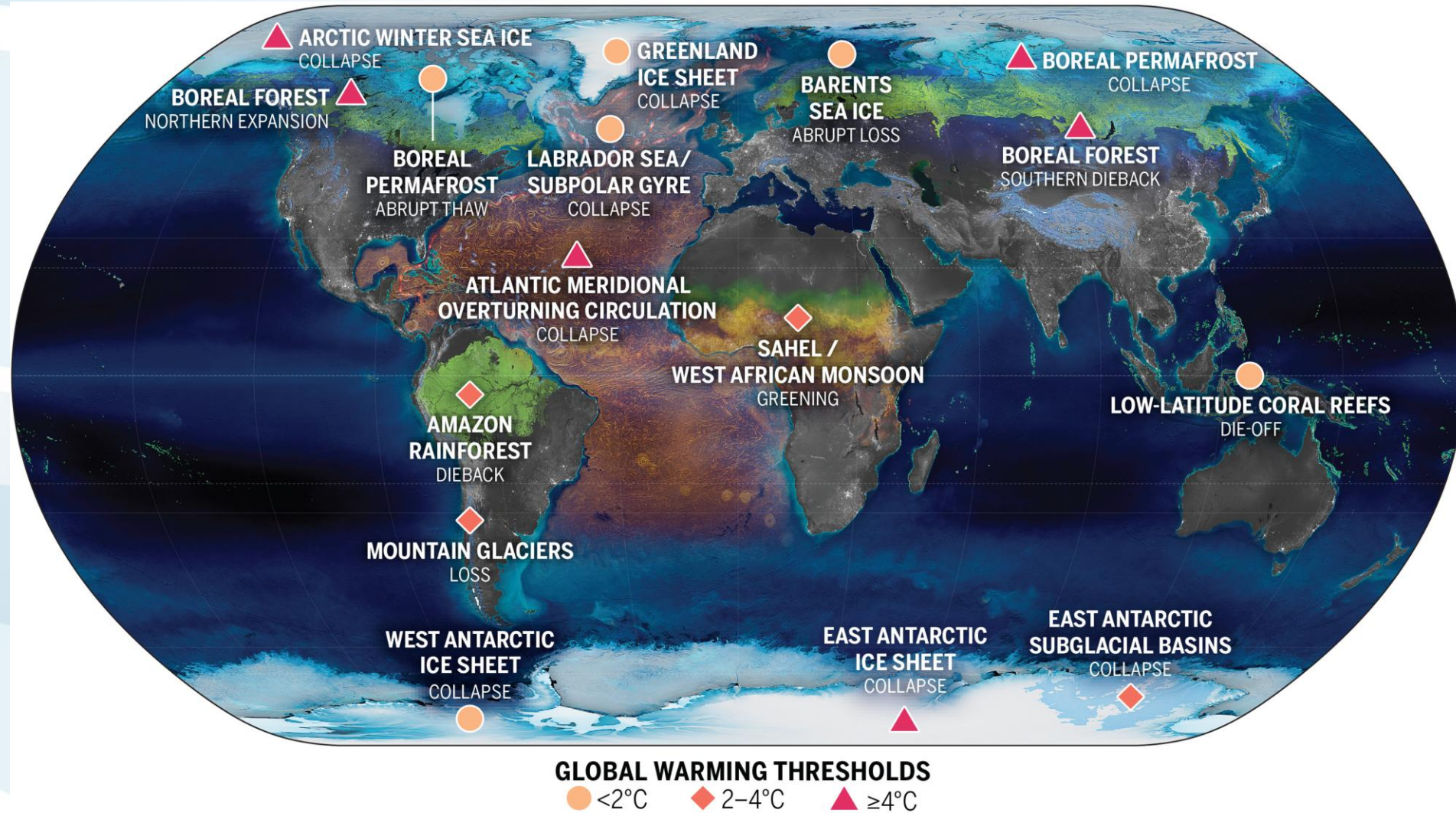


Temperature anomaly (°C)





# What are the Earth-system boundaries and tipping points?



## 16 Earth-system tipping elements

# From Holocene to Earth-Systems Tipping

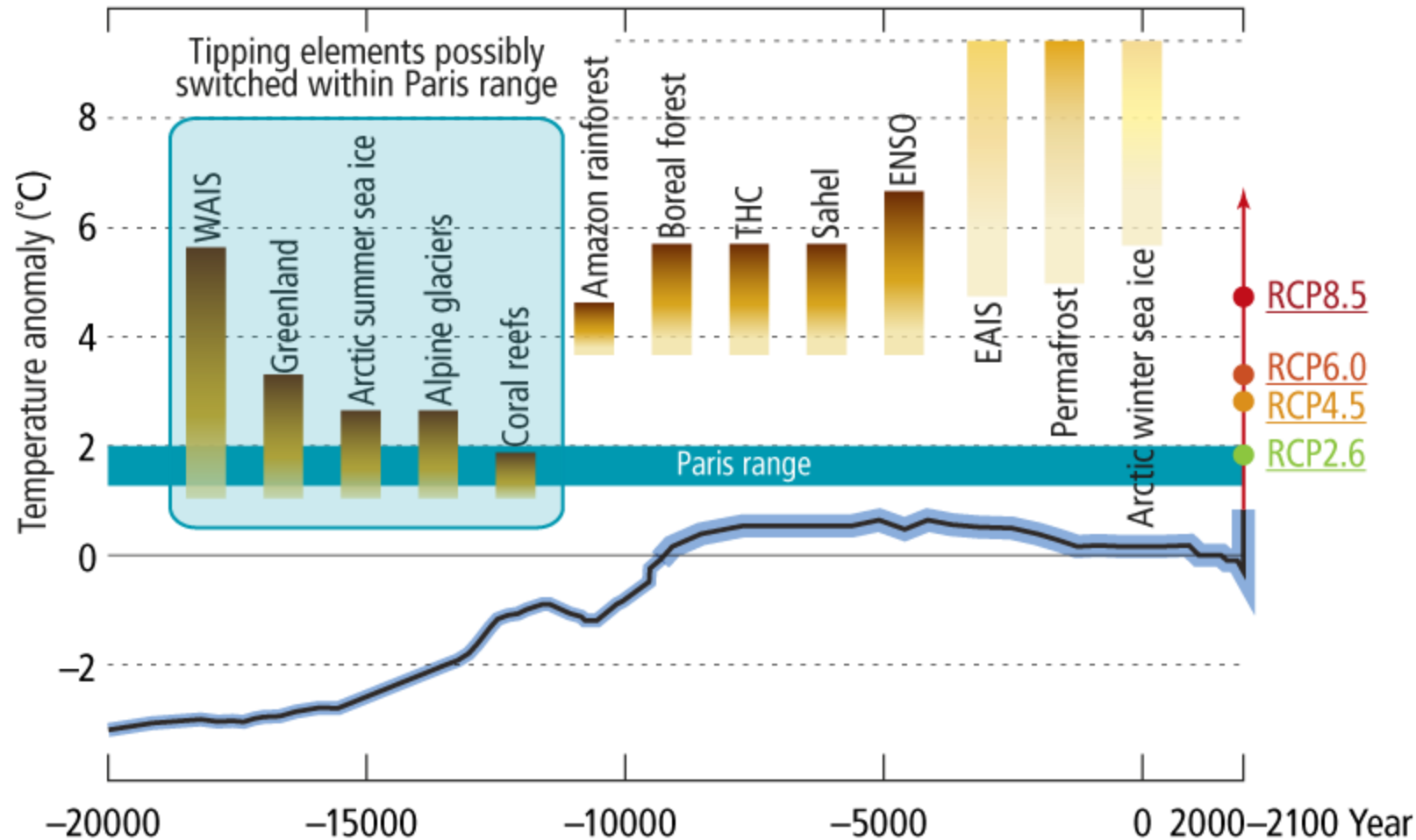
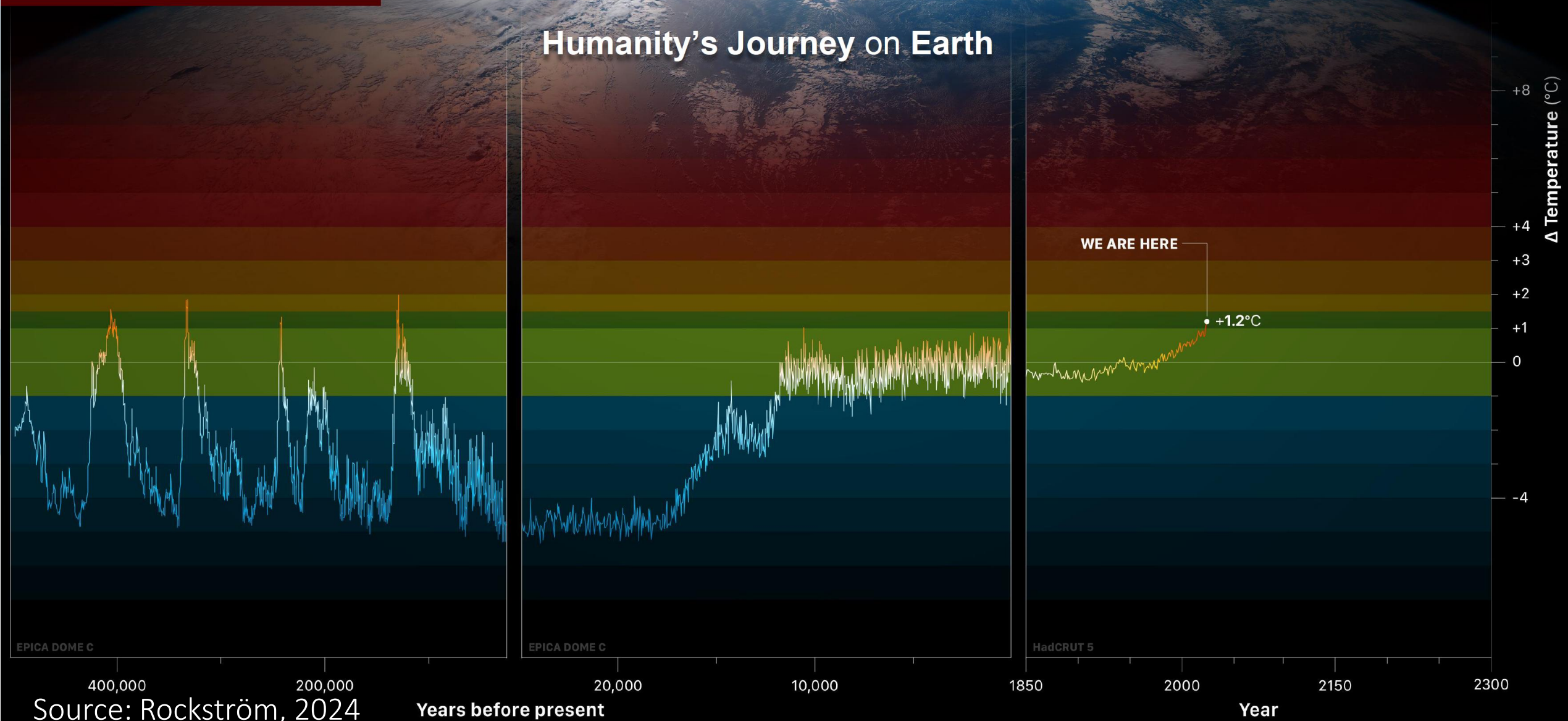




Figure pending revision

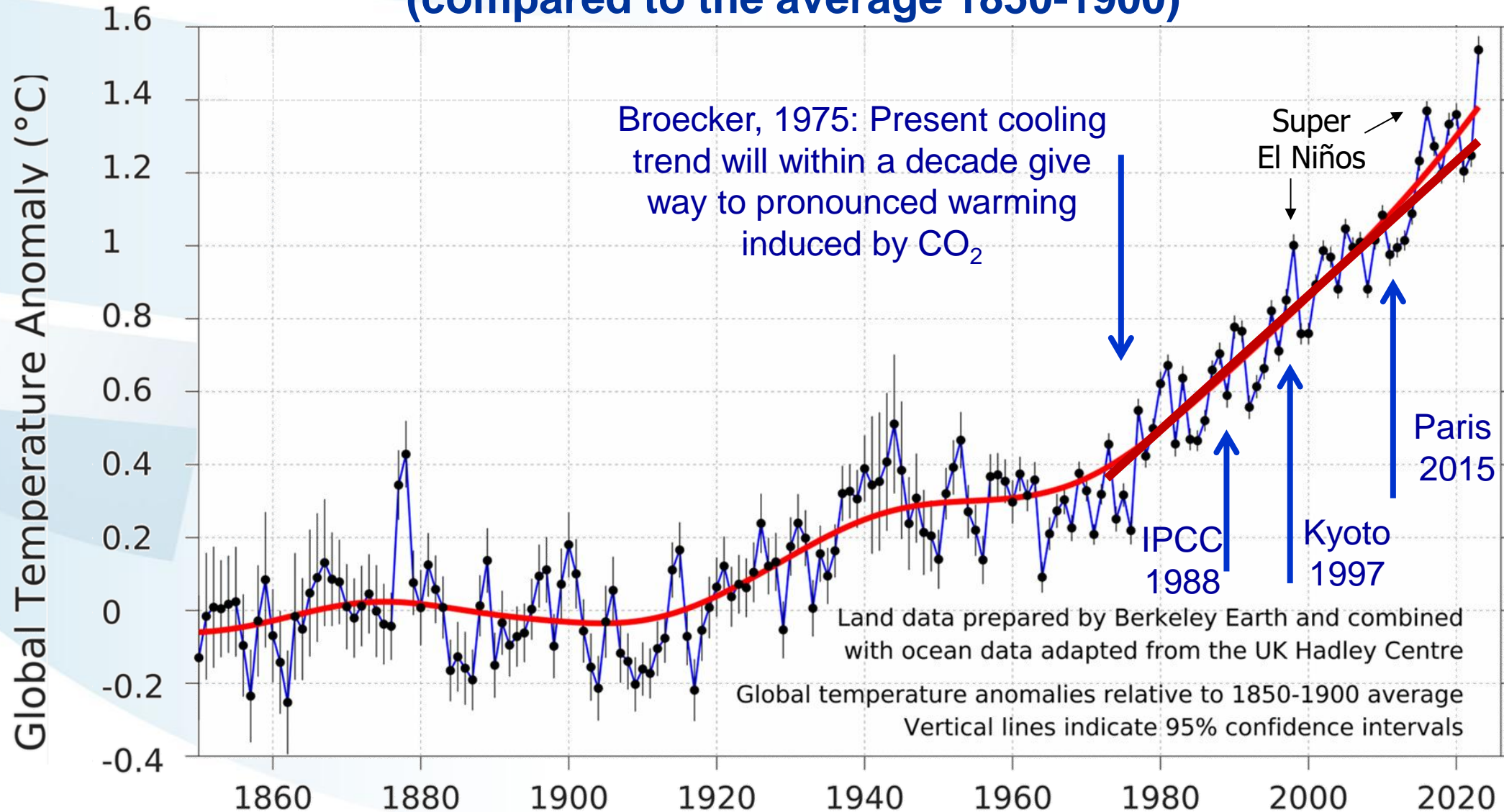
## Humanity's Journey on Earth





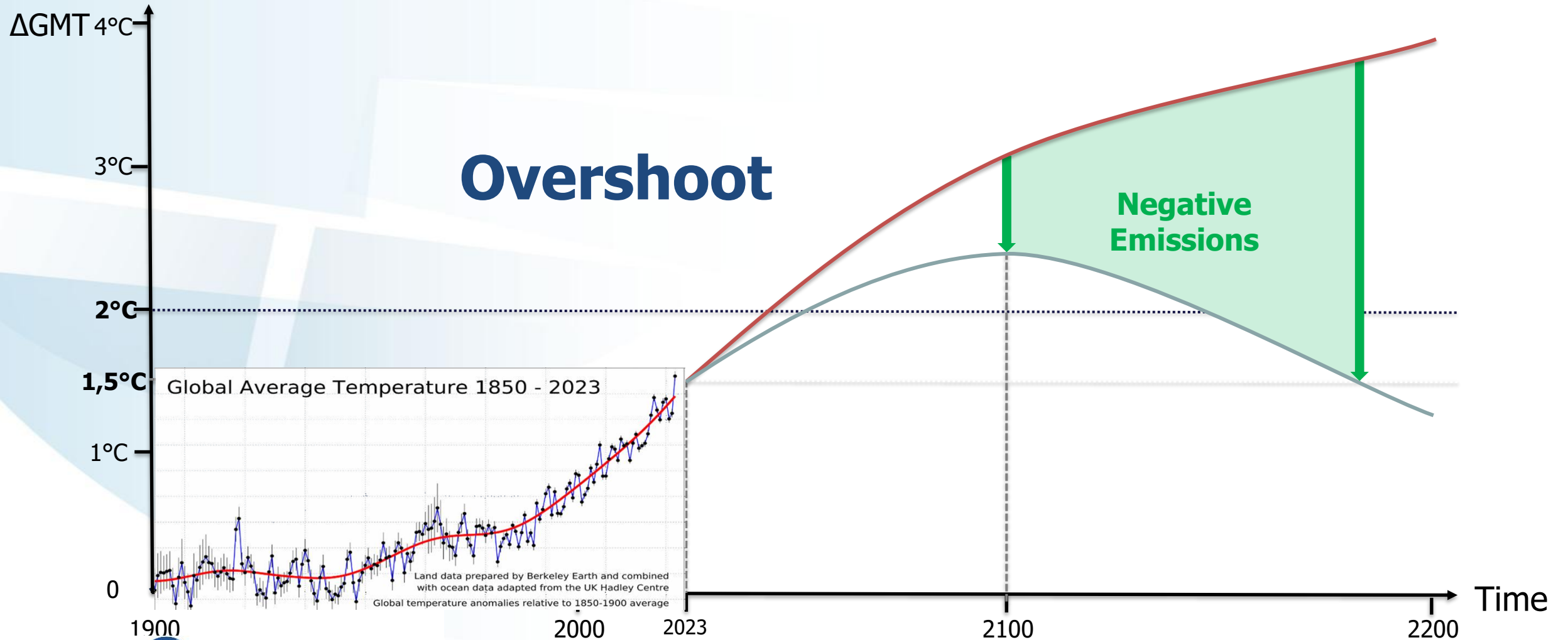
# Global Average Temperature

(compared to the average 1850-1900)

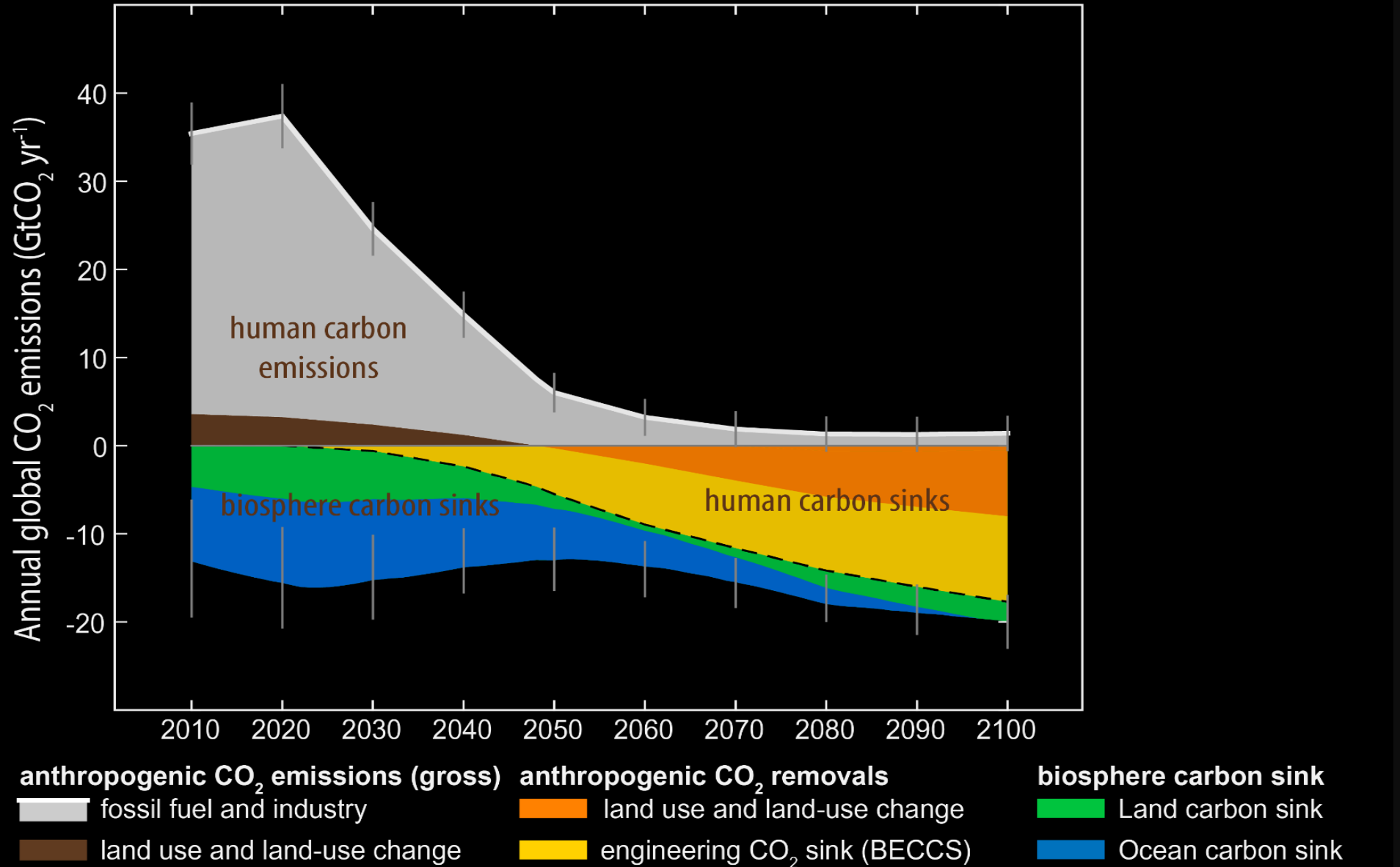


# Global Average Temperature

## Climate Restoration: Repair or Despair!



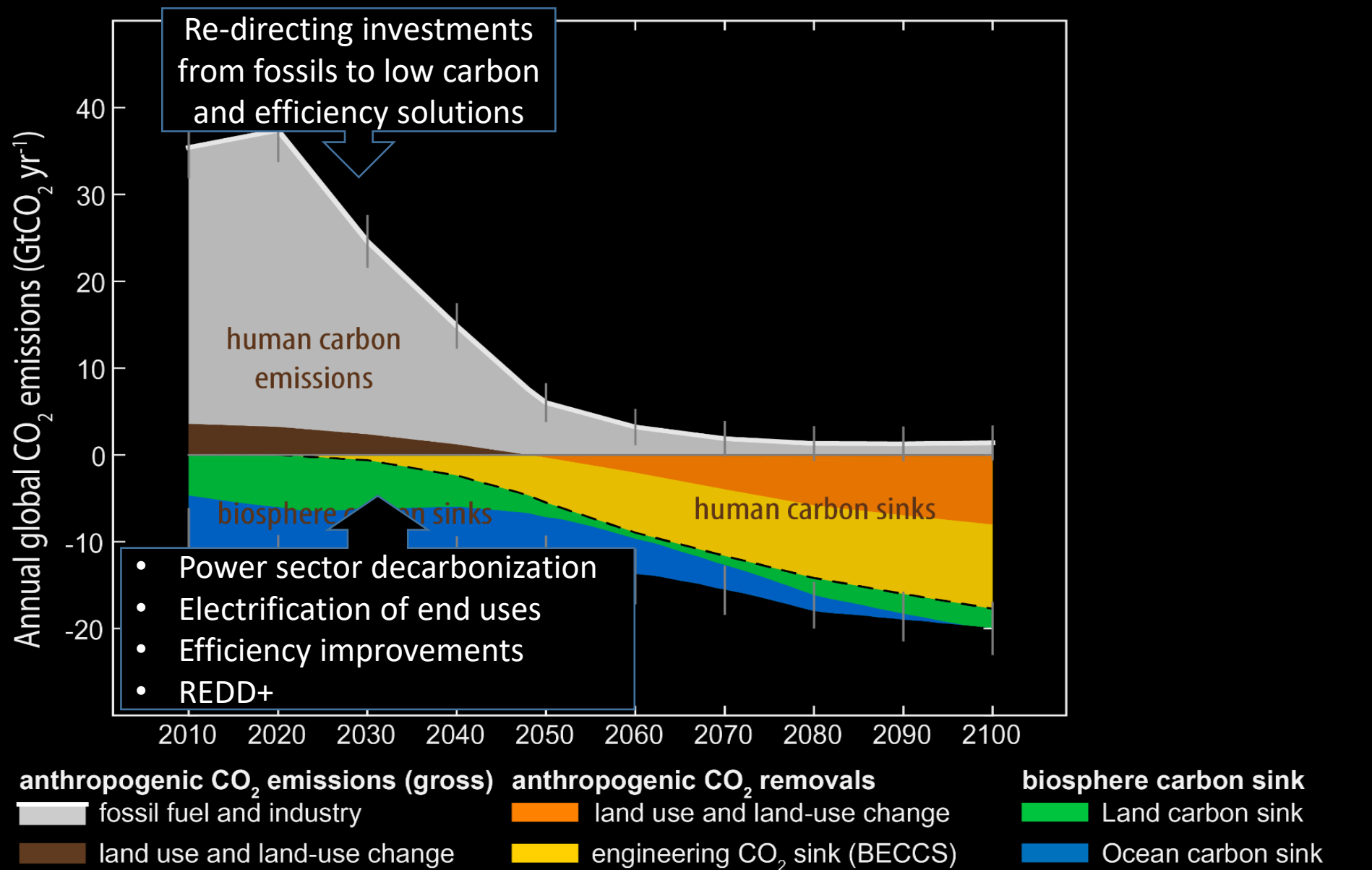
# “Carbon Law”



Source: Rockström, Gaffney, Rogelj, Meinshausen, Nakicenovic, Schellnhuber, 2017; IPCC SR1.5, 2019; Kriegler, 2019

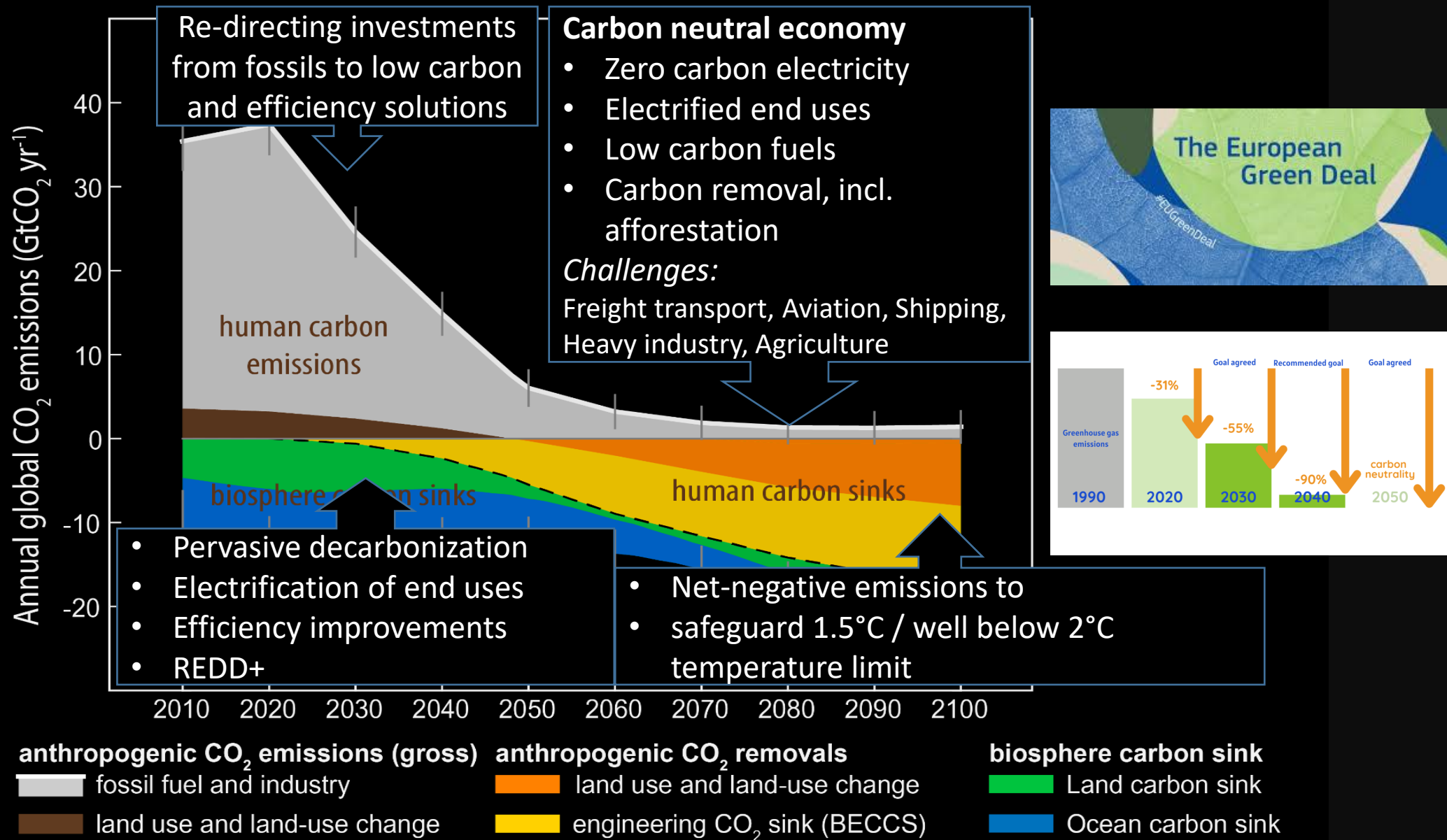


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# Europe's 2040 climate pathway

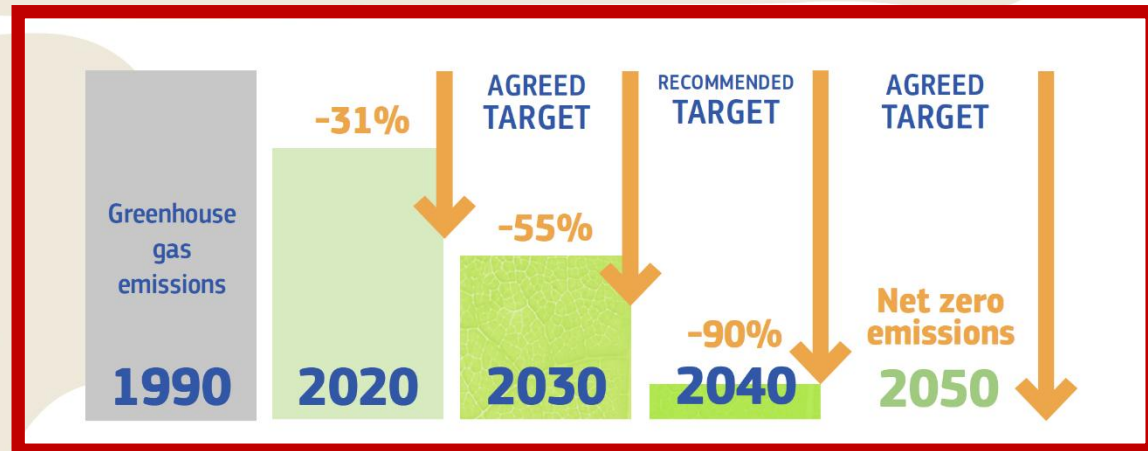
## A path to climate neutrality by 2050



As a global leader in climate action, the EU has committed to **climate neutrality by 2050**. On the path to net-zero emissions, we must now build momentum for a **sustainable and competitive economy** and **a healthier and safer future for Europeans**.

**The EU needs to stay the course** set by the EU Climate Law and the Paris Agreement, and build an economy resilient to climate hazards, free of fossil fuels and other critical dependencies, with a competitive clean tech industry, and a transition that is fair for all.

The Commission is recommending that the EU sets a **90% net greenhouse gas emissions reduction target for 2040**, as compared to 1990 levels, **in line with scientific advice**. This recommendation is **the start of a political debate and an open dialogue with all stakeholders** in the process. The political and legislative decision on the 2040 target will need to be taken by the next Commission, after this year's European elections.







# Scientific Advice Mechanism to the European Commission

Group of Chief  
Scientific Advisors

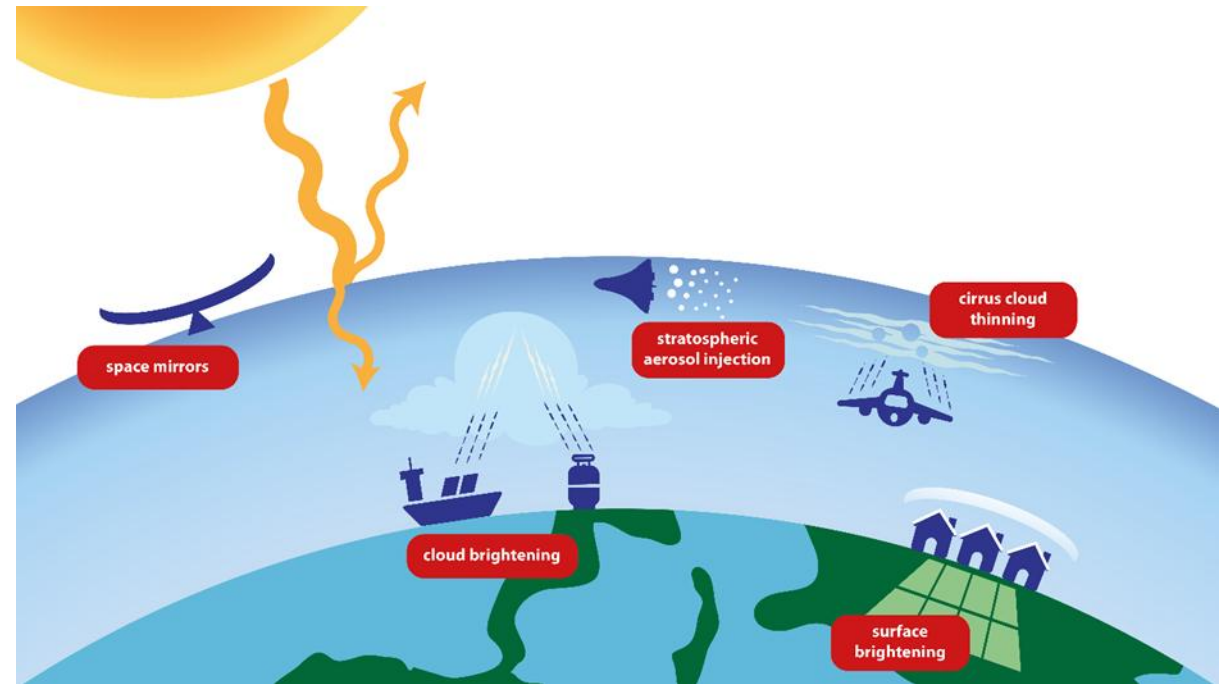
SAM secretariat

SAPEA consortium  
of academy  
networks



# What are the SRM technologies?

- Reflect sunlight (or more emit more infrared)
- net cooling effect
  - Stratospheric aerosol injection (SAI)
  - Cloud brightening
  - Cirrus cloud thinning
  - Surface brightening
  - Space mirrors



**Prioritise reducing GHG emissions as the main solution to avoid dangerous levels of climate change.**

The EGD, FIT for 55, 90% reductions by 2040 and net-zero by 2050 are the best goals

***1.1 Continue to treat emissions reductions and adaptation to climate change as the highest priority in reaching net zero by mid-century and minimize “overshoot” and its adverse effects***

- ➔ Efficiency improvements and substitution of fossil through carbon-free energy sources
- ➔ Mitigation of land-use emissions and enhancing sinks (nature-based solutions)
- ➔ Carbon removal from fossil fuels (CCS)
- ➔ Carbon dioxide removal from the atmosphere (CDR)

***1.2 Continue to actively and vigorously invest in research on and deployment of climate mitigation and adaptation.***



1. Develop **flexible, efficient, and resilient EU energy systems** for delivering clean, accessible, and affordable energy services by integrating decarbonised energy sources, electrification and the use of blue and green hydrogen.
2. Recognise the roles of all actors and stakeholders in **creating an inclusive and participatory environment** that incentivises and supports low-carbon energy choices.
3. Support a coordinated combination of policies, measures and instruments, including carbon pricing as a driving force, to **shape an effective, consistent and just regulatory system**.

# **What is the role of science diplomacy for policy advice, e.g. to manage global commons such as the Arctic, Antarctica, the ocean floor, outer space (or digitalization)?**

- ➡ A bridge between self-centered, short-term gains and interests and safeguarding planetary commons and justice for the benefit of all
- ➡ Science for Diplomacy (IPCC, IIASA, US-China Academies)
- ➡ Diplomacy for Science (space station, human genome)
- ➡ Science in Diplomacy (IAEA and NPT, ABM, chemical weapons)
- ➡ Diplomacy in Science (from silos to holistic approaches)
- ➡ Scientific advice must be evidence-based, independent, open, trustworthy, capacity building, inclusive, and avoid self-interests
- ➡ Declining trust in science and evidence-based advice

# State of the Union Address by President von der Leyen at the European Parliament Plenary

Brussels, 16 September 2020

Original Speech: [here](#)



Shaping more beautiful, sustainable and inclusive forms of living together **To restore the climate**

#neweuropeanbauhaus



New European Bauhaus  
beautiful | sustainable | together

Horizon Europe-New European Bauhaus  
Nexus Report

Conclusions of the High-Level Workshop on 'Research and Innovation for the New European Bauhaus'  
jointly organised by DG Research and Innovation and the Joint Research Centre

**The nature-based solution!**



# DEEPER UNDERSTANDING: EARTH SYSTEM JUSTICE

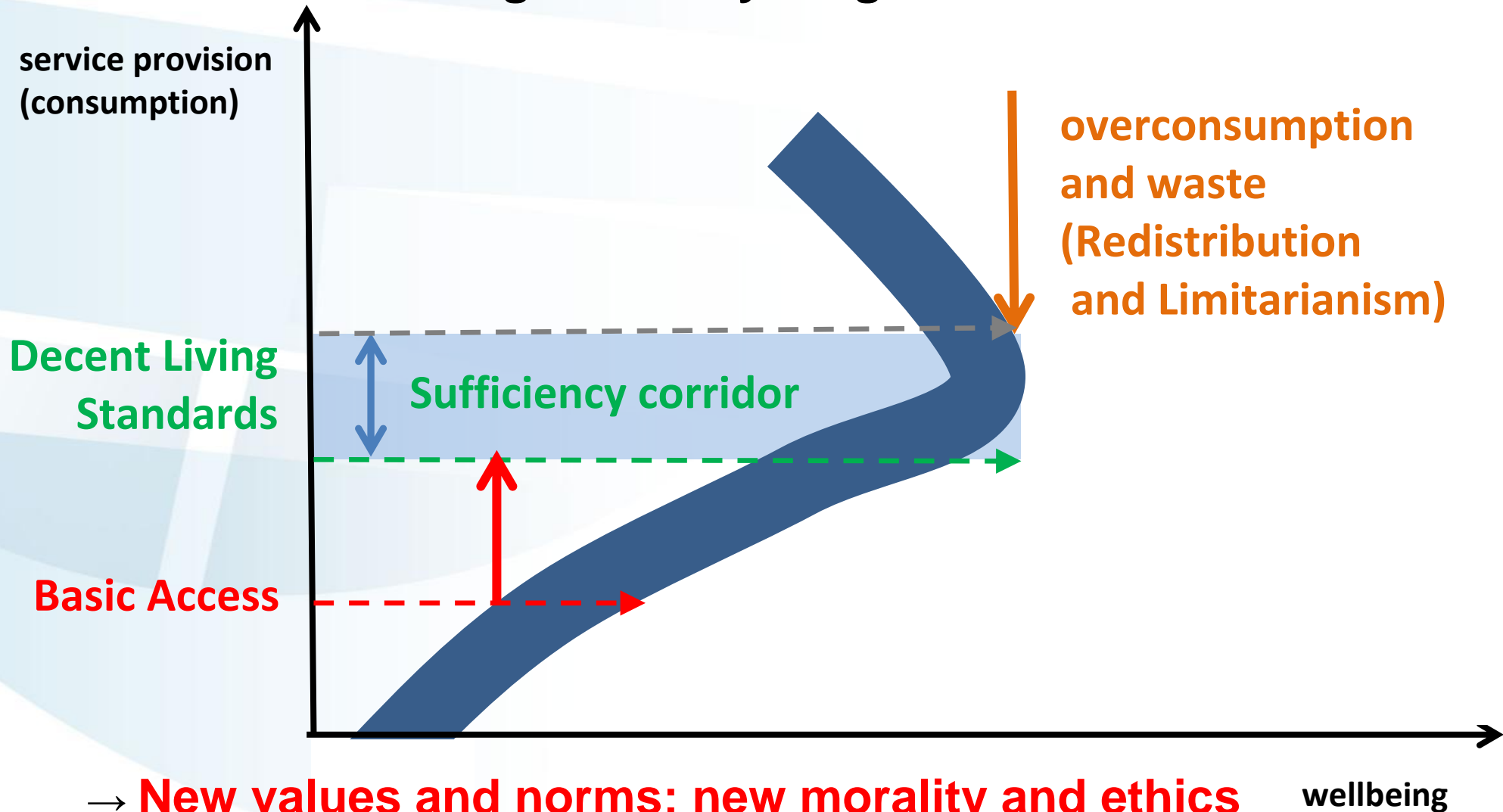
The **main goals** of Earth system justice are to:

- **minimise significant harm** to people (and nature) through the adoption of safe and just boundaries **to avoid negative tipping in Earth systems (Ceiling)**
- **ensure access** to resources for a life free from poverty for all people, **toward decent life of enough for all but not too much (Foundation)**

To achieve these goals, **just transformations are needed.**

# Decent Living and Sufficiency

→ Enough of Everything but not too Much!



→ New values and norms; new morality and ethics for a just, safe and beautiful future for all

# Disruptive IC Technology Convergence



Source: Grubler et al., 2018



# Disruptive IC Technology Convergence



5 Watt

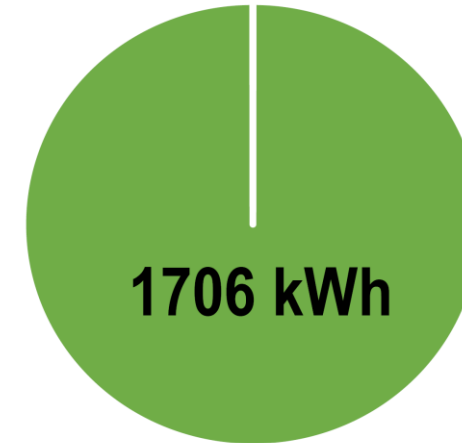
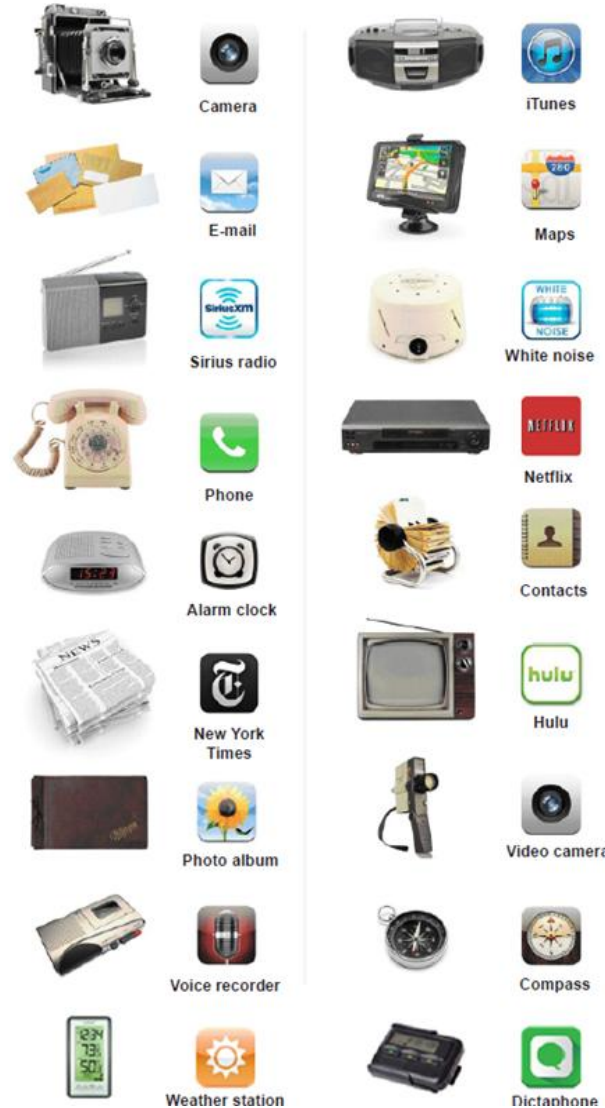
2.2 Watt

75 kWh

0.1 kg



=



Embodied energy

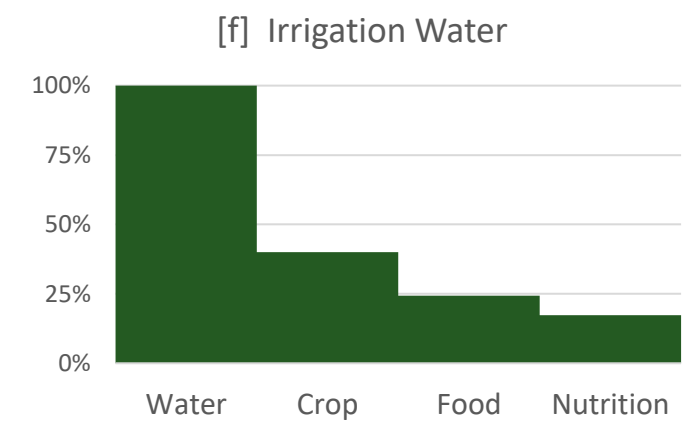
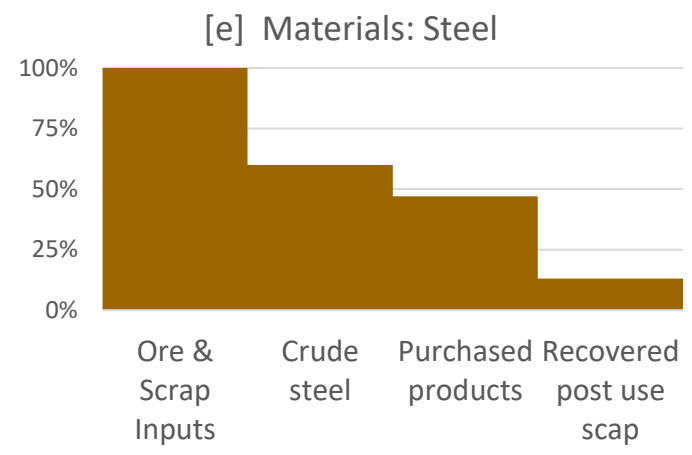
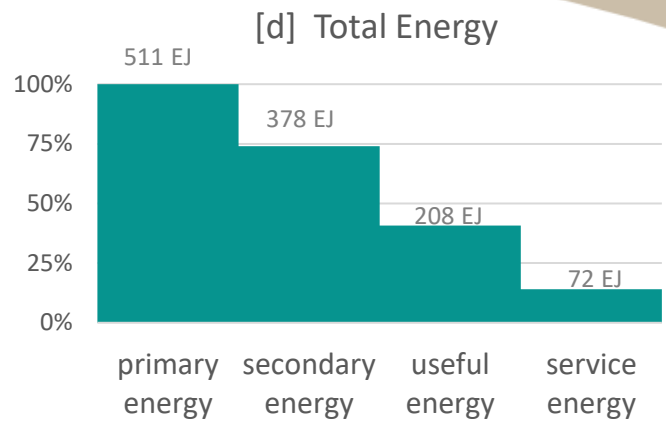
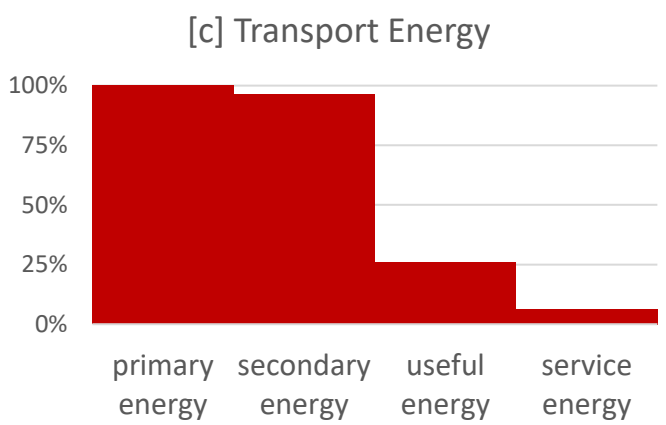
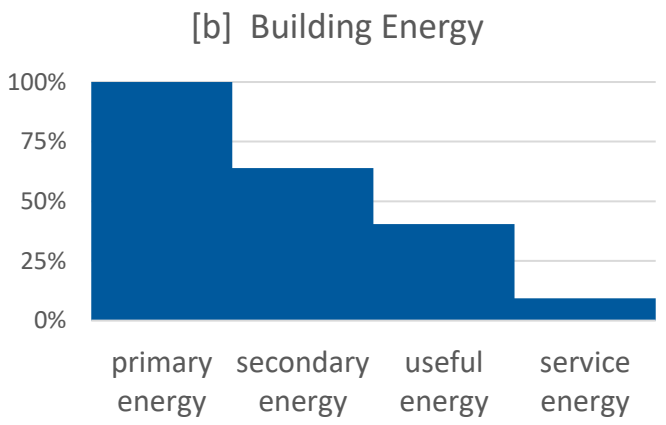
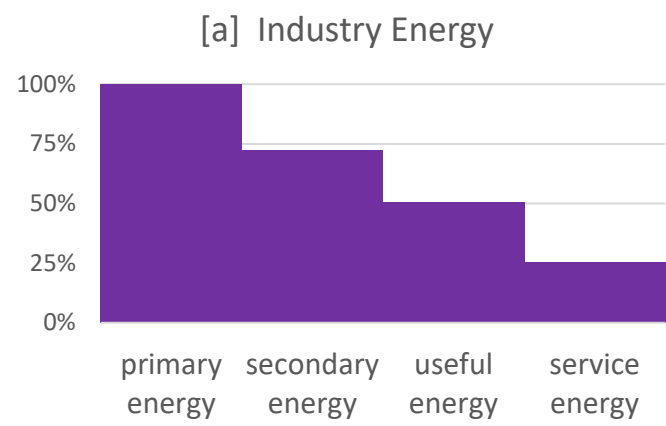


Weight

# Tapping the enormous potential for services-led transformation

Source: Wilson, Grubler, and Zimm (2022). Energy-Services Led Transformation. In: *Routledge Handbook of Energy Transitions* (Ed: Araujo).

Data from: Grubler et al. (2018), De Stercke (2014), Nakicenovic et al. (1993), Nakicenovic (1990).



← savings  
← amplify back up through resource conversion cascade ...  
and provide more flexibility, security, and resilience in resource conversion and provision of services.

# Governance and coordination challenges in the 'High-with-Low' scenario



## decent living standards

- universal and essential conditions for achieving basic human wellbeing
- quantitative thresholds and indicators for energy and material pre-requisites
- *challenges*: scaling locally-adapted services, market access, interoperability

## innovation

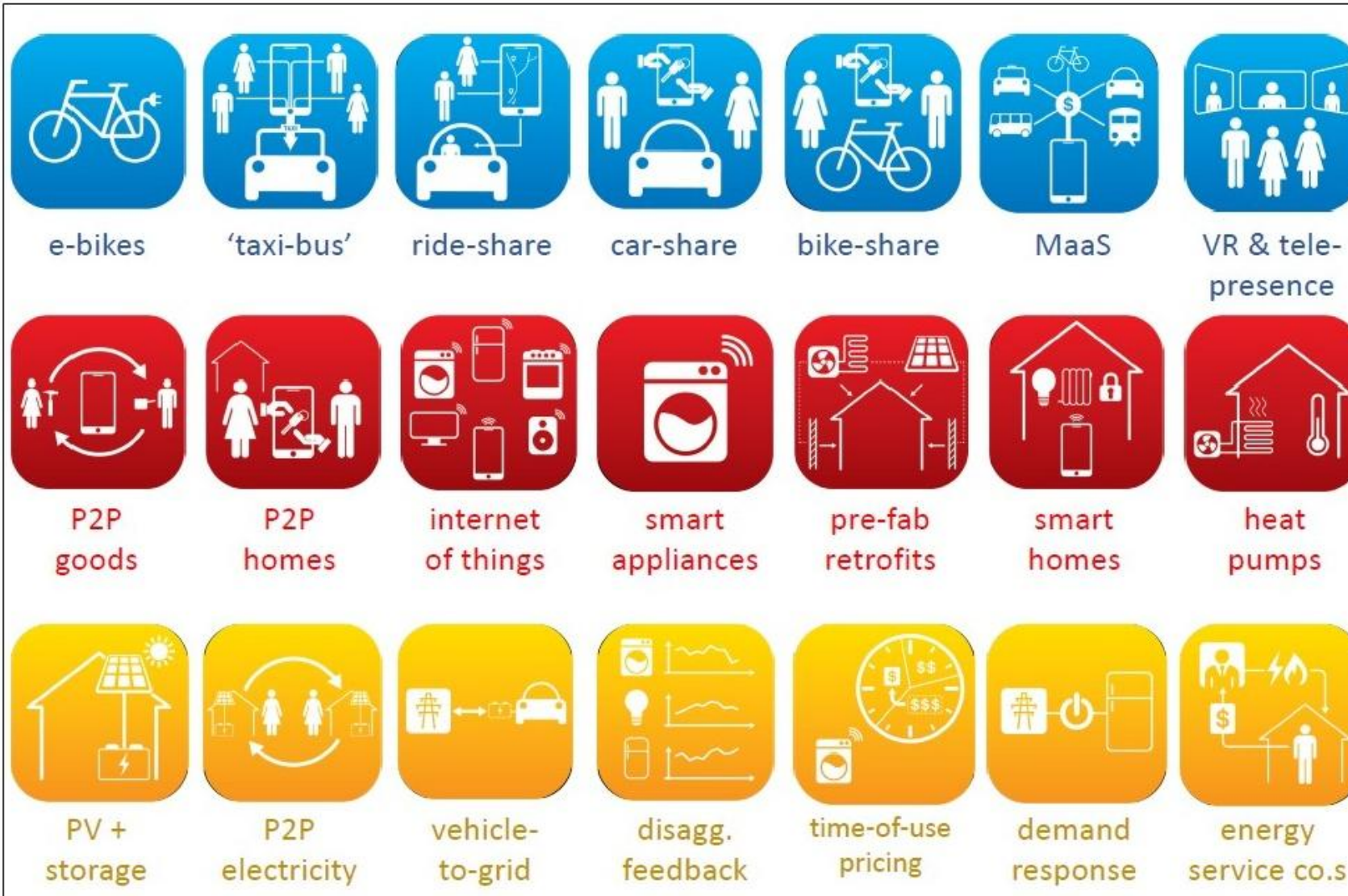
- service-oriented, multiple attributes, heterogeneous adopters
- distributed, small-scale, rapid iterative learning
- *challenges*: local system integration, managing rebound, avoiding lock-ins

## digitalisation

- general purpose enabler of service-efficiency across sectors and functions
- substitution, coordination, optimisation, enfranchisement
- *challenges*: public purpose governance and regulation, data rights, skills



# Disruptive End-User Innovations



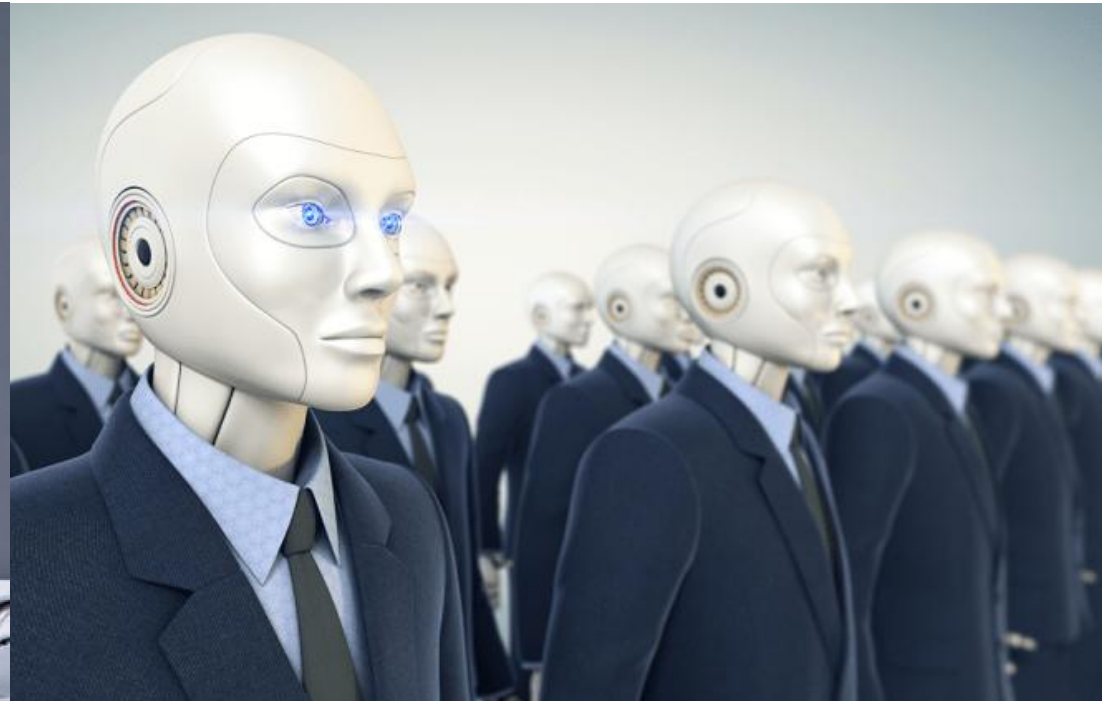
✓ Ownership to usership

✓ Sharing economy

✓ Automated to connected

# Digital Age – Just, Safe and Beautiful?

**Artificial Intelligence**, Deep Learning, Big Data, **Robotics**, Drones, Nanotechnology, **Quantum Computing**, **Synthetic Biology**, The Internet of Things, 3D Printing, Block Chain, Autonomous Vehicles, Augmented Reality





# The Map of Artificial Intelligence Ethical Issues

AI as agents

AI as subjects



Short Term

Long Term

Structural unemployment

Fairness in algorithms

Machine ethics

Proliferation of autonomous weapons

Legal status of autonomous systems

Suffering in reinforcement learners

Finalizing human values for machines to propagate

Status of humanity in a world dominated by artificial agents

Controlling artificial general intelligence and creating friendly superintelligence

Consciousness in artificial intelligence

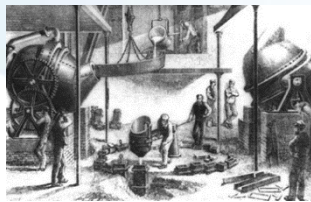
Well-being of AIs

Moral status of mind uploads

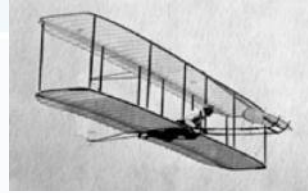


# Transformational Change and Systems Tipping

1850



1900



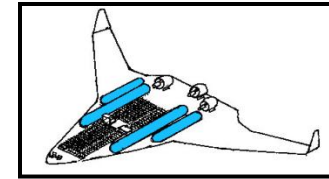
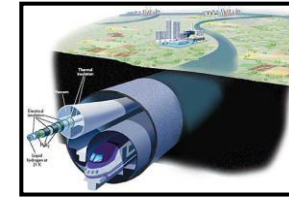
1950



2000



2050



ありがとう!



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