

Technological Dynamics & Social Change for a Carbon-Neutral Future: Navigating Geopolitics & Inequality to Achieve a Safe & Just Transition

ALPS International Symposium, Tokyo, 4 February 2026, For achieving the carbon neutral and green economy policies in the major countries, region; 

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Distinguished Emeritus and Honorary Scholar



Emeritus Professor of Energy Economics



Earth Commission Ambassador



Creation: 1962 & 1967 to 1972

Form Glassboro Summit to Royal Society Zoo





New York Times Bestseller

Nuclear War

A Scenario

Annie Jacobsen

Pulitzer Prize finalist and author of *First Platoon* and *Area 51*

biosecurity 🔍



midnight



...sity of Chicago scientists
...the Bulletin of the Atomic
...y of apocalypse (midnight)
...convey threats to humanity
...ence and Security Board in
...laureates. *The Clock* has
...global catastrophe caused

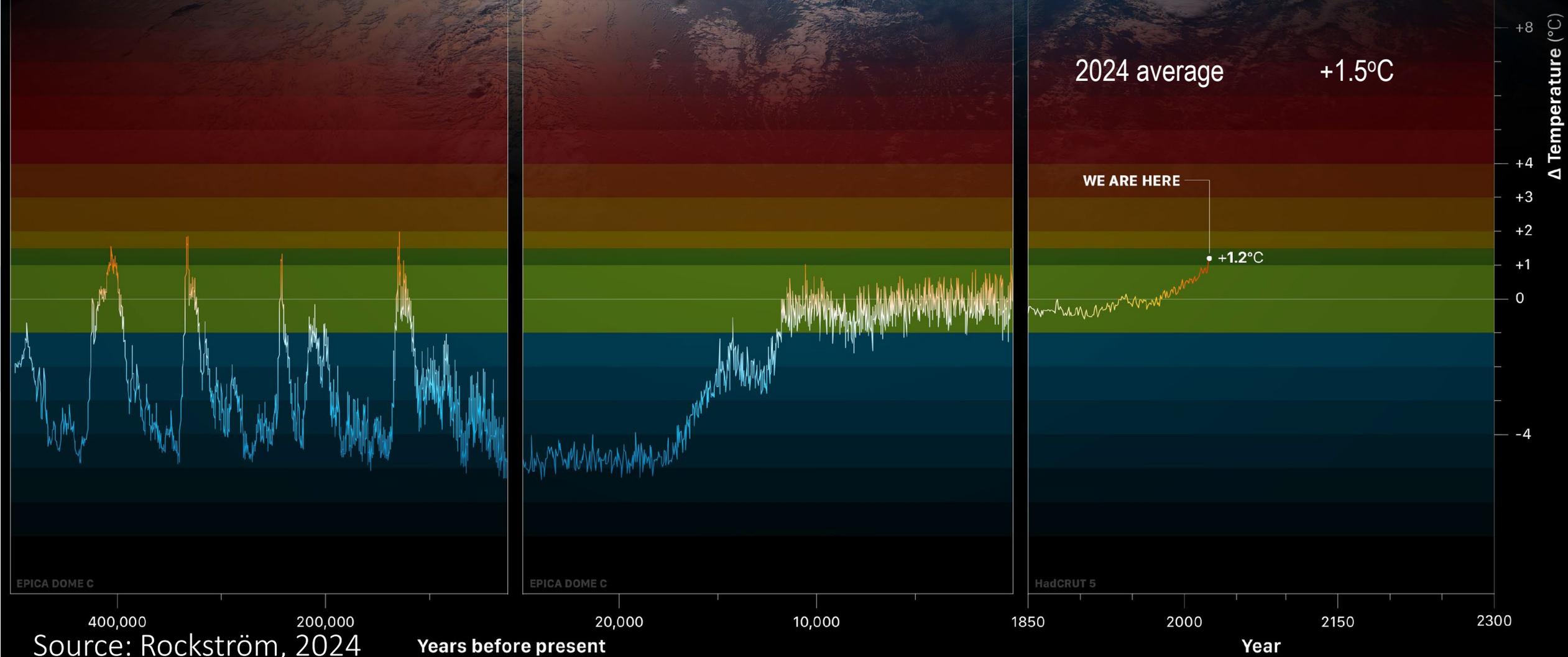


The Science and Security Board

The *Bulletin's* Science and Security Board (SASB) is composed of a select group of globally recognized leaders with a specific focus on nuclear risk, climate change, and disruptive technologies. [Learn more...](#)

Figure pending revision

Humanity's Journey on Earth



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EPICA DOME C

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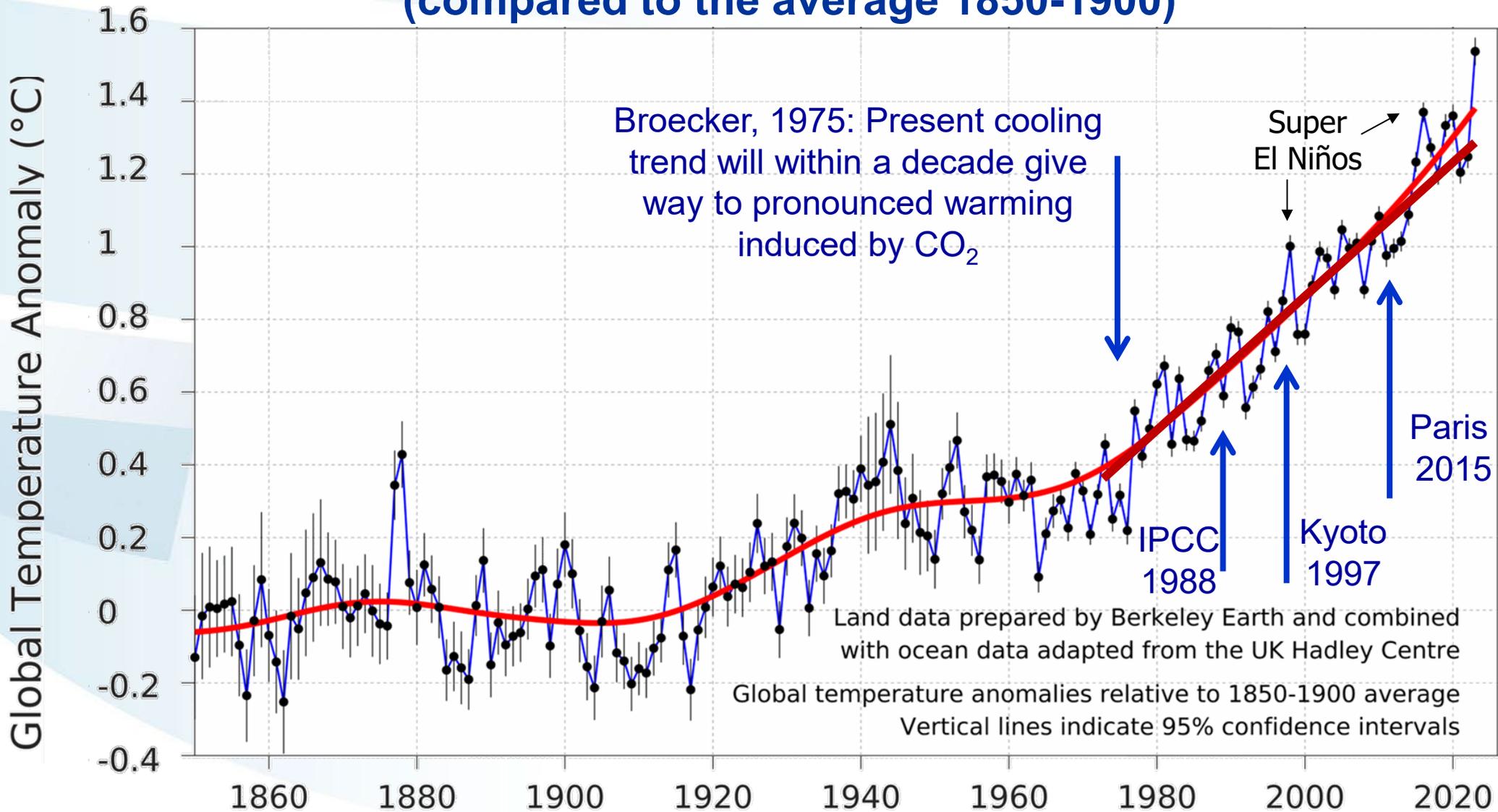
Source: Rockström, 2024

Years before present

Year

Global Average Temperature

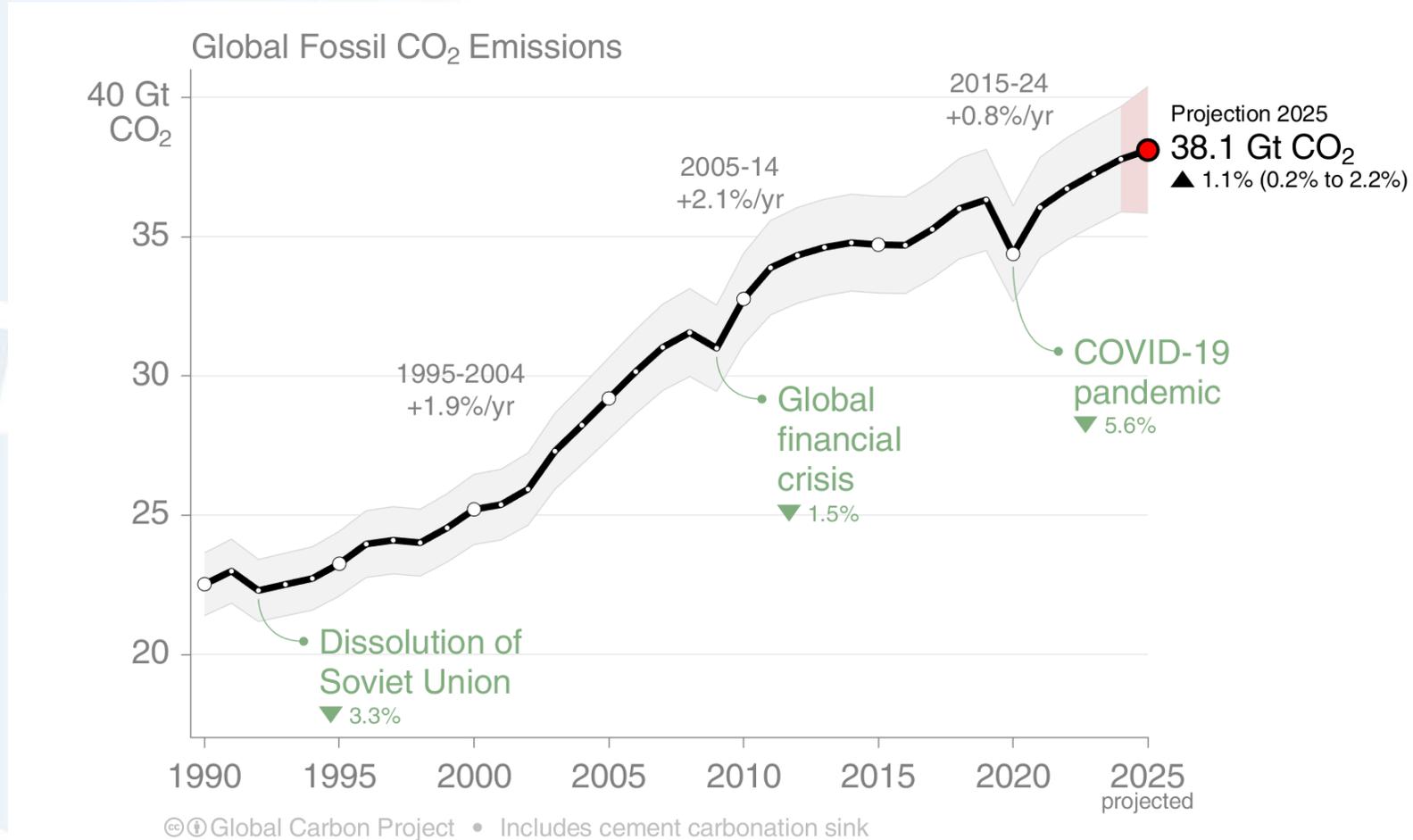
(compared to the average 1850-1900)



Global Fossil CO₂ Emissions

Global fossil CO₂ emissions: 37.8 ± 2 GtCO₂ in 2024, 69% over 1990

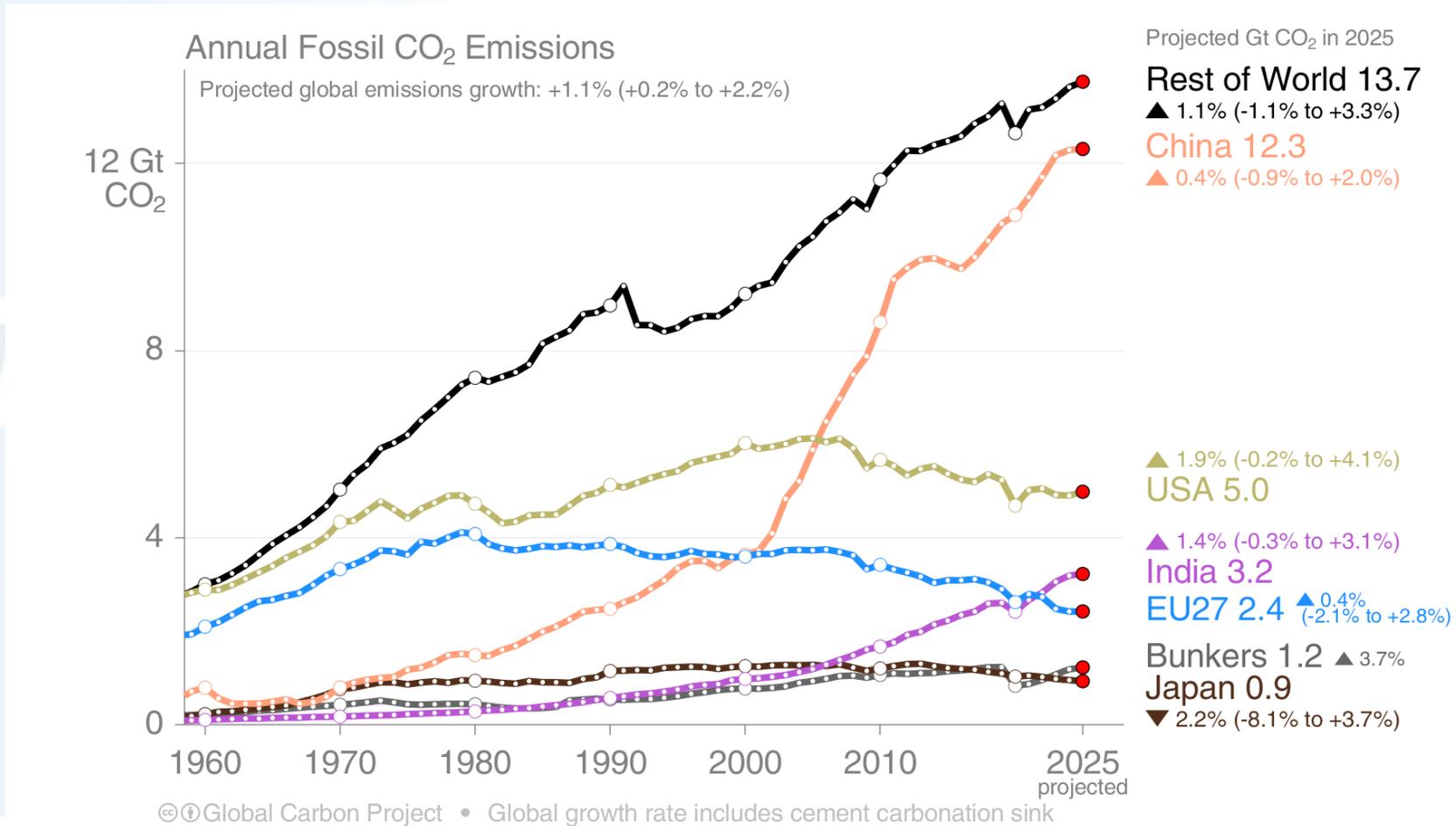
- Projection for 2025: 38.1 ± 2 GtCO₂, 1.1% [0.2% to +2.2%] higher than 2024



Uncertainty is ±5% for one standard deviation (IPCC “likely” range)

Global Fossil CO₂ Emissions

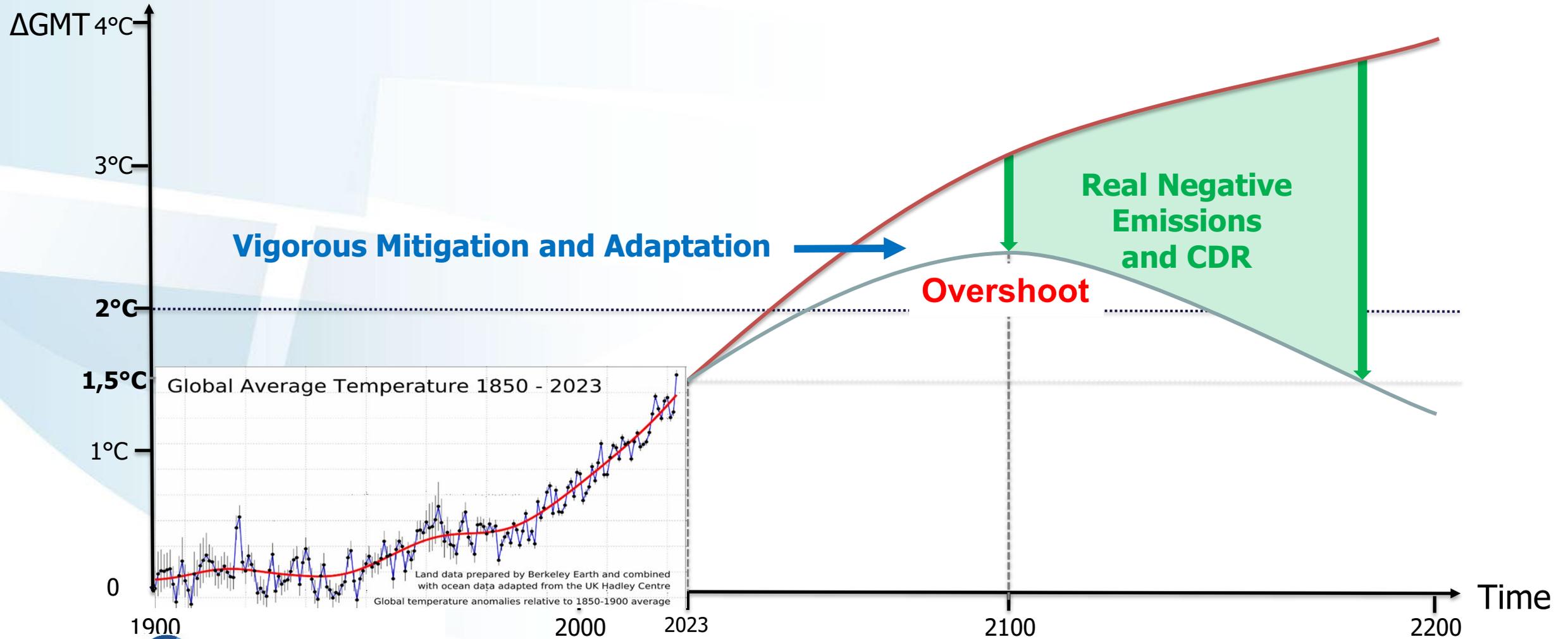
Fossil CO₂ emissions growth is from different regions in 2025 compared to 2024:
 The USA rising, and EU27 flat, reversing recent declines. China flat, India low growth, contrasting recent strong growth.



The 2025 projections are based on preliminary data and modelling.
 'Bunkers' are fossil fuels used for international shipping and aviation
 Source: [Friedlingstein et al 2025](#); [Global Carbon Project 2025](#)

Global Average Temperature

Climate Restoration: Repair or Despair!



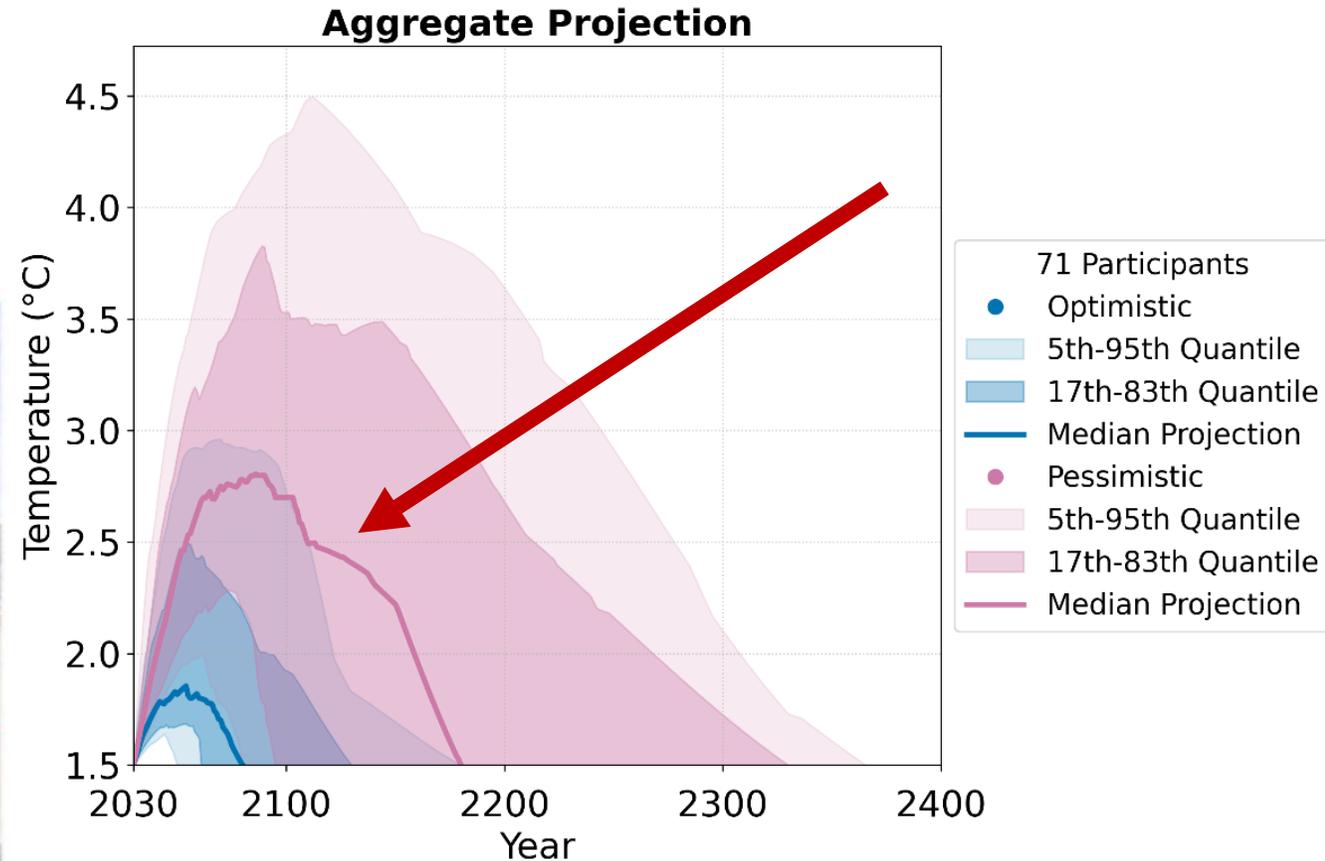
Overshoot is a paradigm shift

OVERSHOOT
CONFERENCE
2025 | Laxenburg
30.Sep – 02.Oct



- Overshoot conference series to be continued in 2026
- Save the date (tbc):
Nov 25-26 in Beijing, China

OVERSHOOT
CONFERENCE
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Expert elicitation conference participants on optimistic and pessimistic climate overshoot scenarios

Outgoing and New Group of Chief Advisors

Group of
Chief
Scientific
Advisors



Group of
**Chief
Scientific
Advisors**



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.

Transformational Change

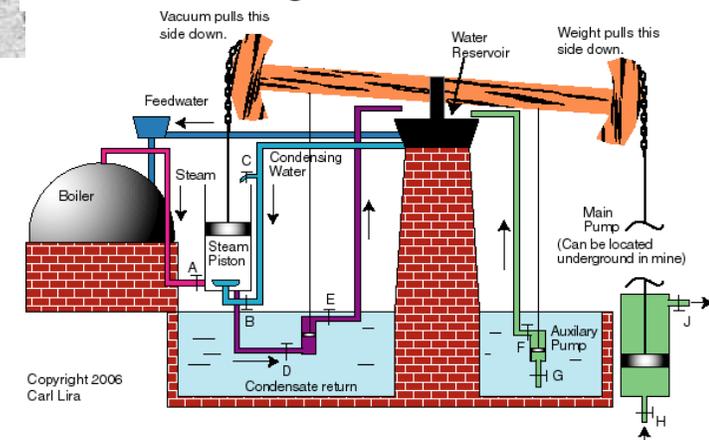
Dynamic, Cumulative, Systemic and Uncertain

- ➔ 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]

Stockton - Darlington Railway
27 September 1825



Newcomen Atmospheric Engine, 1712



Resistance to Niche Innovations

Against Railways in 1838



- ➔ **Resistance to Change:** Arises from uncertainty, disruption of livelihoods, or perceived threats to identity and status.
- ➔ **Sailing-Ship Effect:** Incumbents improve old technologies to delay adoption of new ones.
- ➔ **Lock-In and Path Dependence:** Systems become “locked in” due to infrastructure, skills, routines, values, and norms.

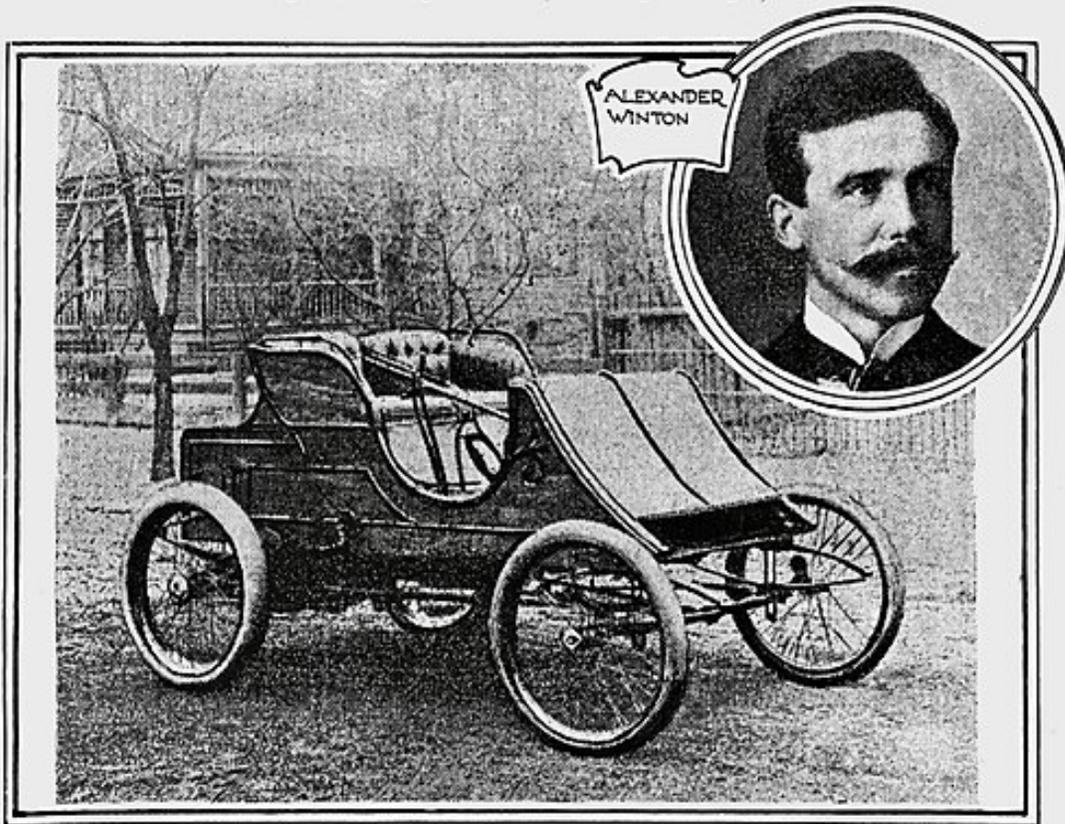
UK – Disruptive Change and Tipping

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

1900: where's the car?

1913: where's the horse?

Das Winton-Automobil für den Bennett-Berger.



Images: L, National Archive, www.archives.gov/research/american-cities/Images/american-cities-101.jpg

R, shorpy.com/node/204.

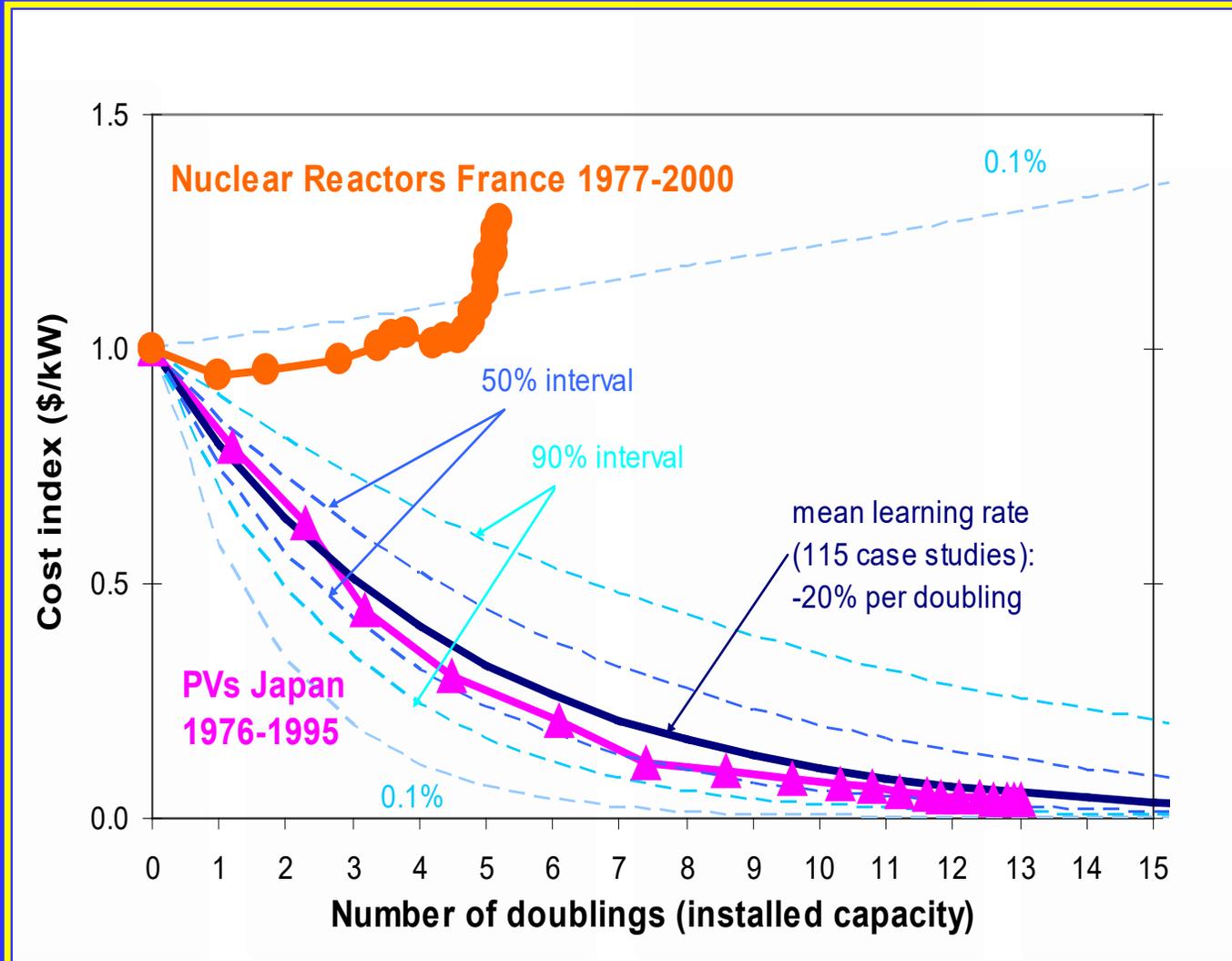
Inspiration: Tona Seba's keynote lecture at AltCar, Santa Monica CA, 28 Oct 2014, <http://tonyseba.com/keynote-at-altcar-expo-100-electric-transportation-100-solar-by-2030/>

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)



\$100/Wp in 1955

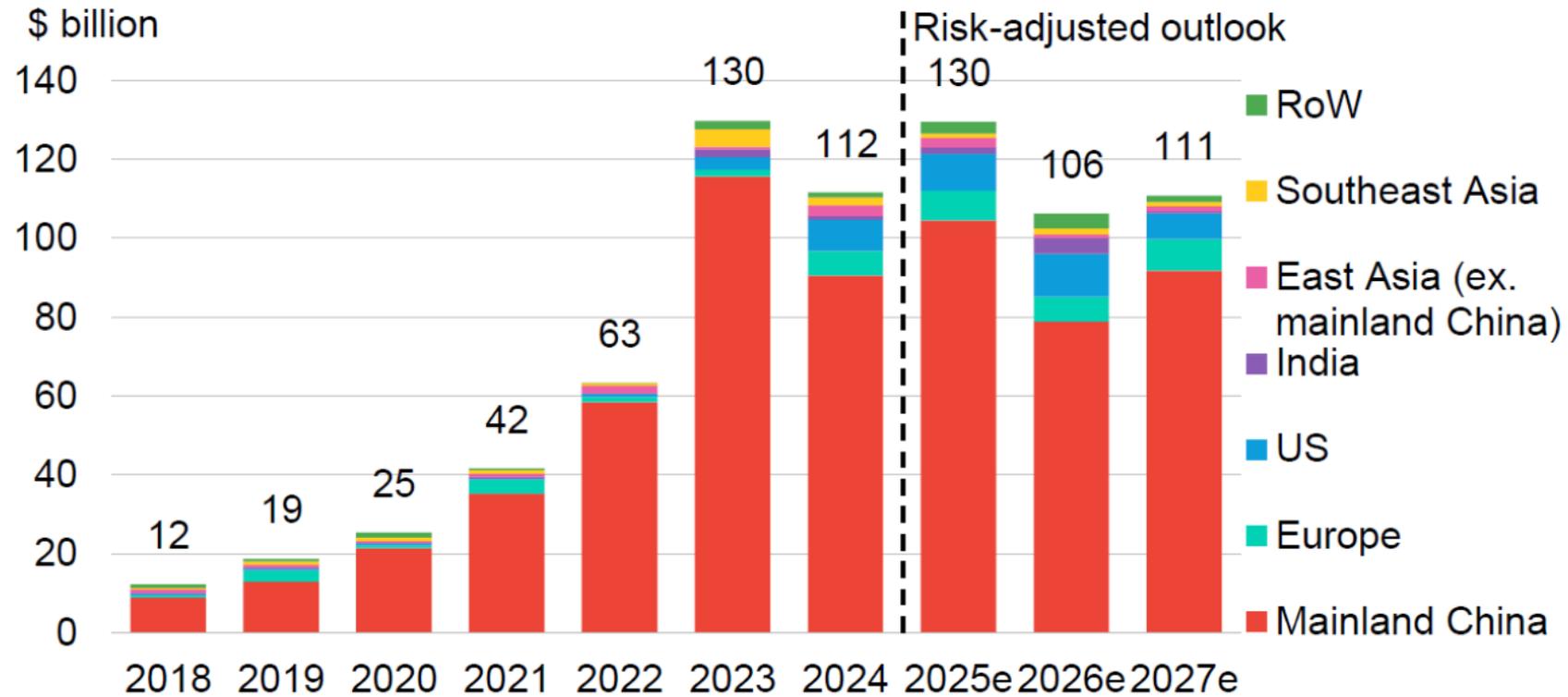
\$0.25/Wp in today

Costs continue to fall 2010-2024

Competitiveness of renewable power offers a compelling business and investment case to triple renewables by 2030



Global clean-tech factory investment happens mainly in China

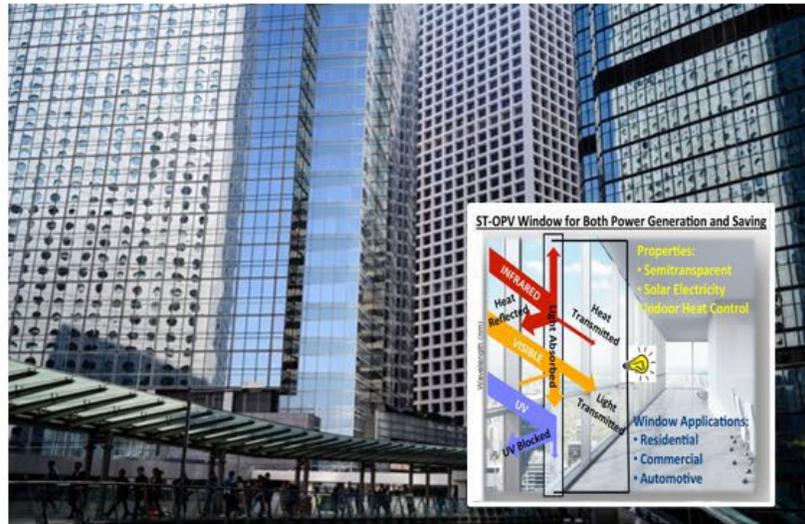


Source: BloombergNEF, Energy Transition Investment Trends 2025

Rooftops



Facades & Windows



Roads



Automobiles



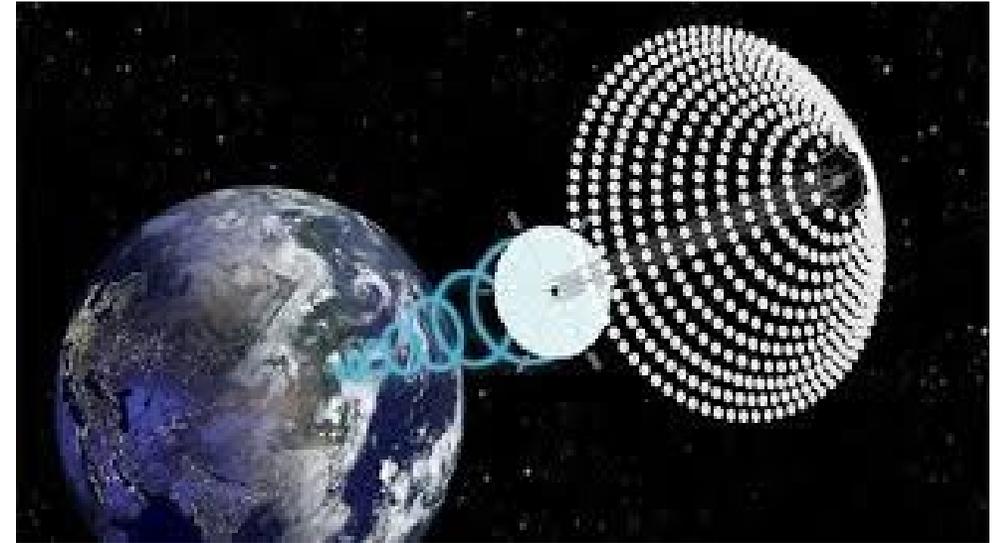
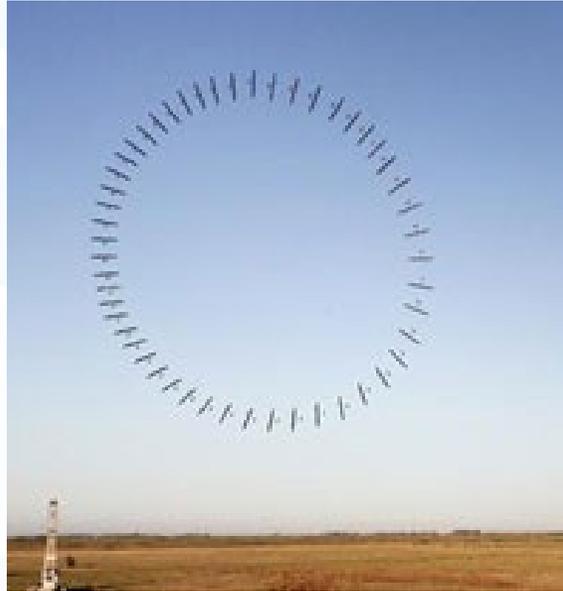
Agriculture & Fisheries



Mountain & Sea



Possible Transformational Technologies?



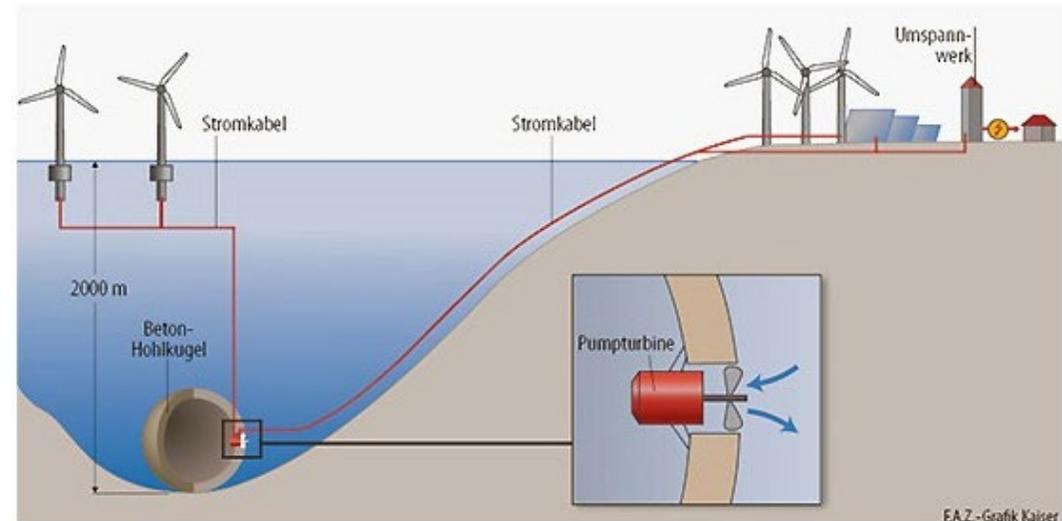
Conventional Turbine Offshore Wind Farm;

- No risk of it being hugely profitable.
- Typical IRR 5-7%

Accelerator Turbine Offshore Wind Farm;

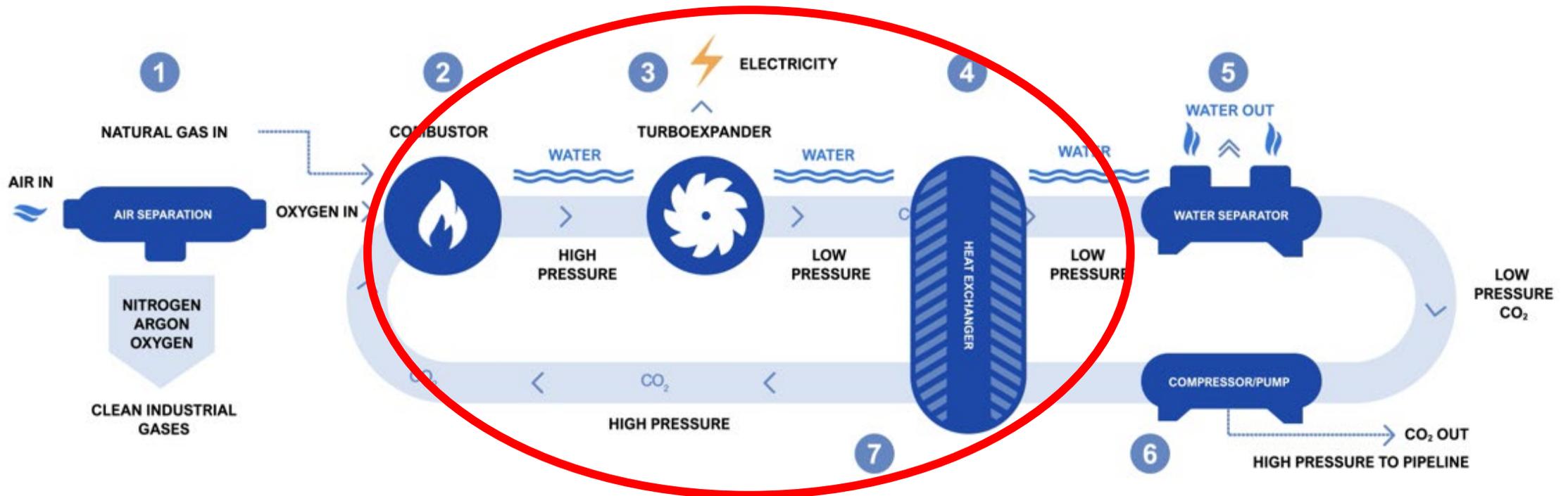
- Excellent chance of being hugely profitable.
- Typical IRR 20-30%

STERLING
WIND POWER



Breaks Ground on Demonstration Plant for Oxyfuel, Natural Gas ZEP, La Porte, Texas

50MWth test facility built in 2018, has performed over 1,600 operational hours and successfully synchronized with grid in 2021.

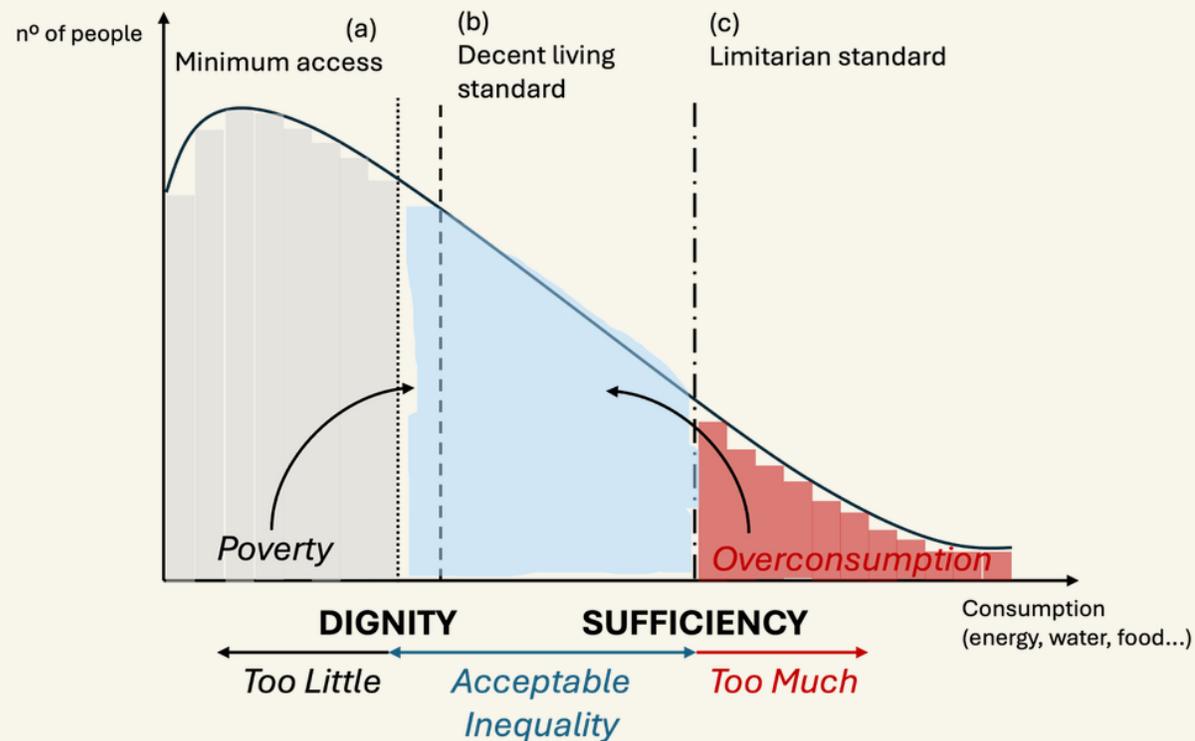
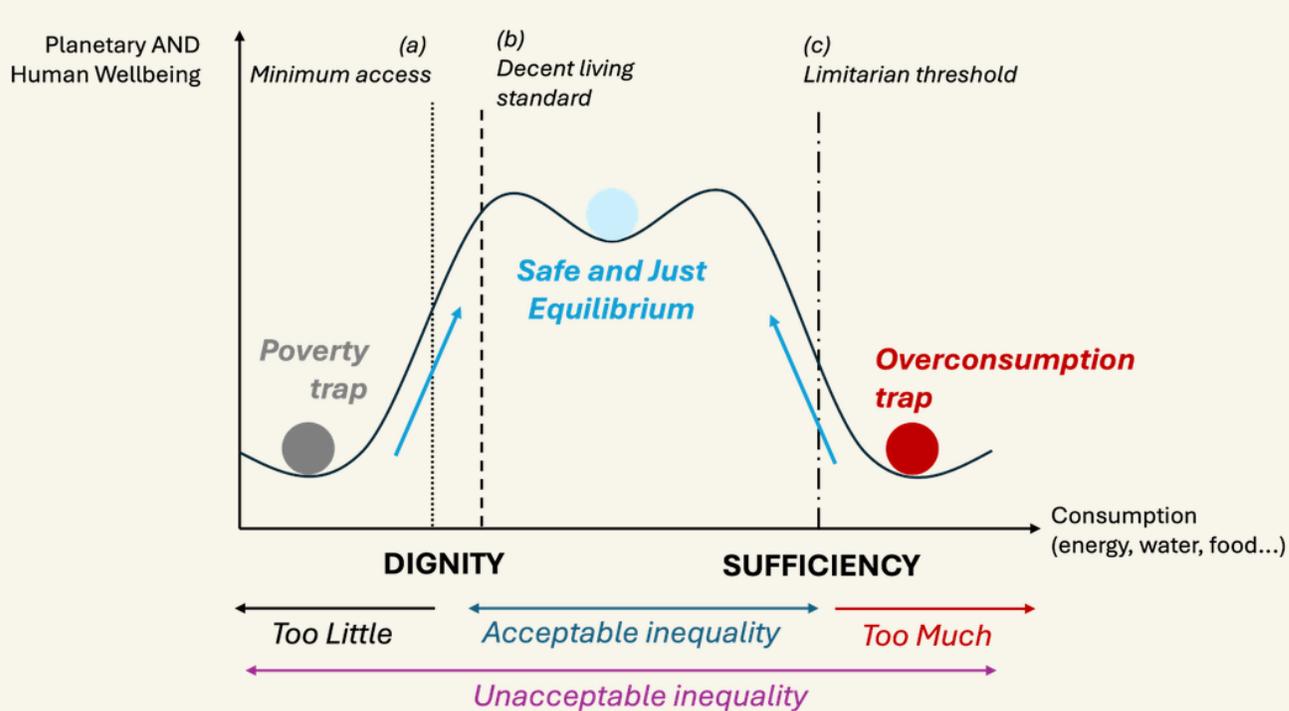


Wood for Cooking and Phone Charging



Source: Modi, 2011 and Yumkella, 2013

Deep Transformation – Dignity & Sufficiency



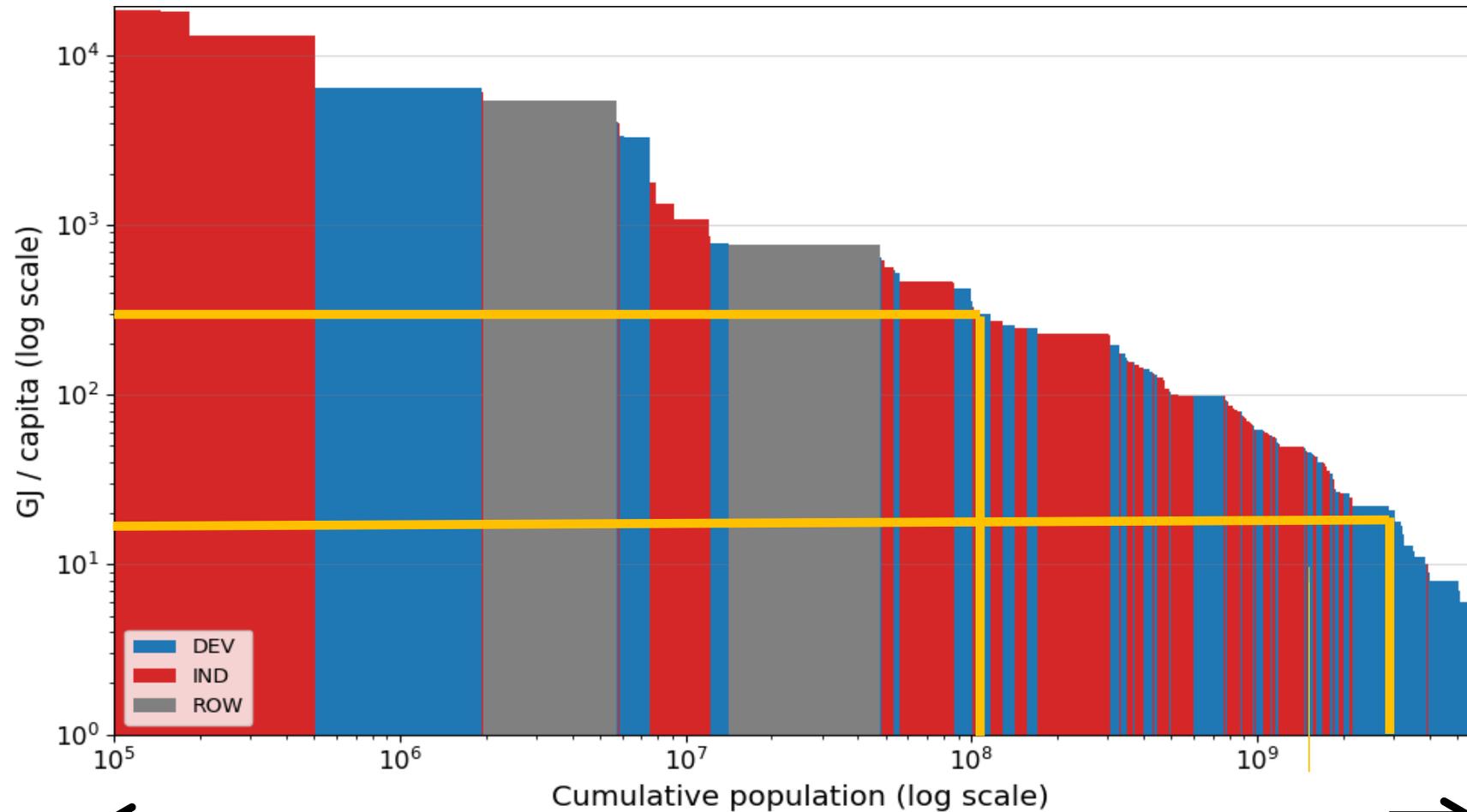
High Valley Model
 Source: Building on Juan Camilo Cardenas (UNIANDES)

Current global climate goals are insufficient to deliver real-zero by 2050



- ⇒ They overlook a critical and underutilized lever of action: energy demand side
- ⇒ Crucial trends are either insufficient (efficiency) or not included in the goals (electrification, excessive consumption)
- ⇒ Given the urgency of climate and sustainable development goals, national strategies should aim to exceed the global targets.

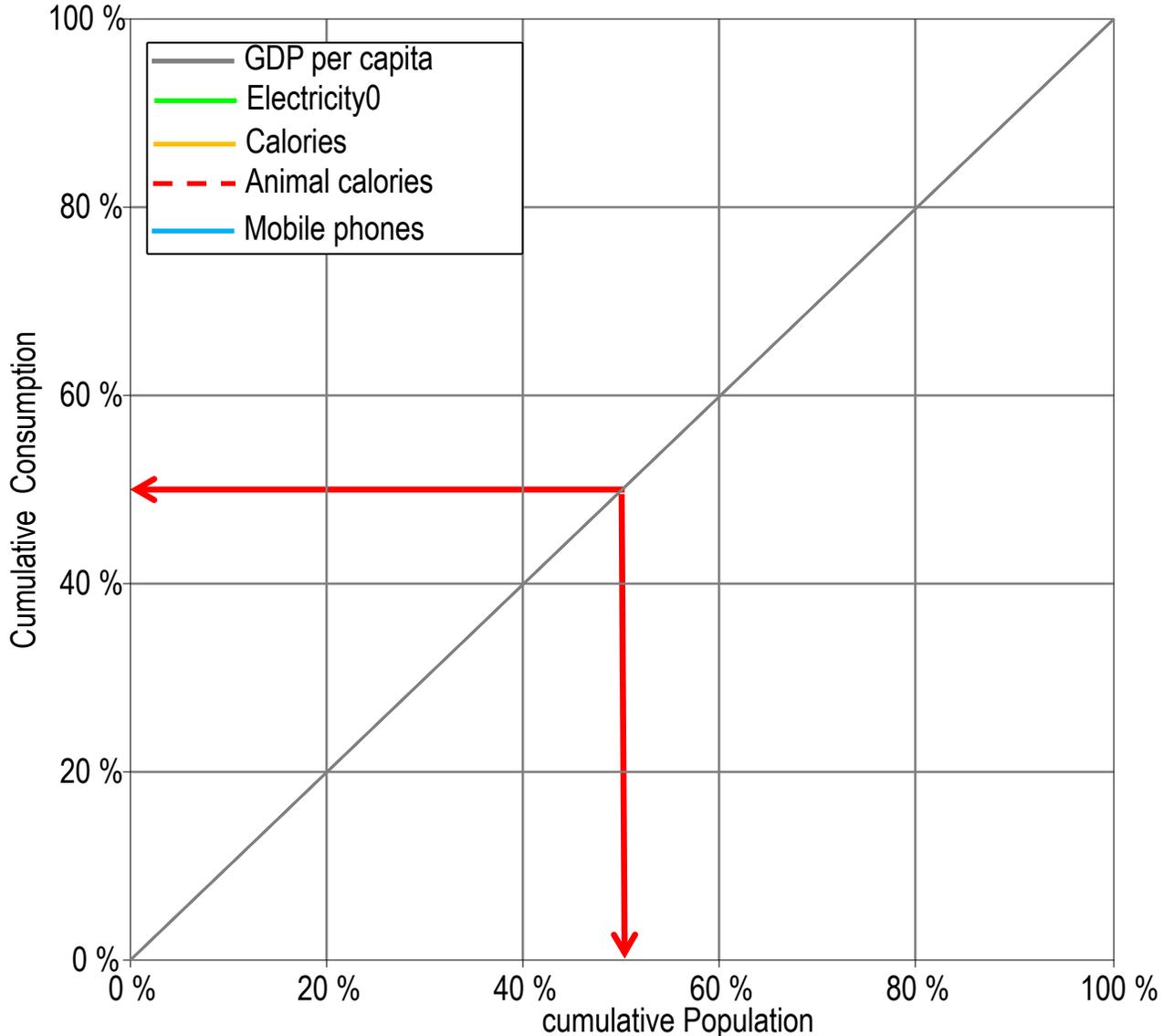
Too much for so few and so little for so many



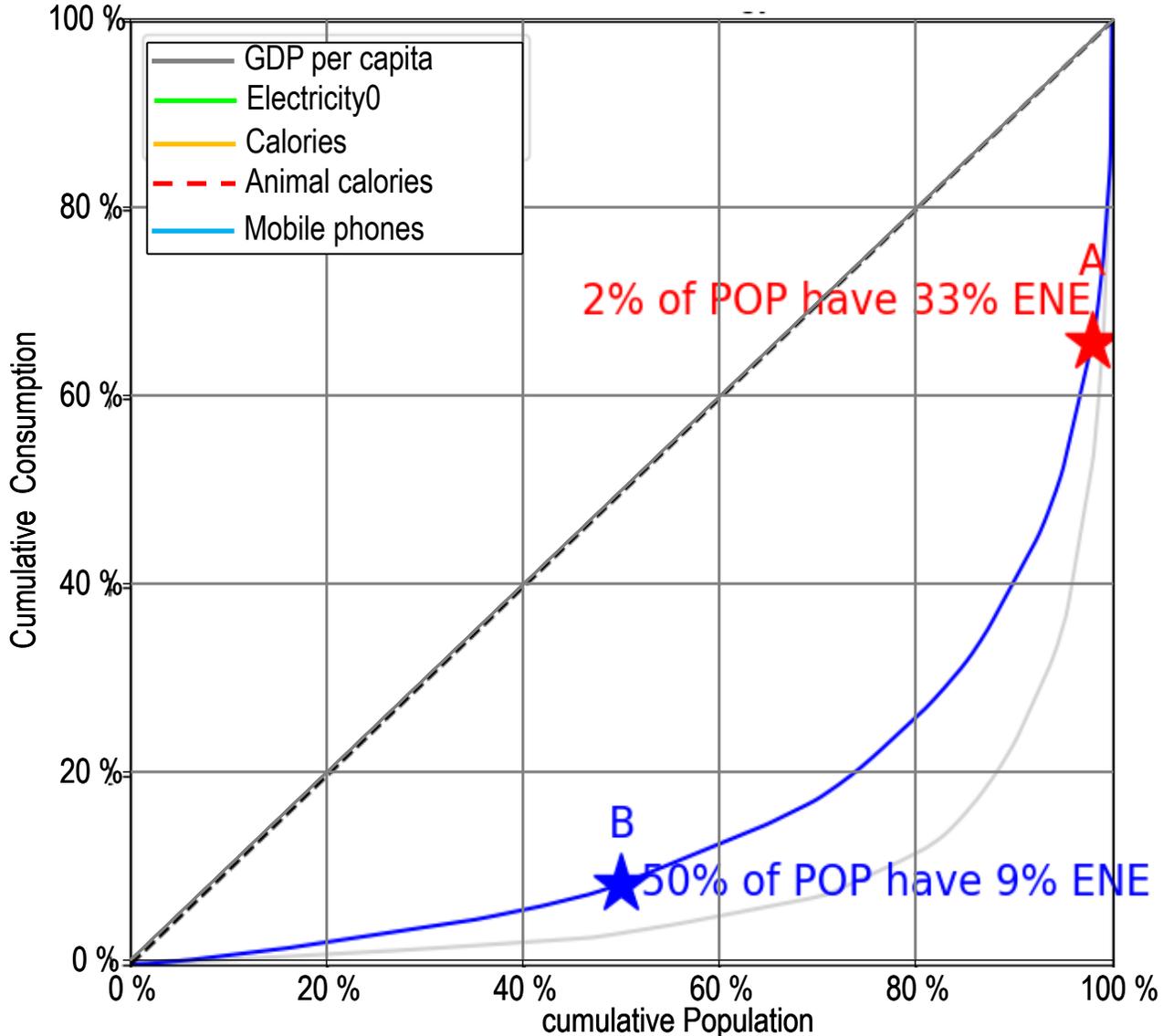
← **too much: 2% (100 Million)
above 300 GJ**

→ **too little: 46-50%
(2.8-3 Billion) below
15-18 GJ (min for DLS)**

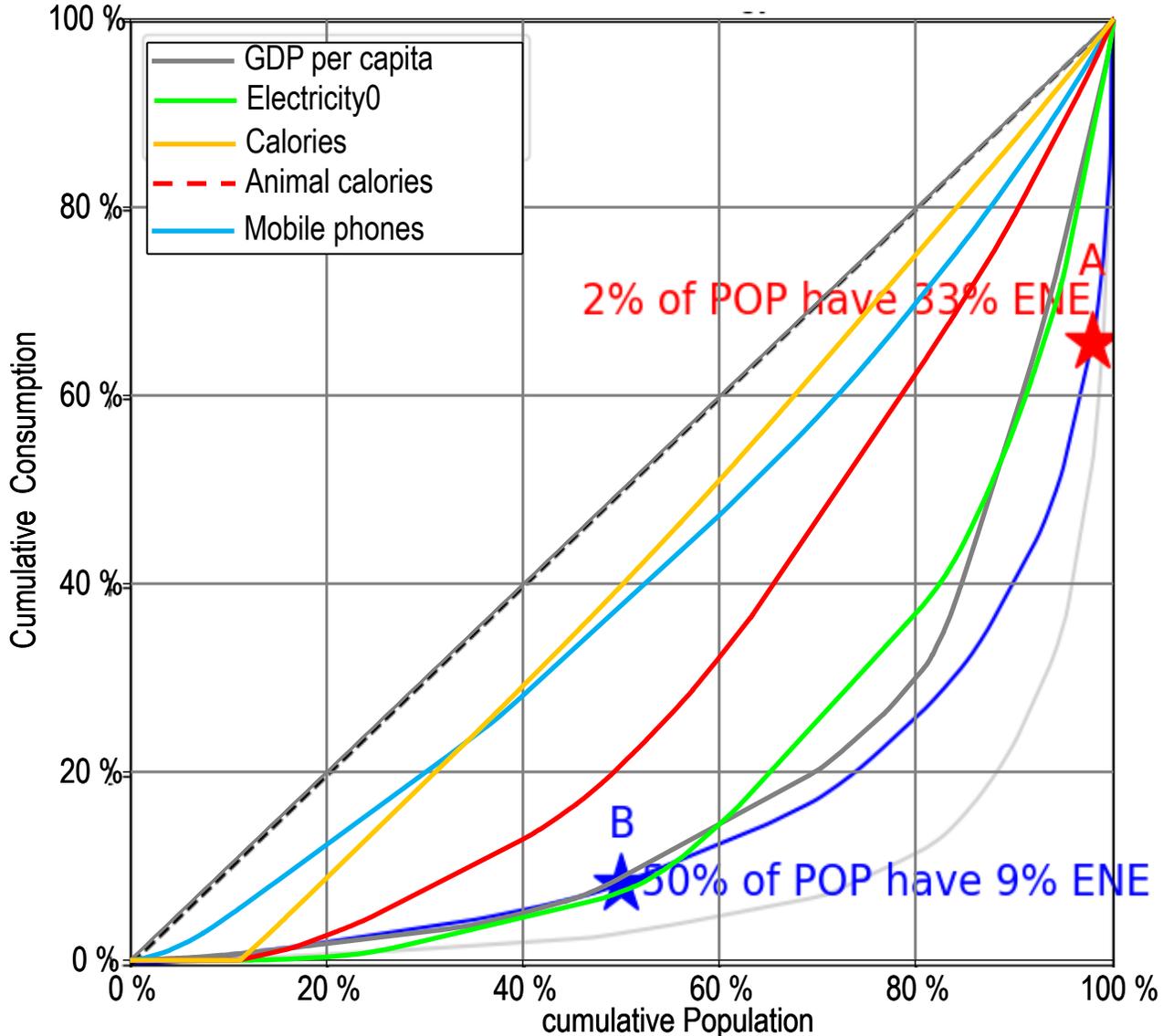
Global Lorenz Distributions



Global Lorenz Distributions

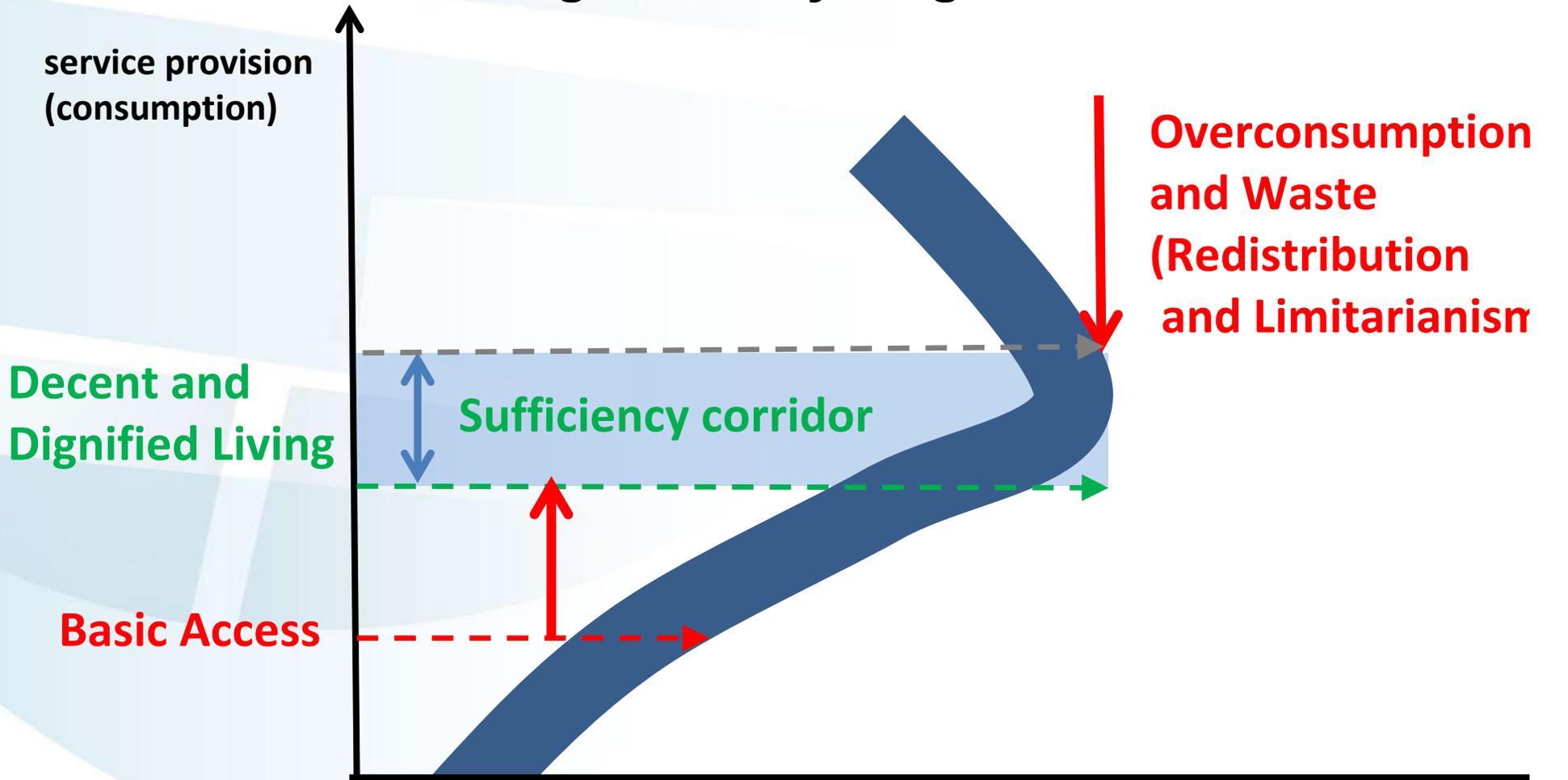


Global Lorenz Distributions



Deep Transformation – Decent Living & Sufficiency

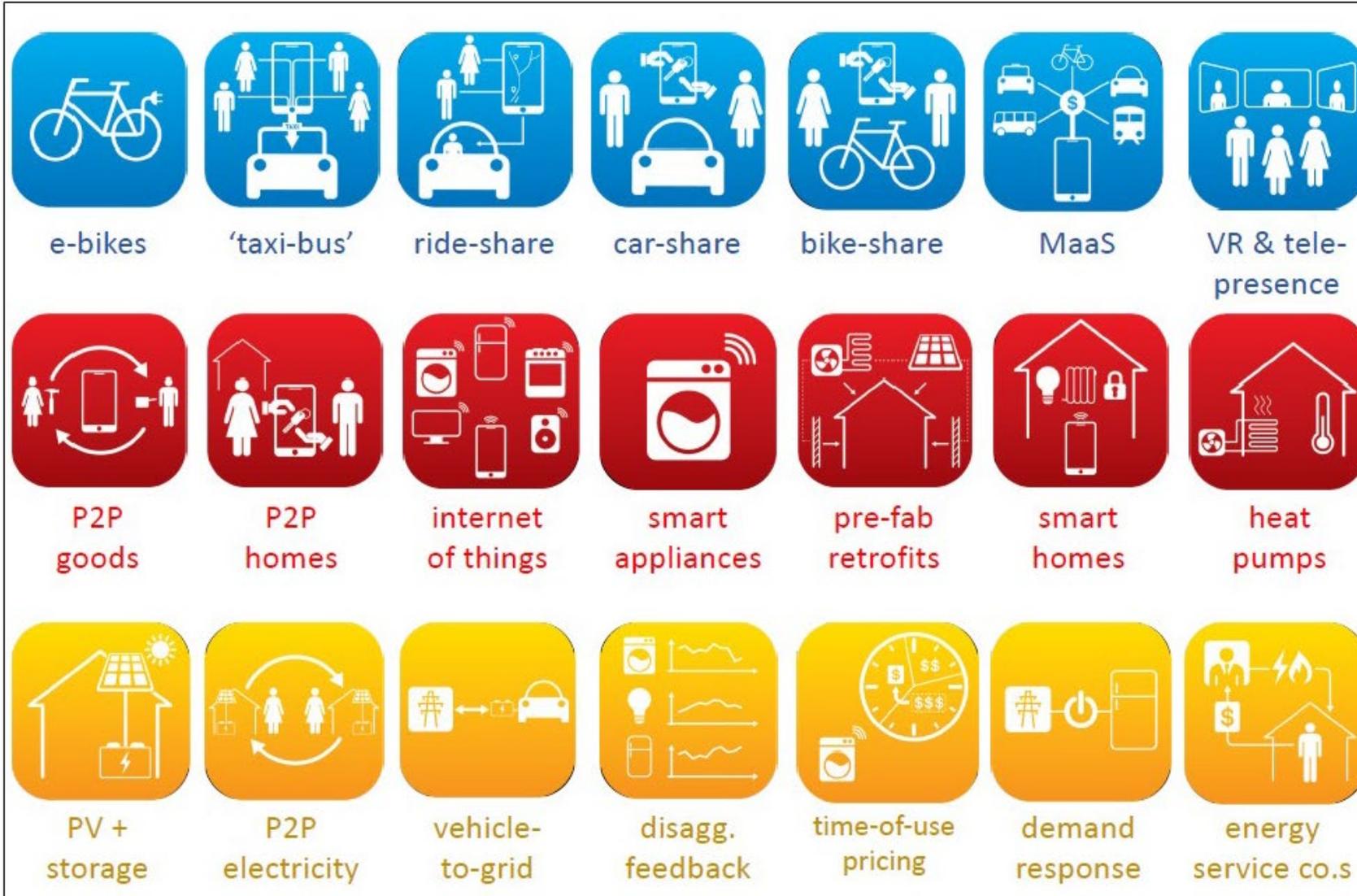
→ Enough of Everything but not too Much!



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

wellbeing

Disruptive End-User Innovations



✓ Ownership to usership

✓ Sharing economy

✓ Automated to connected

Global map of large data center clusters 2024



The Map of Artificial Intelligence Ethical Issues



Short Term

Long Term

AI as agents

Structural unemployment

Fairness in algorithms

Machine ethics

Proliferation of autonomous weapons

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

AI as subjects

Legal status of autonomous systems

Suffering in reinforcement learners

Consciousness in artificial intelligence

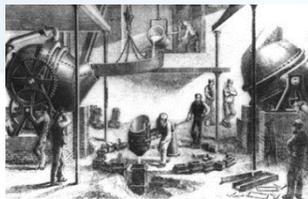
Well-being of AIs

Moral status of mind uploads

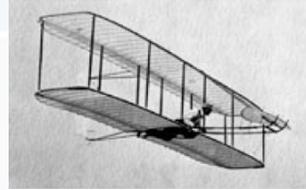


Transformational Change and Systems Tipping

1850



1900



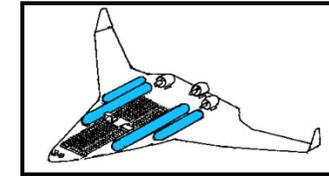
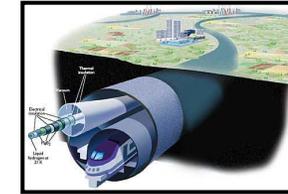
1950



2000



2050





International Institute for
Applied Systems Analysis
www.iiasa.ac.at

science for global insight

ありがとう!



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