

PLAN X

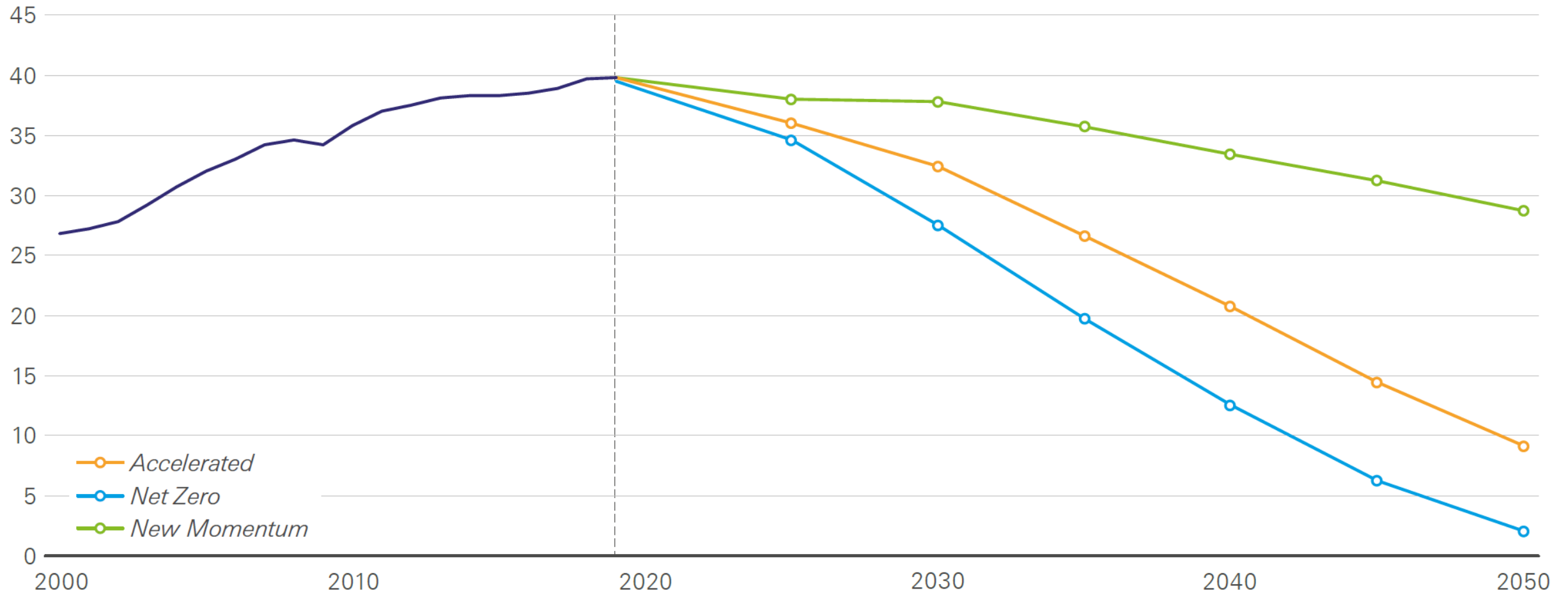
SERGEY IVLIEV

PERM SUMMER SCHOOL 2023

PLAN A: NET ZERO

Carbon emissions

Gt of CO₂e

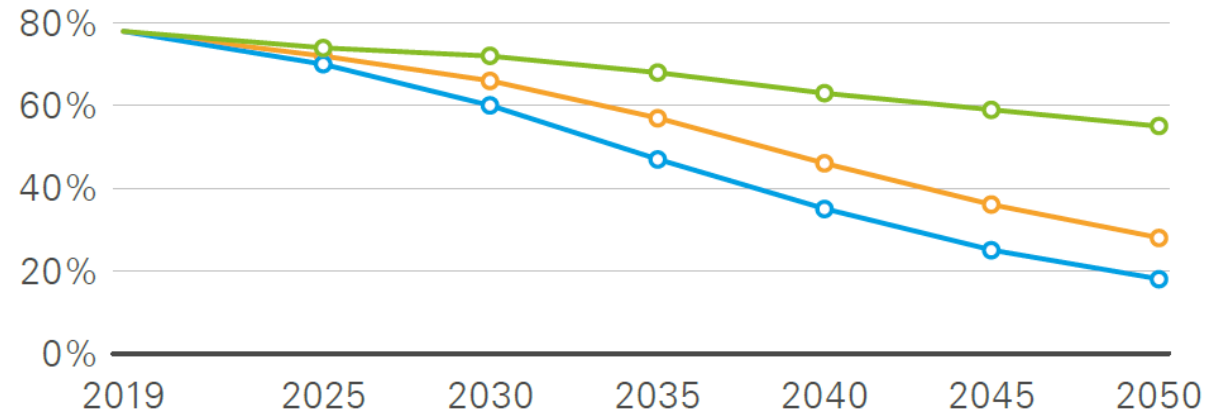


Carbon emissions include CO₂ emissions from energy use, industrial processes, natural gas flaring, and methane emissions from energy production.

PLAN A: ENERGY TRANSITION

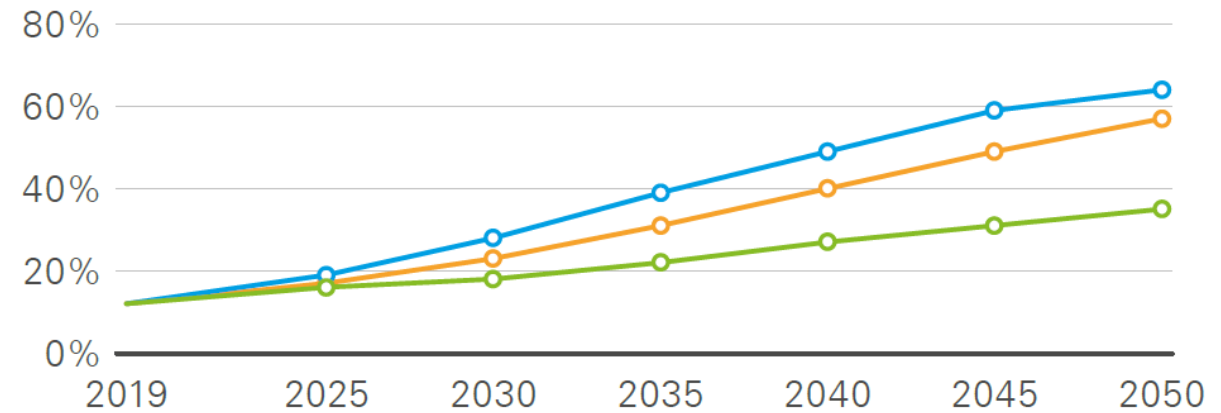
Fossil fuels

Share of primary energy



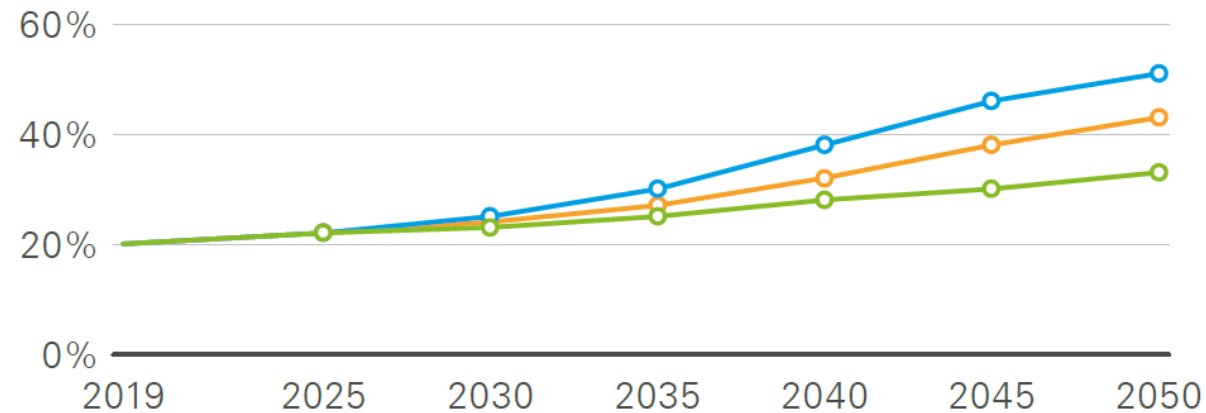
Renewables

Share of primary energy



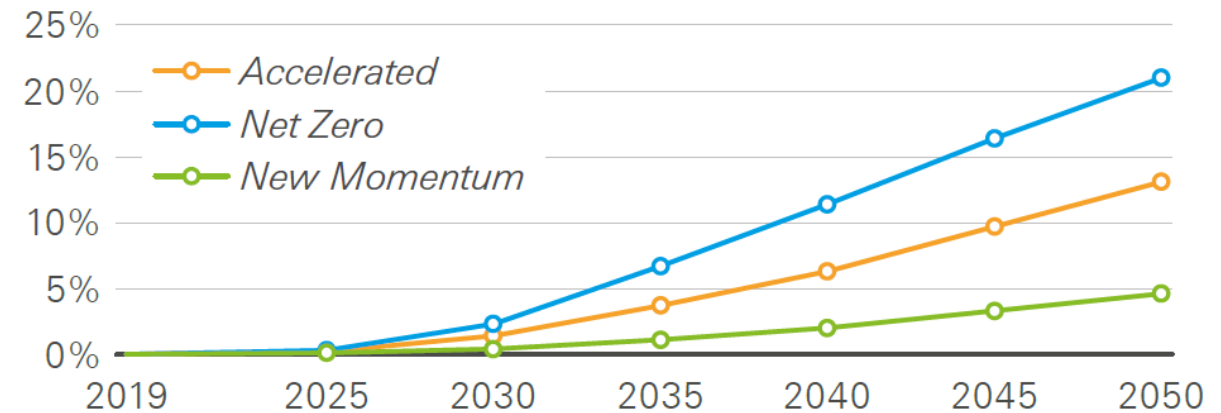
Electricity

Share of total final consumption



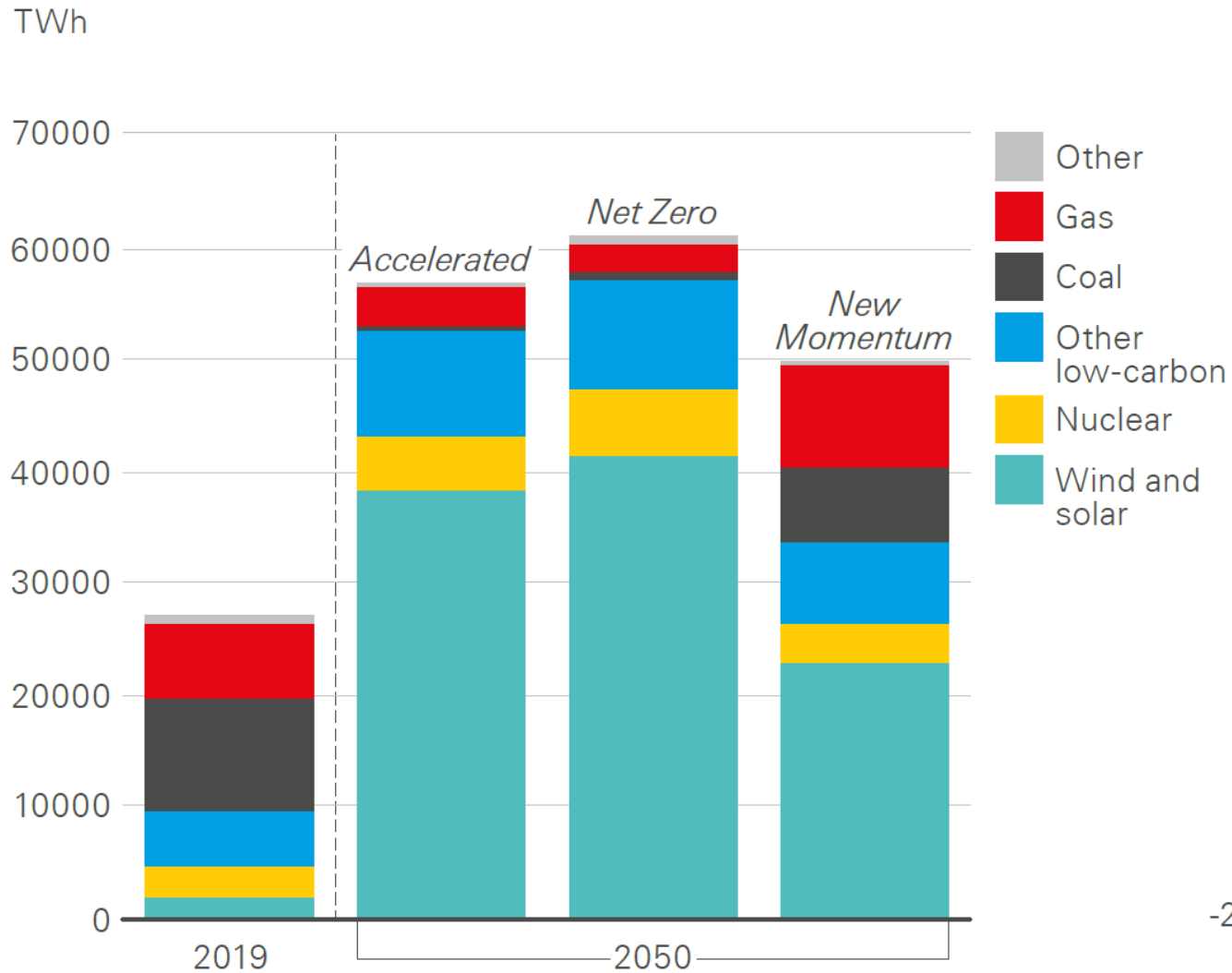
Low-carbon hydrogen

Share of primary energy used in production of hydrogen

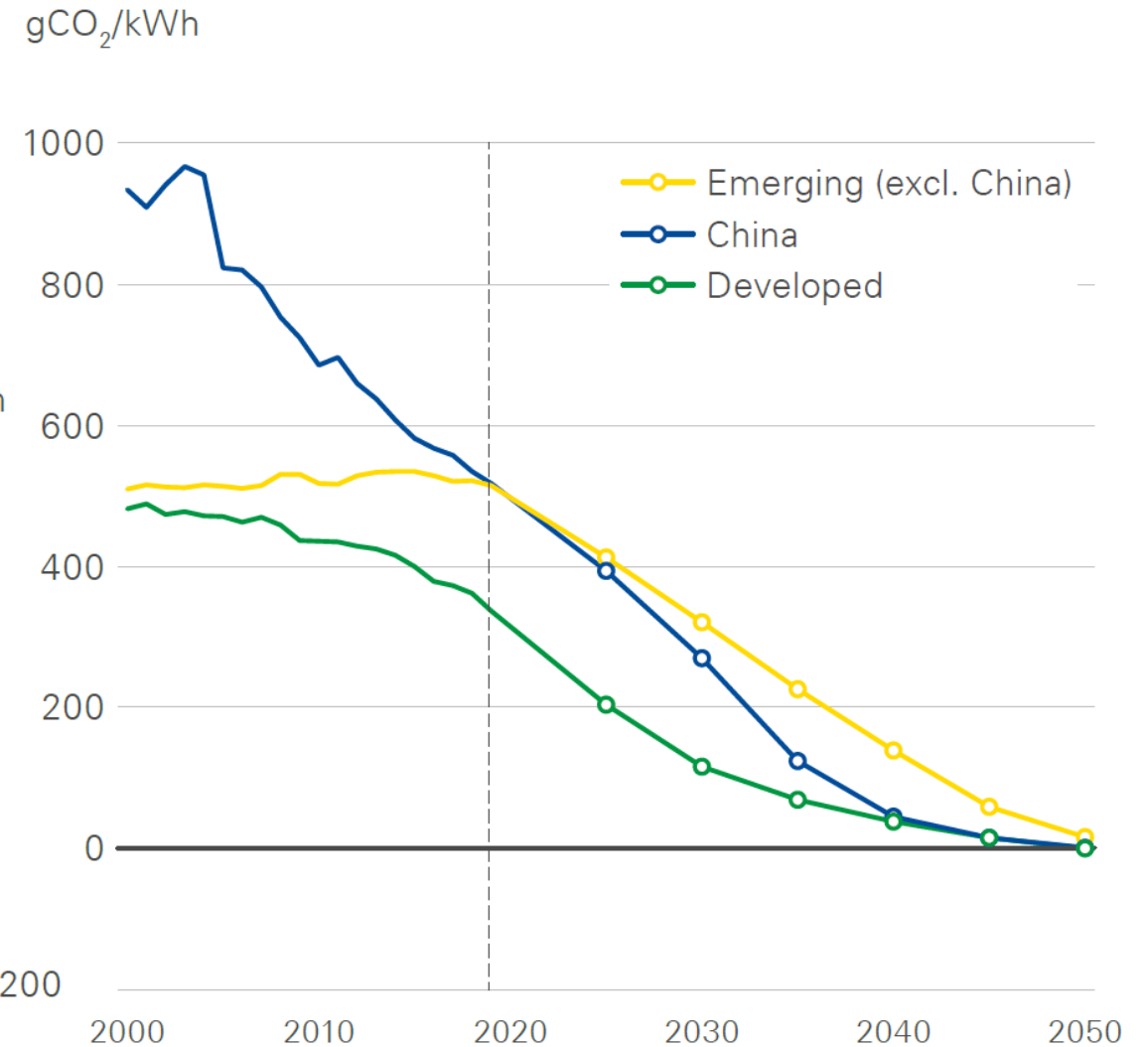


PLAN A: ENERGY TRANSITION

Electricity generation by fuel

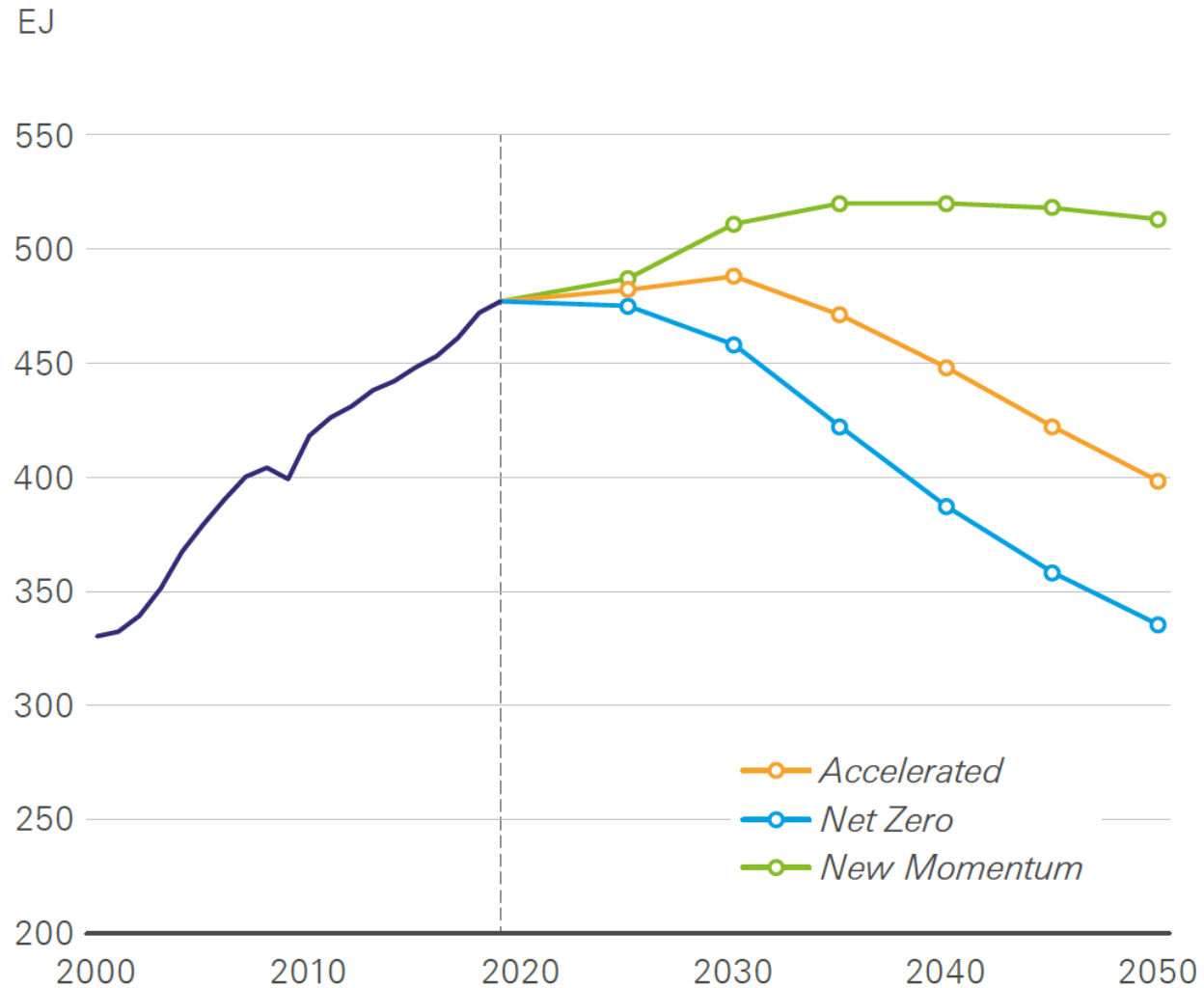


Carbon intensity of power generation in *Accelerated*

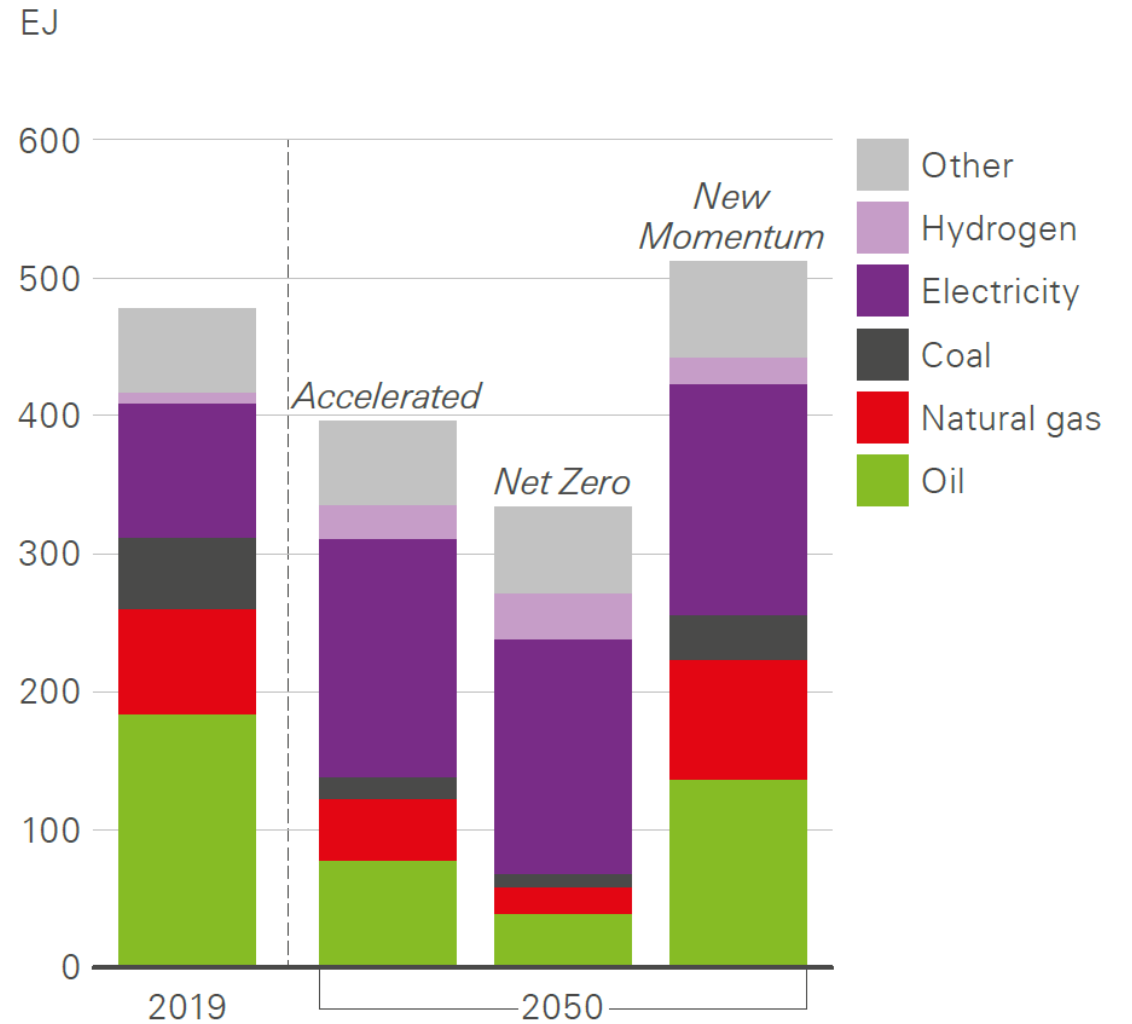


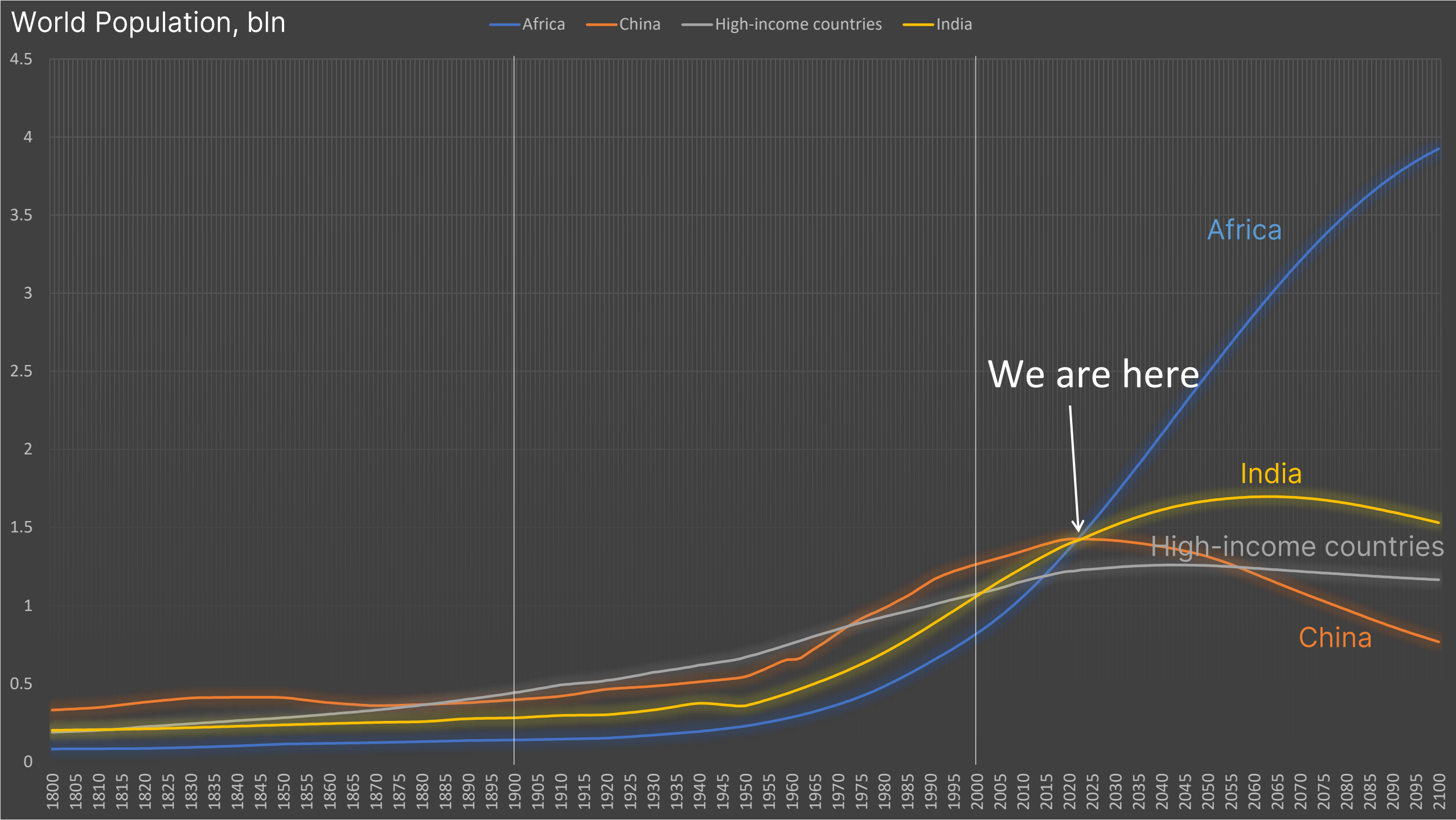
PLAN A: ENERGY TRANSITION

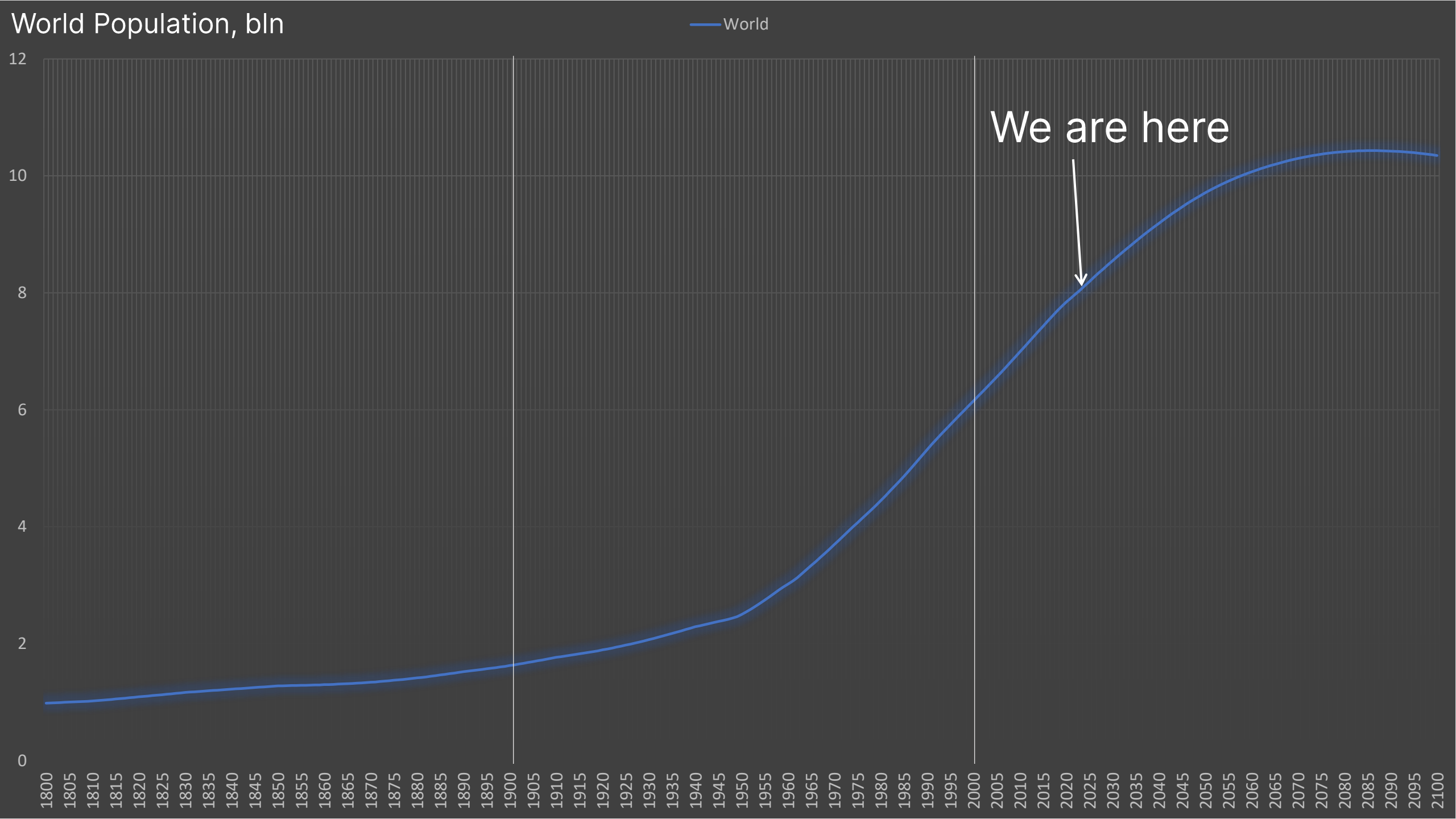
Total final consumption

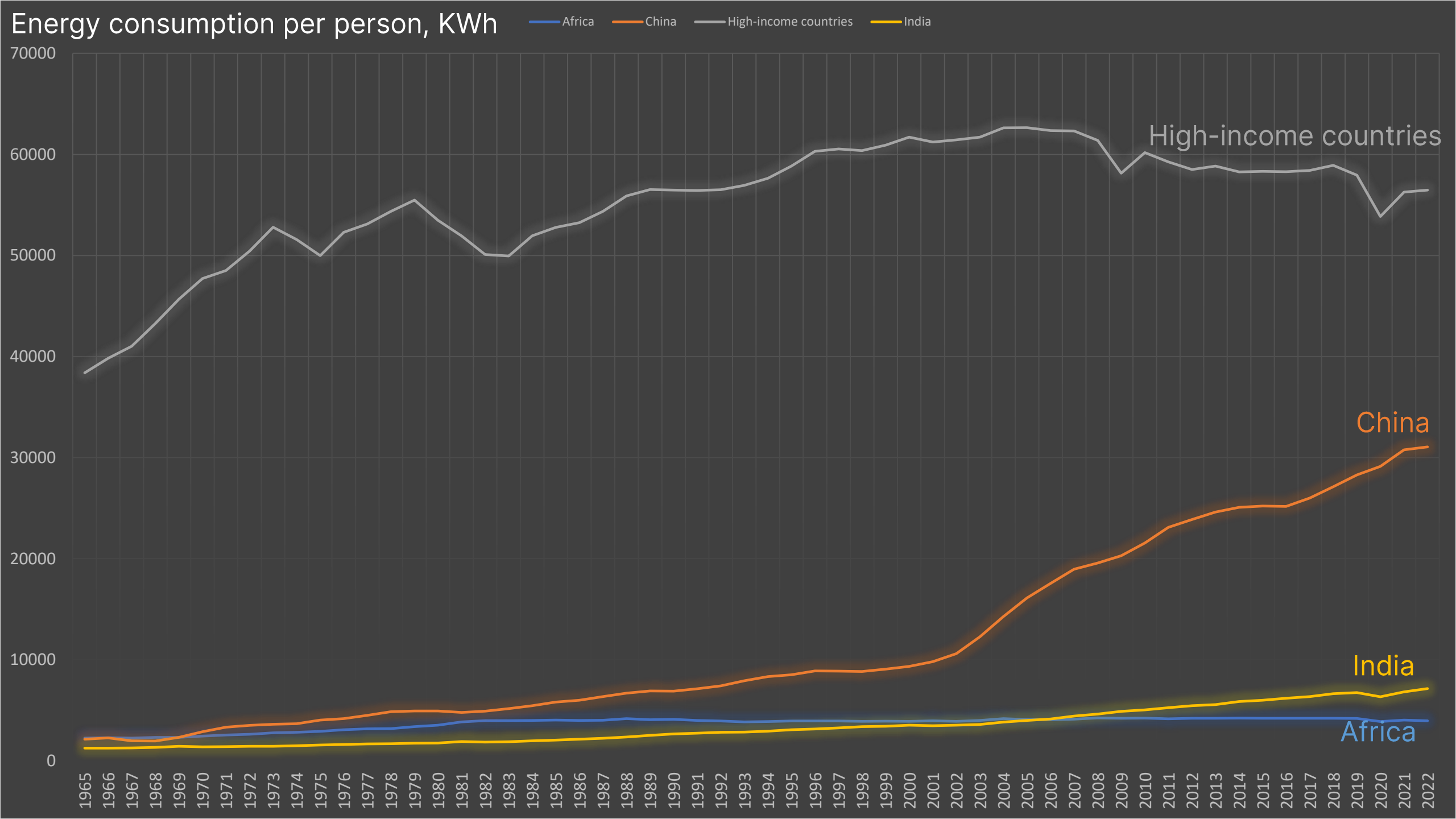


Total final consumption by fuel

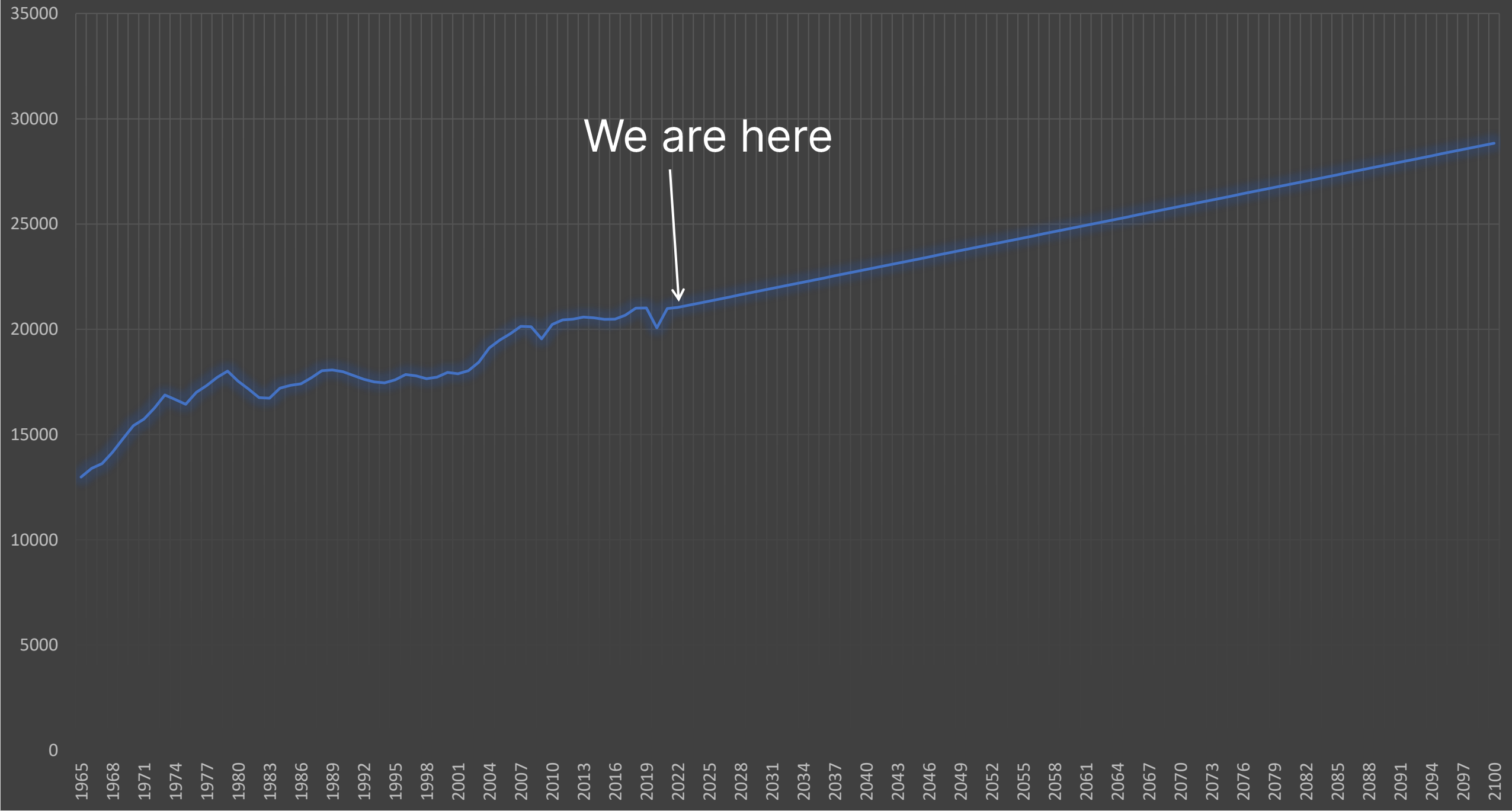






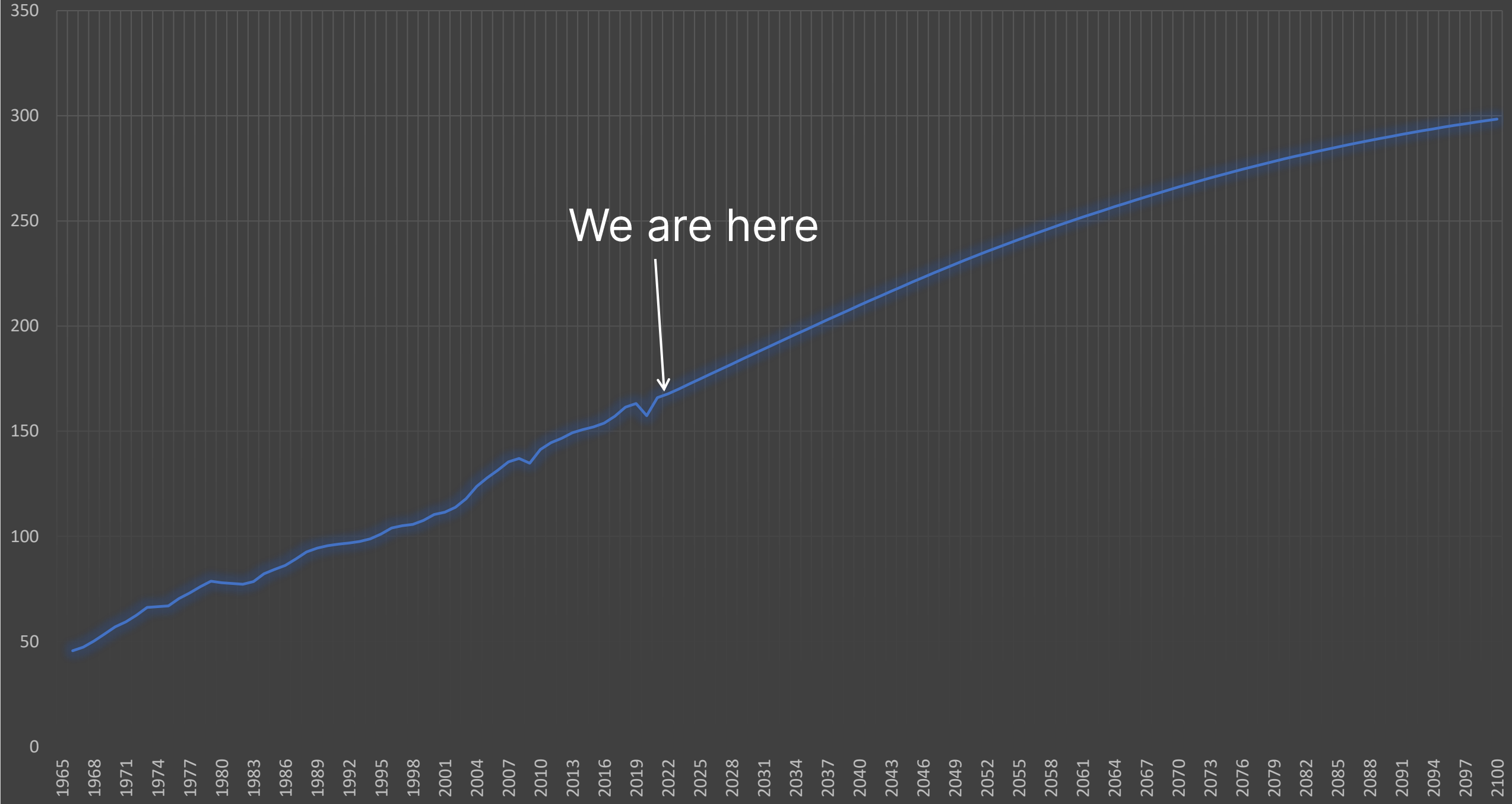


Energy consumption per person, KWh



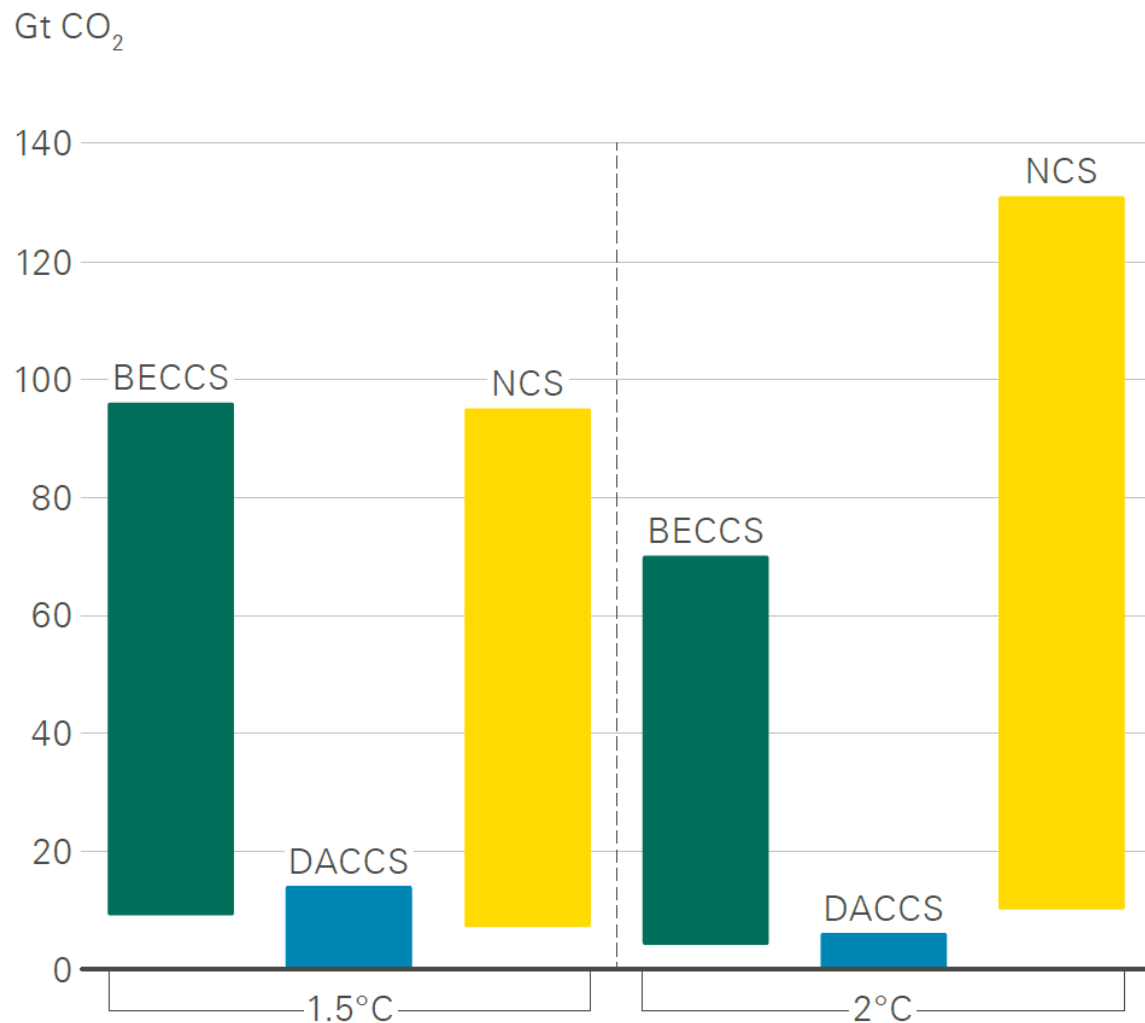
Global energy consumption, thousand TWh

World

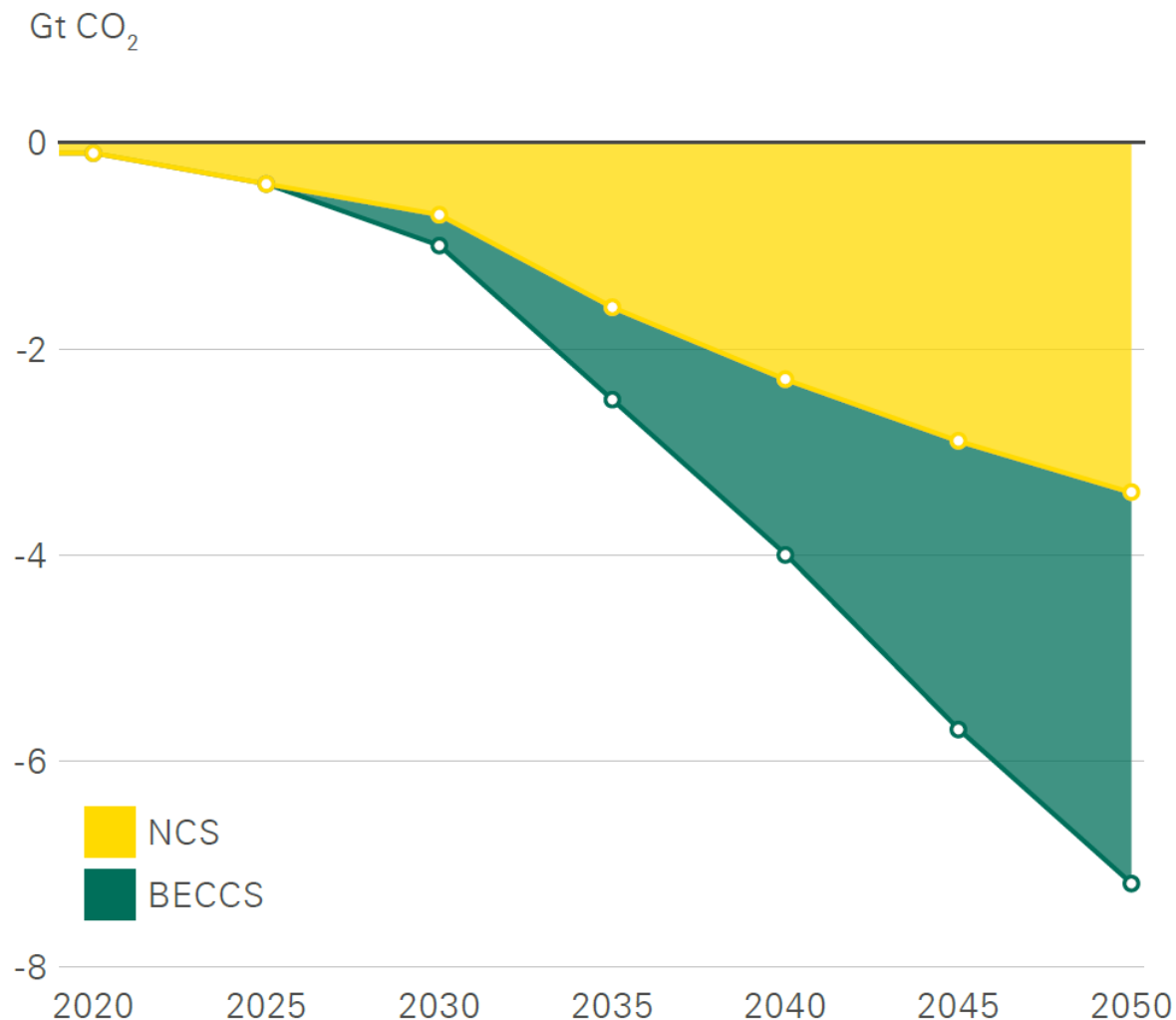


PLAN A: CARBON REMOVAL

Cumulative carbon dioxide removal
in IPCC scenarios: 2015-2050

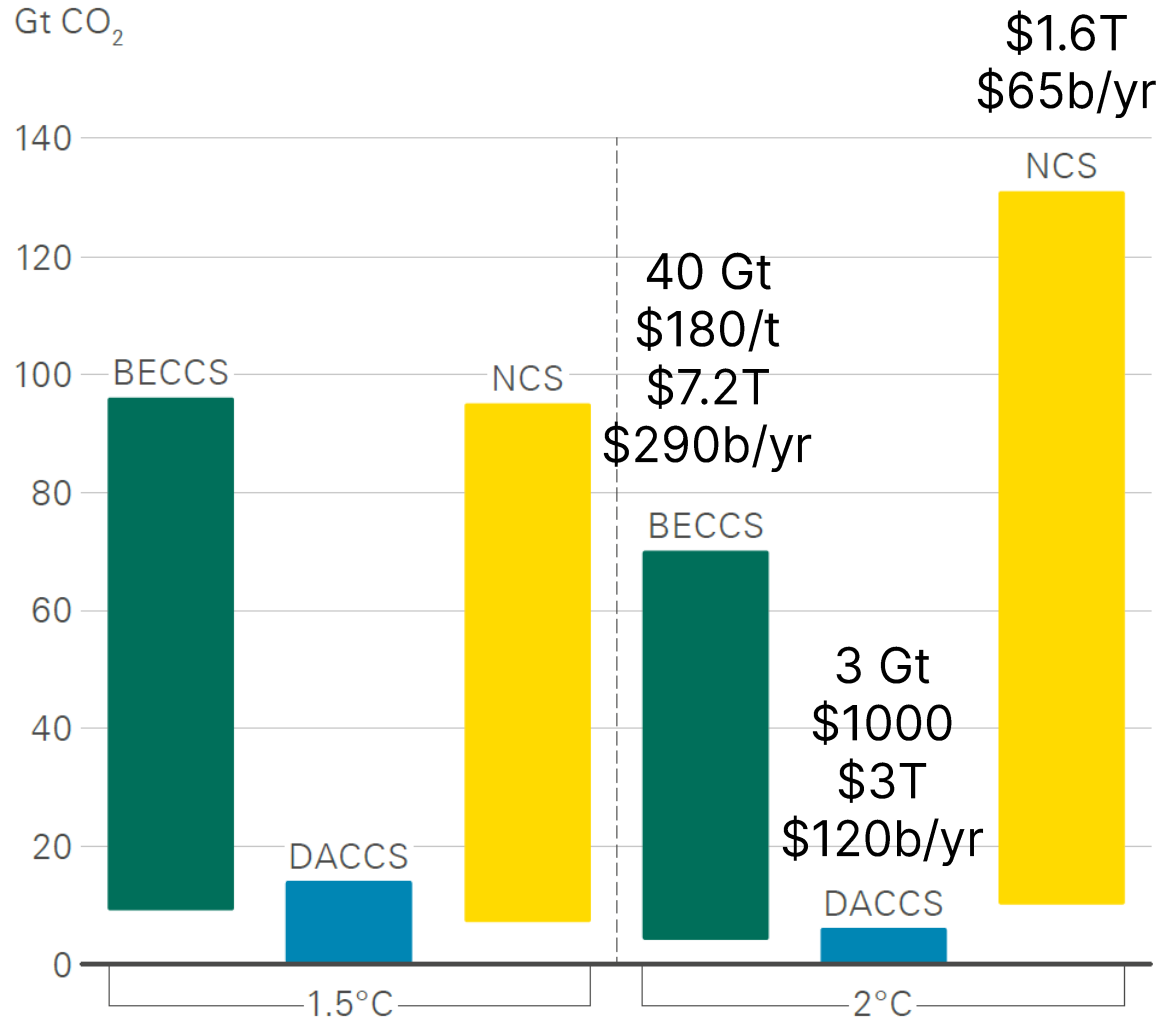


Annual carbon dioxide removal
in median IPCC 1.5°C scenario

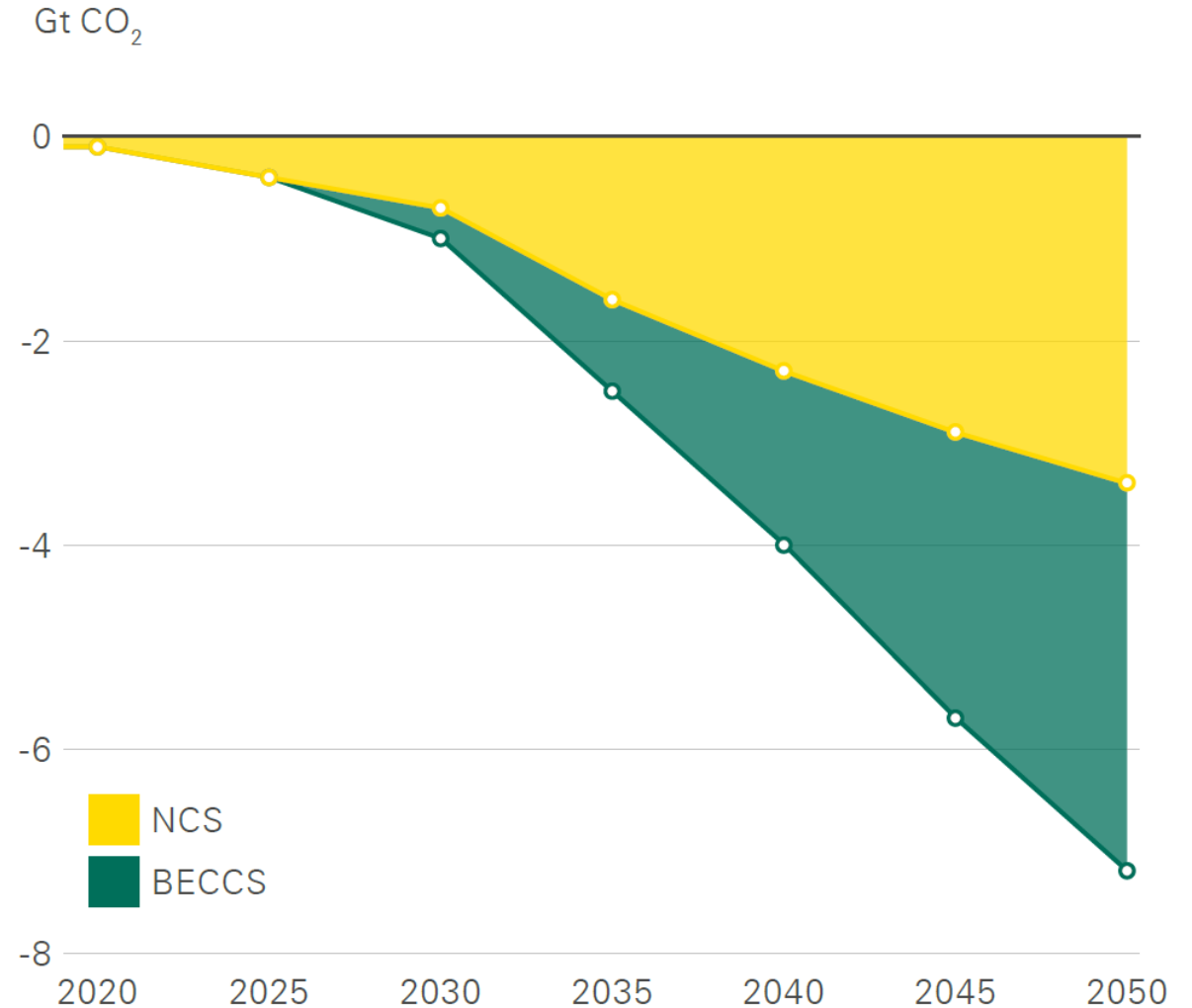


PLAN A: CARBON REMOVAL

Cumulative carbon dioxide removal
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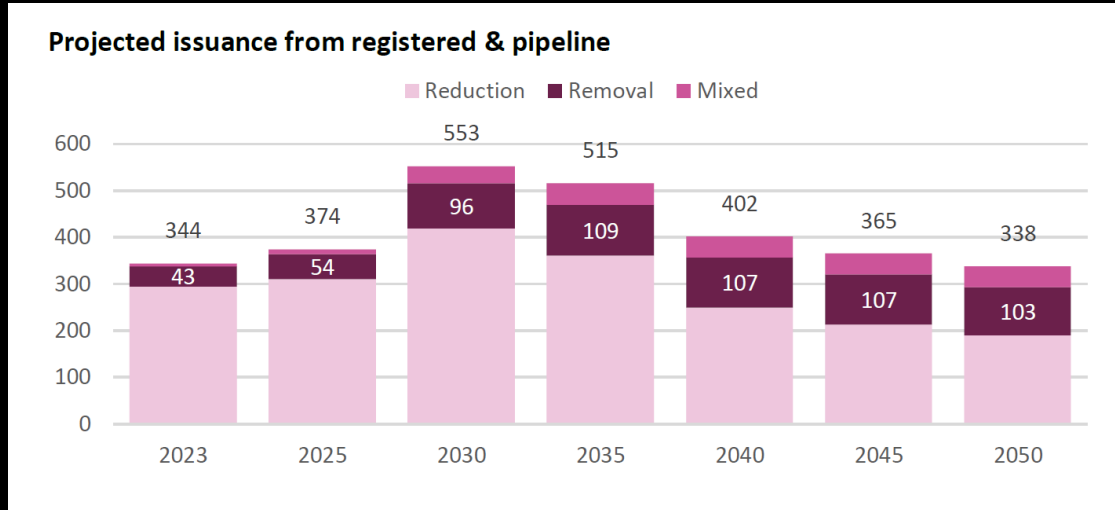


Annual carbon dioxide removal
in median IPCC 1.5°C scenario

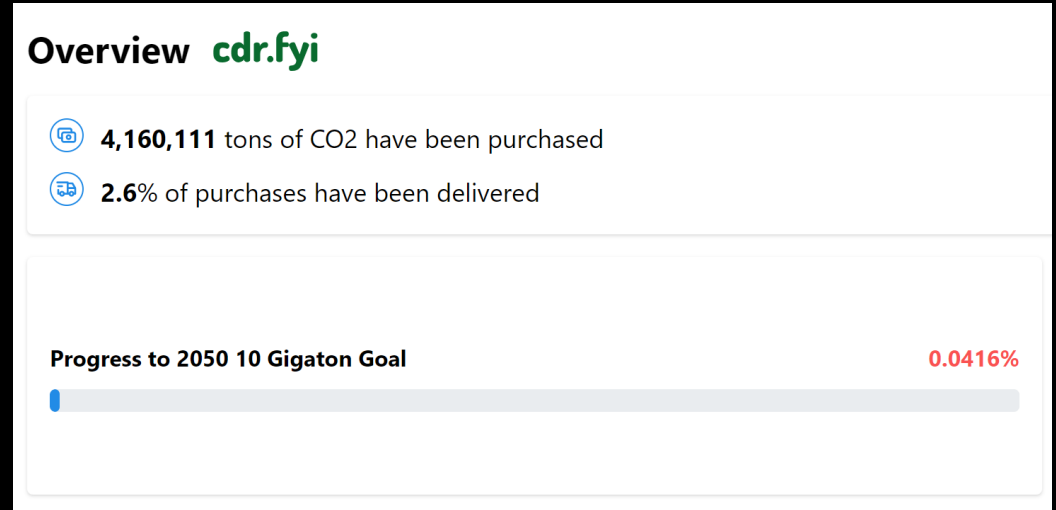


\$475b/yr

PLAN A: CARBON REMOVAL



- 0.1 GtCO₂ NCS removals expected by 2030
- 0.7 GtCO₂ needed by 2030



- 0.004 GtCO₂ durable CDR purchased
- 0.3 GtCO₂ needed by 2030

PLAN A DELAY?

What if we might be unable to reach Net Zero in time:

- some unexpected disaster
- some unexpected tipping point
- lower global coordination & selfish states
- Global South welfare, higher energy consumption
- humble corporate climate action, consumers not willing to pay
- not enough risk capital for frontload investment in carbon removals
- harder to abate emissions in some industries (agriculture, shipping, construction, etc.)

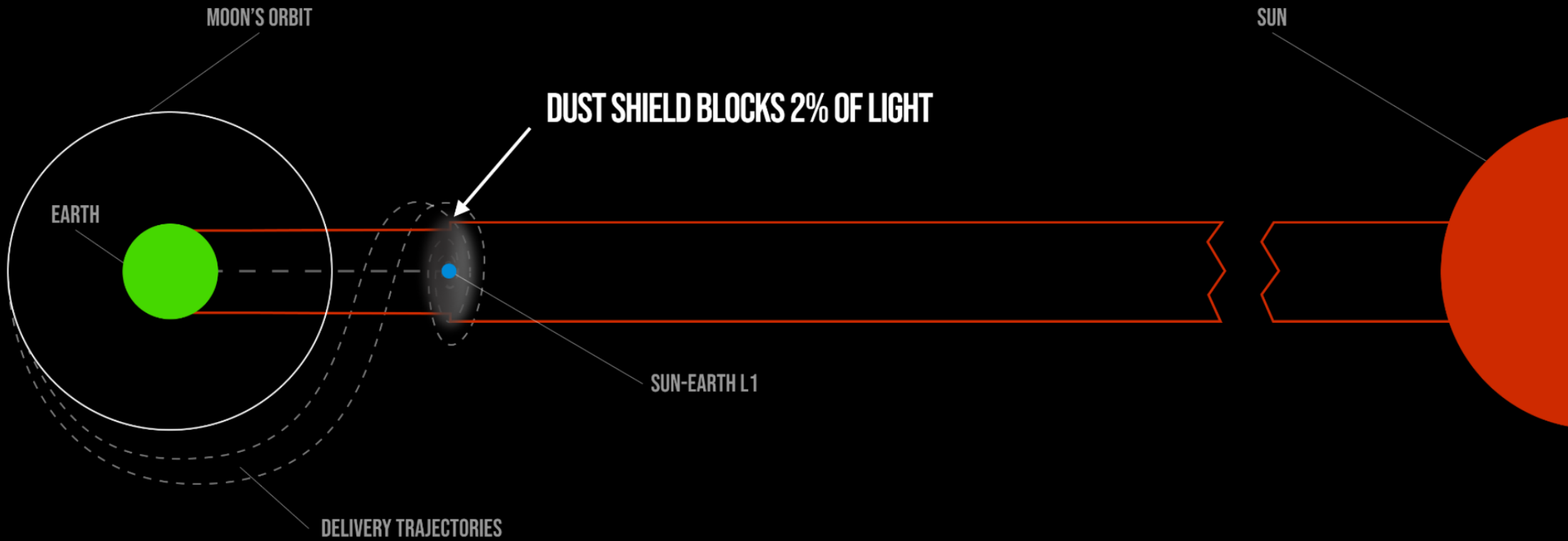
**IS THERE A PLAN X THAT WE
COULD USE IF NEEDED
FOR DAMAGE CONTROL?**

PLAN X: CRITERIA

Plan X should be:

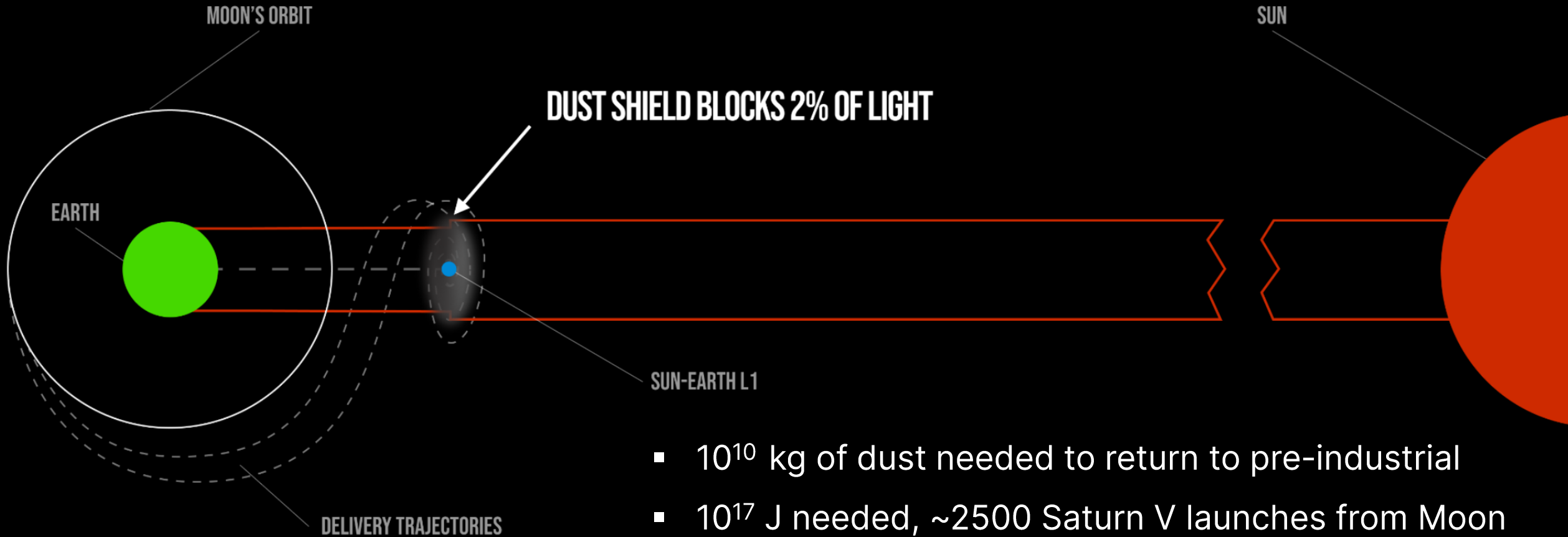
- Safe: no possible danger or permanent damage!
- Lowest cost or best investment
- Can be tested at small scale
- Discussed, assessed, publicly accepted

IDEA



Schematic illustration

IDEA



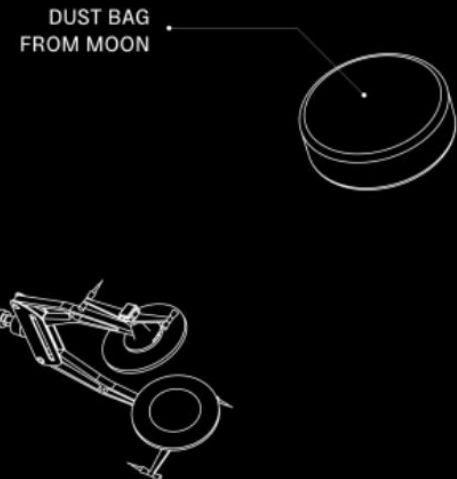
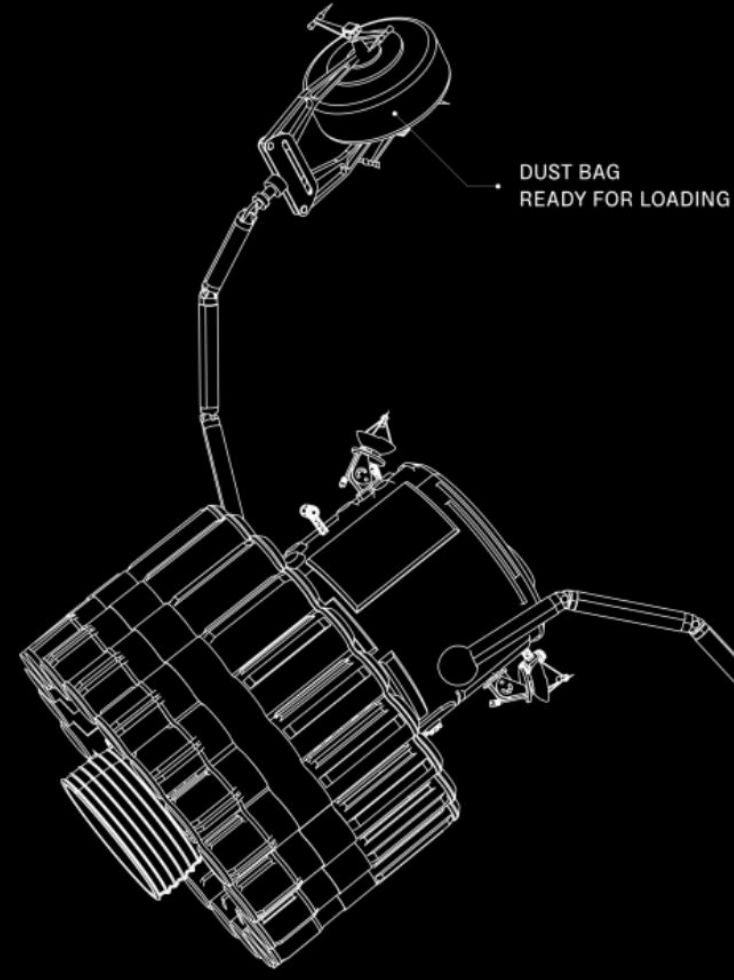
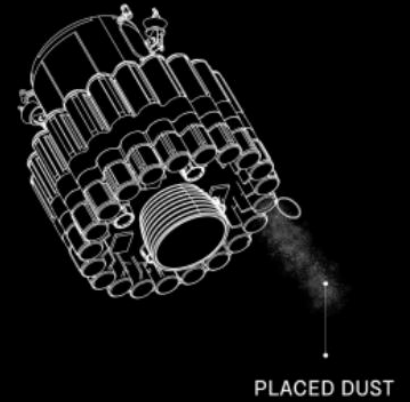
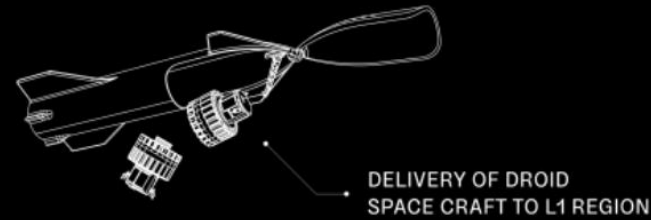
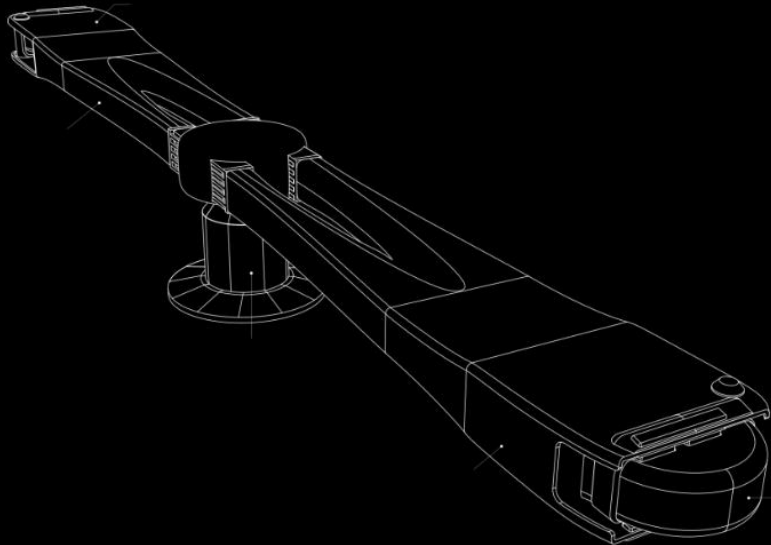
- 10^{10} kg of dust needed to return to pre-industrial
- 10^{17} J needed, ~2500 Saturn V launches from Moon

[Bromley et al. \(2023\) Dust as a Solar Shield, PLOS Climate](#)

- 140x less needed to mitigate further warming, ~17 launches from Moon

HOW IT'S DONE

1. Lunar dust launched to the orbit using centrifuges (TRL 7) or Starship
2. Interceptor robot catches it and distributes it at L1 (TRL 6)
3. Maximum persistence of dust 180 days (we want to test)



WHERE IS BEST PLACE FOR SHIELD?

	SAFETY	COST
SUN-EARTH LAGRANGE L1 (ASTROCOOL)	Drifts to sun in 180 days max (science fact)	Can use moon dust; Least amount needed; Infrastructure investment
GEOSYNCHRONOUS ORBIT (LIKE SATURN RINGS)	Lasts indefinitely! Cannot remove!	— Can use moon dust — More dust needed — Infrastructure investment
TROPOSPHERE/SURFACE “GEOENGINEERING”	Lasts years and will land on Earth!	— Sulfur from Earth — Maybe cheaper — Not an investment

PLAN X: CHALLENGES & BENEFITS

Challenges:

- Technical (e.g. fuel production on the Moon)
- Risks humanity and climate system, e.g. agriculture (see G1 experiment in GeoMIP)
- Government-level funding needed, e.g. ~5 \$bln Artemis lunar program)
- Governance (global coordination?)

Collateral benefits:

- Kickstart “cis-lunar” economy with infrastructure
- Global engagement towards agreed common goal
- Boost research and innovation
- Might find some valuable resources on the Moon! => Delivery to Earth

PLAN X: NEXT STEPS

- AstroCool public benefit corporation
- Crowdfunding (Gitcoin GR18)
- R&D: tech, orbits, climate modeling, risk mitigation
- Test Mission

astrocool.com



COP²⁸
UAE

5-7 December, 2023

Slovenian Pavilion

THANK YOU

