Energy
Transitions
Commission

State of the global energy transition & implications for the ETC

ETC Commissioners meeting

26 June 2025

Agenda

Emissions, political and investment trends

Focus on China, rest of world

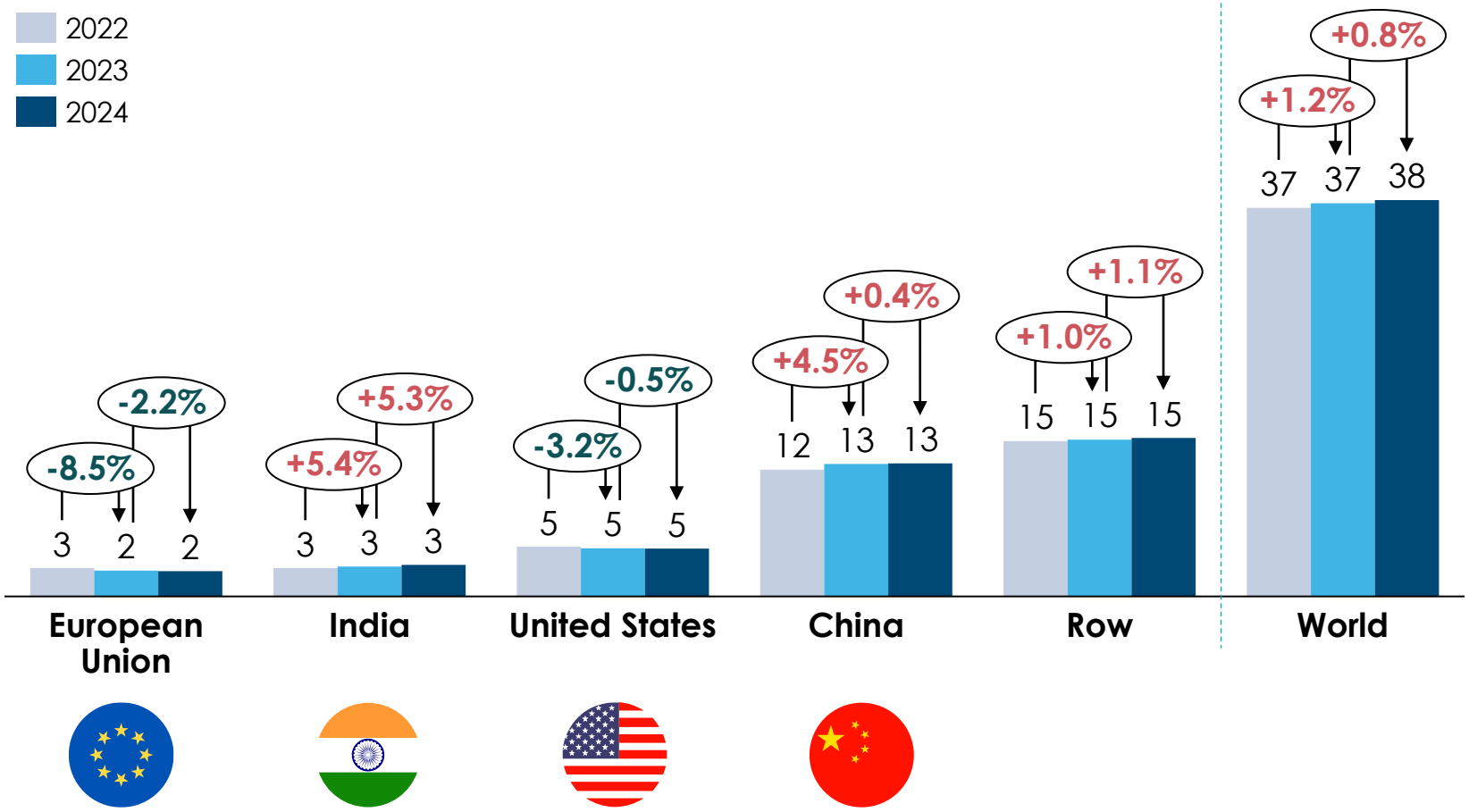
Sector by sector summary

Conclusion and implications for ETC

Rate of CO_2 growth slowing, but not yet falling; Chinese energy sector emissions likely at peak

Global Energy CO2 emissions*, 2022-2024

GtCO2/year



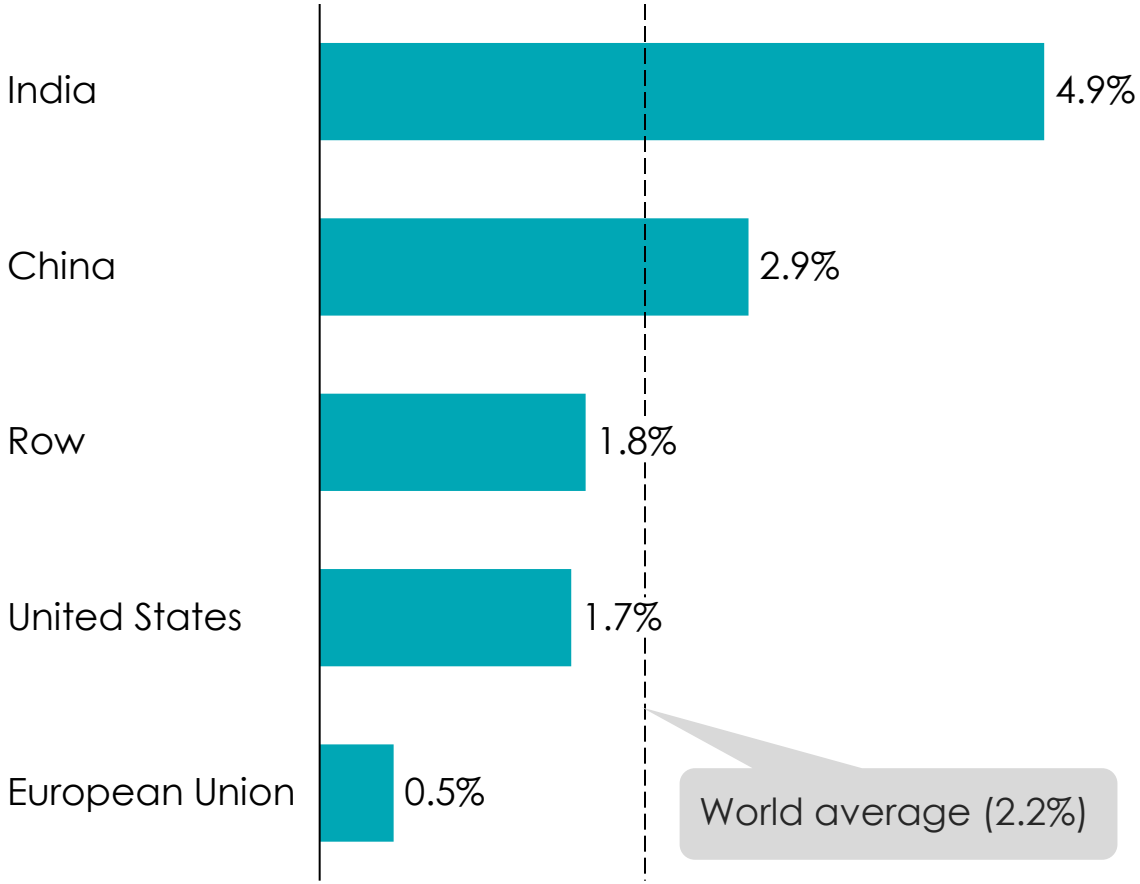
- New high in global energy emissions: **0.8% growth – growth in global south, aviation and shipping outweigh emissions reductions in developed economies**
- Slower growth in China's emissions partially due to the **growth in wind and solar** capacities but also restoration of **hydropower generation (+11% compared to 2023)**
- **India had the highest growth rate among major economies** due to economic growth, infrastructure development and increasing electricity consumption

*Include industrial process emissions
Source: IEA (2025) World Energy Review 2025

Energy demand is growing fast, outside of Europe. Most growth is now electricity. Most electricity growth now met through clean sources.

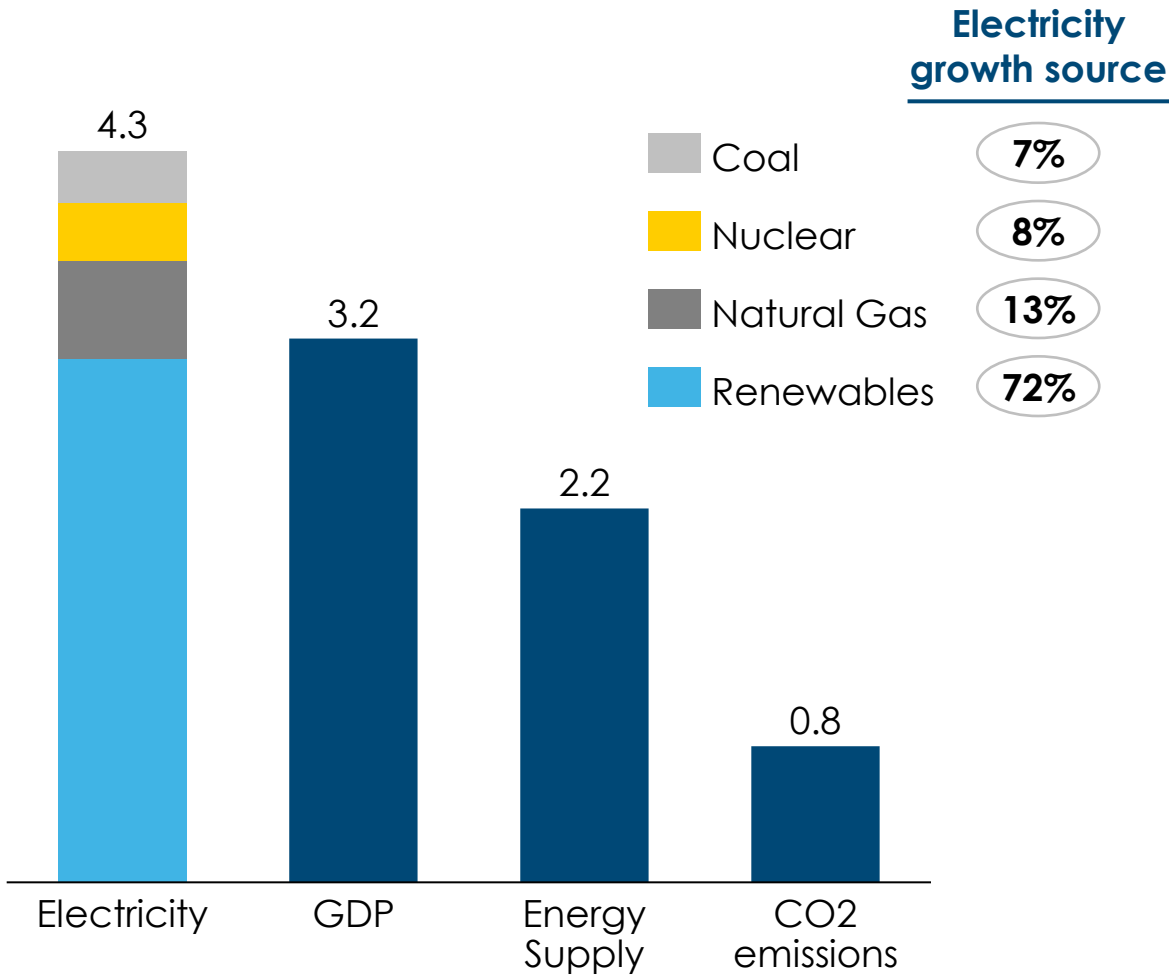
Energy supply growth rates 2023-2024

%



Key global growth rates 2024

%

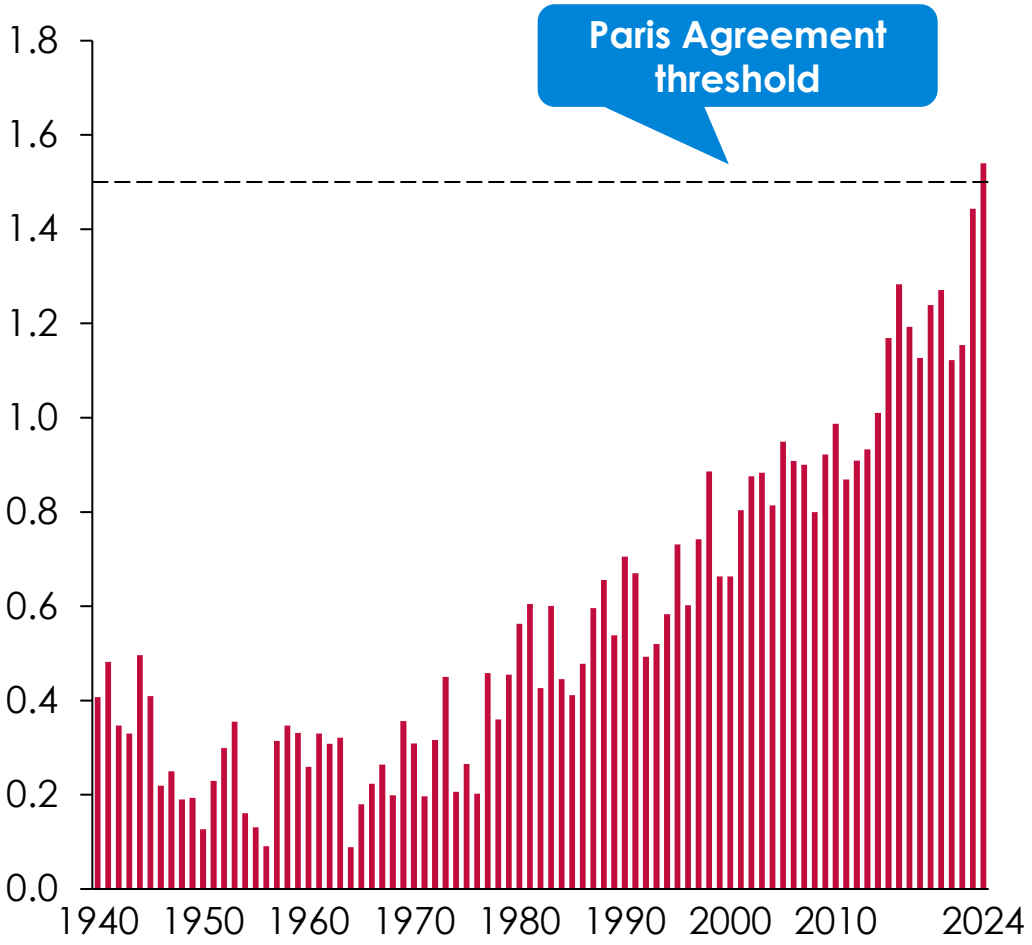


Source: IEA (2025) World Energy Review 2025

2024 saw the Paris agreement threshold breached for the first time and impacts for human systems can be even more catastrophic if we reach 2oC

Global surface air temperature anomalies with reference to pre-industrial period (1850-1900)

°C above pre-industrial levels

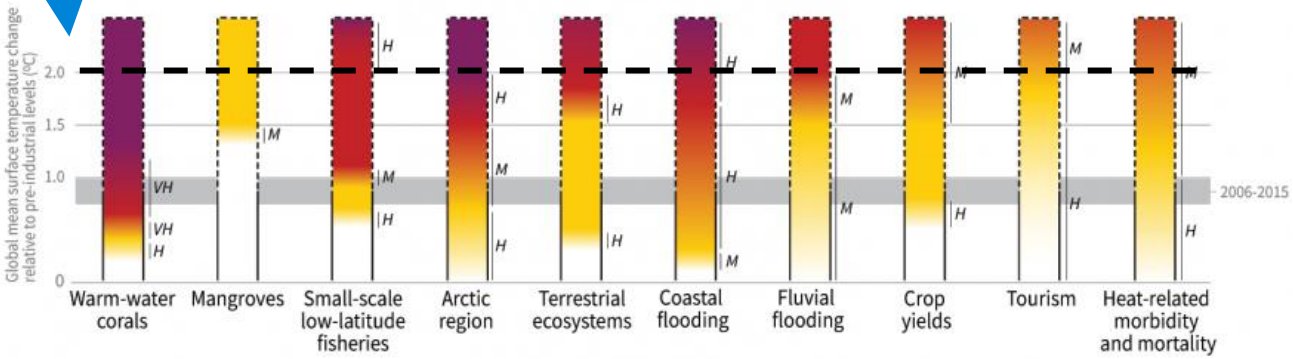


Impacts and risks for selected natural, managed and human systems

Leve of additional impact/risk due to climate change

Undetectable	Moderate	High	Very High
White indicates that no impacts are detectable and attributable to climate change	**Yellow** indicates that impacts/risks are detectable and attributable to climate change with at least medium confidence	**Red** indicates severe and wide-spread impacts/risks	**Purple** indicates very high risks of severe impacts/risks and the presence of significant irreversibility or the persistence of climate-related hazards, combined with limited ability to adapt due to the nature of the hazard or impact/risks

Risks at 2°C

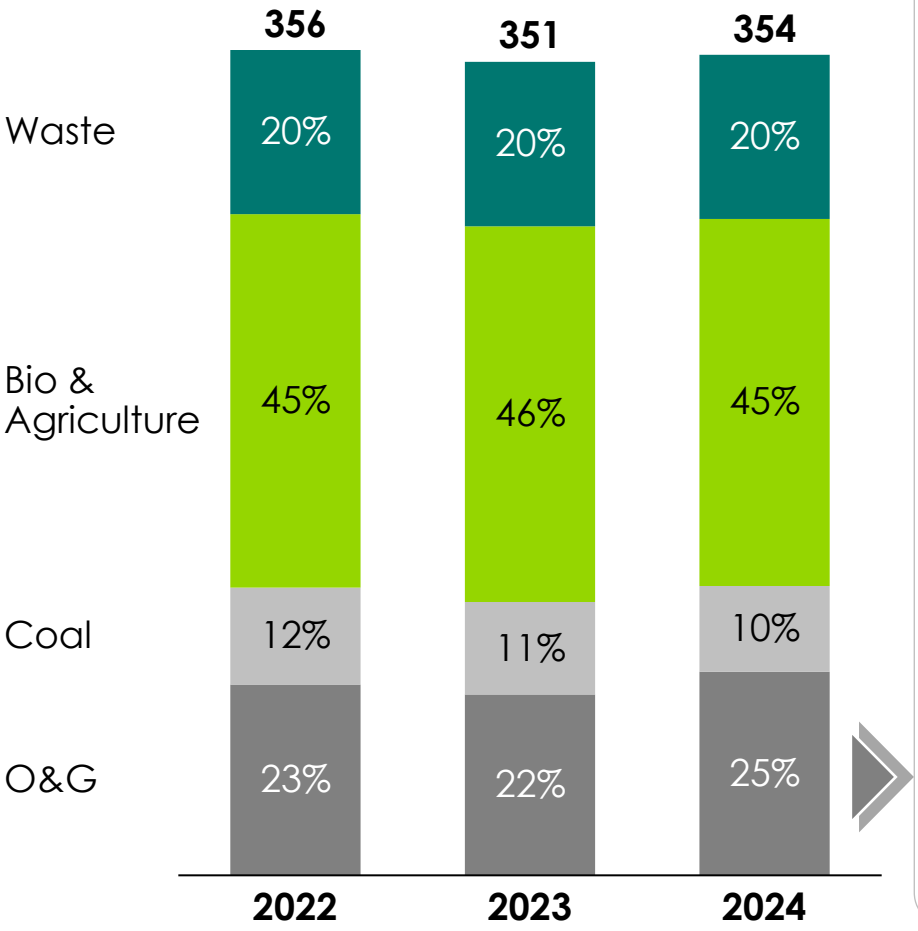


Note: Paris Agreement threshold is officially based on 20 year average temperature increase.
Source: Copernicus (Accessed Jan 2025), Global climate highlights 2024, NOAA global temperature; IPCC (2018) Global Warming of 1.5 °C

>1.5°C calls for renewed focus on methane; energy related methane intensity not declining and rising fossil fuel demand means yet to see evidence of fall

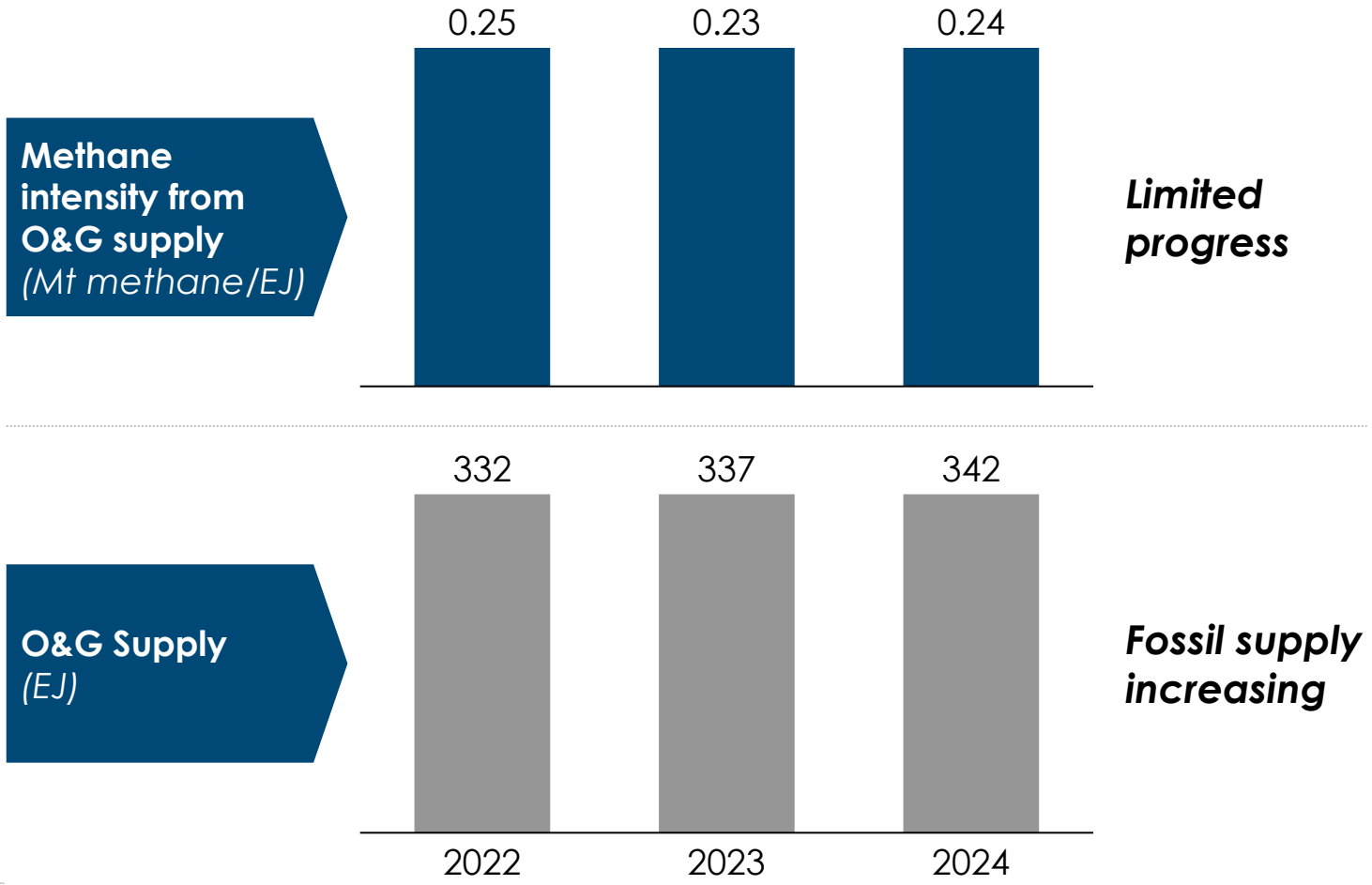
Global methane emissions*, 2022-2024

Mt; % of annual methane emissions



Methane intensity vs Oil & Gas supply, 2022-2024

Mt methane/EJ; EJ

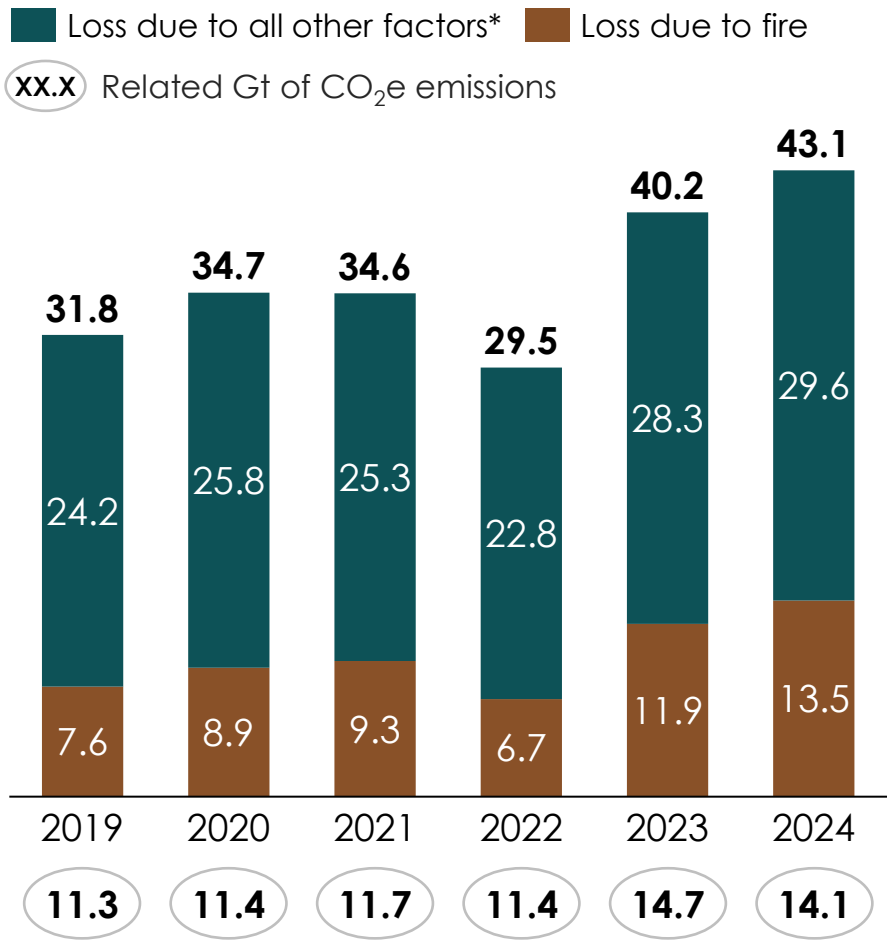


Note: *Does not include natural losses. Estimates of global methane emissions have high levels of uncertainty and can range between 320 – 380 Mt.
Source: IEA (2024), Global Methane Tracker; IEA (2025) Methane Tracker; IEA (2025) World Energy Review 2025

Global tree cover loss increased in 2024, due to natural and manmade factors; permanent loss most prominent in the global south

Global annual tree cover loss, 2019-2024

Mha

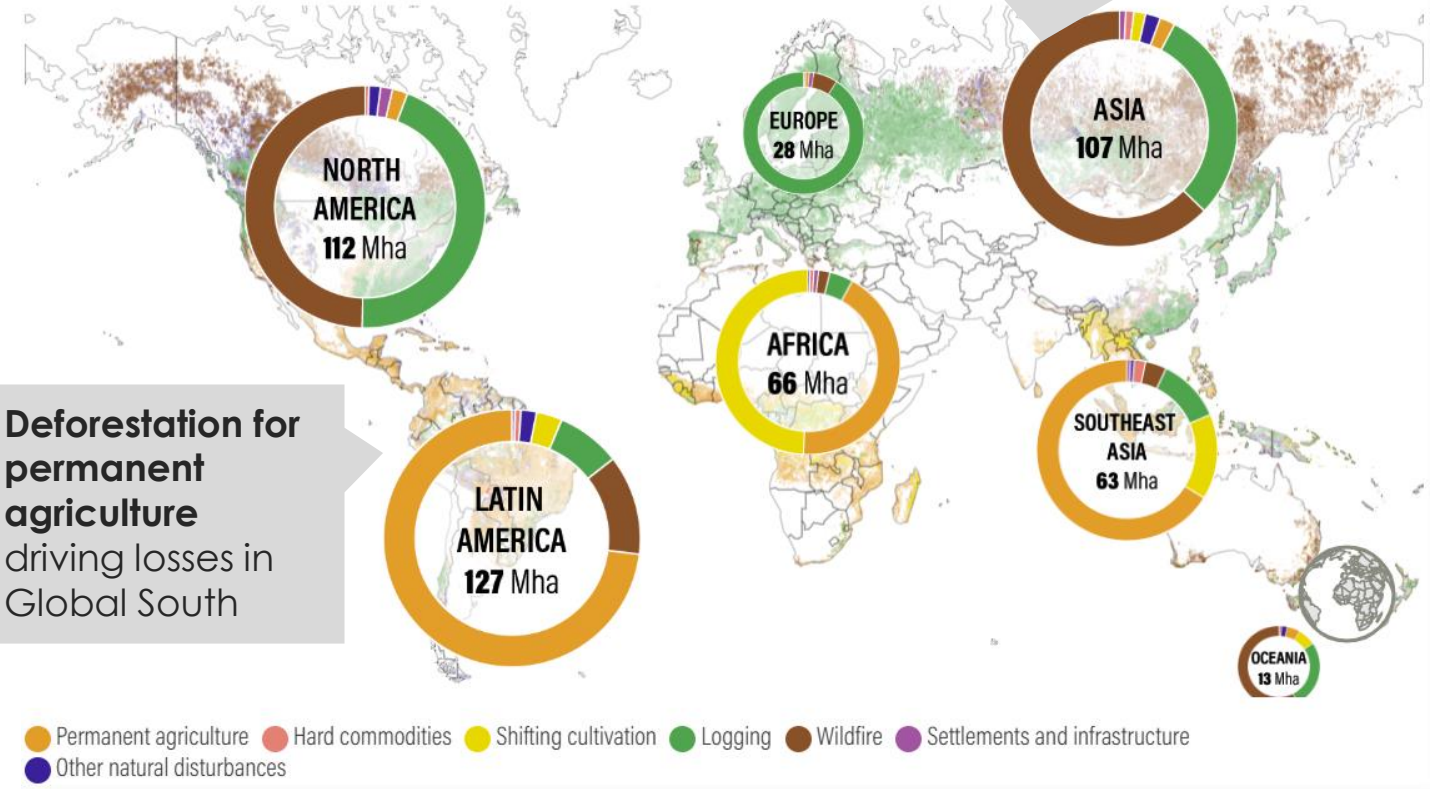


Tree cover loss by dominant driver, 2001-2024

Regional Results

Wildfire driving losses in North America, Europe, Asia and Oceania

Deforestation for permanent agriculture driving losses in Global South



* Other factors of loss include manmade and other natural disturbances, such as landslide, insect damage, storms and changing rivers.
Source: WRI (2025) New Data Shows What's Driving Forest Loss Around the World; Global Forest Watch – accessed June, 2025;

Political support for decarbonisation continues to be mixed

Selected countries

Falling behind
Stagnation or regression in climate policies and actions, with continued support of fossil fuels extraction

US: Recent administrative changes have caused uncertainty in existing fiscal and regulatory support for decarbonisation and reopened fiscal support for fossil extraction

Laggards with unambitious decarbonisation targets and policies

India: Slow current progress but possible potential to advance Net Zero ahead of 2070?

Mixed incentives with ambitious targets but continued usage of fossil fuels

China: Although ranked strongly on renewables expansion, China continues with new coal projects and plans to continue gas extraction

Greener prospects

Stretching targets but on track to 2030

South Korea/Australia: New greener political mandates

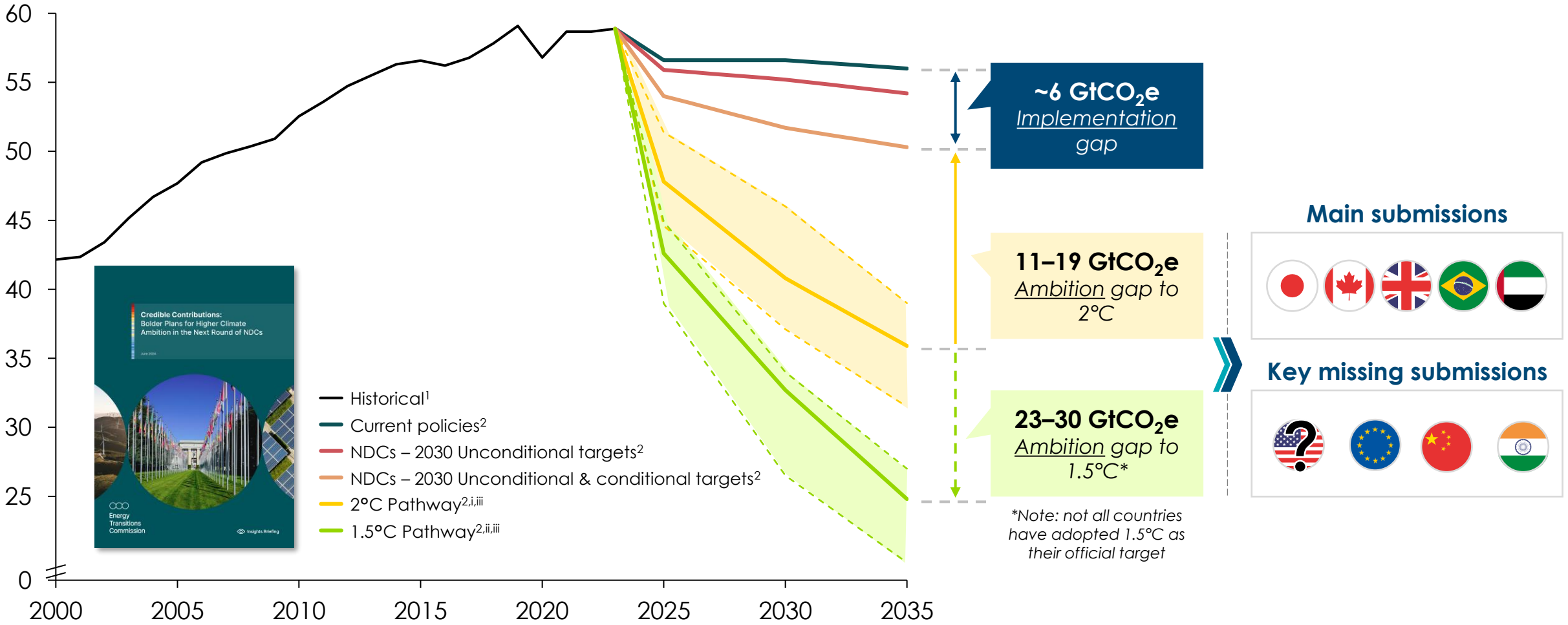
ambitious power sector decarbonisation goals

Despite the impact of the US rowing back on its climate commitments, the impact has been less than originally anticipated and **most countries have continued on their trajectory towards net zero. However climate will continue to be a polarising** issue if decarbonisation has a negative impact on the economy and jobs.

Source: Systemiq analysis for the ETC based on Climate Change Performance Index

Just 23 (of 197) new Nationally Determined Contributions submitted so far; wide expectations are that NDCs 3.0 unlikely to fill ambition gap

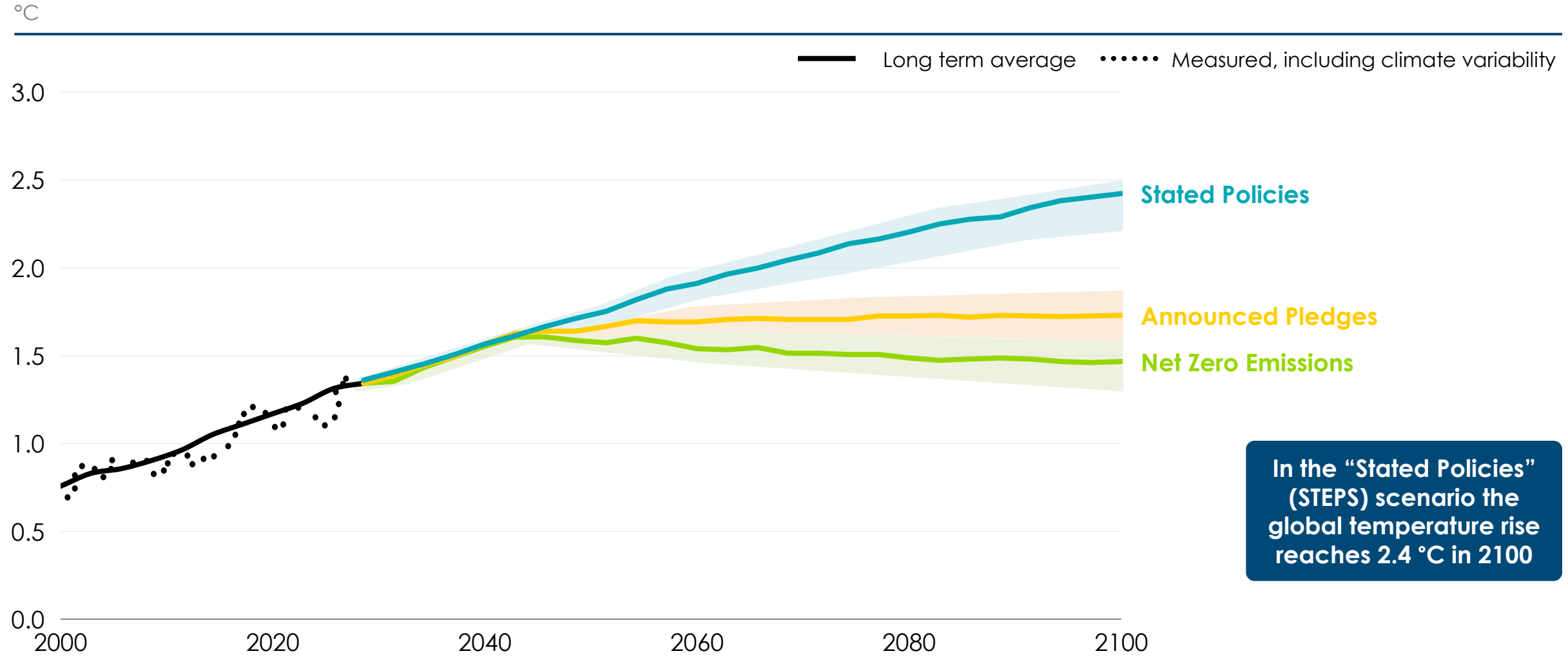
Global GHG emissions



Notes: [i] Based on IPCC Working Group III Sixth Assessment Report scenario class c1 (limit warming to 1.5°C (>50%) with no or limited overshoot). [ii] Based on IPCC Working Group III Sixth Assessment Report scenario class c3 (limit warming to 2°C (>67%)). [iii] Range corresponds to range between tenth and ninetieth percentile, central line corresponds to median.
Sources: ETC (2024), Credible Contributions: Bolder Plans for Higher Climate Ambition in the Next Round of NDCs. Systemiq analysis for the ETC based on [1] IPCC (2022), Metadata Browser: Data for Figure SPM.5 - Summary for Policymakers of the WGIII Contribution to the IPCC AR6, [2] UNEP (2023), Emissions Gap Report: Broken Record; NDC 3.0 submissions registry accessed on June, 2025.

Current trends suggest we are heading for 2.4 degrees of warming, before Trump's election

IEA scenarios for global temperature increase vs preindustrial level



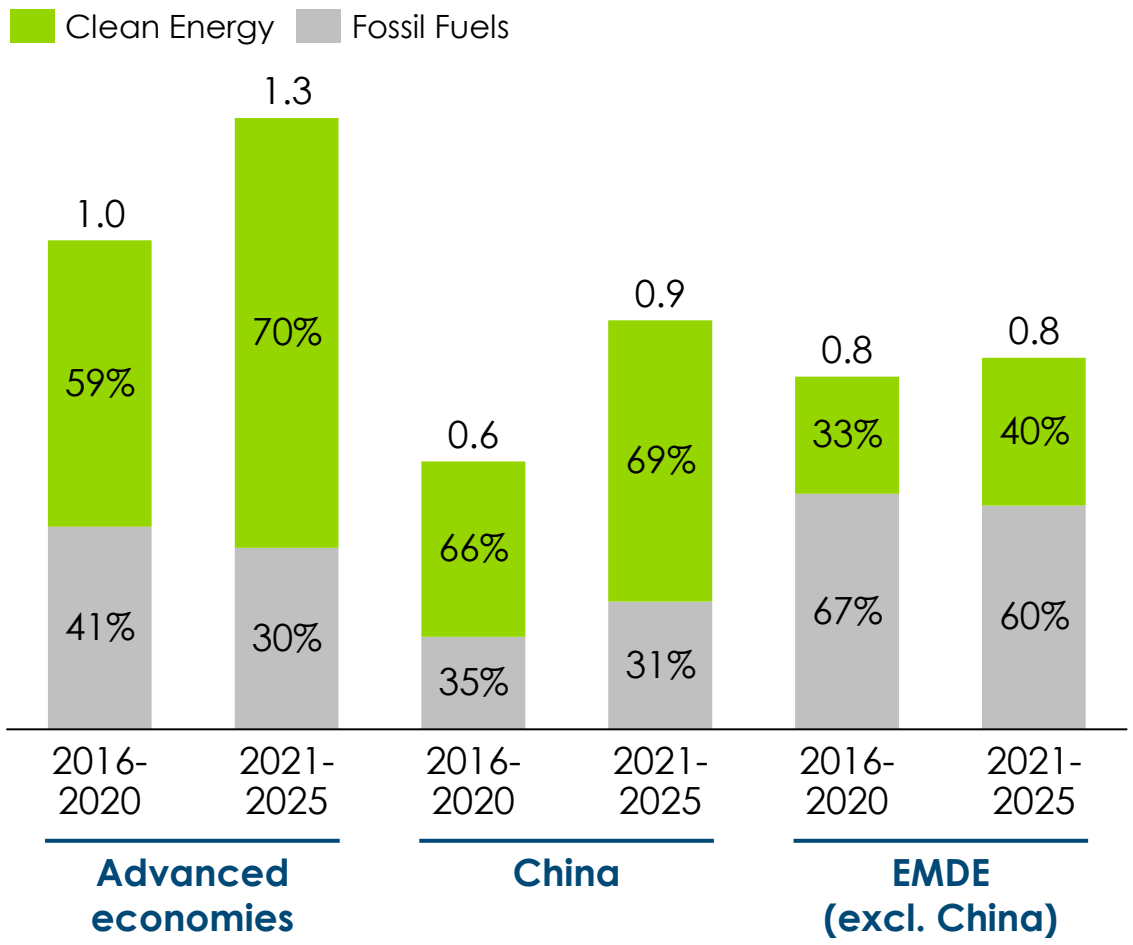
In the "Stated Policies" (STEPS) scenario the global temperature rise reaches 2.4 °C in 2100

Notes: IEA STEPS scenario projects what will happen under current stated policies and trends; APS projects what will happen under all announced policies and net-zero commitments; NZS describes what needs to happen to limit warming to levels consistent with 1.5°C of warming.
Sources: IEA (2024), World Energy Outlook

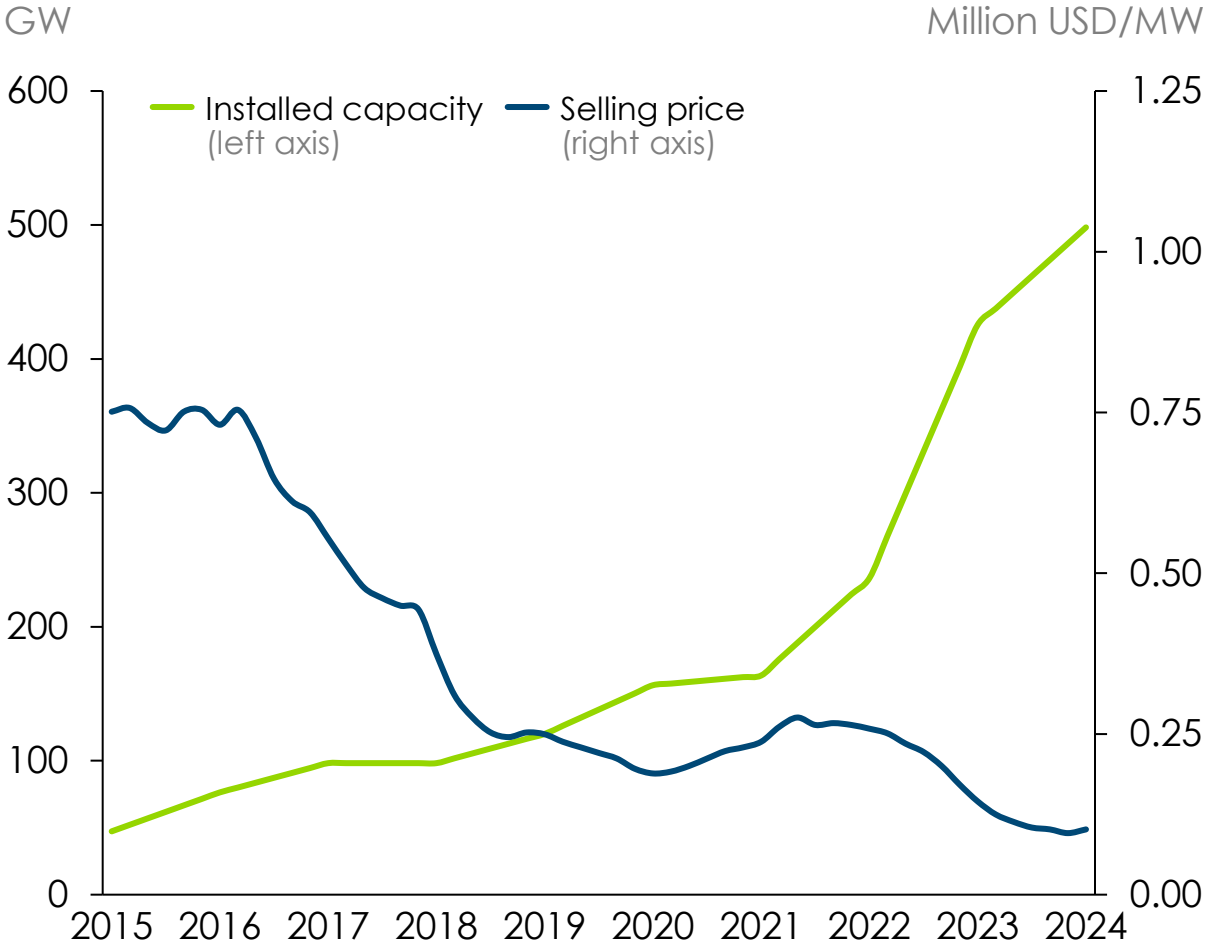
Green investment continues to rise, including in developing countries, even with renewables getting cheaper

Share of clean energy investment

Trillion USD (2024, MER)



Global solar capacity additions vs. Chinese manufacturers' average selling price, 2016-2025



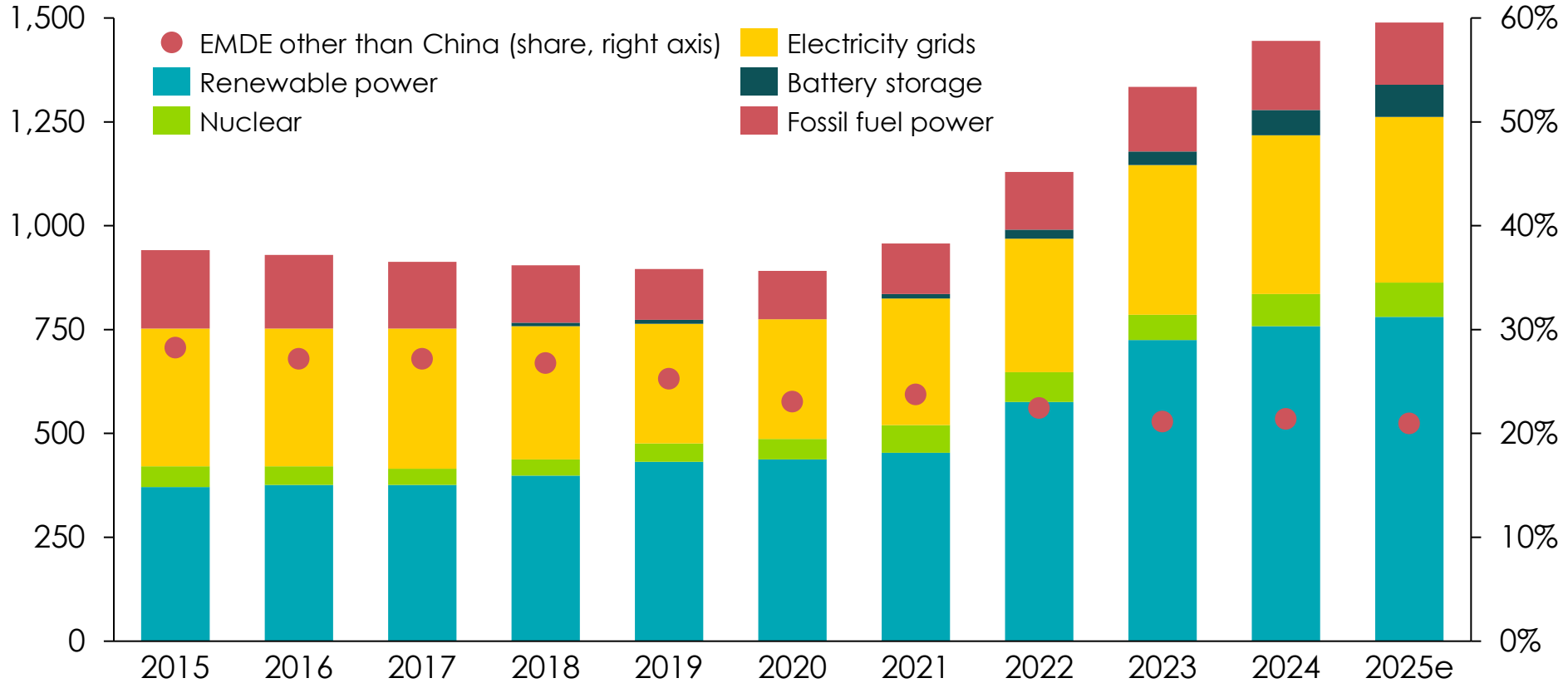
Source: IEA (2025) World Energy Investment 2025 – 10th Edition; https://www.iea.org/data-and-statistics/data-tools/investment-data-explorer

Overall clean energy is dominated by power. Renewables outpaces grid investment and overall investment is disproportionately in rich countries.

Total power investment grew 8% to USD 1.5 trillion in 2024

Global annual investment in the power sector by category, and EMDE share, 2015-2025

Billion USD (2024, MER)



- **Grid investment** growing at 5% per year – but at $375bn/year **still less than half required need** identified by ETC
- **EMDE investment not growing in aggregate and remains small overall share**

IEA (2025) *World Energy Investment 2025*.

Agenda

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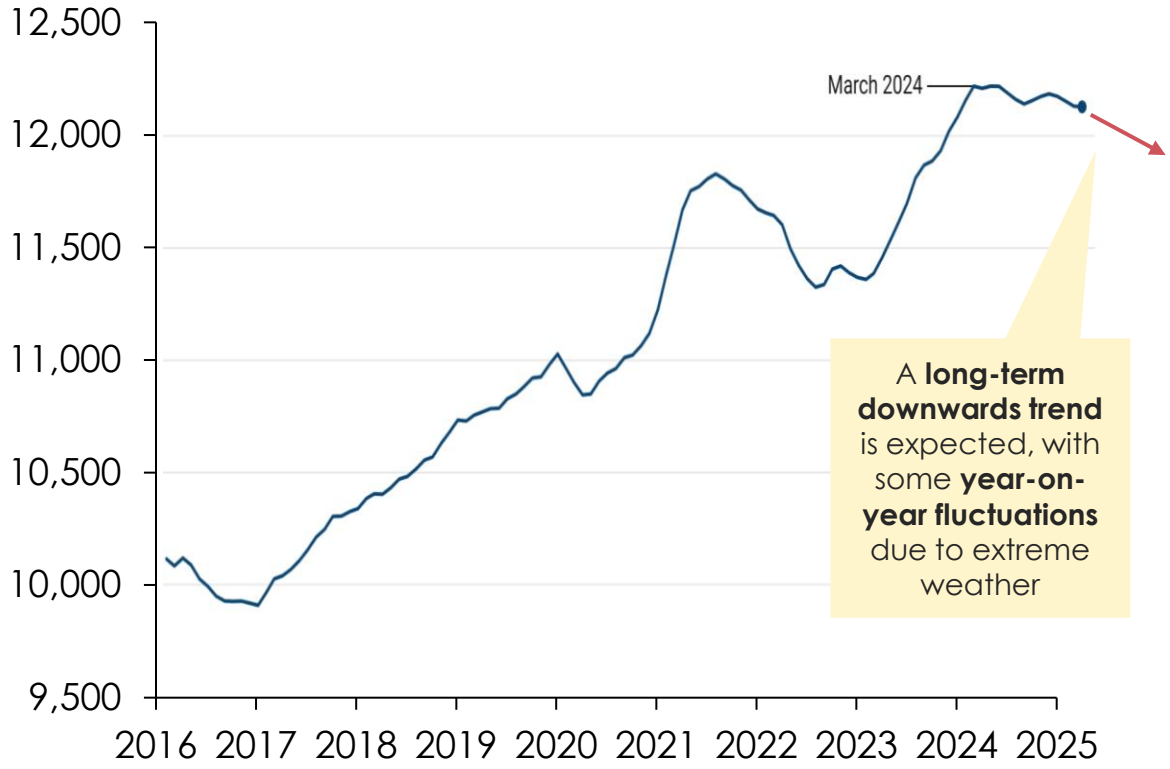
Did China's emissions peak in 2024? Coal usage in power declines alongside rising power demand and renewables deployment

Emissions from fossil fuels and cement

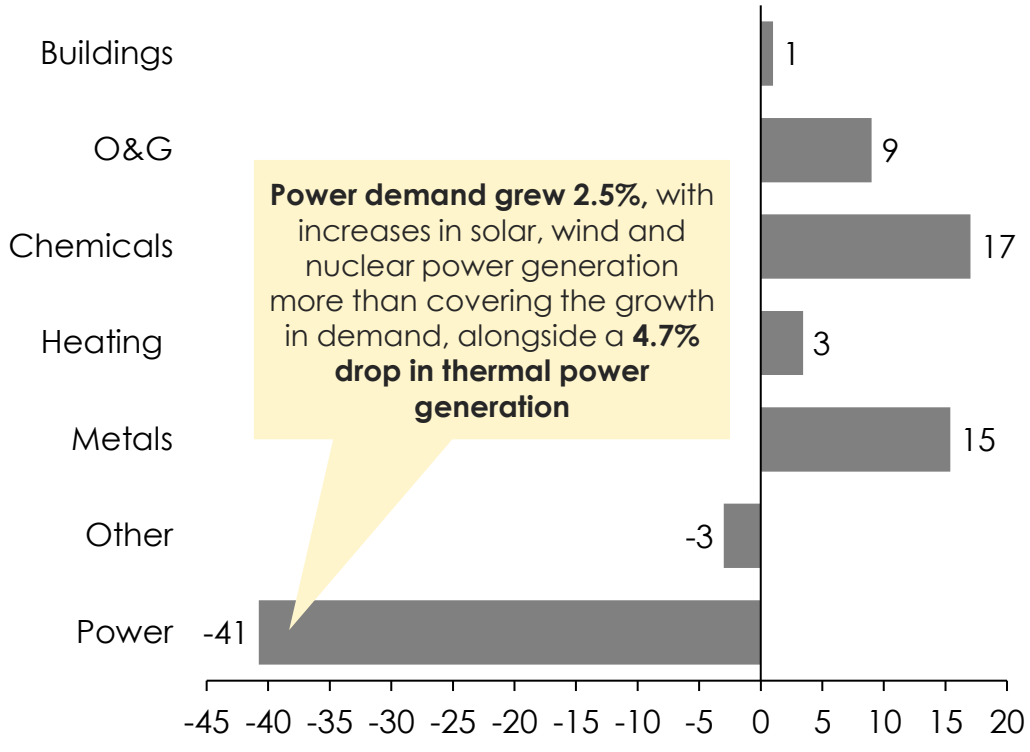
MtCO2, rolling 12-month totals



Predicted that emissions have entered a structural decline beginning 2024

Actual year-over-year change in emissions in March 2025

$MtCO_2$, by sector and fuel



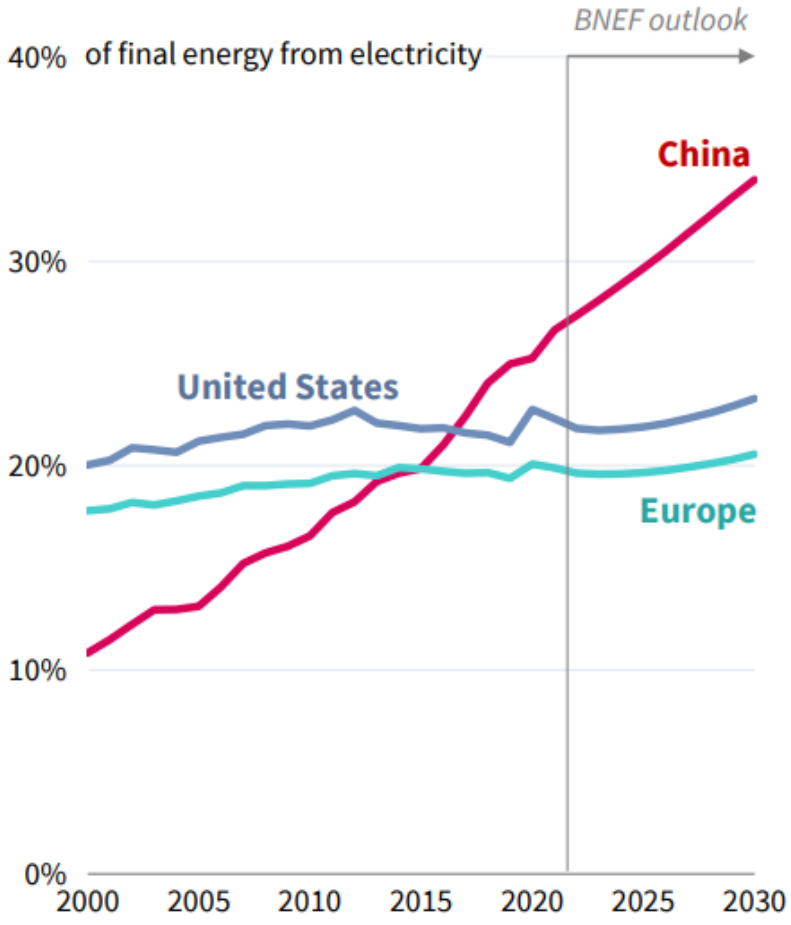
Actual drop driven by clean energy growth, outweighing rises elsewhere

Source: CREA (2023) China's Climate Transition Outlook 2024; Carbon Brief (May 2025) China Briefing: CO_2 emissions fall

Electrification is under way, with very strong growth in China

Electricity share of total final energy consumption

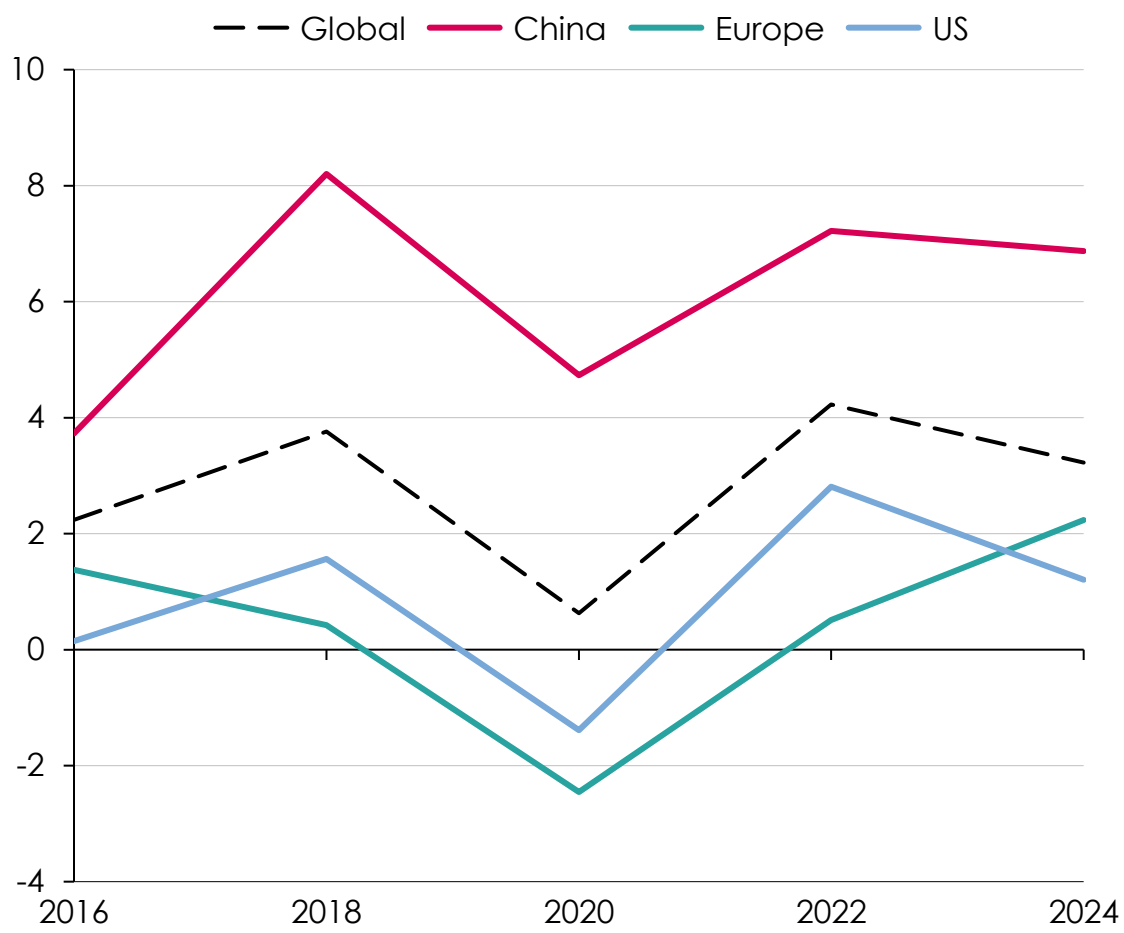
%



2024
China = 28%
US = 22%
Europe = 20%

Electricity demand growth rate

2-year CAGR (%/year)

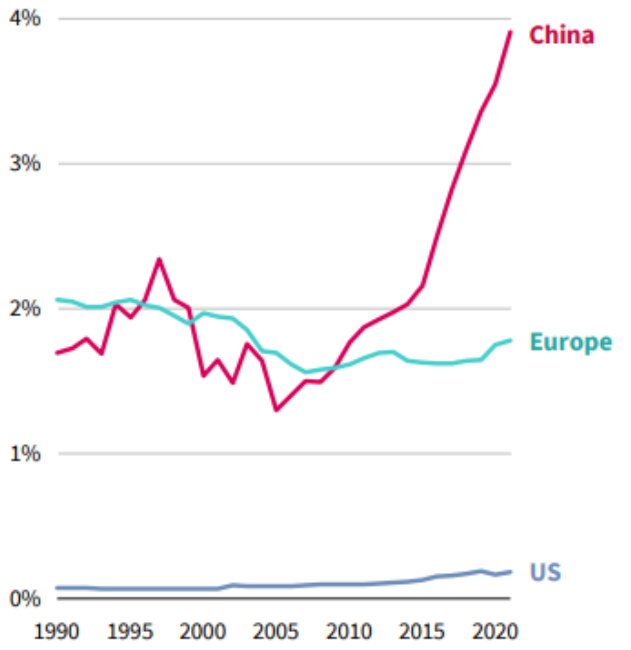


* For European Union
Source: Our World in Data, Ember, RMI, IEA (2025) Electricity 2025, Sources: BNEF (2025), *New Energy Outlook,* Ember (2025), *Global Electricity Review 2025*

China is the world's first electrostate: clean electrification is increasing in sectors across transport, buildings, and industry

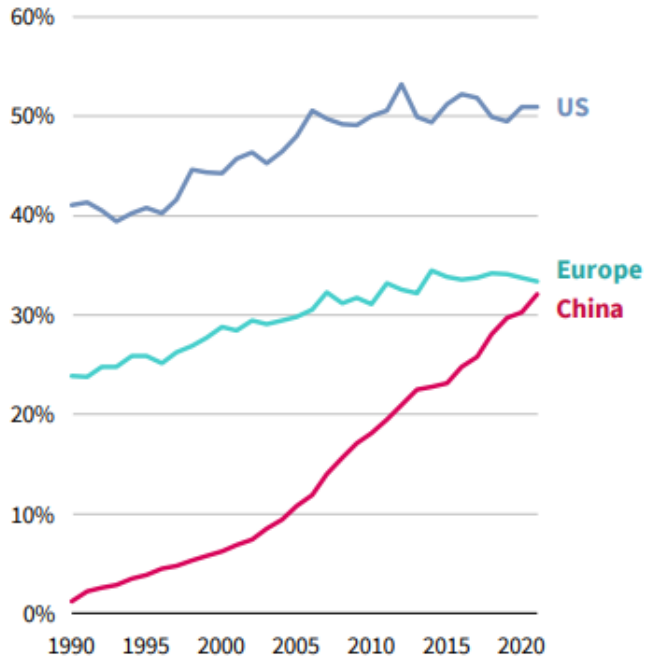
Note: data to 2021

Electricity's share of final energy in transport, %



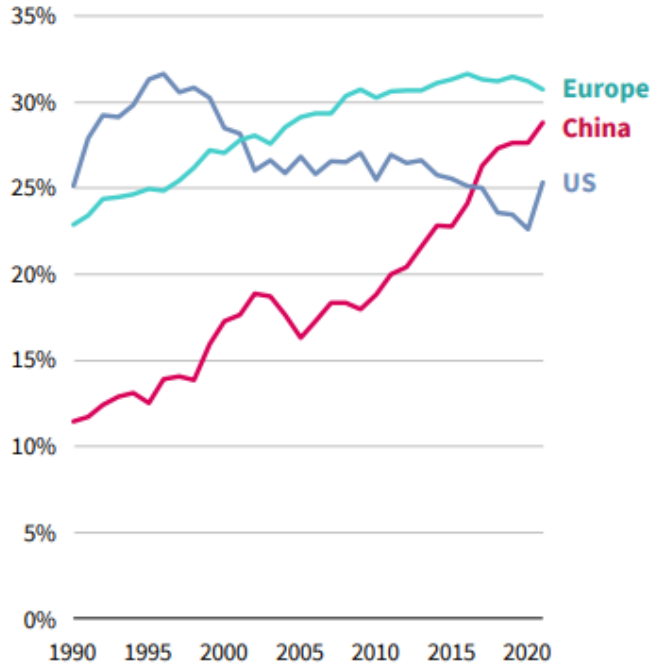
China is rapidly electrifying its transportation system across cars, trucks, buses and high-speed rail

Electricity's share of final energy in buildings, %



Rising air conditioner usage is a key driver in buildings, related to increasingly extreme temperatures

Electricity's share of final energy in industry, %

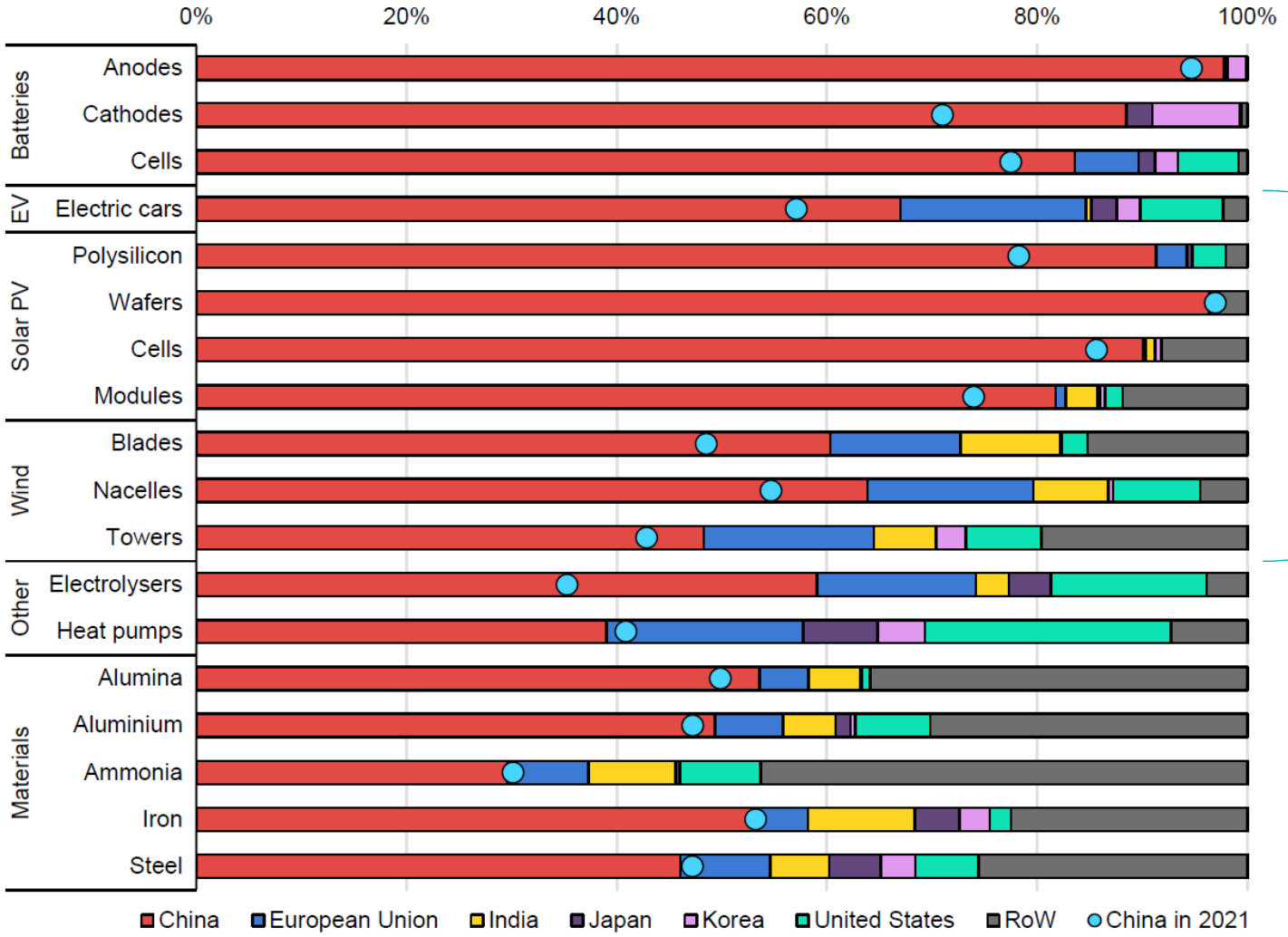


The industrial sector becoming more electricity intensive across industrial uses including chemicals and clean tech manufacturing

Source: RMI (2024), X-Change: The Race to the Top Cleantech competition between China, Europe, and the United States https://rmi.org/wp-content/uploads/dlm_uploads/2024/03/X_change_the_race_to_the_top.pdf

China produces and installs the majority of the world's clean tech

Installed global manufacturing capacity by country/region 2023



Source: IEA (2024) *Clean Technology Perspectives*

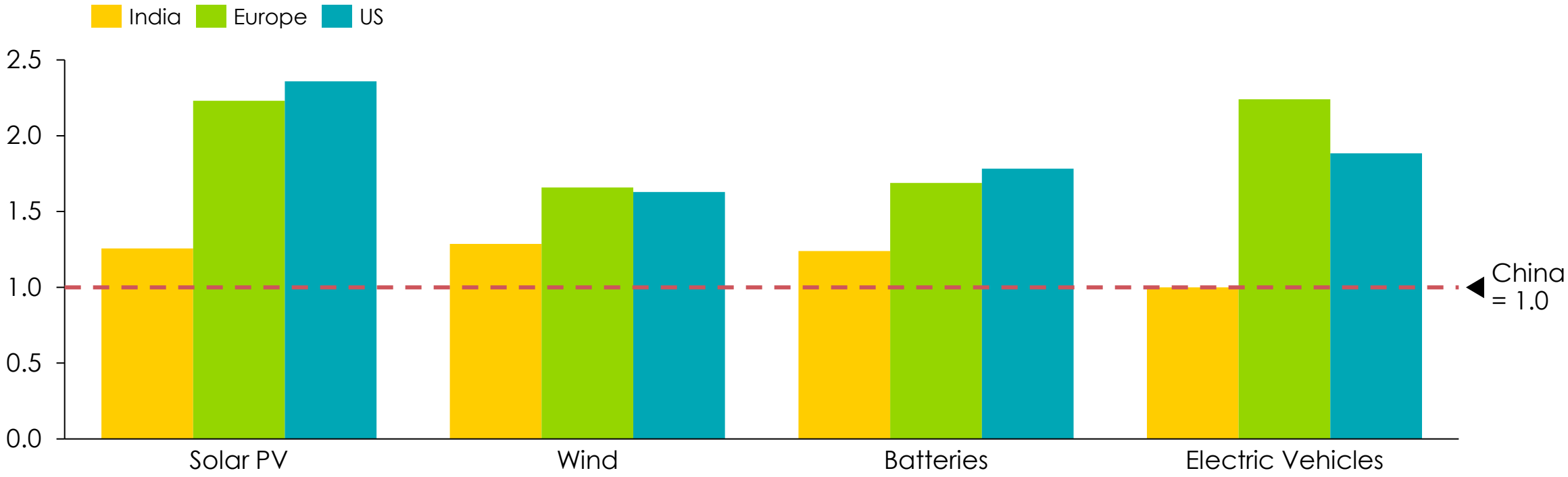
2024 Clean Tech Additions

	China	Rest of the World
EV (million units)	11.3 (65%)	6.2 (35%)
Solar (GW)	339 (57%)	261 (43%)
Wind (GW)	86 (70%)	37 (30%)

[1]BNEF (2025) *Electric Vehicle Outlook 2025*. [2]BNEF (2025) *Capacity: BNEF Solar Forecasts*. [3]BNEF (2025) *Capacity: BNEF Wind* Forecasts.

Chinese clean tech goods are lower cost in nearly all areas

Indicative capital costs indexed against China, 2023



Capital costs in China, 2023	Solar PV	Wind	Batteries	Electric Vehicles
	185 USD/kW	**260** USD/kW	**75** USD/kWh	**7,100** USD/vehicle

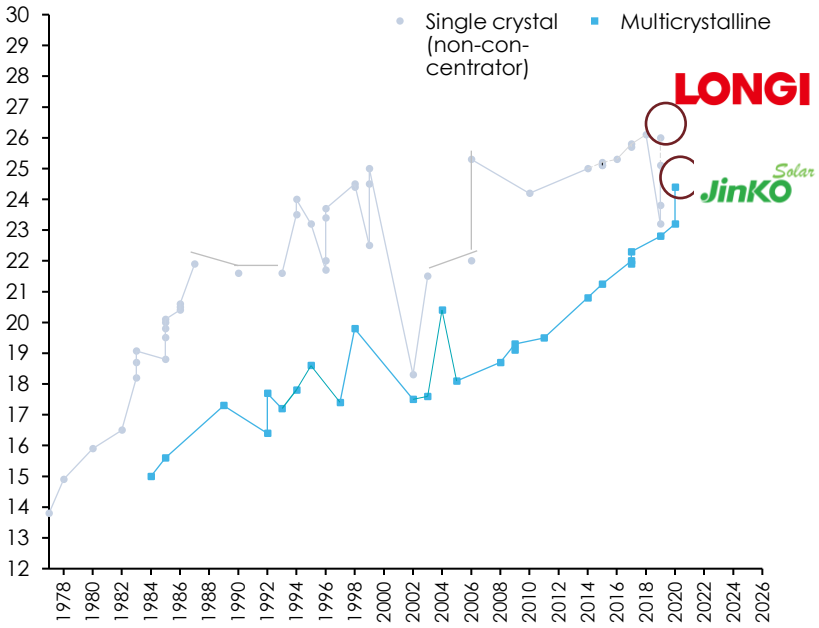
Note: Capital costs are shown per unit of annual rated capacity. Solar PV includes polysilicon, wafer, cell and module production facilities; batteries include cell, anode and cathode production facilities; wind includes nacelle, tower and blade facilities. Costs refer to greenfield, non-integrated facilities where these attributes could be isolated in the data and constitute averages across plants of different sizes today. Data gaps were filled using regional multipliers based on differentials in cost for constructing other facilities where more data are available. No explicit policy incentives (e.g. investment tax credits) are applied in this assessment. USD = USD (2023, MER) (IEA (2024), *Energy Technology Perspectives*).
Source: Systemiq analysis for the ETC; IEA (2024), *Energy Technology Perspectives.* This is a work adapted by the ETC from IEA material and ETC is solely liable and responsible for this derived work. The derived work is not endorsed by the IEA in any manner.

China continues to lead on innovations in leading technologies, including solar, batteries and EVs

Solar

Solar PV best research-cell efficiencies

Crystalline Si cell efficiency in %

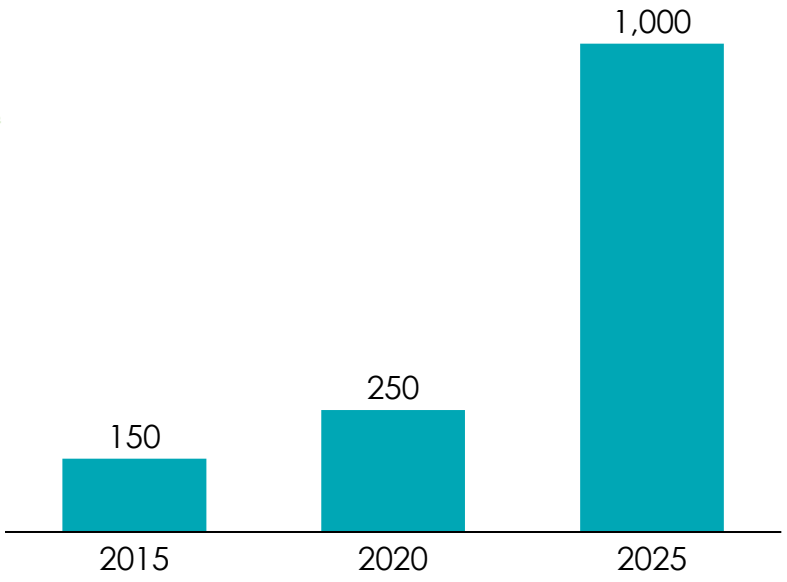


Chinese companies are leading advancements in solar PV cell (shown above) and module efficiency, notably Trina Solar, Jinko and LONGi.

Batteries

Maximum Fast-Charging Power

kW

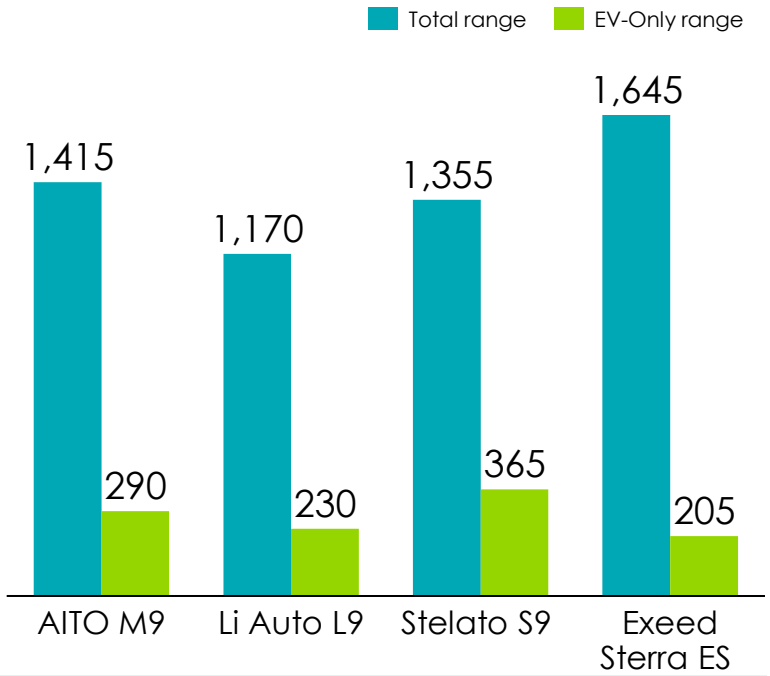


Chinese cell manufacturers e.g. BYD pushing charging rates, promise of '5 minute charge'

EVs

Chinese Extended-range EV model ranges

kms



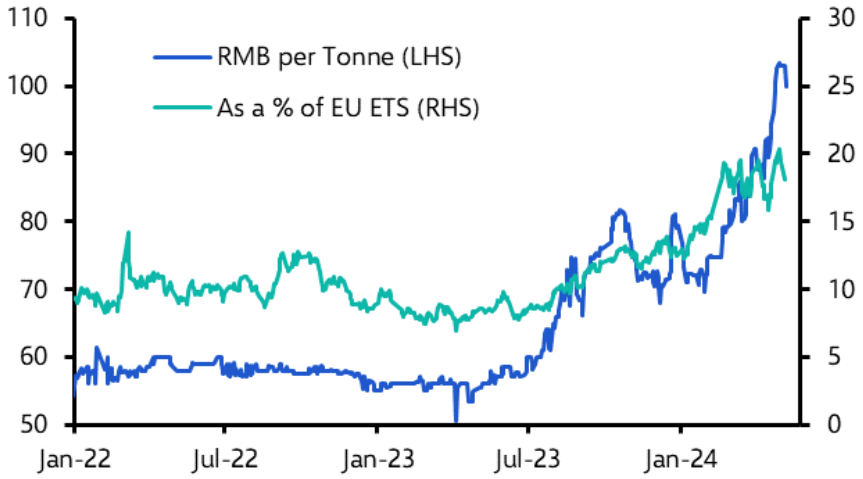
Extended-range EVs (EREVs) now reaching upwards of 1,000km range in China by pairing an EV range of 200-265km with gasoline backup

Source: LHS = NREL (2025), Best Research-Cell Efficiency Chart; Centre = Bauer et al (2021), Charging Up America: Assessing the growing need for U.S. charging infrastructure through 2030; RHS = GC Auto (2024), 7 Long-Range Electric Cars from China; 2024 Update

China: Emergence of domestic carbon price and cost effective hydrogen will continue to support industrial decarbonisation

Successful national ETS scheme with hard to abate sectors being added

- China national ETS scheme saw successful 2024, with a price surge earlier this year
- Cement, steel and aluminium are also expected to be included in the ETS soon, with supply projected to reach 8 billion tons



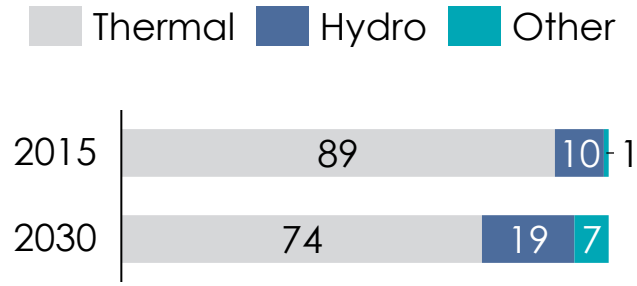
Maintains ambitions to produce green hydrogen at $2/kg by 2030

- Back in 2022, China Hydrogen Alliance predicted China could produce green hydrogen at $2.40/kg by 2030
- In 2024, BCG a report stated that in that year China was producing green hydrogen at $1.7/kg in a few regions, such as inner Mongolia
- This year, Rystad updated projections to $2/kg by 2030
- In January 2025, Bloomberg forecasted that production costs in China will drop to USD 2.5/kg by 2030 and USD 1.6/kg by 2050

Industry – mixed progress

- 2025-27 Aluminium action plan includes **target for 30% clean energy in primary energy usage**

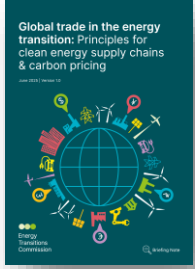
Primary Alu energy supply, %



- China's petrochemicals industry, largely reliant on coal is forecast to grow – decarbonisation of this is crucial to prevent additional emissions

Source: Press search

Latest ETC briefing on trade and industrial policy makes a clear distinction between industries



PRICE-PARITY HAS ALREADY BEEN REACHED

1. Aim for diversified supply chains but **not complete autarky**
2. Think straight about **different dimensions of "security"**
3. **Vary policy by sector** to reflect different starting points and inherent characteristics
4. Use **tariffs in a fact-based and WTO compliant** fashion
5. Focus primarily on the **location of employment and value added**, rather than ownership.
6. Work with China to **increase climate finance flows to lower income countries** to support the accelerated deployment of clean technologies

PRICE-PARITY NOT POSSIBLE IN NEAR-FUTURE

Significant green cost premium at B2B level, widther in perpetuity or for several decades

↓

Decarbonisation needs **carbon pricing or equivalent regulation** + Many sectors widther **internationally traded or inherently international**

↓

- Unless there are **globally agreed carbon prices** covering hard-to-abate sectors…
- Domestic carbon prices or equivalent regulation / targets must be accompanied by **CBAMs or regulations which apply to imports…**
- Otherwise, production will move to other countries and **decarbonisation will not occur**

US: initial worries about domestic impact overblown, but still substantial

The Trump administration's actions may severely limit future emissions reductions

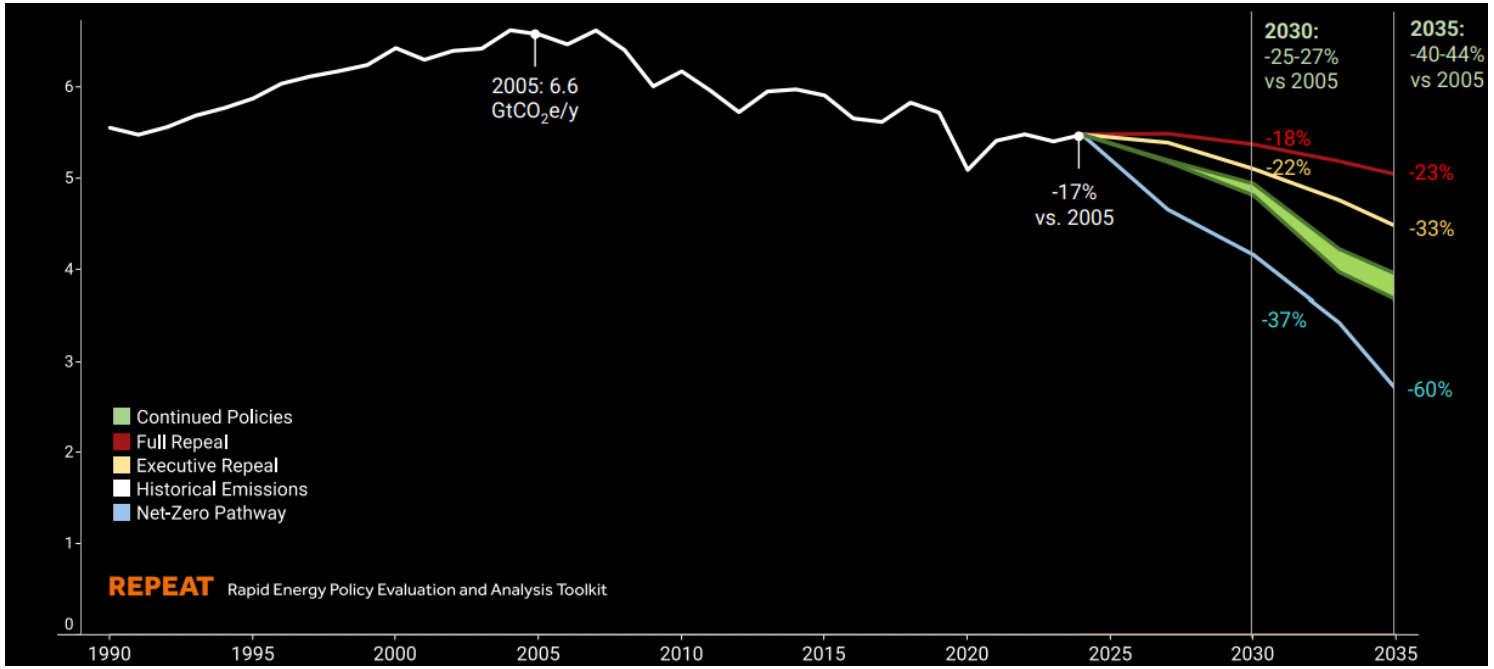
- EPA departments and programme budgets slashed (including staff layoffs)
- Executive order halting all onshore and offshore wind leasing and permitting for new sites
- Proposal to repeal rules on CO_2 emissions limits for existing coal and new gas-fired power plants
- Repeal of the excess methane fee (set by the IRA) charged to oil and gas producers

Budget bill H.R. 1 ("One Big Beautiful Bill Act") would repeal nearly all IRA tax credits

- Under bill H.R. 1 ("Full Repeal" scenario shown right), U.S. GHGs could increase by ~0.5 Gt CO_2e in 2030 and more than 1 $GtCO_2e$ by 2035
- Cumulative capital investment in U.S. electricity and clean fuels production could be reduced by 1 trillion USD from 2025-2035

Historical and modelled net U.S. GHG emissions[1]

billion metric tons CO_2 equivalent (Gt CO_2e)



Continued Policies = continuation of the full suite of policies enacted under the Biden Administration
Executive Repeal = executive actions the Trump administration has stated to unwind Biden-era climate policies
Full Repeal = includes all actions under Executive Repeal and full repeal of IRA (i.e. implementation of bill H.R. 1)

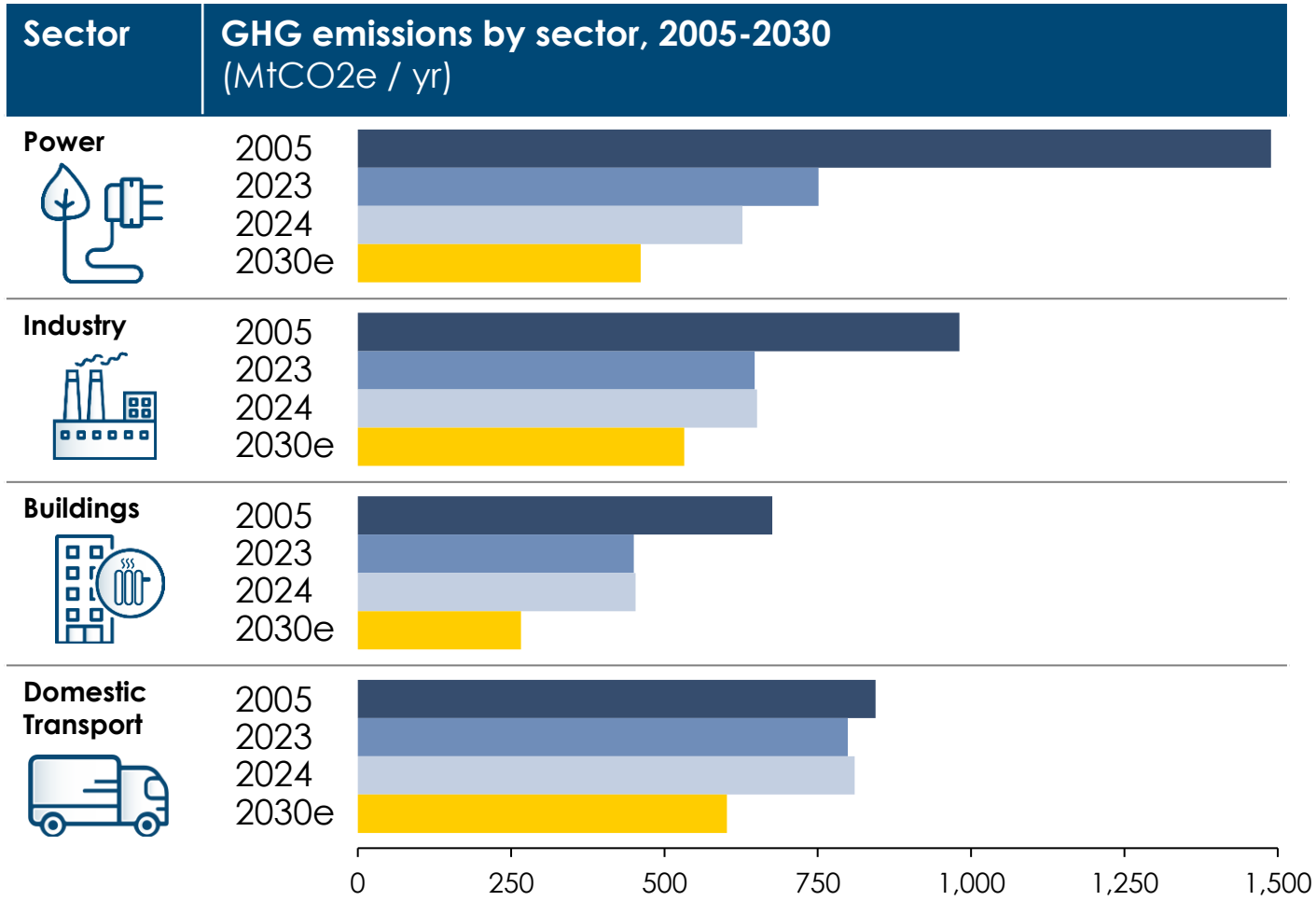
Sources: Jenkins et al (May 2025), *A Fork In The Road: Impacts of Federal Policy Repeal On The U.S. Energy Transition;* Reuters (June 2025), *Trump administration moves to repeal Biden power plant pollution rules;* Utility Dive (Jan 2025), *Trump executive orders halt wind development, declare energy emergency;* Journal of Petroleum Technology (Mar 2025), *Trump Signs New Law To Block US Methane Fee*

Notes: 1. Including land carbon sinks.

US: Implications for global policy

- **Paris Agreement and UNFCCC exit sends a signal to the world:**
  - **though ripple effect not really felt:** while Argentina had signalled dropping out, did not occur
  - **-> Balance of power on COP negotiations shifts** towards EU and/or Chinese climate leadership
- **'Sentiment' effect in financial markets and 'ESG' in corporates is material –** but likely less damaging than initially appeared, as dust settles
- Withdrawal of US funding for climate finance **likely to impact New Collective Quantified Goal (NCQG) on finance implications**
- **Domestic incentives for industrial decarbonisation were some of the strongest in the world** – likely to impact progress in hard-to-abate sectors if fully removed
- **Tariffs: main effect likely on US domestic decarbonization, but with global emissions implications.**

EU: On course to meet 2030 target, despite dampened pace of emissions reductions in 2024 suggesting some risk of delivery



Emissions fell by 2.9% in 2024 but increased outside of the power sector

- Power sector emissions fell by 17%, driven by increased wind and solar, plus hydro and nuclear
- Emissions in other sectors stalled progress—transport emissions increased by 1.4%, industry and buildings by 0.6%

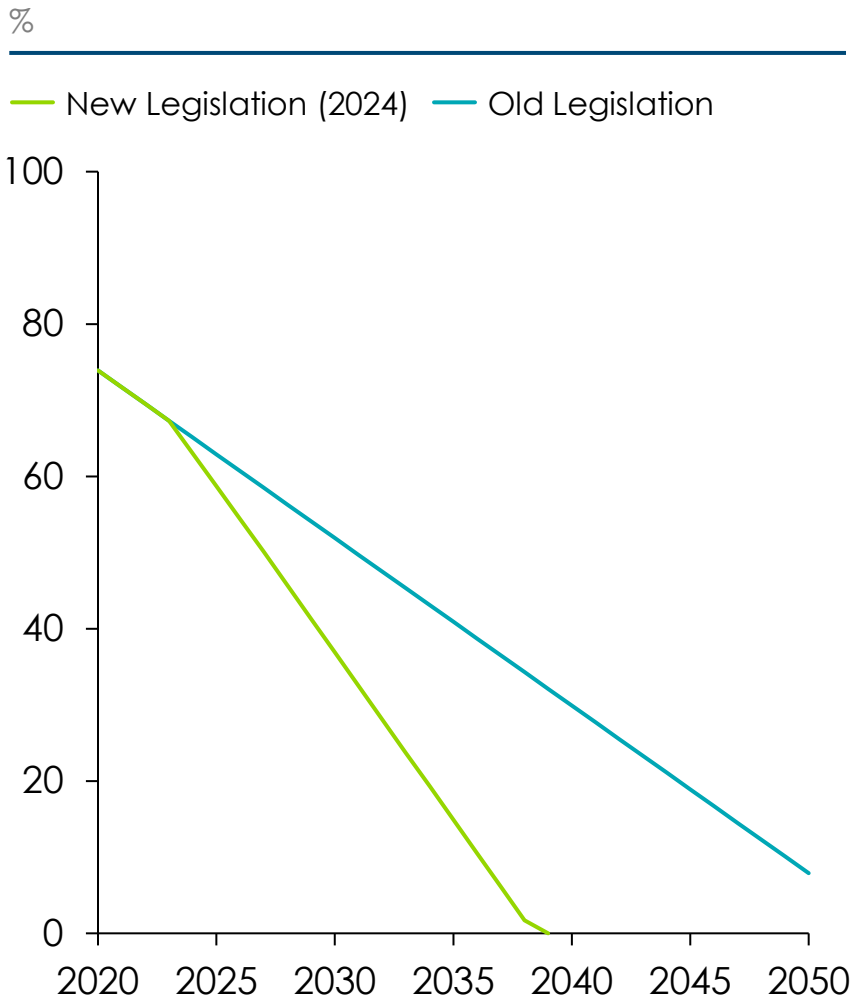
EU expected to meet 55% 2030 climate target despite 2024 reduction pace falling short – requiring 3.3% annual decrease through existing and planned policies

Note: 2030e refers to the 2030 "MIX 55" scenario from EEA, which is a policy scenario underpinning the 2030 Climate Target Plan. 2024 emissions estimates are preliminary. Industry and buildings increase from 2023 to 2024 based on combined increase of both sectors and subject to change with official accounting.

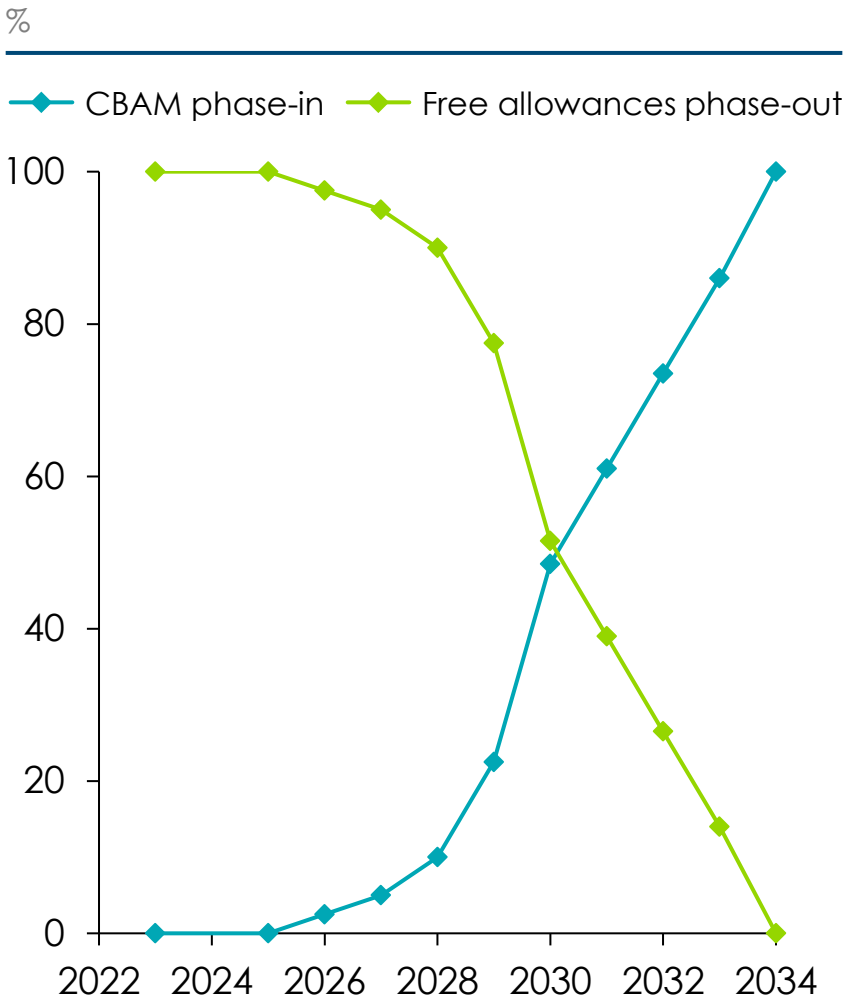
Sources: European Environment Agency (2024), *Trends and Projections in Europe 2024;* CREA (2025), *EU's CO2 emissions fall 2.9% in 2024 but rise outside the power sector;* European Commission (May 2025), *EU closing in on the 2030 climate and energy targets, according to national plans*

EU – CBAM pioneering international carbon pricing, expected to lead to industrial decarbonisation inside and outside of EU

EU emissions cap as share of 2005



Phase out of free allowances



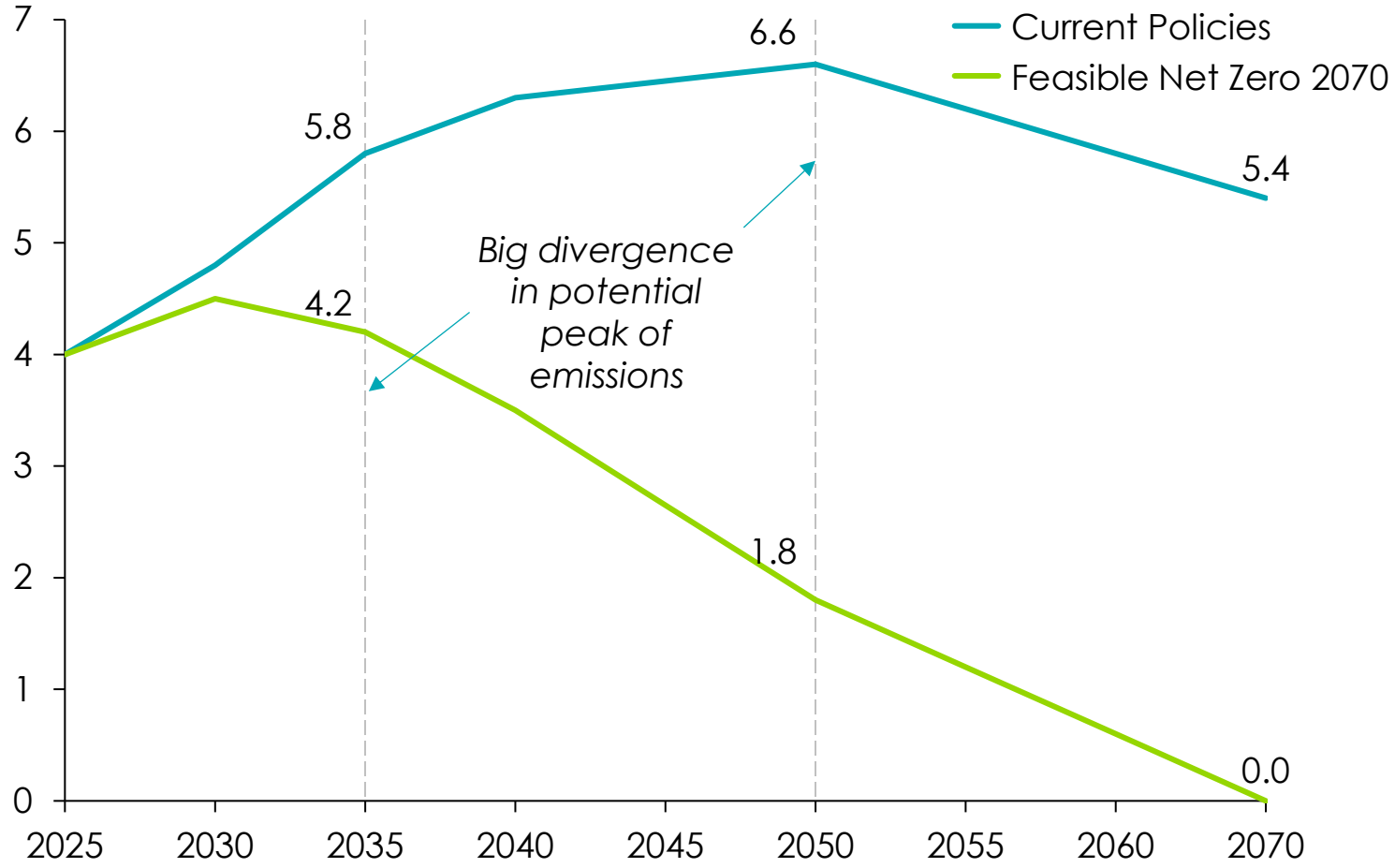
EVER-EVOLVING POLICIES

- **Steel and Metals Action Plan** significantly tightened 3 CBAM dimensions: exports, carbon intensity, and downstream products
- **Omnibus package** exempts ~90% of importers from EU CBAM, while still covering 99% of emissions[1]
- **Carbon credits not applicable** to EU ETS or CBAM due to concerns about integrity and effectiveness
- Next year's **ETS2 could significantly impact households** and small business

Note: 1. To ease administrative burden, February simplification exempted ~80% of EU companies from CSRD; in response, CBAM introduced cumulative annual threshold of 50 tonnes per importer, eliminating CBAM obligations mostly for SMEs; both measures were done to focus on biggest companies (EC Europa)

India: NZ target still 2070; despite renewables growing, most electricity demand growth still being met with coal

Emissions | CO_2 (Gt CO_2/yr, net)



- **High growth:** India's expected real GDP growth rate: 6.2% p.a. 2025-50
- **Large ambitions** (500 GW renewables by 2030; 100 GW nuclear) **but current deployment not in line** (~137 GW wind and solar capacity and 7.5 GW nuclear today)
- **Coal generation grew by 4.3% in 2024** (vs 8.8% average in the prior 3 years). Coal generation **met 64% of India's 2024 electricity demand growth, declining from 91% in 2023**.

Source: Montek Ahluwalia, BNEF (2025), 1H 2025 India Market Outlook: Clean Power, Transport Shine, Ember (2025) Global Electricity Review 2025
Note: Scenarios are illustrative.

Brazil's most recent NDC met with criticism and confusion

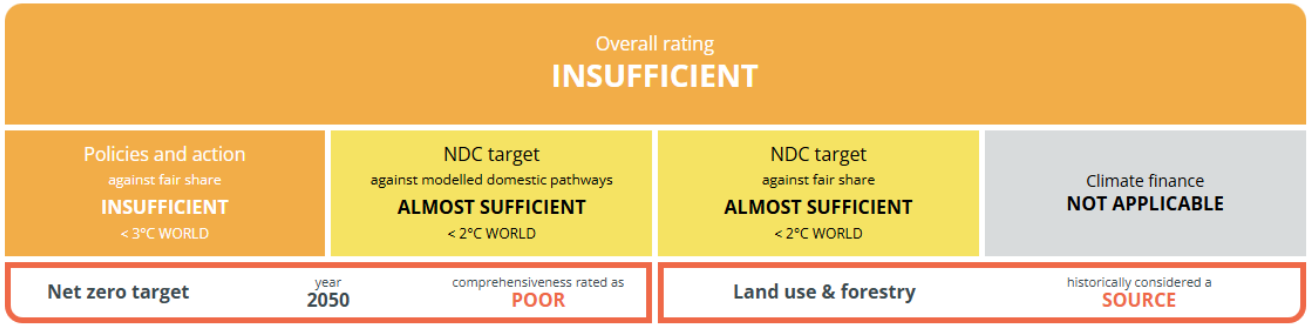
Brazil's recent NDC

- Submitted in November 2024, aims to cut **GHG emissions by 59-67% by 2035 compared to 2005 levels.** This target covers all sectors and all gases.
- **No explicit reference** to President Lula's pledge to reach **zero deforestation in the country by 2030**
- **Reference to the expansion of biofuels and bioenergy. No numerical targets** on meeting new **power** growth with clean sources and on reducing emissions from the **transport and industry sectors**
- **Uncertainty around contribution of the land use sector to the NDC target** makes it difficult to assess feasibility of emissions reductions in other sectors
- Brazil has signaled **intention to use the Paris Agreement's Article 6,** with carbon offset transfers being authorised to sell its emission reductions.

WWF

New Brazilian NDC brings important progress and points the way forward, but the climate emergency requires greater ambition

Climate Action Tracker's assessment of Brazil's NDC



Source: Climate Action Tracker)2025), WWF, 14th November 2024 "New Brazilian NDC brings important progress and points the way forward, but the climate emergency requires greater ambition", 350.org, November 14, 2024, "Brazil's NDC falls short of true ambition"

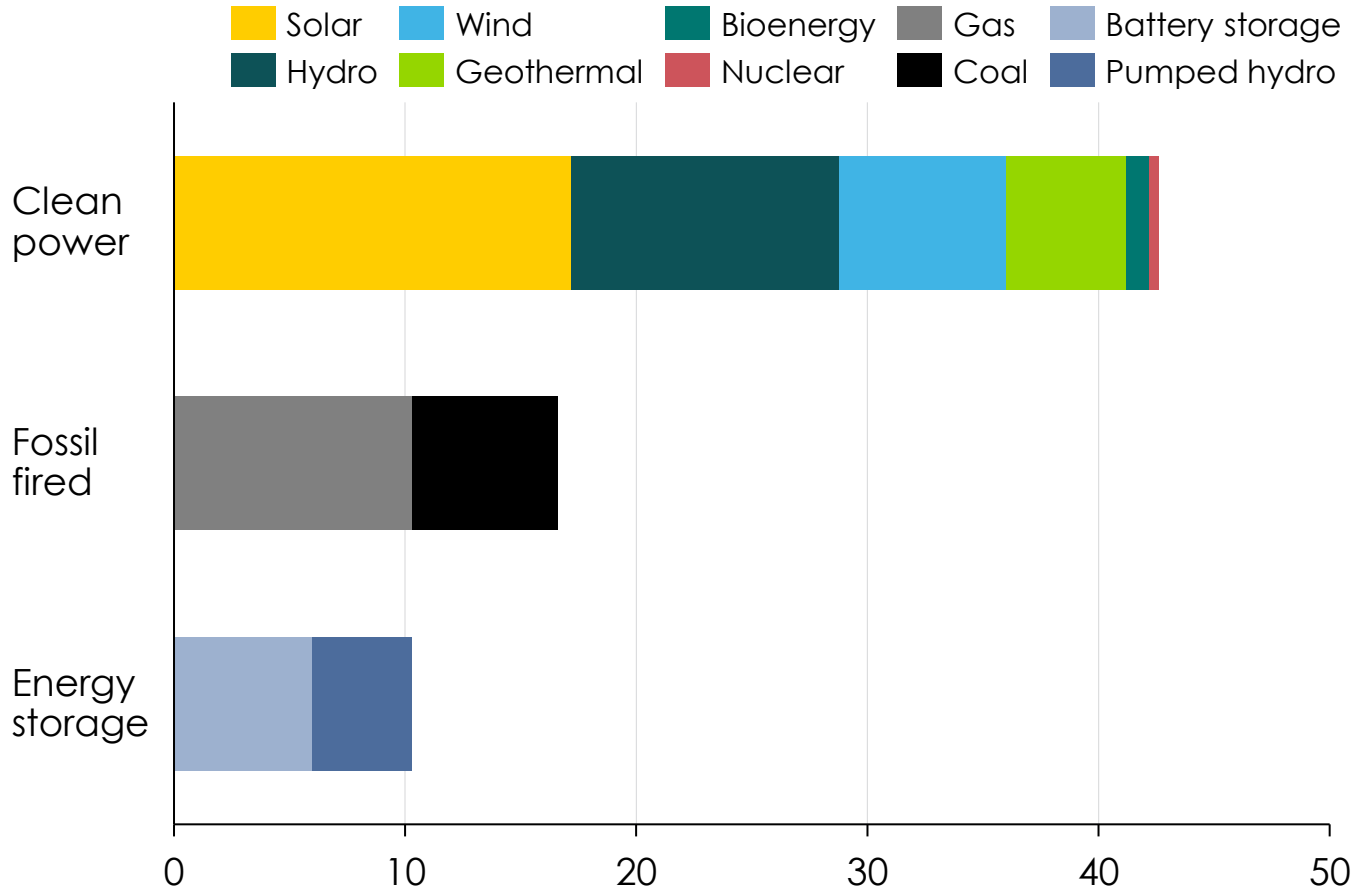
Indonesia's latest power plan to expand both renewables and fossil

RUPTL 2025-2034

- Indonesia announced its **latest 10-year power plan in May 2025.** It sets out:
  - A **quadrupling of renewable power generation** capacity to 57 GW by 2034, but a downgrade of new renewable capacity by 2030 vs RUTL 2021-2030 (17 GW vs 21 GW)
  - A **significant role for coal and gas expansion,** particularly in the next five years –**40%** expansion in from 2024 **to 2034**, higher than previous target
- **Plan will depend on private financing**, as majority of expansion expected to be developed by IPPs
- State utility PLN has previously **struggled to deliver renewable expansion**

BNEF planned additional capacity in Indonesia's 2025-2034 power plan

GW



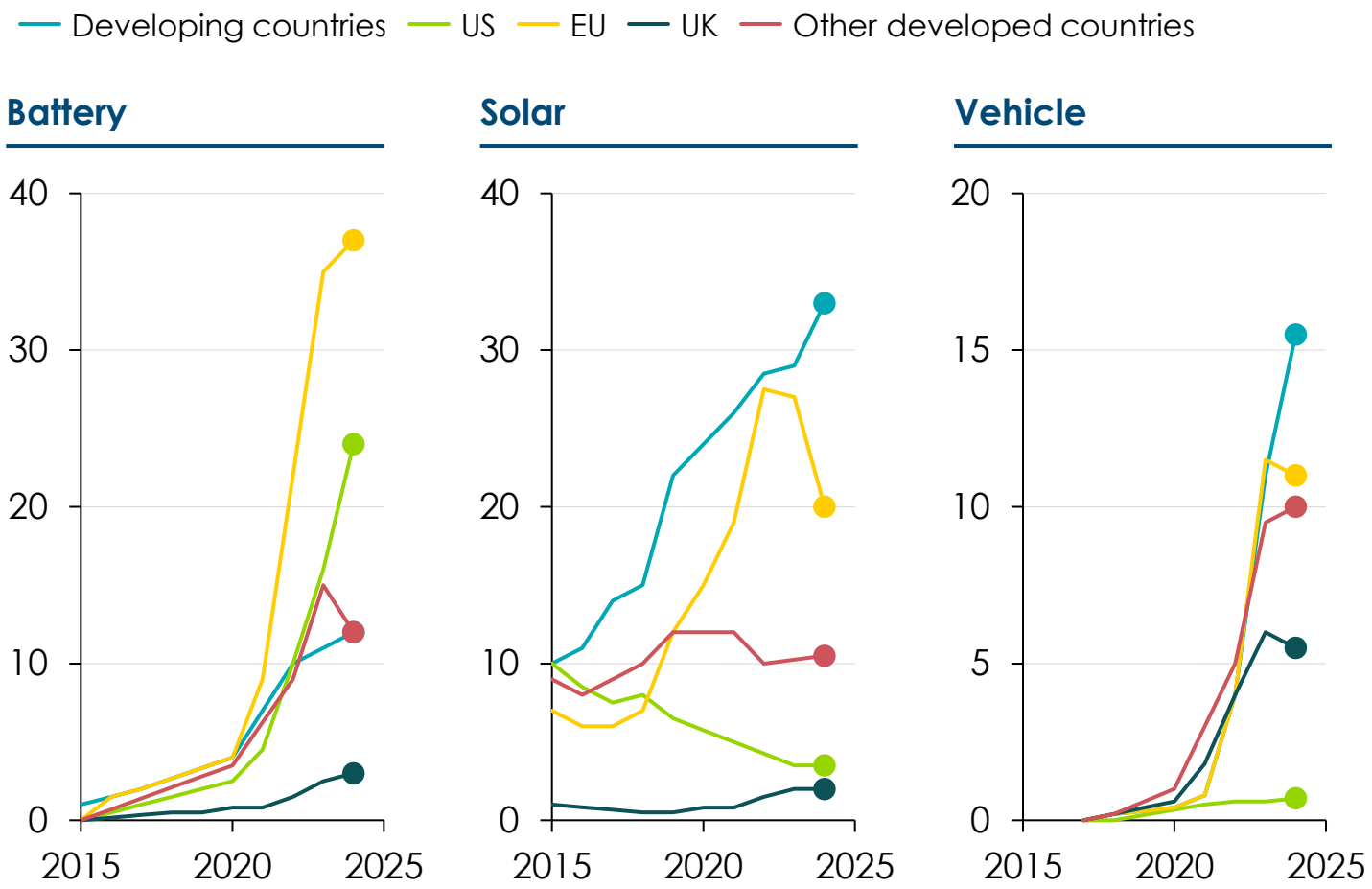
ETC's upcoming work with IESR to show how clean power can help meet the goal of 8% GDP growth

BNEF (2025) *Indonesia $185 Billion Power Plan Hinges On Private Funds: React*

Rest of the world: Cleantech exports from China are increasing around the world. Solar scaling in developing countries.

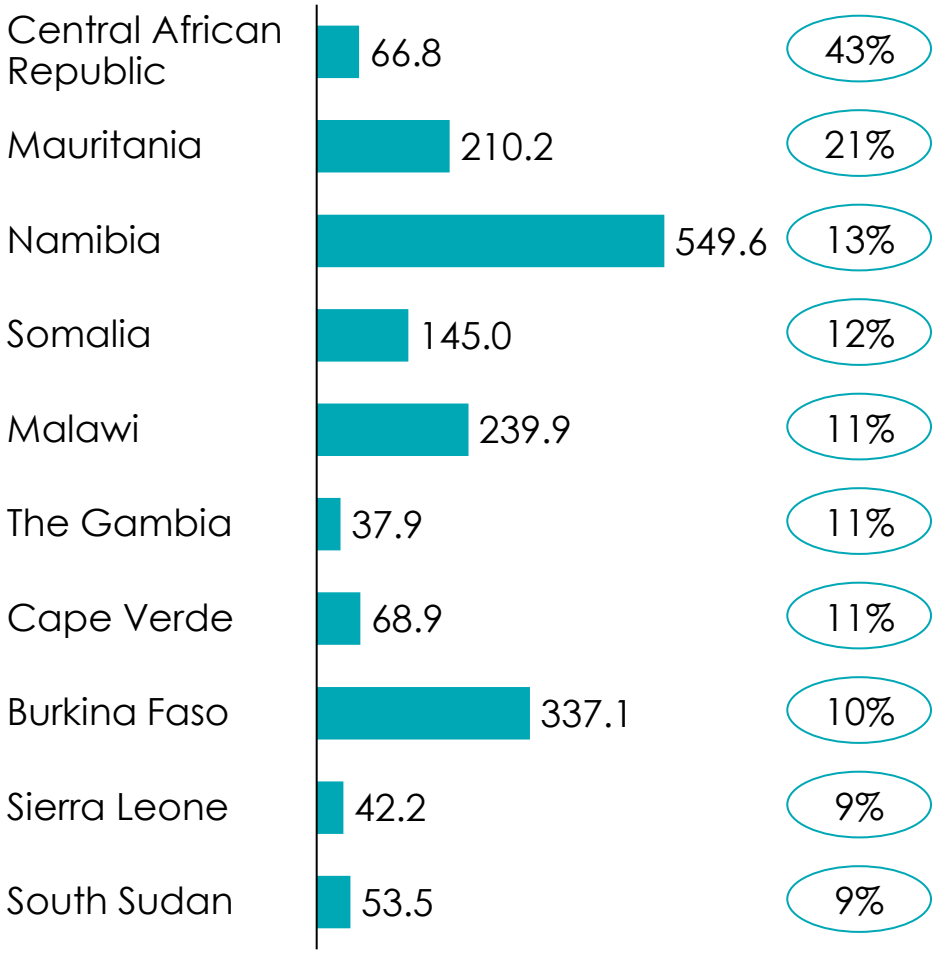
Value of clean tech exports from China

$bn



2024 solar generation & share* in selected markets

GWh, %



*Based on 2022 generation.

Source: Centre for Research on Energy and Clean Air analysis of Comtrade data. Value of imports shown at constant 2022 prices, based on averaged unit costs. Nat Bullard (2025) Decarbonization: 2021 Things, The Complex, Reagents

Agenda

Emissions, political and investment trends

Focus on China, rest of world

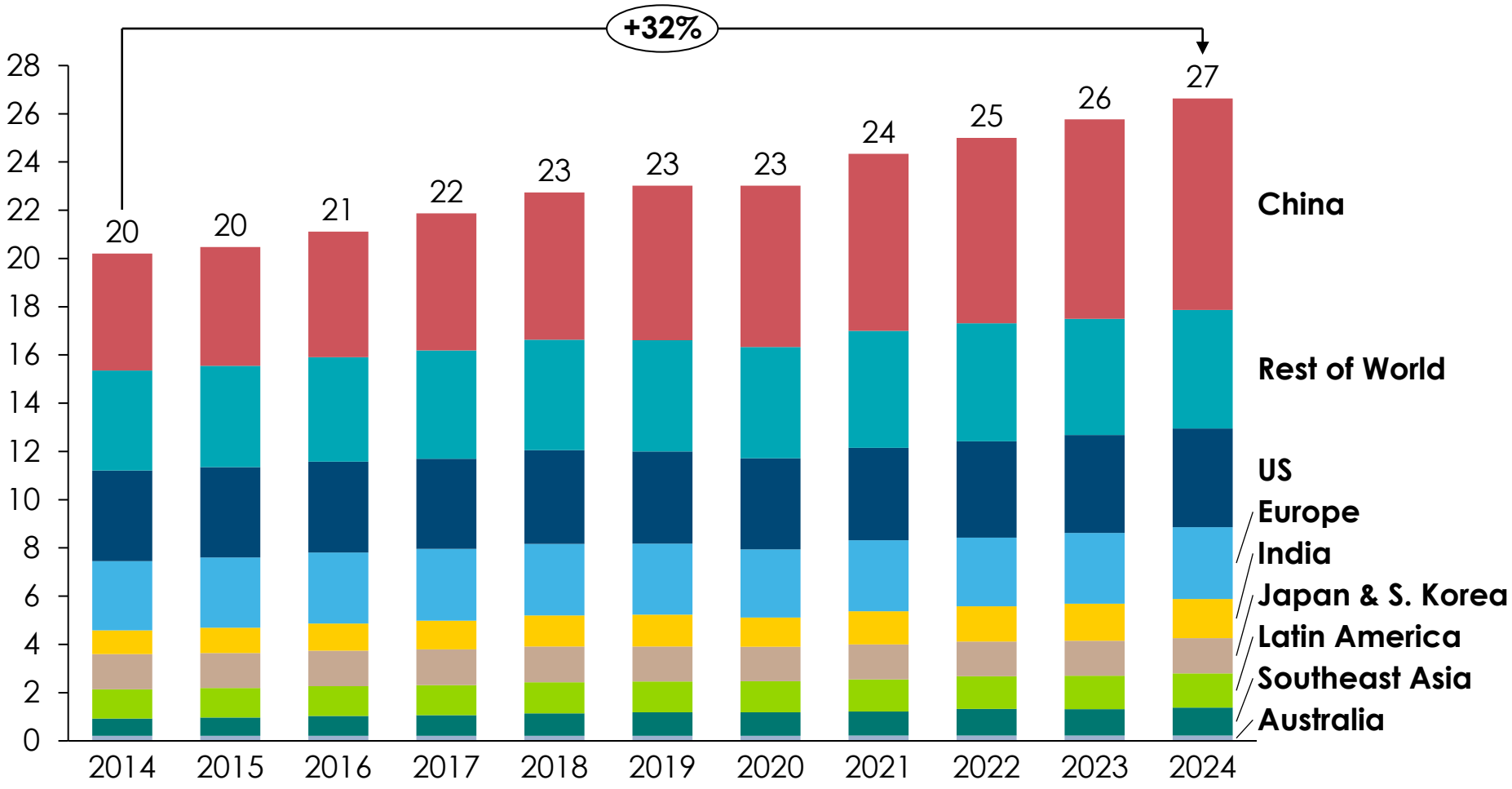
Sector by sector summary

Conclusion and implications for ETC

Global electricity use has increased by ~30% over the last decade

Annual electricity demand by country/region over the last decade

'000 TWh/year



Key regional drivers

China increase is driven by electrification of industry and transport

Rest of world (Africa, Middle East, Caribbean) increase is mainly driven by building demand

Demand in US and Europe has remained flat

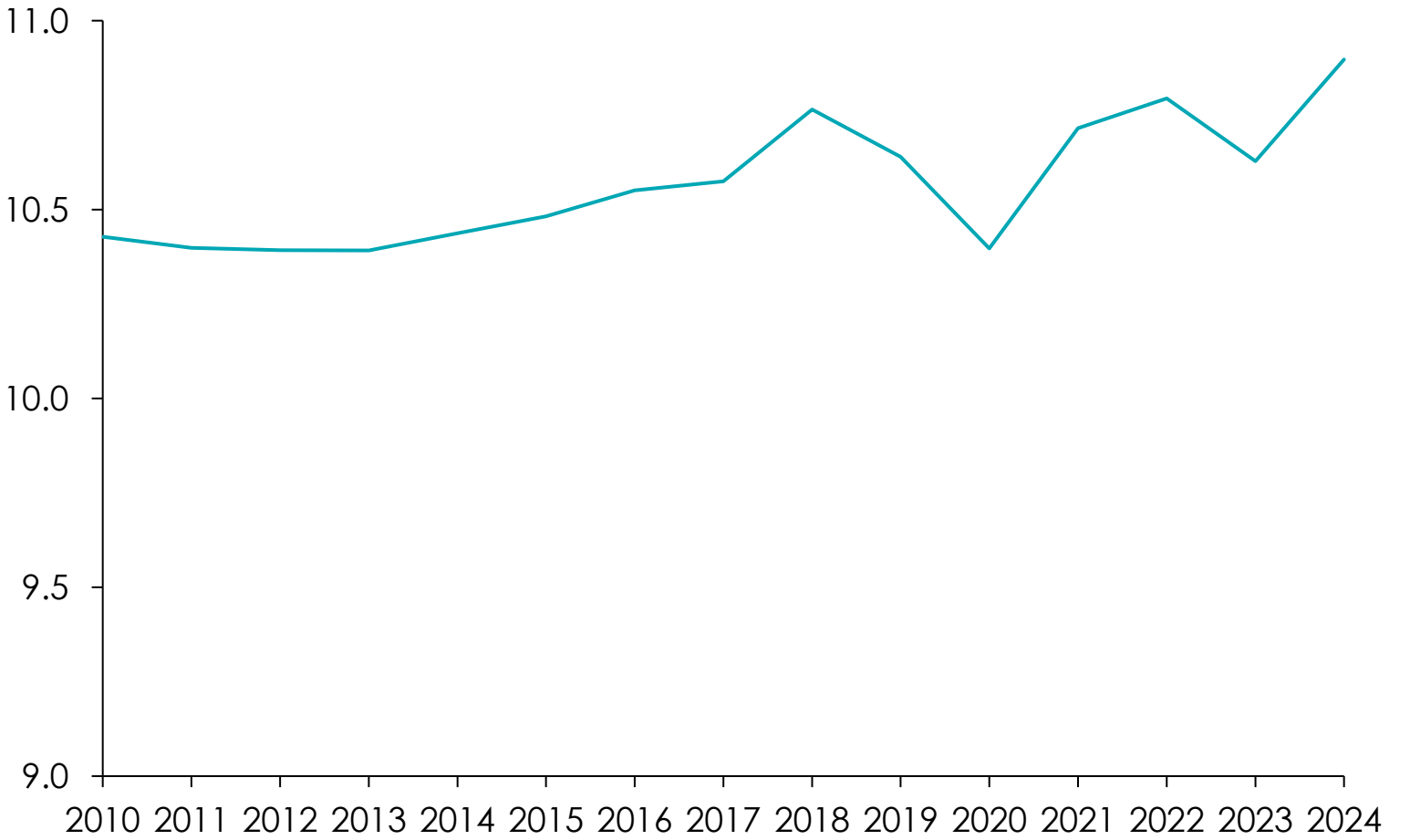
India and SEA increase is driven by buildings and industry

Sources: BNEF (2025), *New Energy Outlook*

Advanced economies electricity demand has been flat, mainly due to efficiency gains

OECD total annual electricity generation by year

'000 TWh



Key drivers of stagnation:

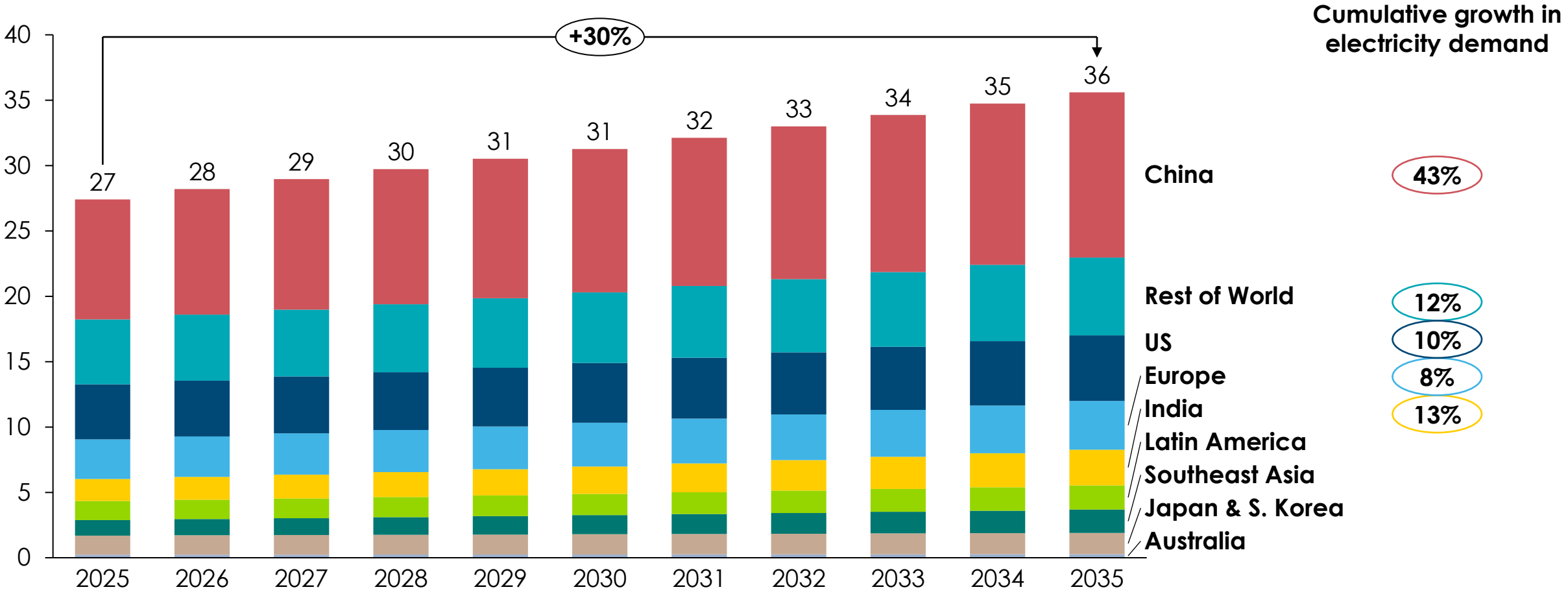
- **Energy efficiency improvements** driven by policy and innovation, e.g. Appliance standards, LEDs, efficient motors
- **Slow electrification and demand saturation**: modest historical uptake of EVs and heat pumps, saturated appliance ownership including due to limited population growth
- **Structural economic transformation** from heavy industry to services, with lower energy intensity
- **Economic shocks and price pressures**: demand suppressed by financial crises, COVID-19, and recent energy price spikes

Source: IEA Monthly Electricity Statistics, May 2025

Looking forwards – demand growth will be driven by China and India, and Southeast Asia and Latin America to a lesser extent

Annual electricity demand by country/region over the coming decade under BNEF's ETS

'000 TWh/year

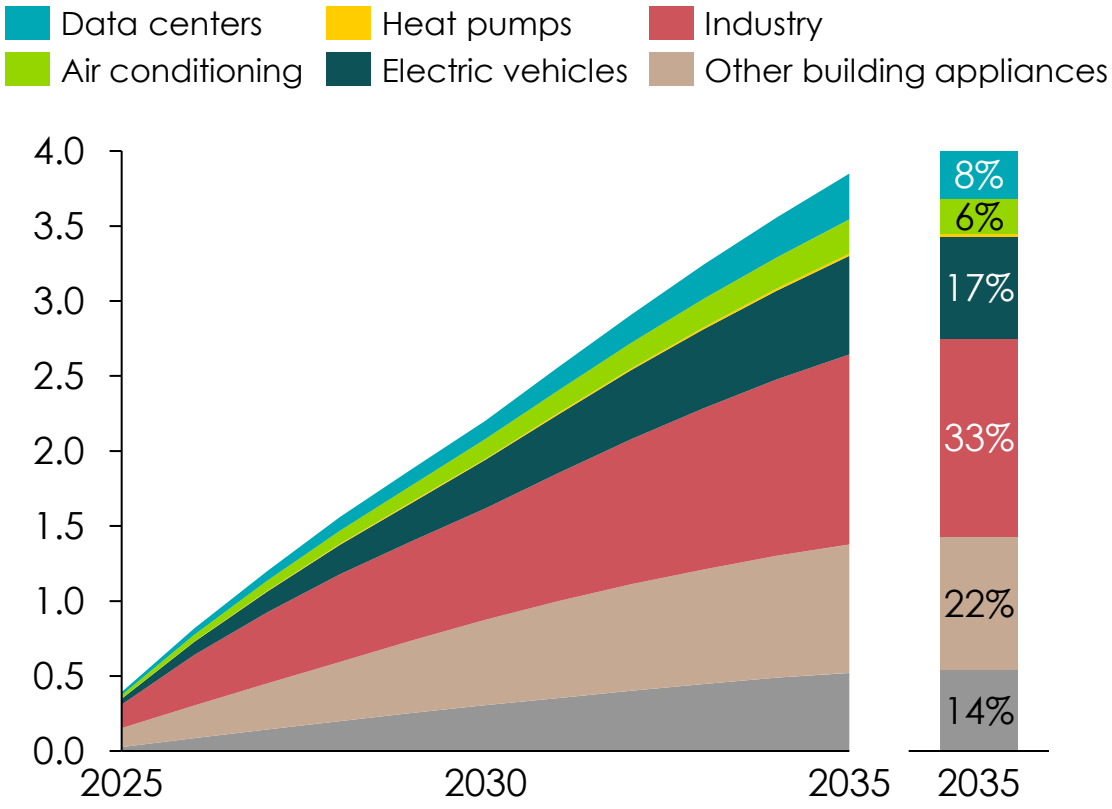


Notes: ETS = Economic Transition Scenario, in which the energy transition is purely driven by technology cost-competitiveness, rather than climate concerns. Some non-EU European countries are included in Rest of World rather than Europe.
Sources: BNEF (2025), *New Energy Outlook*

China and India electricity account for over half of global demand growth, which will be driven by industry, buildings, electric vehicles, and data centres

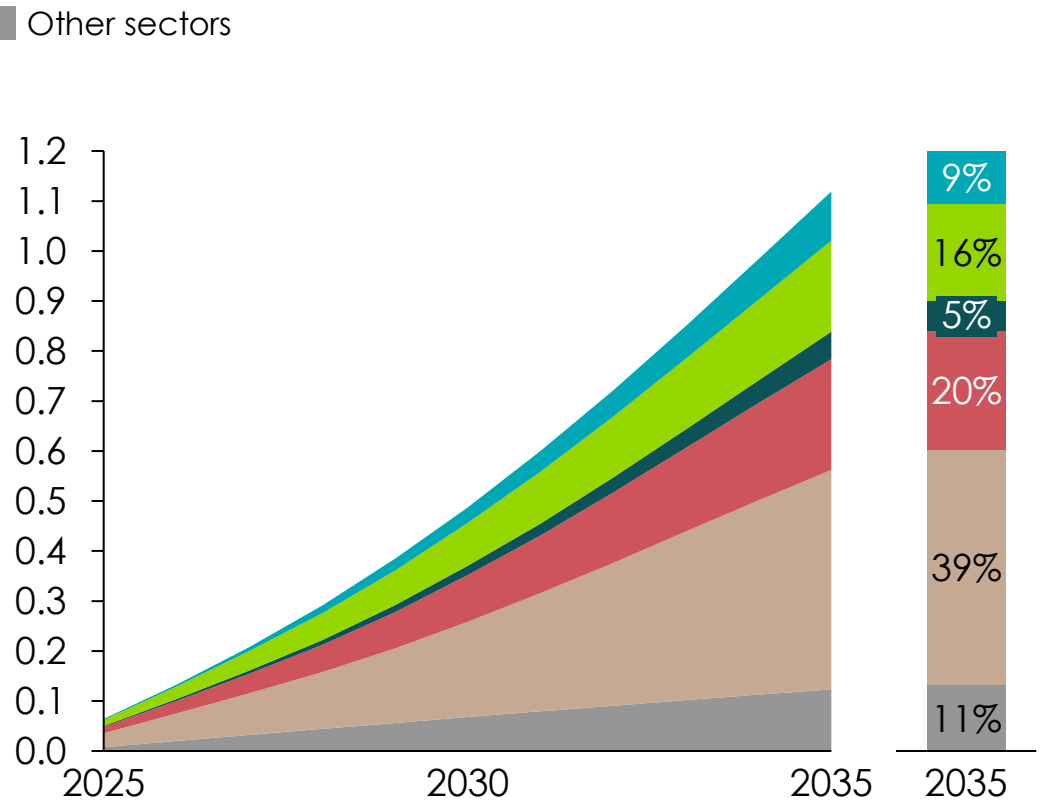
Drivers of future electricity demand under ETS, China

Net change from 2024, '000 TWh



Drivers of future electricity demand under ETS, India

Net change from 2024, '000 TWh



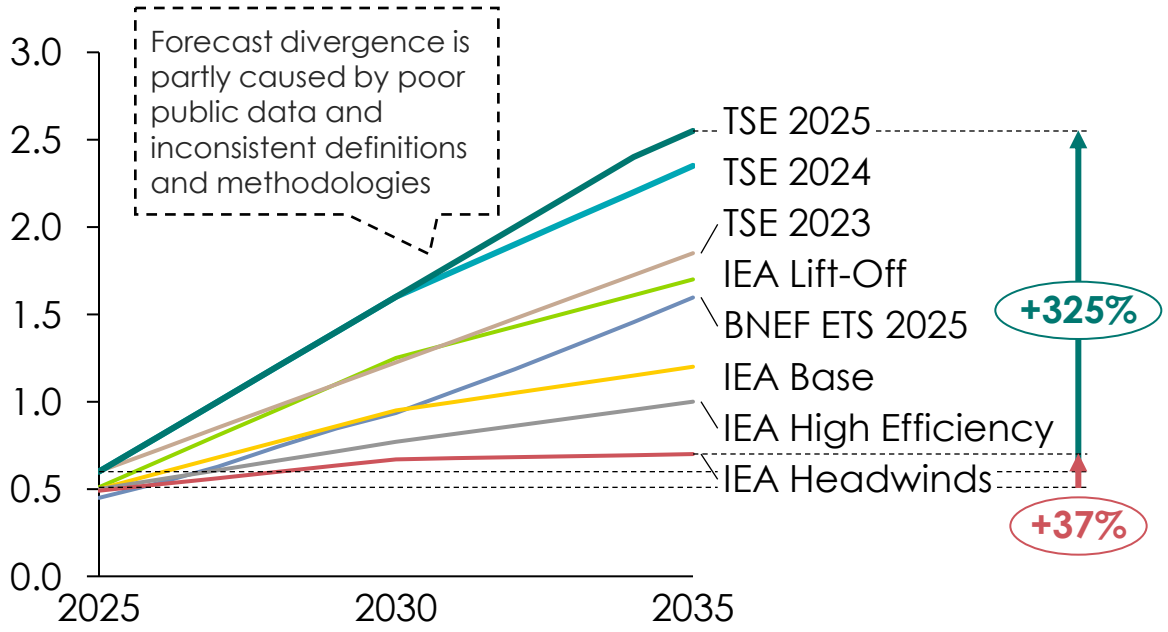
China's growth is more heavily weighted towards industry and EVs, while building appliances (including AC) play a larger relative role in India

Notes: ETS = Economic Transition Scenario
Sources: BNEF (2025), *New Energy Outlook*

Data centre demand growth scenarios have large uncertainty, but their concentration make grid operations critical in certain geographies

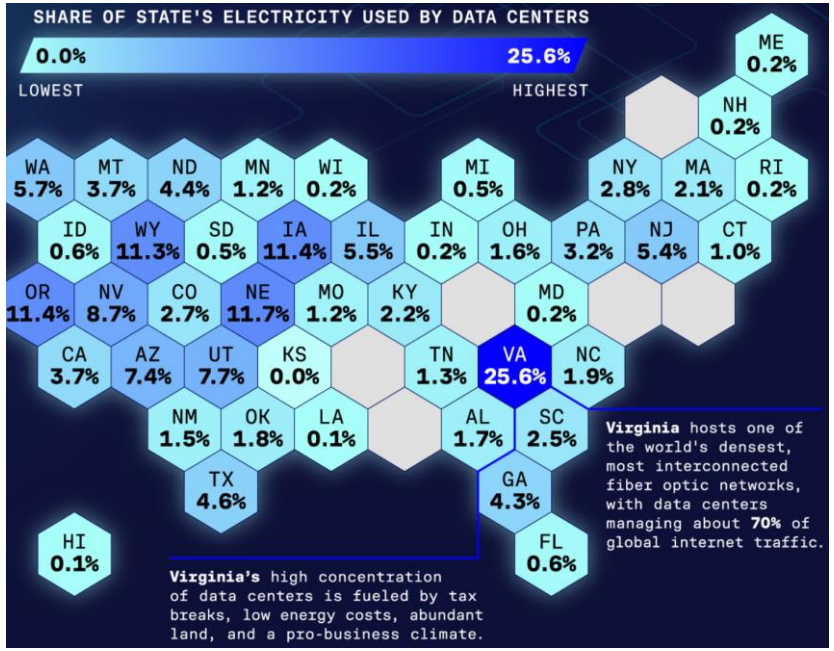
Global data centre annual demand projections by scenario

'000 TWh/year



US data centre electricity demand share by state, 2023

%



- BNEF ETS forecasts **2% to 7% of 2035 global demand**
- **Unclear interaction between demand drivers** (e.g. digitalisation, demand growth, AI training) with **downturns** (e.g. efficiency breakthroughs, uptake overestimation, grid connections access, AI monetisation, supply chain and tariffs constraints)

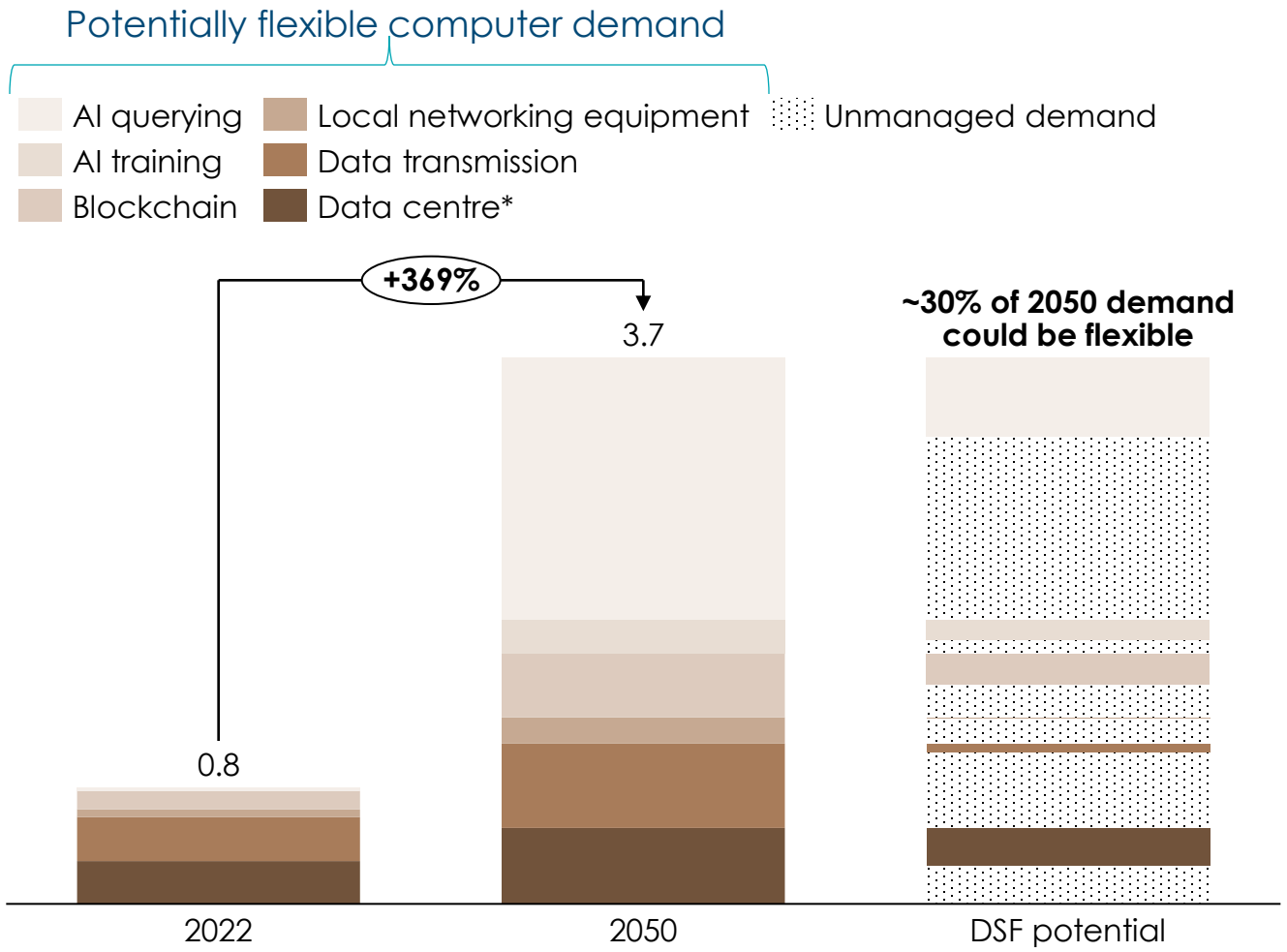
- **4% of total US demand** in 2023 - 15 states account for 80% of national data centre load
- High concentration is leading to **negative local impacts** including grid connection bottlenecks, community pushback, regulatory scrutiny, and environmental impacts

Sources: BNEF (2025), *New Energy Outlook;* IEA (2025), *Energy and AI;* Thunder Said Energy (2025), *AI energy: industrial demand and the Jevons effect?*

Growth in AI Data Centres could theoretically create some shiftable demand

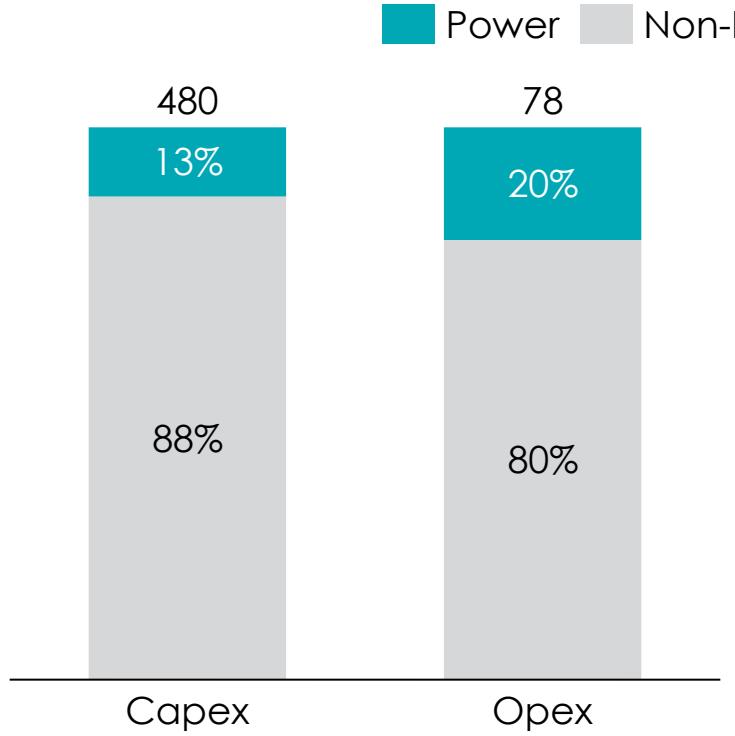
Global internet electricity demand and theoretical DSF potential, 2050

'000 TWh



Breakdown of data center costs

Share of capex and opex



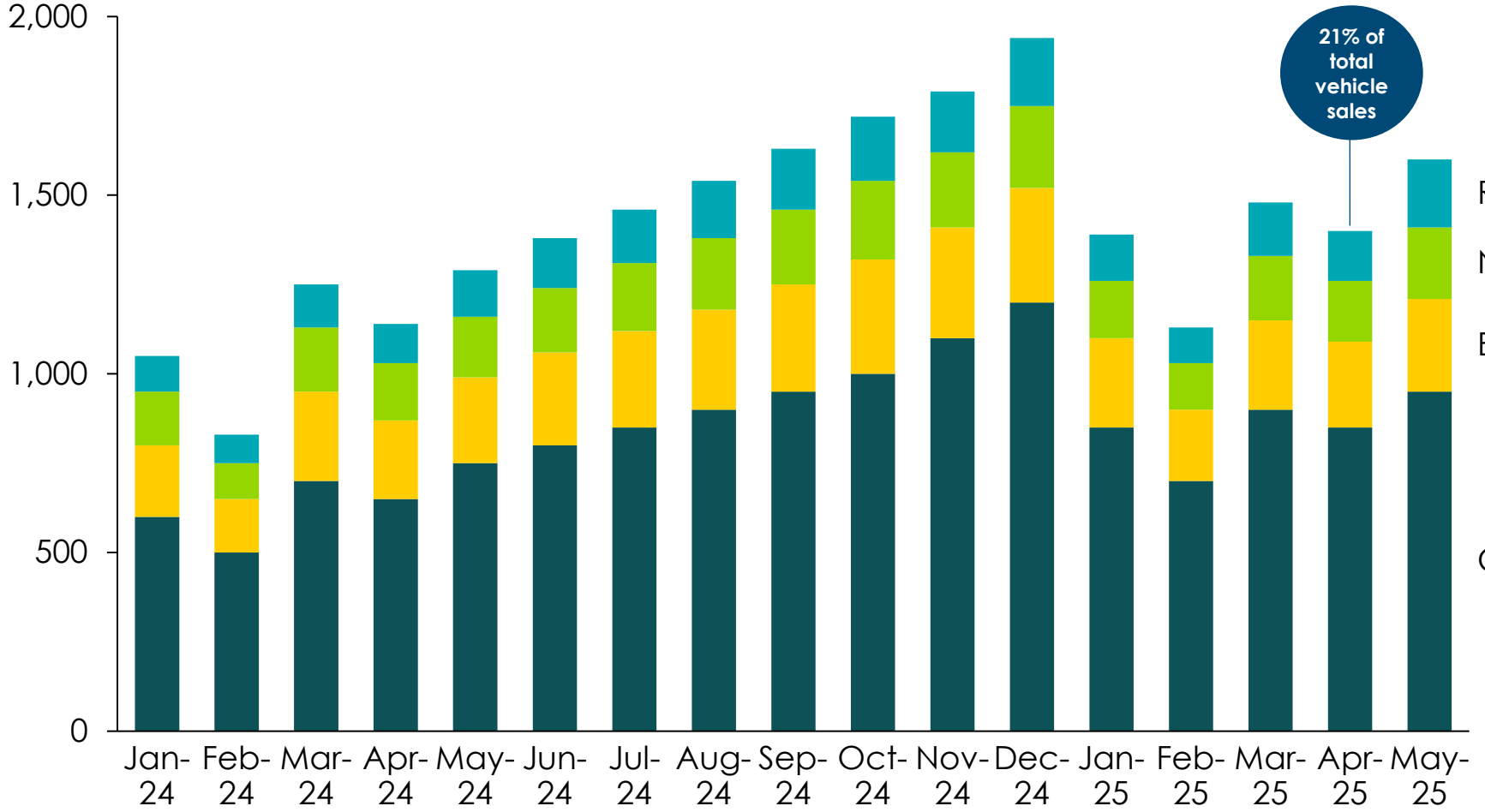
Data center owners are not incentivised to optimise energy costs – power costs are ~10-20% of total costs and passthrough to customers

*Note: Electricity demand in data centres is mainly from two processes, with computing accounting for 40%; and cooling requirements for another 40%.
Source: Own analysis, 2022 and 2050 demand data from Thunder Said Energy (2024), Internet energy consumption: data, models, forecasts; RMI (2024), How Data Centers Can Set the Stage for Larger Loads to Come; SIP (2014), Data center flexibility: a call to action

Electric cars expected to make up 25% of global vehicle sales this year, China leads with over 50% market share

Electric vehicle sales, 2024-2025

'000 units sold



Sales peak in December in China due to Christmas sales period

May 2025 market share

RoW

EVs increasing steadily, but hold a low 10% share

North America

Adoption stagnates at 10-11% of market

Europe

EV sales in Europe reach ~25% of market

China

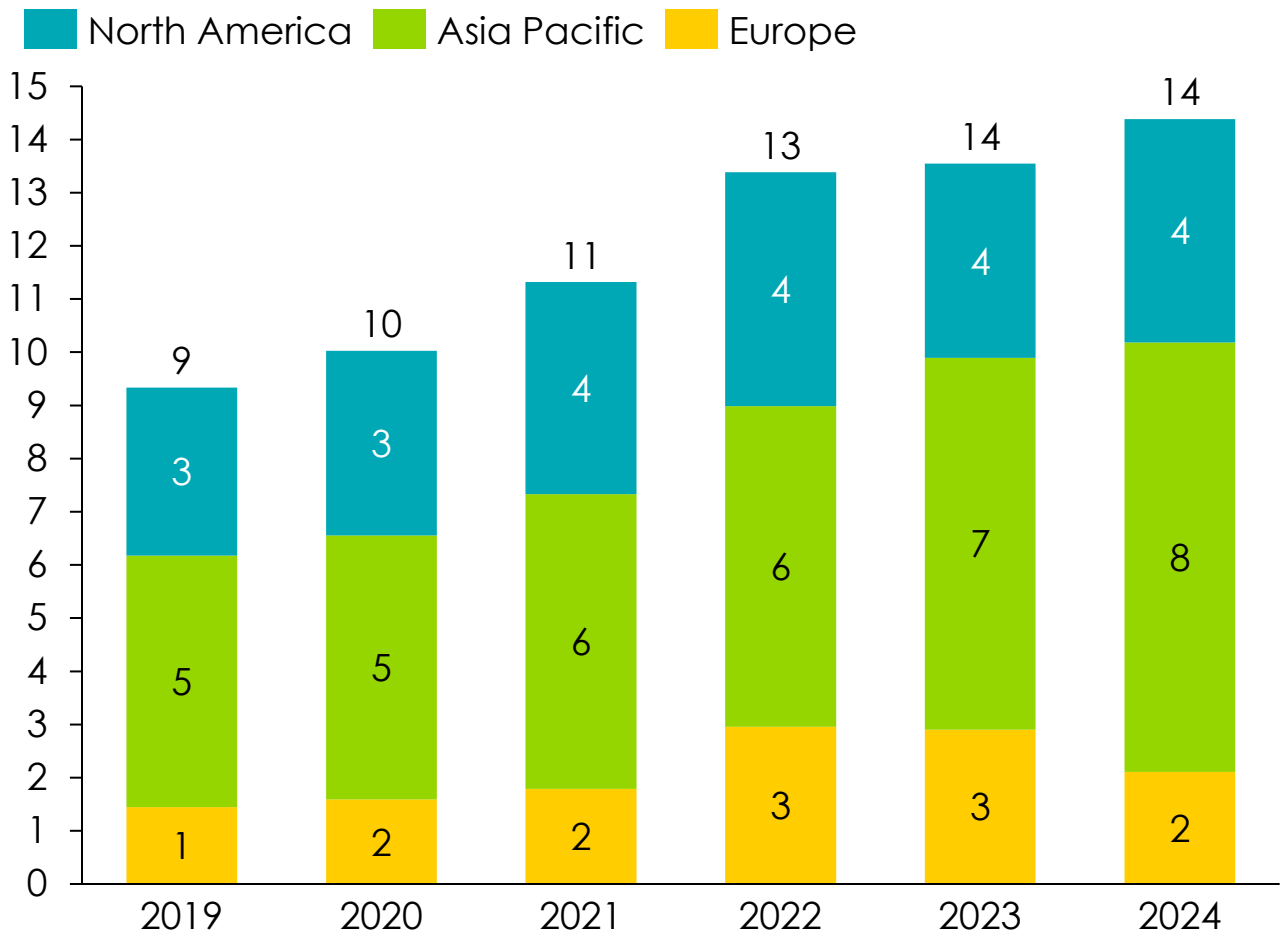
EVs reached 60% of total vehicle sales

Note: includes BEV, PHEV, PC and LDV sales. Source: Rho Motion

Other electrification – heat pumps showing some progress, but far from enough

Annual sales of residential heat pumps by region

Million units sold



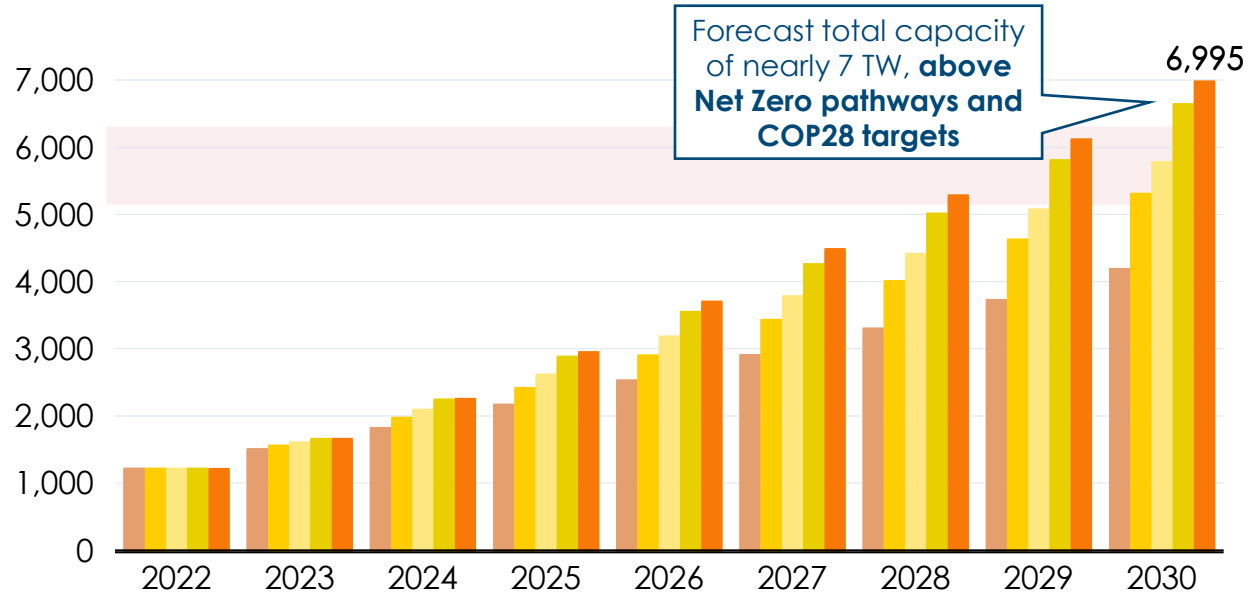
- **Global heat pump sales increasing but only a 1/3 of** 44m annual installations pace required by 2035 in US, Europe, UK alone, as noted in ETC's buildings decarbonisation scenarios
- **Slowdowns in heat pump deployment in Europe** due to removal of subsidies. **China's heat-pump sector is growing**, but limited by cost, skills, and system-integration hurdles
- **Cautionary note on uptake in US:** pushback in Massachussetts due to high electricity prices
- **Extension of heat electrification into industry still nascent** – electricity prices remain a barrier in regions such as Europe. Recent EU innovation fund helpful.

Note: Note: North America includes US and Canada, Asia Pacific includes Japan and China, Europe includes France, Germany, Italy, Spain, Poland, the UK and the Rest of EU-27, Switzerland and Norway
Source: https://www.bnef.com/insights/36591

Solar capacity forecasts are powering past pathway for 1.5C, thanks to enhanced manufacturing, while wind capacity lags, hampered by restricted growth outside China

Recent solar forecasts are now aligned to ETC 2030 milestones

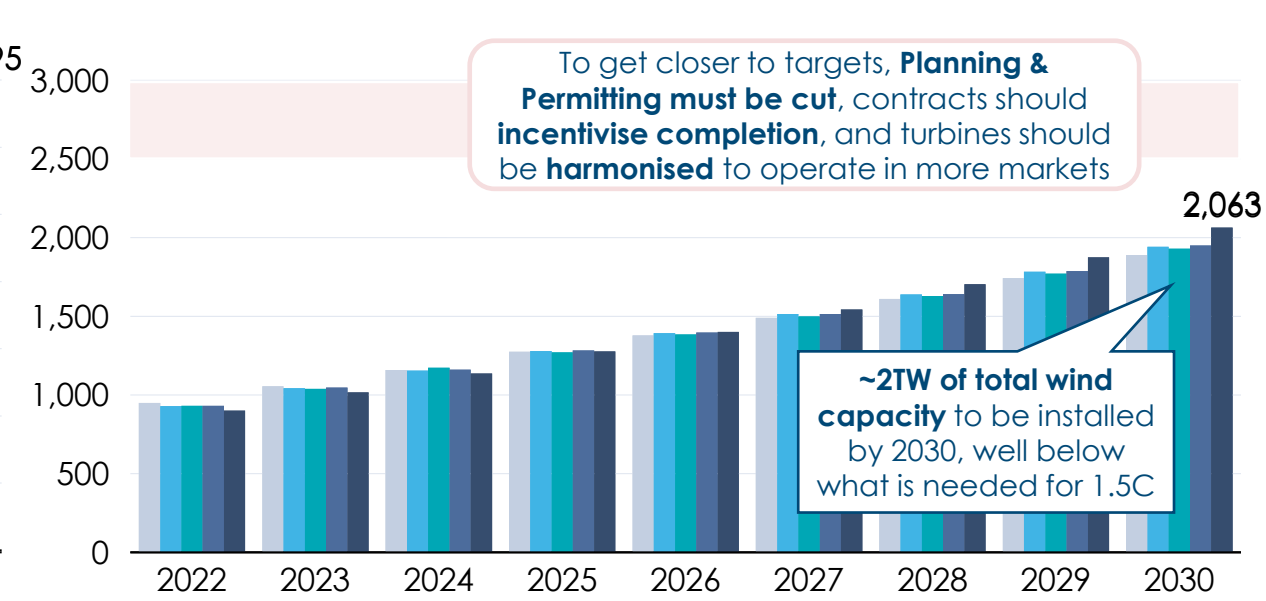
GW total capacity installed



October 2022 forecast | October 2023 forecast | June 2025 forecast | June 2023 forecast | June 2024 forecast | Range for 1.5C Net Zero Pathways and COP28 Targets[1]

Recent wind forecasts still fall behind ETC 2030 milestones

GW total capacity installed



October 2022 forecast | October 2023 forecast | June 2025 forecast | June 2023 forecast | June 2024 forecast

Solar capacity forecasts keep accelerating due to manufacturing capacity buildup and the modularity of panels

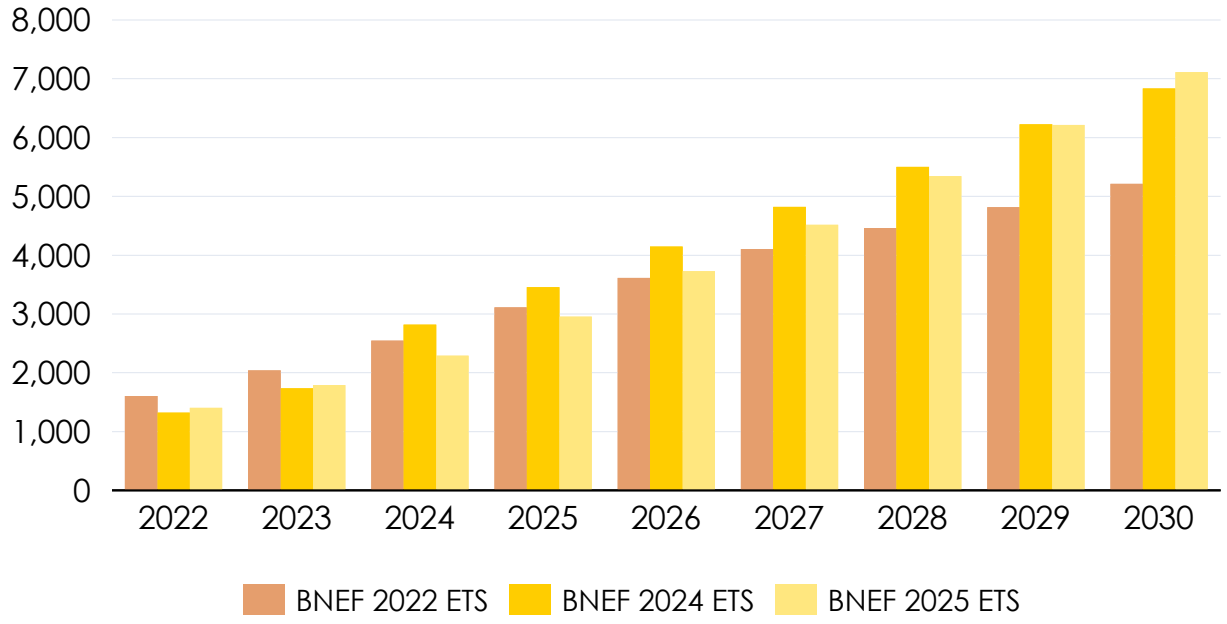
Continued slow growth for wind ex-China, where barriers are higher (e.g. supply chain, land allocation, permitting)

Note: [1] The COP28 presidency has a target to treble renewables (incl. solar, wind, hydropower, bioenergy, geothermal) by 2030. This would involve a roughly 5x increase in solar PV and 3x increase in wind from 2022.
Source: Systemiq analysis for the ETC; BNEF (2022/23/24/25) *Global Installed Capacity*

Generation forecasts for solar are rising towards the end of the decade but they are being revised down for wind

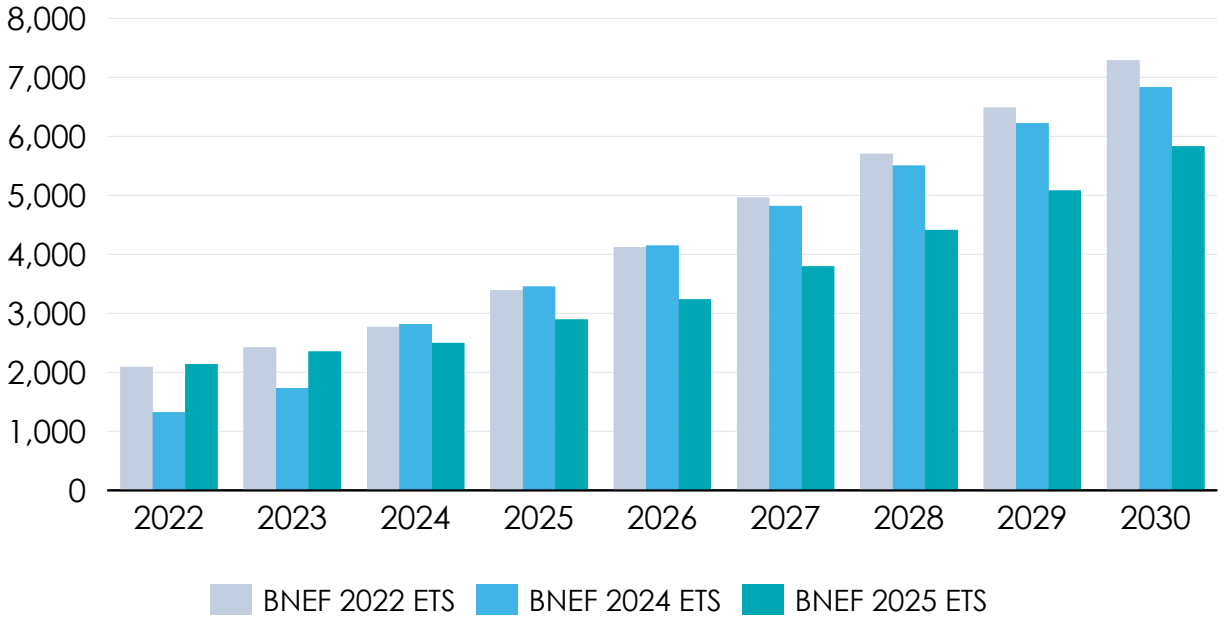
Recent solar generation forecasts variable but increase by 2030

TWh



Recent wind forecasts are decreasing due to recent headwinds

TWh



Solar generation forecast changes are more variable than capacity ones, with rising curtailment hampering delivered electricity

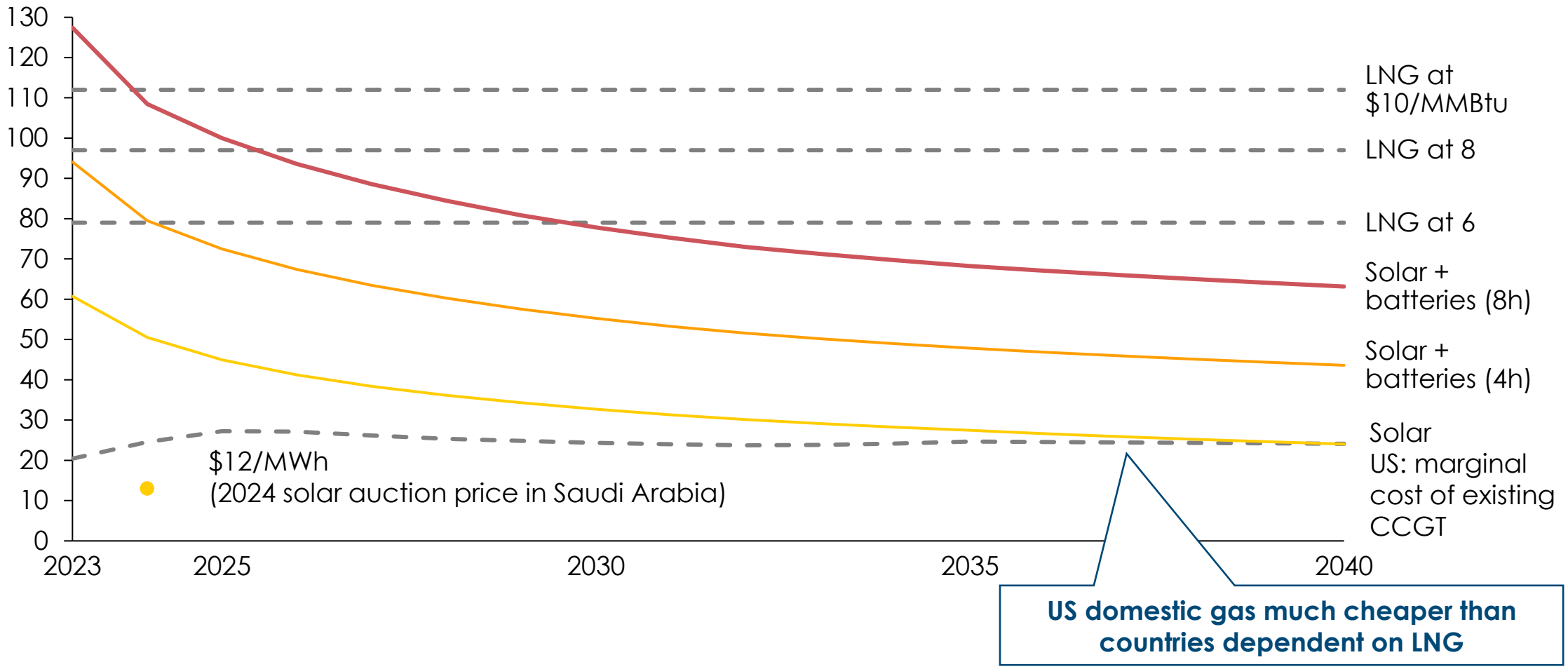
Barriers to wind deployment are also increasingly expected to impact generation, shown by recent forecasts being revised down

Source: Systemiq analysis for the ETC; BNEF (2022/24/25) *New Energy Outlook*

As solar and batteries costs fall, gas for power is increasingly uncompetitive, especially in 'sunbelt' countries reliant on LNG

LNG far more expensive than solar and batteries

$/MWh

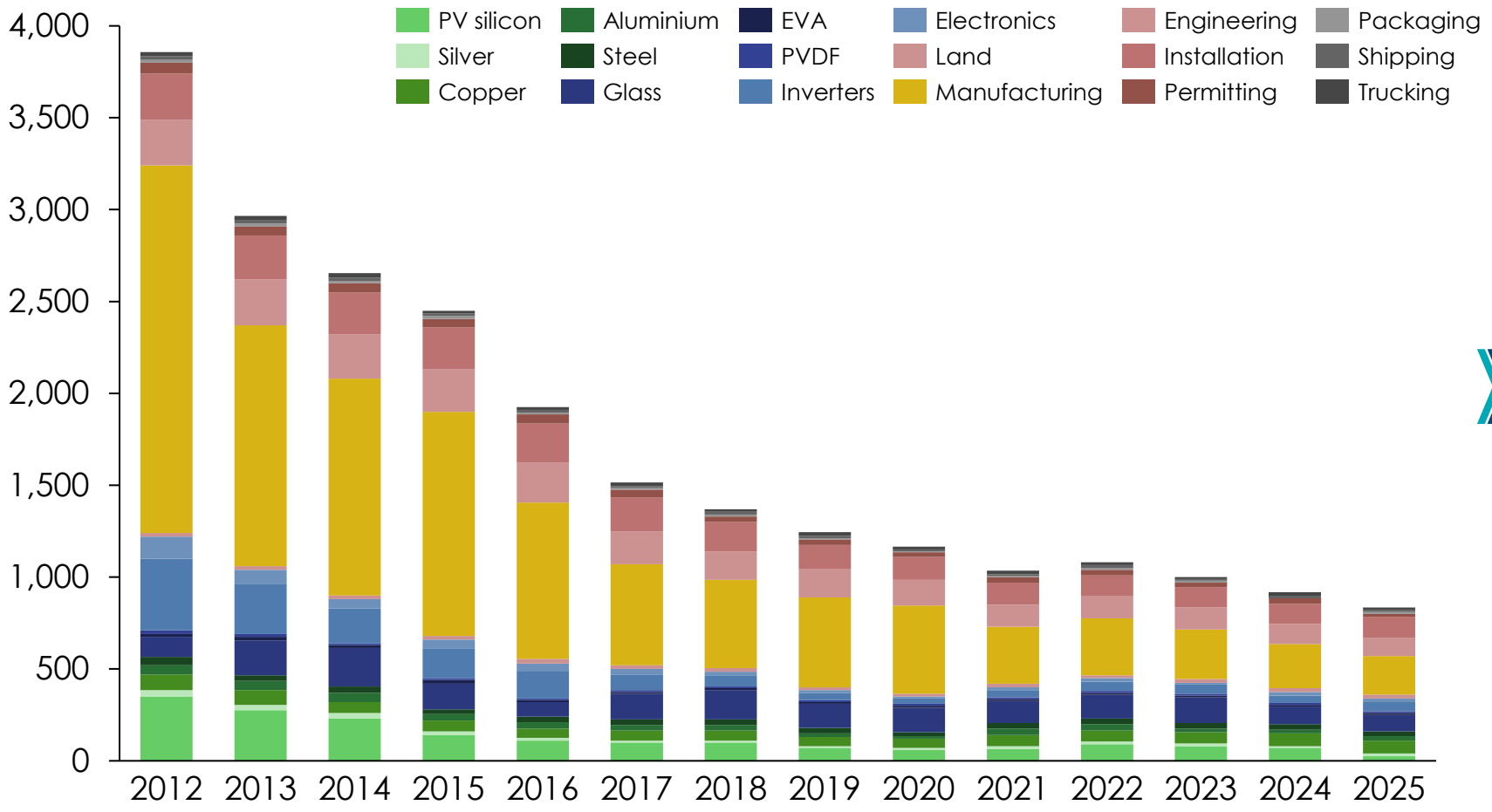


Notes: RMI estimates at different gas prices per MMBTU. Estimates for solar based on Vietnam. Battery cost estimates for China.
Source: LNG prices from RMI (2024); Solar, solar + battery, CCGT from BNEF (2023), LCOE 2H 2023; RMI (2024) Powering up the global south; PV Magazine (2024), Saudi Arabia's 3.7 GW solar tender attracts lowest bid of $0.0129/kWh

Solar costs could plausibly halve again in the next 10 years

Utility scale solar costs

$/kW



Key drivers of cost reductions:

- **Higher module efficiency** cuts material use and balance-of-system costs
- **Larger wafers and modules boost energy yield** and reduce installation costs
- **Scaling and automation** lower capex and labour expenses
- **Material innovation** (e.g. less silver) helps manage input cost volatility

Source: ThunderSaid Energy (2025), Solar costs; A breakdown over time

Total costs of clean firm projects, and systems, becoming more favourable – even in windbelt

LCOE costs of solar + batteries projects in respective markets

$/MWh

			
Year	2025	2025	2024
Solar + Battery Cost ($/MWh)	**70** **40*** *(including pumped hydro)	**120-140**	**110-160**
Fossil Cost ($/MWh – new build)	**58** coal	**136** coal	**137** gas

Key takeaways:

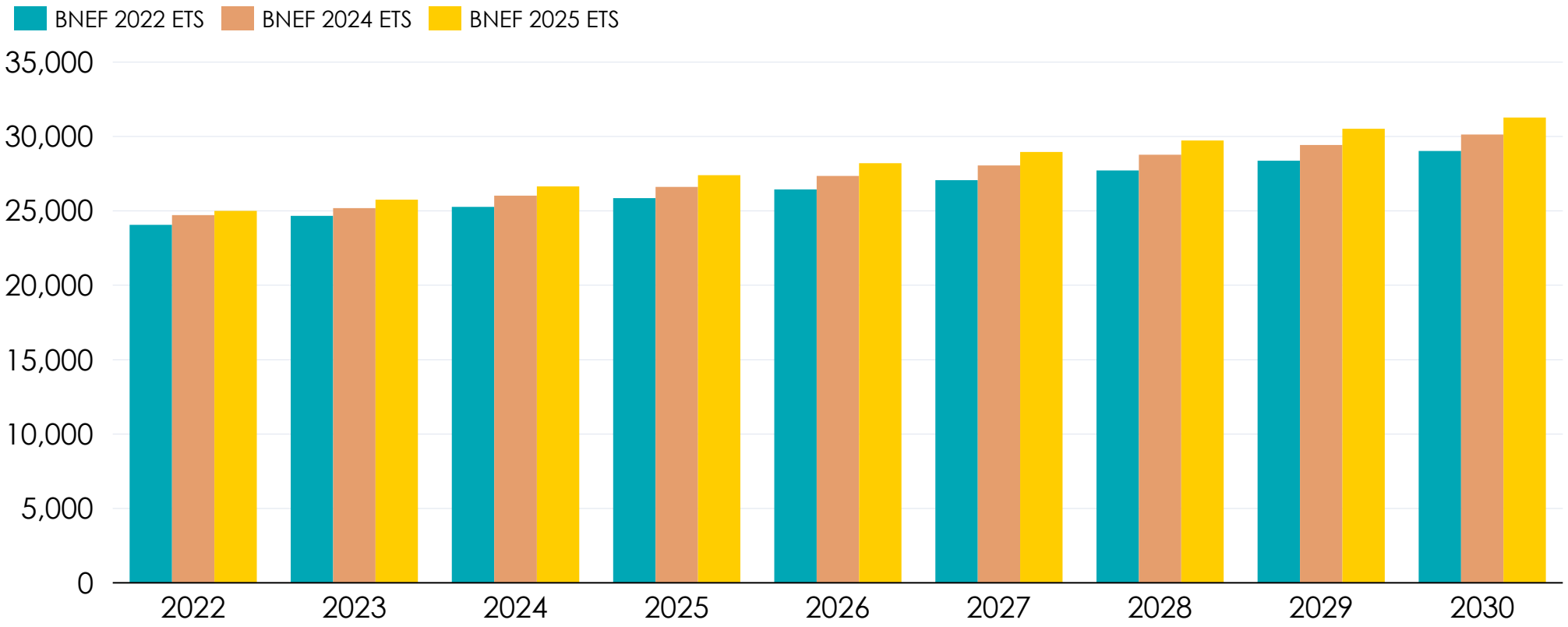
- **>90% clean-firm supply is now viable:** Pairing 5 GW solar with 3 h batteries can deliver near round-the-clock power at ~$120/MWh[1].
- **Clean-firm PPAs are emerging**: 24/7 renewable contracts now de-risk long-duration storage.
- **Even viable in windbelt regions**: In Germany, low solar + batteries costs enable clean-firm power even in less sunny markets.

Note: [1] Based on a project basis, not national basis. Source: Systemiq analysis for the ETC (2025); Ember (2025), Frauhofer ISE (2024), Photovoltaic Plans with Battery Cheaper than Conventional Power Plants; LDES Council (2025), A path towards full grid decarbonization with 24/7 clean Power Purchase Agreements; Discussions with industry participants; BNEF (2025) LCOE Data Viewer Tool

Demand projections in BNEF's ETS scenarios have been revised upwards

BNEF's ETS global demand projections by publication year

TWh



Data centre demand would only push this up by **~1,000 TWh in the most aggressive** deployment scenario (TSE 2025)

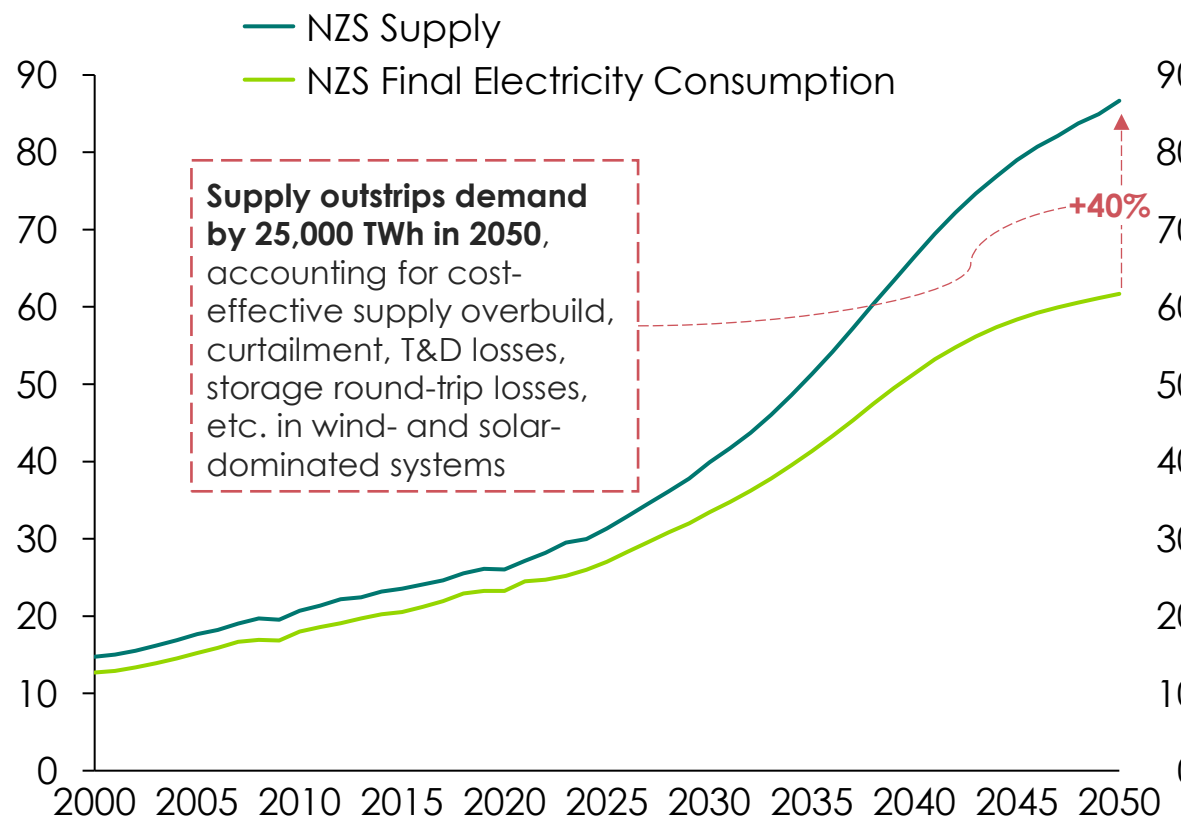
Continuously increasing demand projections could require increased ambition to meet growing demand and squeeze out fossil fuels from electricity production

Source: Systemiq analysis for the ETC; BNEF (2022/24/25) *New Energy Outlook*

BNEF's projections indicate global electricity oversupply of 15-40% of demand by 2050 – similar to ETC power systems conclusions

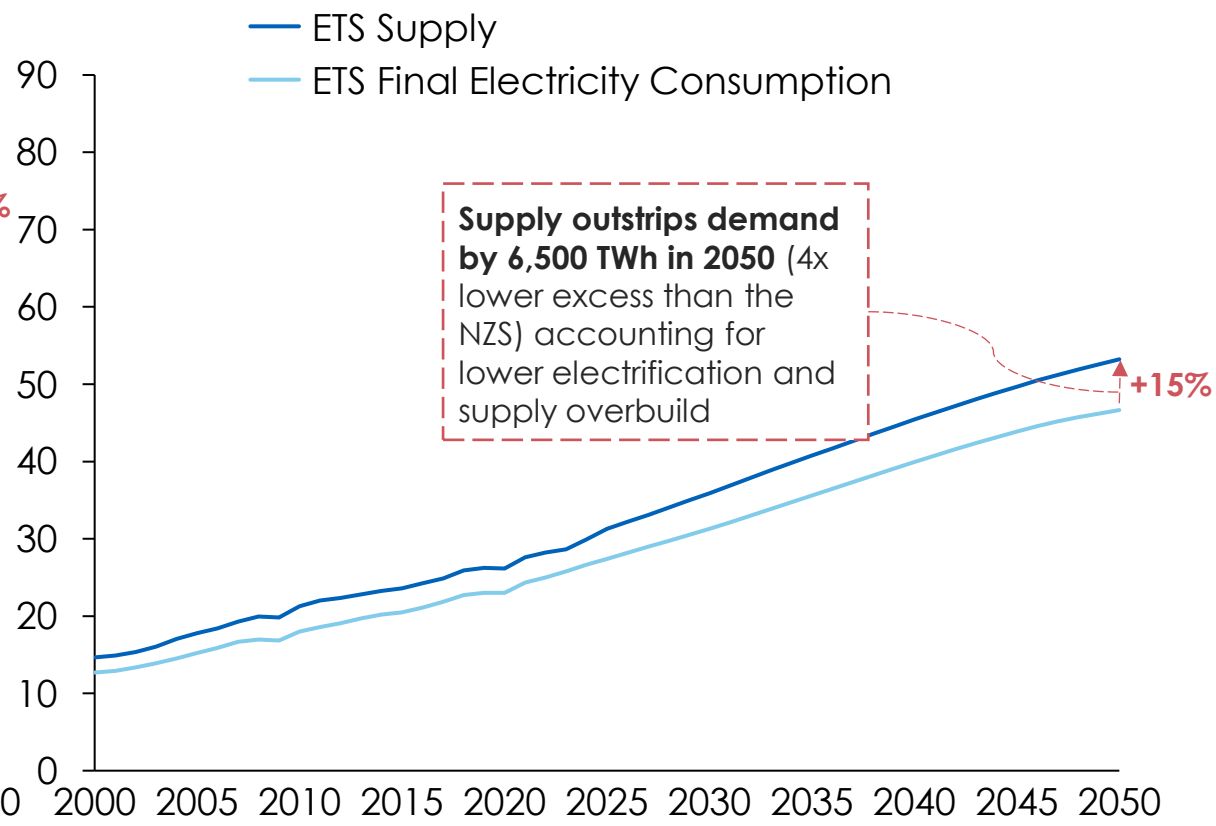
BNEF NZS supply vs demand, 2000-2050

'000 TWh



BNEF ETS supply vs demand, 2000-2050

'000 TWh



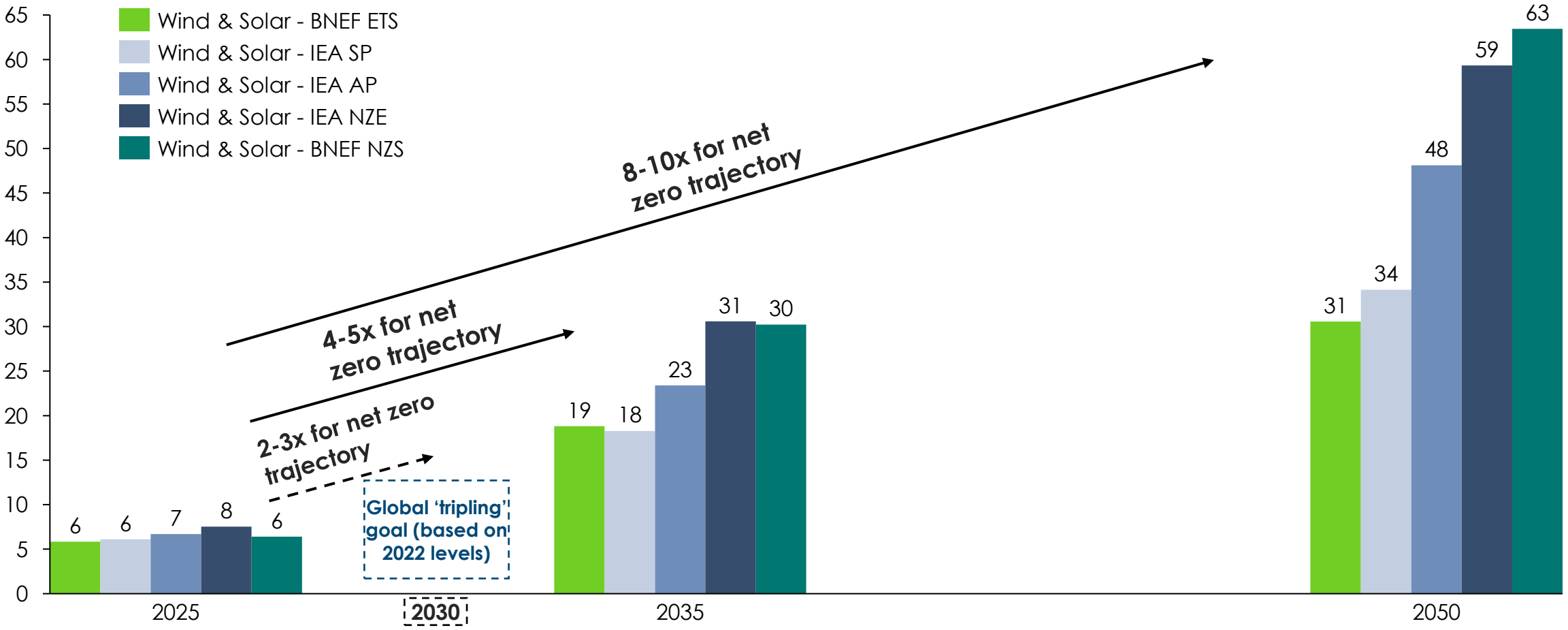
Risk of extreme supply and demand divergence (e.g., if generation trends towards NZS and demand towards ETS). Governments will need to carefully balance supply and demand to avoid electricity price inflation.

Notes: ETS = Economic Transition Scenario, NZS = Net Zero Scenario, T&D = Transmission and Distribution
Source: BNEF (2025), *New Energy Outlook*

An updated renewables generation target to 4-5x 2025 by 2035 is needed to get on track for Net Zero system requirements of 8-10x by 2050

Global wind and solar generation projections by scenario

'000 TWh

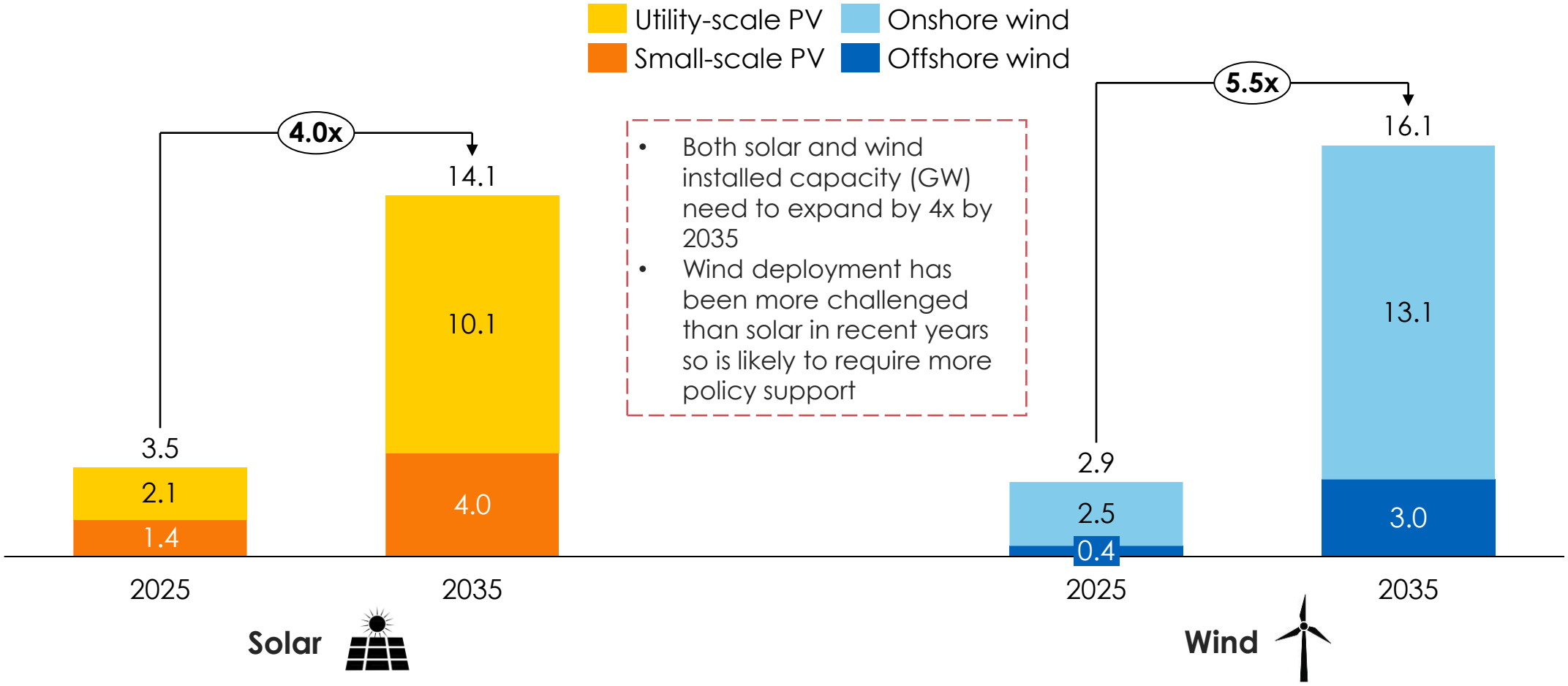


Notes: ETS = Economic Transition Scenario, NZS = Net Zero Scenario, T&D = Transmission and Distribution
Source: BNEF (2025), *New Energy Outlook*

Policy should target 4x solar and 5.5x wind generation by 2035 to align with net zero buildout rates; the latter is likely to require stronger support

Global generation change in BNEF NZS broken down by wind and solar

'000 TWh

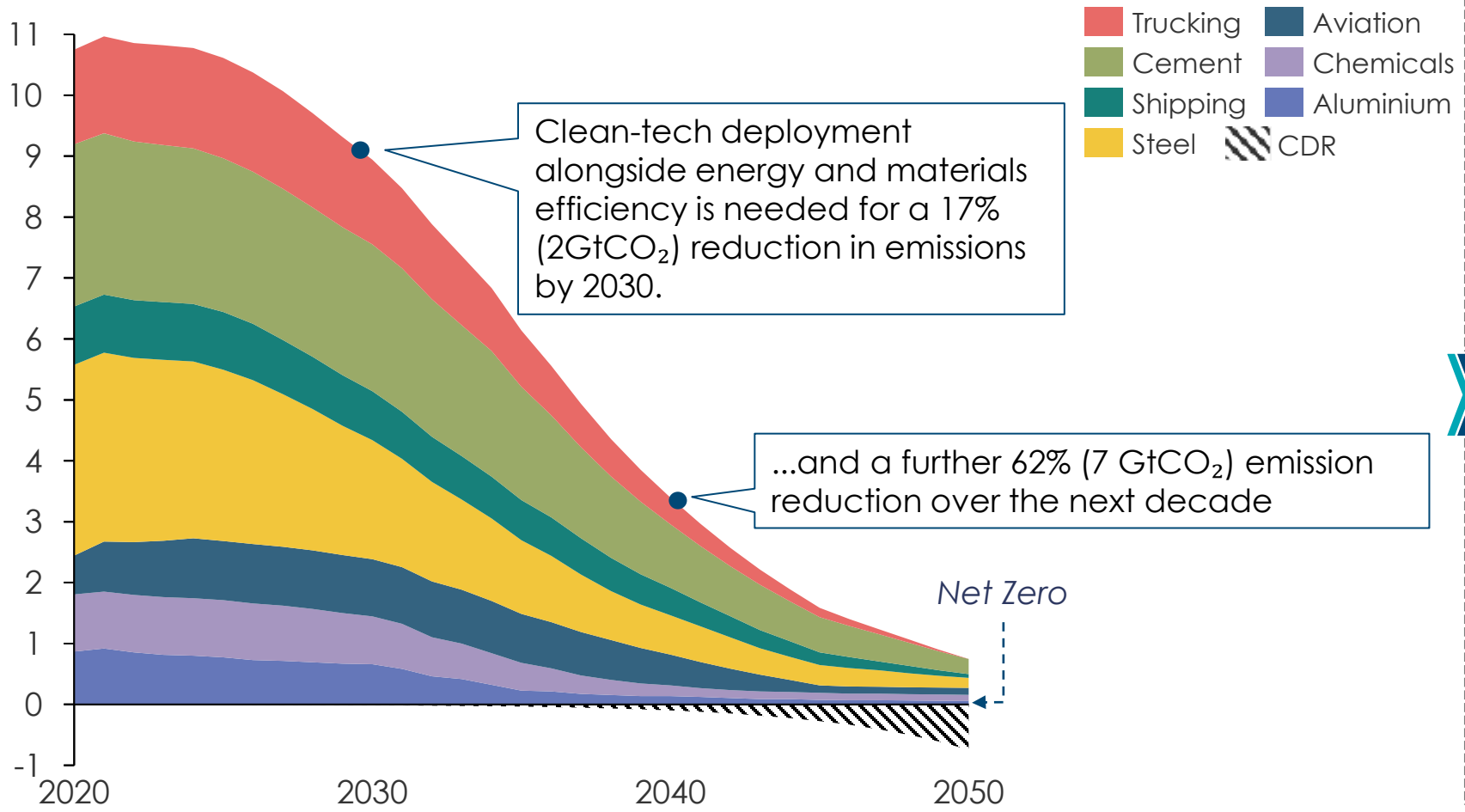


Source: BNEF (2025), *New Energy Outlook*

Massive emissions cuts can be achieved if progress scales rapidly

Scope 1 & 2 emissions by sector for Net Zero by 2050

Gt CO2 p.a.



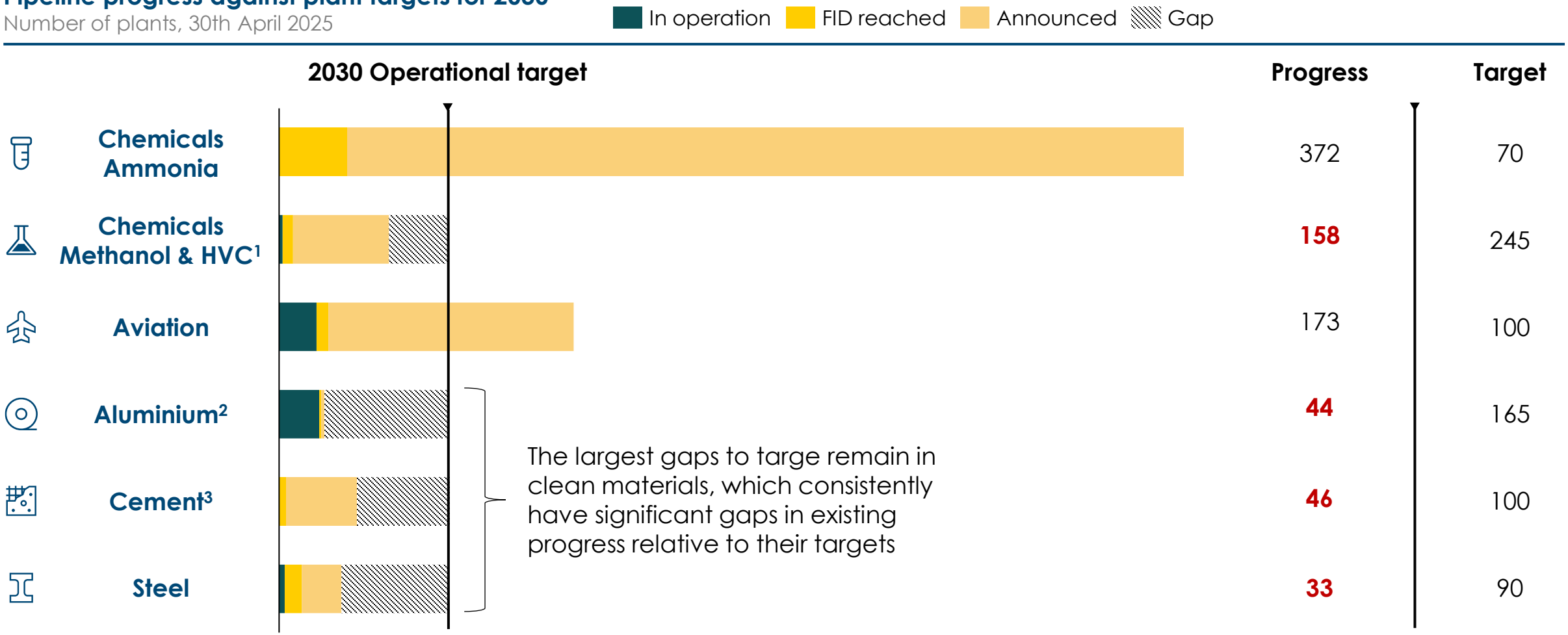
- **MPP's industry-backed scenarios for the sectors to be on a 1.5°C trajectory require a 17% and 62% by 2030 and 2040 respectively** (including trucking). The deployment of green industrial plants based on near-zero emissions technologies from now to 2050 would contribute 70% of these reductions, with the remaining 30% coming from energy and materials efficiency.
- **To achieve 2030 and 2040 goals, the full pipeline of projects must be financed and begin construction within the next two years**.

Note: Updated numbers from MPP forthcoming.
Source: Mission Possible Partnership (2021-2023) *Sector Transition Strategies*

Heavy Industry: Good progress for chemicals and aviation, but decarbonising aluminium, cement and steel remains slow

Pipeline progress against plant targets for 2030

Number of plants, 30th April 2025

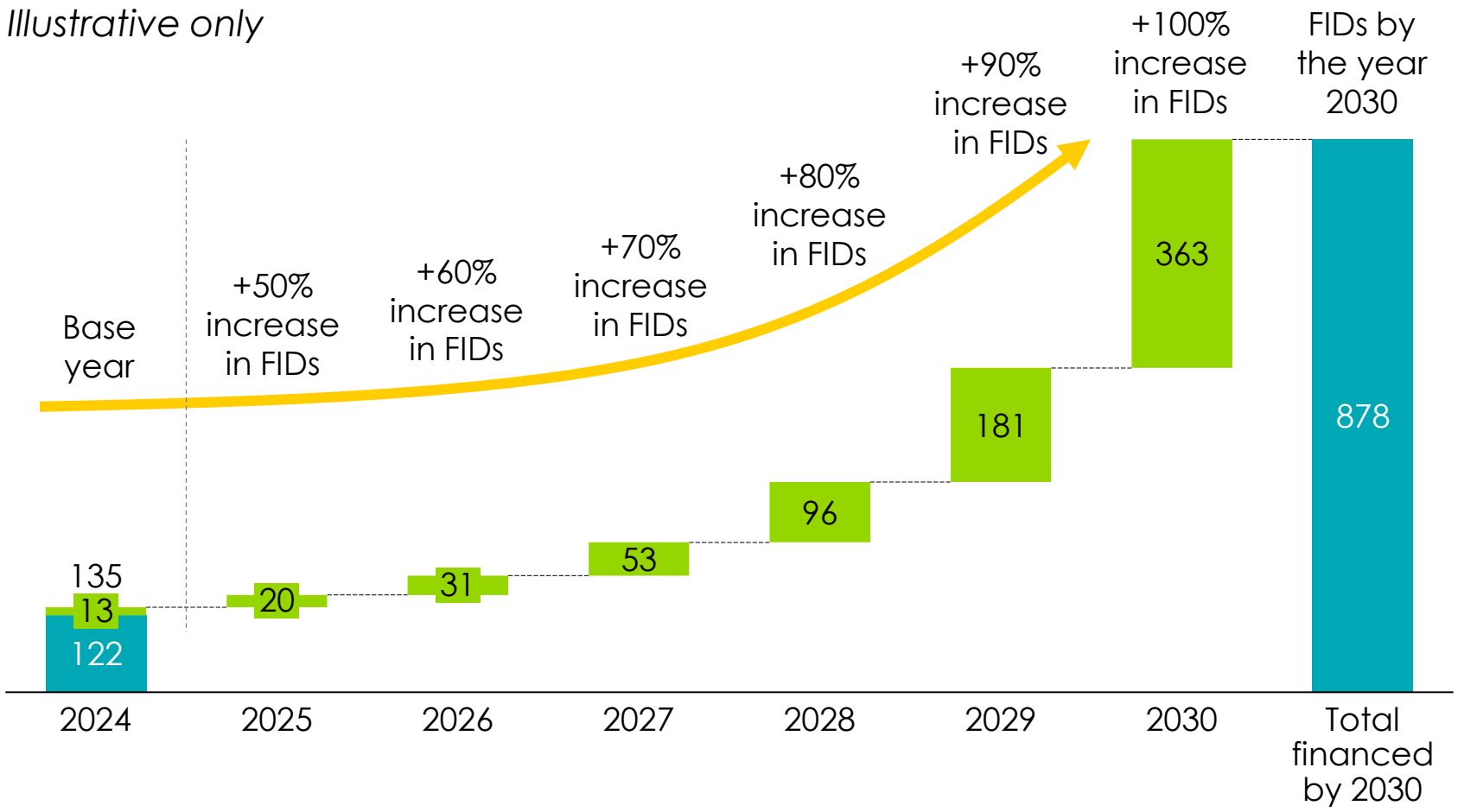


Notes: 1) HVC (High Value Chemicals) includes: Olefins (Ethylene, Propylene), Aromatics (Butadiene, Benzene, Toulene, Xylene) 2) Over half of operational plants are in the Aluminium sector, most of which are legacy clean assets 3) Heidelberg Materials' Brevik CCS plant in Norway began ramp-up operations following a 9 May announcement. As this operating date sits outside of the Tracker data cutoff (30 April), it is listed as 'Reached FID' in this report. Nevertheless, it is currently the only commercial-scale cement plant with CCS in operation worldwide as of May 2025.

Sources: MPP Global Project Tracker. For per sector sources, products in scope and technologies in scope please refer to MPP Global Project Tracker

Heavy industry – new industrial decarbonisation remains ambitious, but shifts away from 1.5°C pathway

BUILD CLEAN NOW: Accelerating FIDs for industrial decarbonisation



- **Build Clean Now.** MPP/ITA focusing on exponential increase in FIDs, starting now – to achieve 800+ FIDs by 2030
- **Shifting targets.** Original 2030 target (previous page) was ~700 plants to be online by 2030, but data showing only ~135 plants past FID currently
- Lack of policy in some regions, and lack of cost decline in hydrogen key reasons underpinning **shift away from strict 1.5°C pathway in near term.**

Note: 'Build Clean Now' is the working title of MPP's industrial decarbonization campaign for COP30 - subject to change and embargoed until September.
Source: https://tracker.missionpossiblepartnership.org/mpp-global-projects-map/pipeline

Summary of trends influencing global sectors' 2030/35 transition pathways

XXX Policy and global sector's recommendation

Carbon pricing

Policy: EU CBAM

- CBAM introduces early cost pressure on carbon-intensive exports.[2]
- China expanding ETS coverage and global cleantech investment.
- Risk of fragmented supply chains and carbon arbitrage.

Heavy industry faces rising export costs and must adapt to dual pressures from domestic regulation and green trade standards. Supply chains may shift in response to cost and policy asymmetries.

Maritime sector policy

Policy: IMO Carbon Levy (2027+)

- Levy (~$100/t) shifts economics of shipping fuels.
- Project cancellations signal rising delivery risk.

Shipping companies need to accelerate ammonia/methanol adoption and bunker readiness amid growing financial risk and project delays.

Aviation sector policy

Policy: ICAO CORSIA & SAF Mandates

- SAF mandates (EU, Asia) driving deployment now.
- Stronger demand guarantees needed.[3]

The aviation sector must scale SAF supply while managing investment risks and policy-driven demand uncertainty.

Industry diversification: Over half of new projects now in EMDEs, driven by cheap renewables and national incentives.

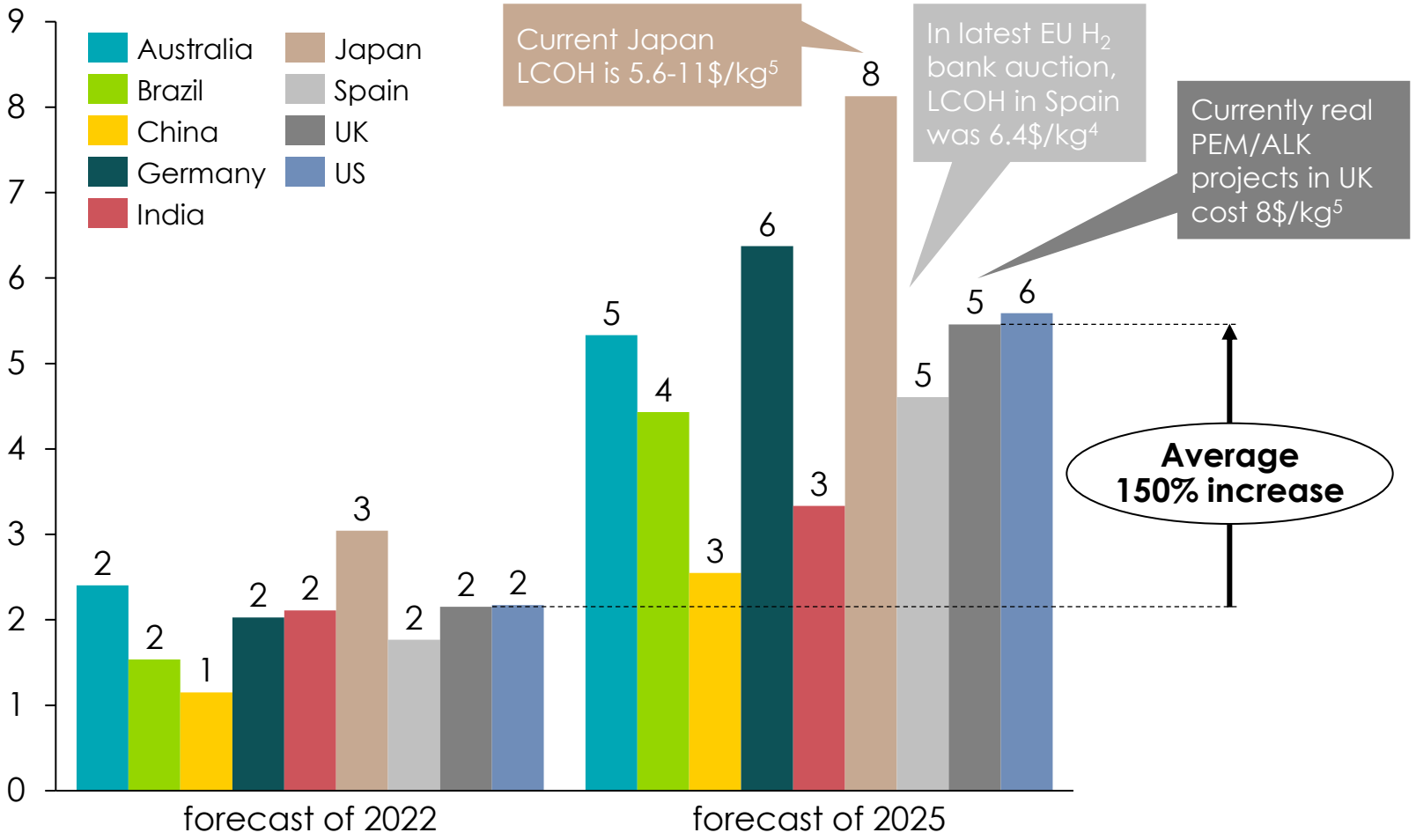
Industrial players likely to diversity, including pivoting to emerging markets (e.g. India, Brazil, Namibia) and adapt to a more distributed deployment landscape.

Source: 1) MPP November 2024 Update 2) Carbon Border Adjustment Mechanism (March 2025) 3) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) 4) Elisabetta Cornago et al. (2024) Learning from CBAM's transitional phase 5) BCG (September 2023) The Start of CBAM: A Major Landmark for Global Trade and Carbon Accounting

Hydrogen enters a reality check: slower momentum but tangible progress, led by China's $2.5/kg 2030 projections

Levelised cost of Hydrogen from renewable electricity BNEF revised projections for 2030

$/kg H2



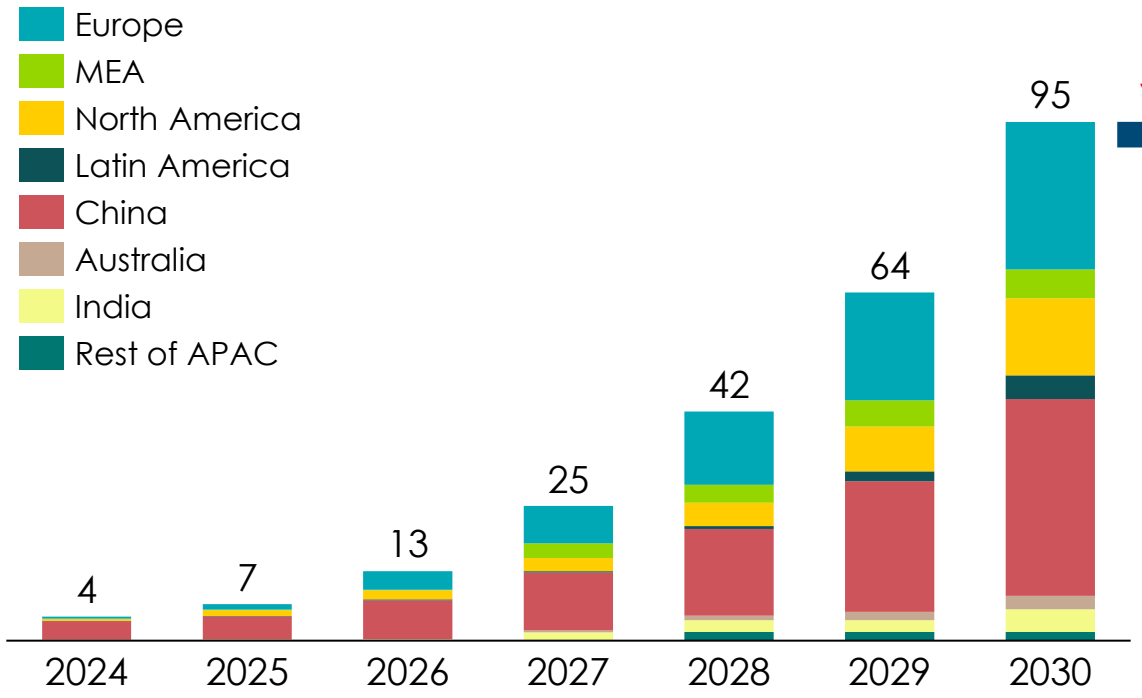
- **China and Middle East are setting the pace** with large-scale projects and production costs falling below $3/kg, without subsidies.
- **The EU continues to invest heavily** (with EIB support), aiming to build a hydrogen economy even as costs remain above global targets[2]. Current EU renewable H_2 costs range is 5-12 €/kg in auctions.[3]

Source: 1) BNEF (December 2024) Hydrogen Levelized Cost Outlook 2025 2) Clifford Chance (March 2025) Focus on Hydrogen State of the market 2025 3) International PtX Hub: Key takeaways from the first EU Hydrogen Bank auction 4) IF24 Auction 5) The Platts Hydrogen Wall

Green hydrogen supply could exceed demand by a factor of 5 by 2030

Cumulative electrolyser supply capacity forecast

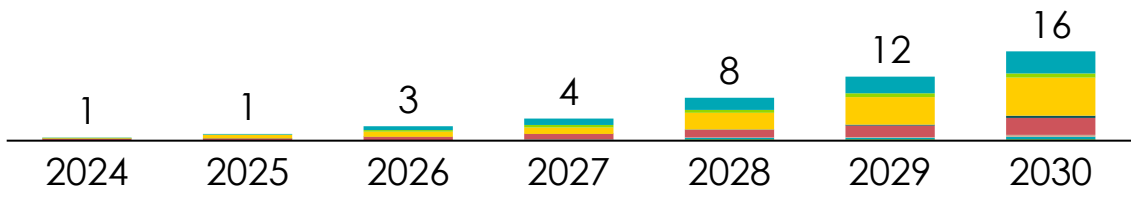
Gigawatts



5x less

Low-carbon hydrogen production forecast

Million metric tons H2 per year



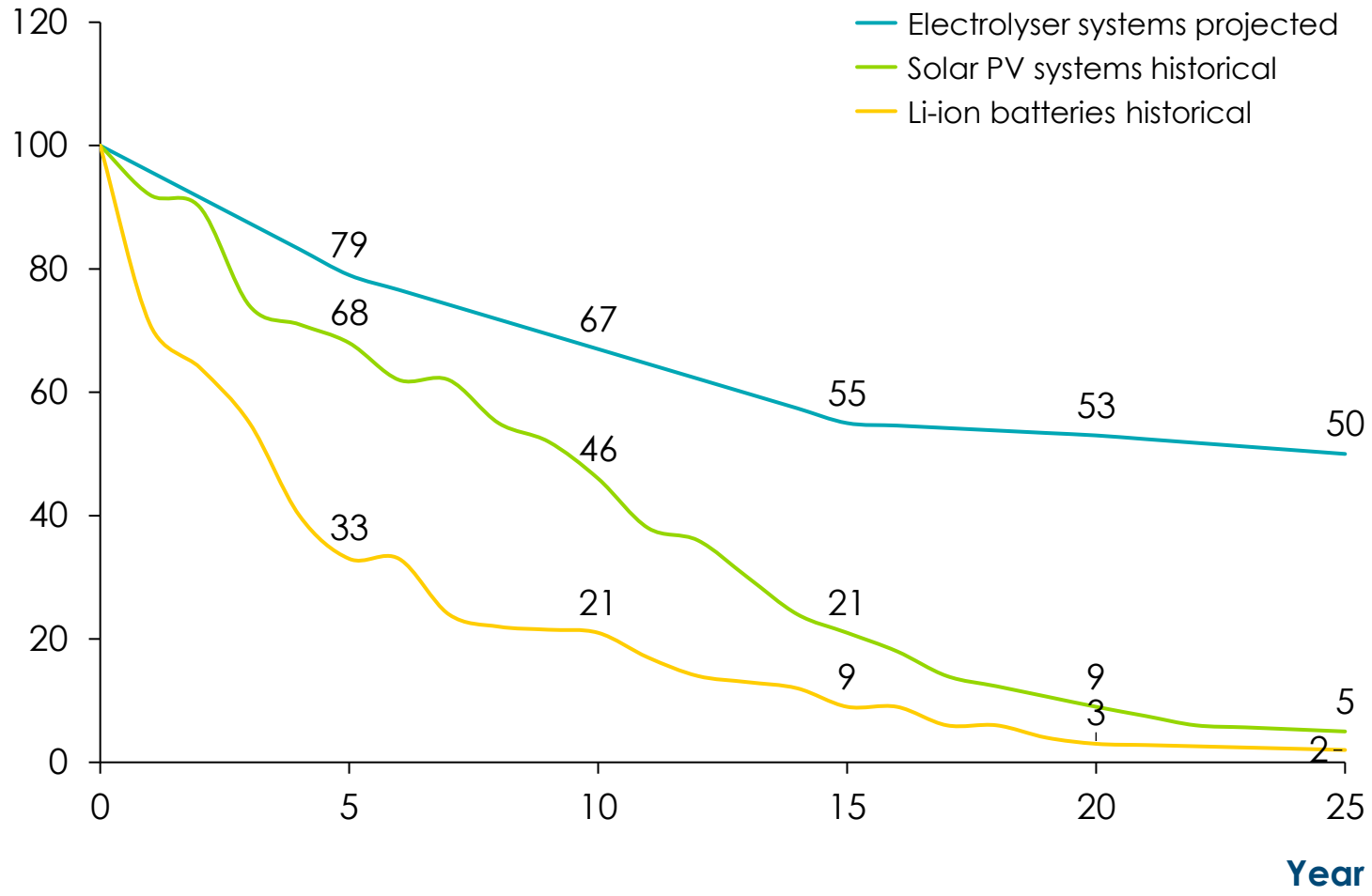
- As of October 2024 **only 12% (9Mt) of annual clean H_2 production by 2030 has identified an offtaker**[2]
- **EU is likely to achieve only about 3 Mt/year of clean hydrogen production by 2030**, falling far short of the 10 Mt/year target.[3]

Notes: 'MEA' refers to Middle East and Africa. 'APAC' refers to Asia-Pacific
1) BNEF Hydrogen Supply Outlook 2024: A Reality Check 2) BNEF Hydrogen Demand: 2H 2024 Update 3) Clean Hydrogen monitor 2024

Electrolyser cost reductions are plateauing, threatening the scalability of green hydrogen.

Learning rates

Index = 100



Electrolyser CAPEX down ~15% by 2040, which is too slow for cost competitive green hydrogen. Unlike solar PV or Li-ion, **no steep learning curve is expected**.

Structural cost barriers limit future reductions

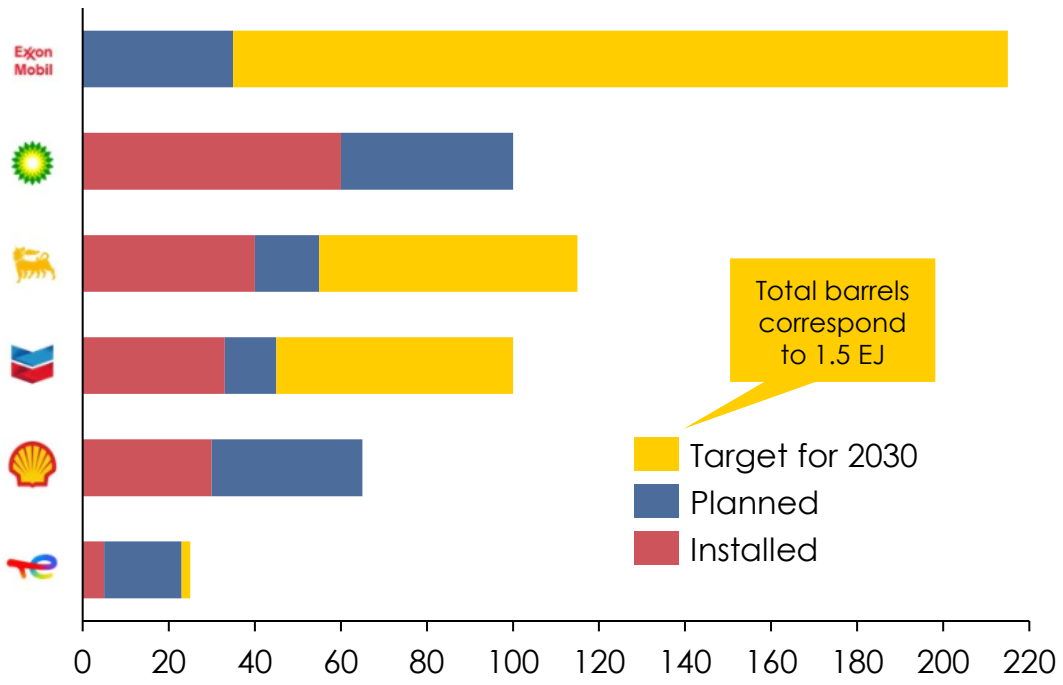
- Only 1/3 of the Cost Can Improve Fast
- Remaining 2/3 (Balance of Plant) includes mature components (e.g., compressors, tanks, purifiers) which are widely used, and show flat learning curves.[2]
- Even 1 GW electrolyser projects show only modest CAPEX reduction, while most projects are still in the sub-200MW scale.[3]

Source: 1) Learning rates: The implications of slow decline in electrolyser system cost projections 2) Fletcher, 2025; Martin, 2022 3) Hydrogen Council & McKinsey, 2023

Bio: Transition from 1st to 2nd generation biofuels is accelerating, but production portfolio must double to meet 2030 targets

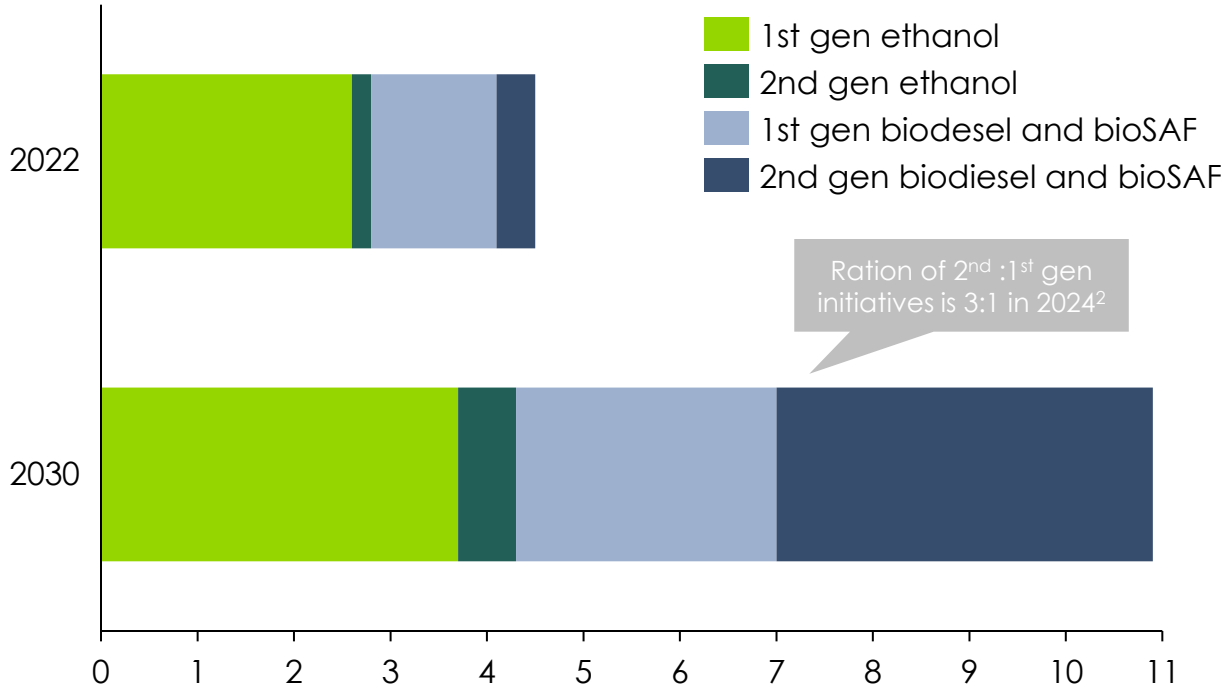
Oil majors' Biofuel production portfolio capacity[1]

Thousand barrels per day



Liquid biofuel production by feedstock and technology in 2022 and IEA 2030 target[2]

EJ



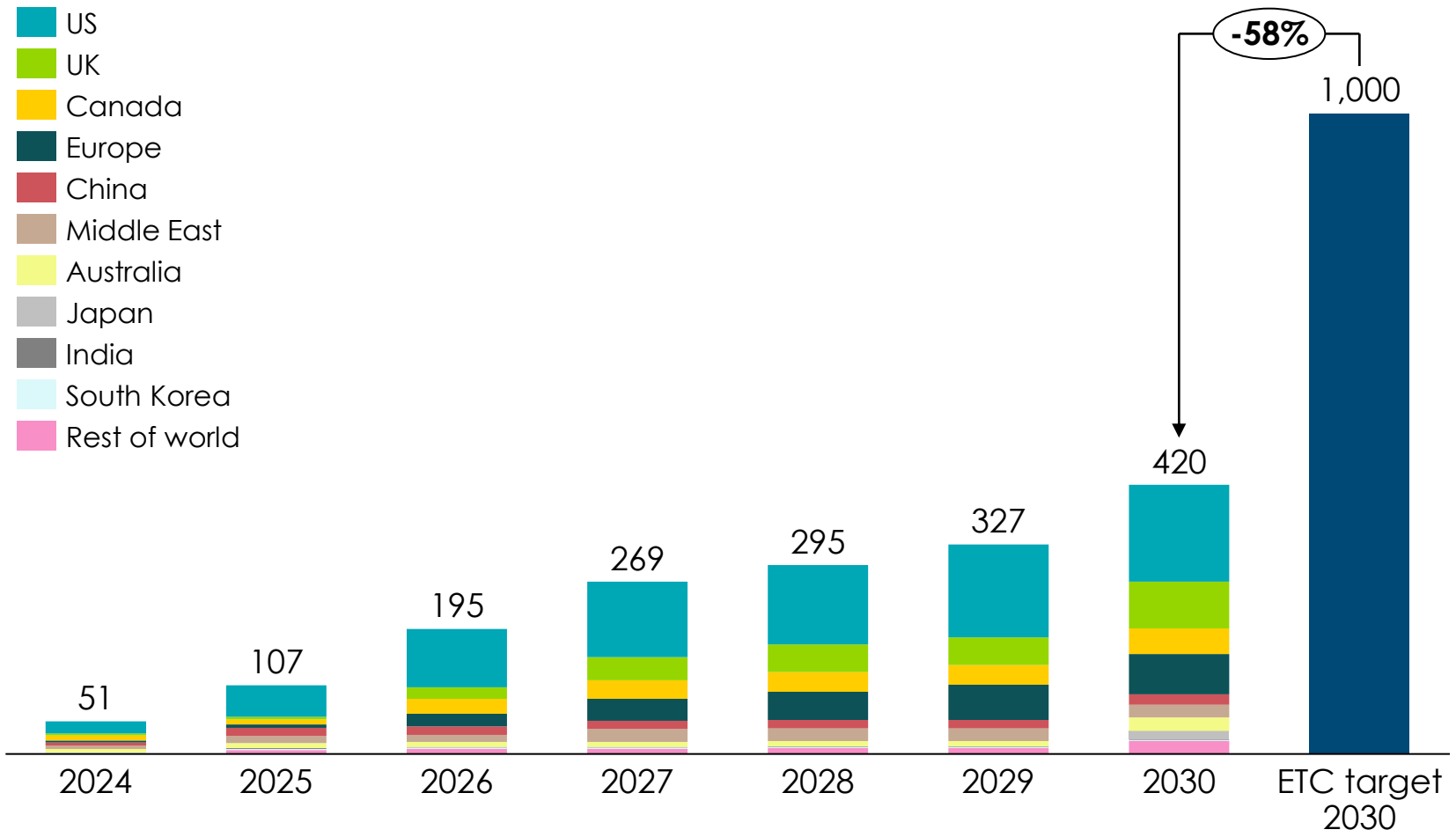
- Currently, IEA Database consists of **258 biofuel projects**, of which 39 are on-hold/cancelled.[2] Major oil companies plan for **43 projects** until 2030, focusing on sustainable aviation fuel (SAF) and 2nd generation diesel.[3]
- New biofuel projects are shifting from road use **toward heavy transport**.

Notes: 1) Includes both operated and equite share projects.
Source: 1) Rystad Energy's BioEnergy Solution, November 2024 2) IEA Bioenergy (December 2024) Development and Deployment of advanced biofuel demonstration facilities 3) Energy News November 2024

CCUS: pipeline falls far short of 2030 target as viability and infrastructure constraints remain critical barriers

Proposed annual carbon capture capacity, by market and commissioning year

Million Metric tons CO_2



- **Economic viability remains uncertain:** Many CCS projects depend on subsidies or high carbon prices to be profitable[3] and require additional derisking mechanisms alongside carbon price - UK good example.

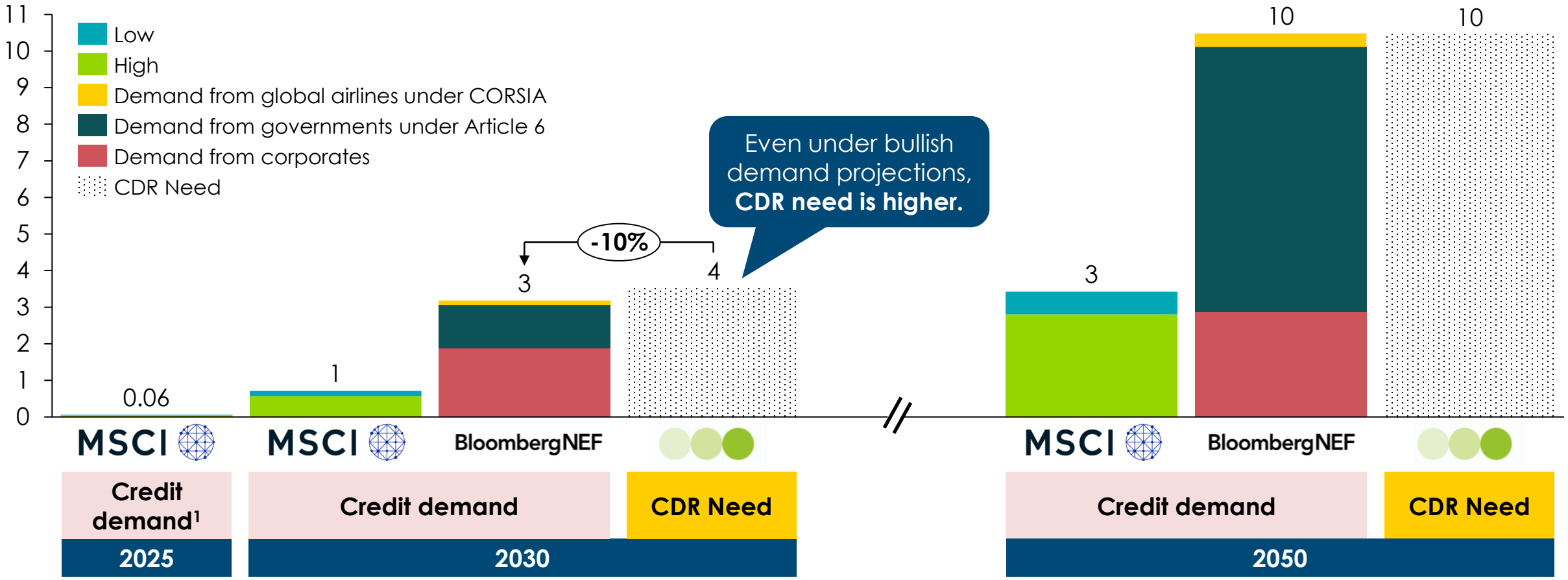
- **Transport and storage remain key constraints:** reliance on liquefaction adds cost and complexity, while injection volumes are often restricted by safety limits in depleted reservoirs. This is reflected in the modest 1.5 $MtCO_2$/year capacity of Northern Lights.[3]

Sources: 1) Carbon Capture Market Outlook 1H 2025 2) IEA Net Zero Roadmap, 2021 3) Euronews 2024

CDR: massive gap between demand vs. need – poses fundamental problem to 1.5°C

Demand projections for carbon market vs. ETC CDR pathway

GtCO2/year



Source: BNEF (2025), *Long-Term Carbon Credit Demand Outlook 2025*. Corporate demand is BNEF's 'price elastic' scenario; MSCI Carbon Markets (2025), *Frozen Carbon Credit Market May Thaw as 2030 Gets Closer*.

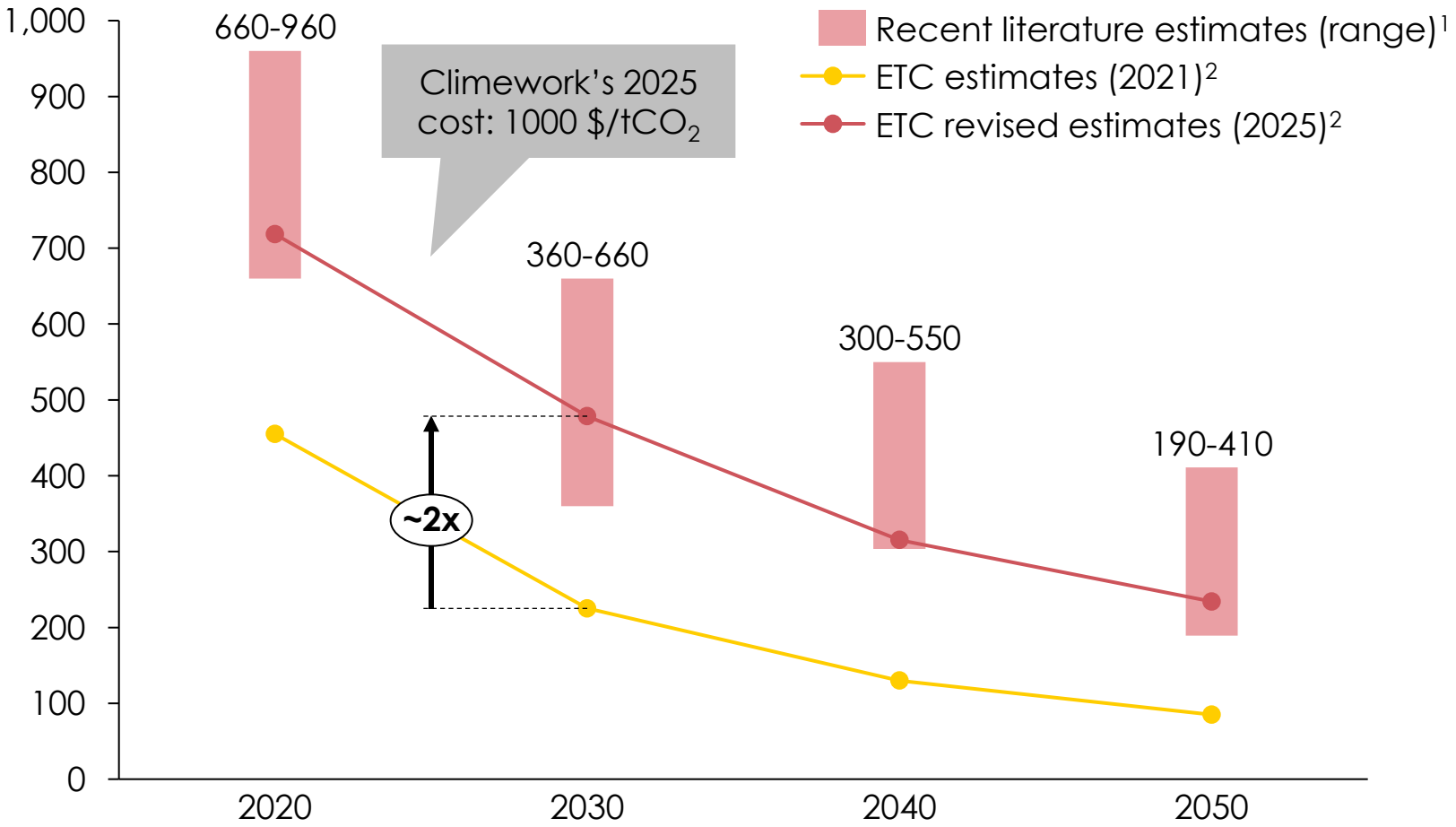
Notes: *MSCI credit volume calculated by multiplying projected market size ($) by ETC average cost of carbon removal in each year ($/tCO$_2$). CORSIA*= Carbon Offsetting and Reduction Scheme for International Aviation is a global market-based measure developed by the International Civil Aviation Organization (ICAO) to address carbon emissions from international flights.

Recent estimates of levelised cost of DAC are higher than previously predicted, which could hinder the technology's scale-up in the long-term

2025 ETC Estimates Highly Preliminary

Levelised cost of CO_2 capture via DAC – projections 2020-2050

$/tCO_2$



Key take-aways

- **Historical DAC cost projections have been optimistic** with lower-than-realised capital costs and ongoing energy costs[3]
- Recent **credible publications predict higher costs of DAC until 2050**[1], which could hinder the technology's scale-up

Sources/notes: 1) 2020 and 2030 estimates: Lorenzo Sani (2024) Bridging the gap between the UK's CCUS targets and reality. 2040 and 2050 estimates: Katrin Sievert et al. (2024); Manon Abegg et al. (2024); 2) Levelised cost of DAC refers to a fully electrified DACC system for 5,000 full load hours per annum. Assumes weighted average cost of capital of 7% and plant lifetime of 20 years, growing to 30 years by 2050. 3) Reality check on technologies to remove carbon dioxide from the air (MIT Energy Initiative, 2024)

Agenda

Emissions, political and investment trends

Focus on China, rest of world

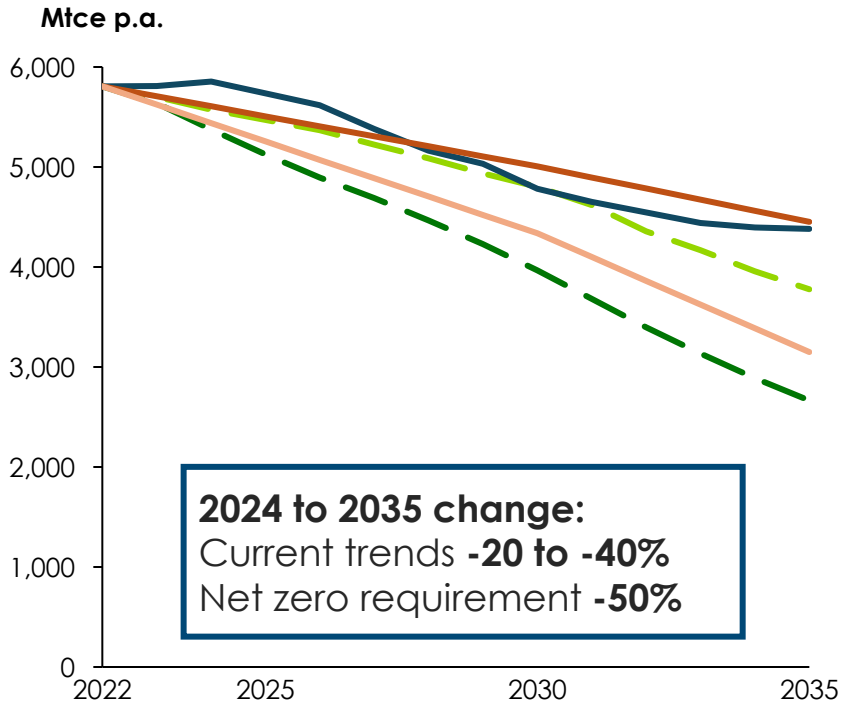
Sector by sector summary

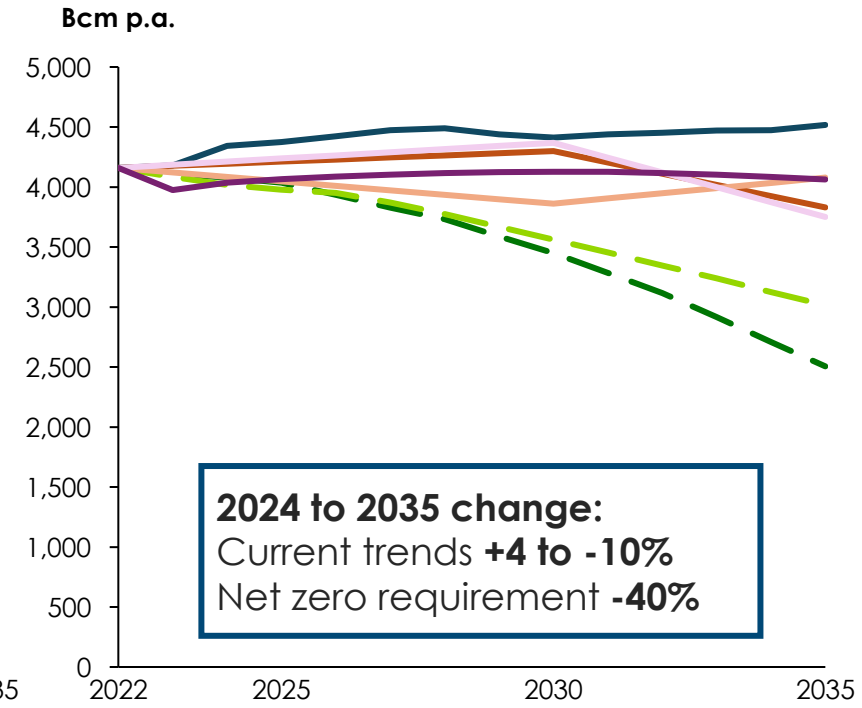
Conclusion and implications for ETC

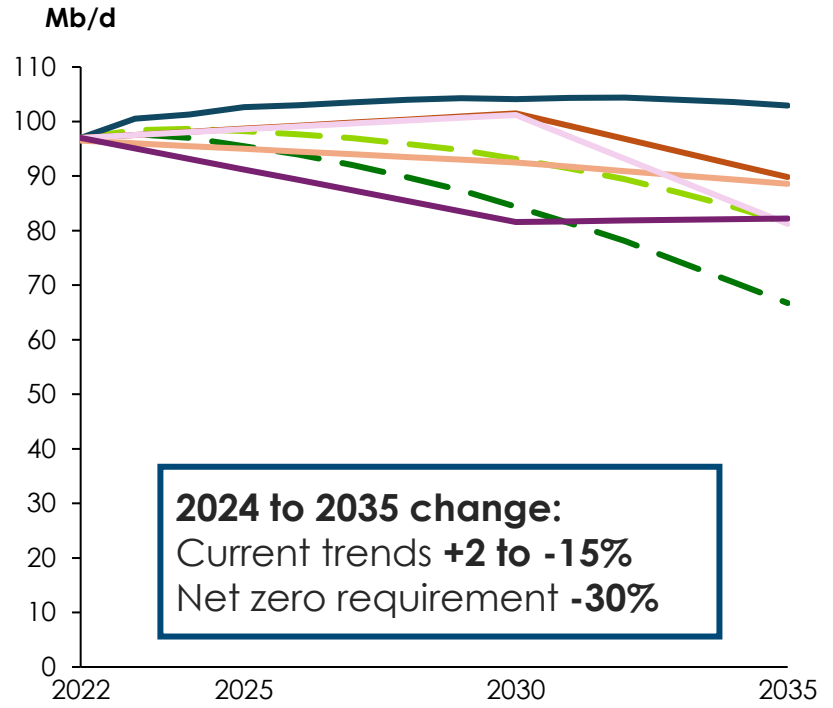
Projections of fossil fuel demand to 2035 vary significantly

Fossil fuel demand
Specific units

ETC - PBS
ETC - ACF
BNEF - Economic Transition Scenario
IEA - Stated Policies
IEA - Announced Pledges
BP - Current Scenario
Shell - Archipelagos





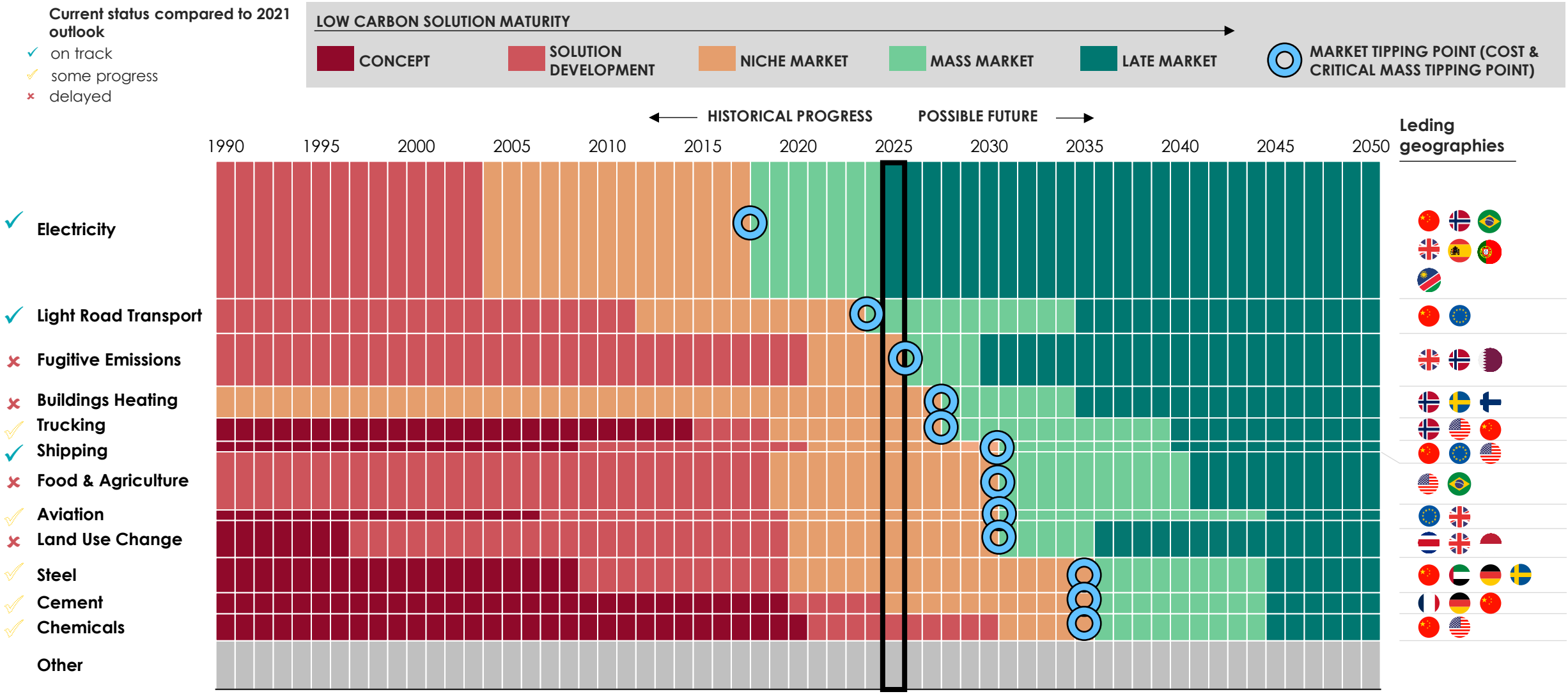


Coal | Natural Gas | Oil

Current Trends — Net-zero scenarios

Note: 2022 values for all scenarios fixed using the IEA's 2022 data. Only BNEF data is on year-on-year basis, e.g. Other data points are decade to decade and interpolated. BNEF ETS coal converted to Mtce from 6,000kcal/kg. Source: ETC (2023), *Fossil Fuels in Transition;* BP (2024), *Energy Outlook;* BNEF (2025), *New Energy Outlook 2025;* IEA (2023), *World Energy Outlook; Shell (2025), Energy Security Scenarios; BP (2024), Energy Outlook*

Assessing low-carbon solutions: low-carbon electric technologies largely ‘on track’, other sectors show delayed progress towards tipping points



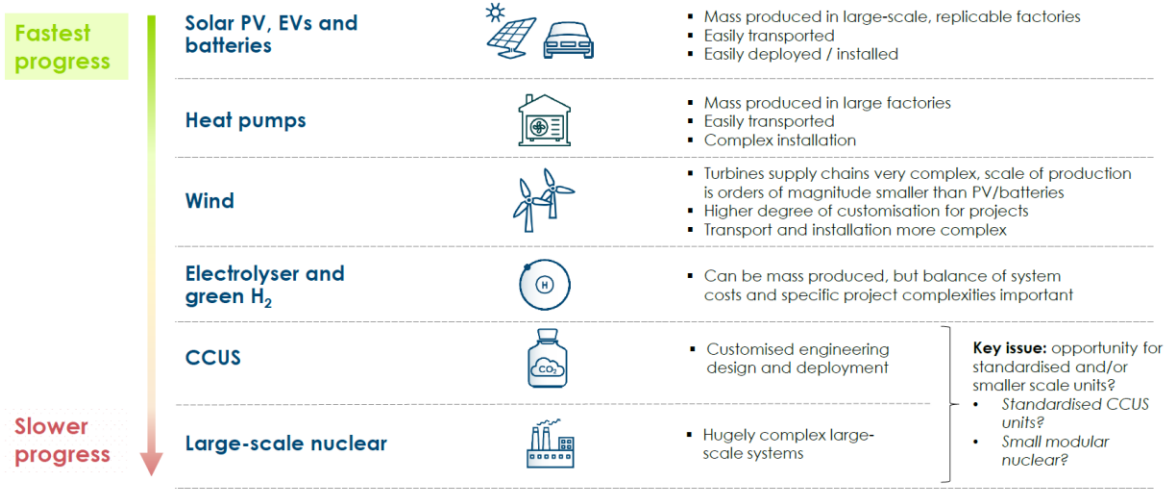
Note: Section sized according to 2023 emission impact (CO2e); Other include cooking; rail transport; light industry and other minor sources of emissions
Source: UN (2024) Emission Gap Report 2024, CCPI Index, MPP tracker

From which we take two key lessons:

1) Modularity leads to cost reductions & rapid deployment

As the ETC has said before…

The technologies which are deploying fastest are those most susceptible to mass production and easy deployment



2) Importance of policy as an enabler of transition

- Awaiting phase out of free allowances/**rollout of CBAM for industrial decarbonisation** to really take off
- **Delayed mandates on heat pumps** in new/existing homes failing to deliver heating transition
- **Lack of action in food and land use sector down to lack of regulation** (e.g. deforestation?) or perverse incentives

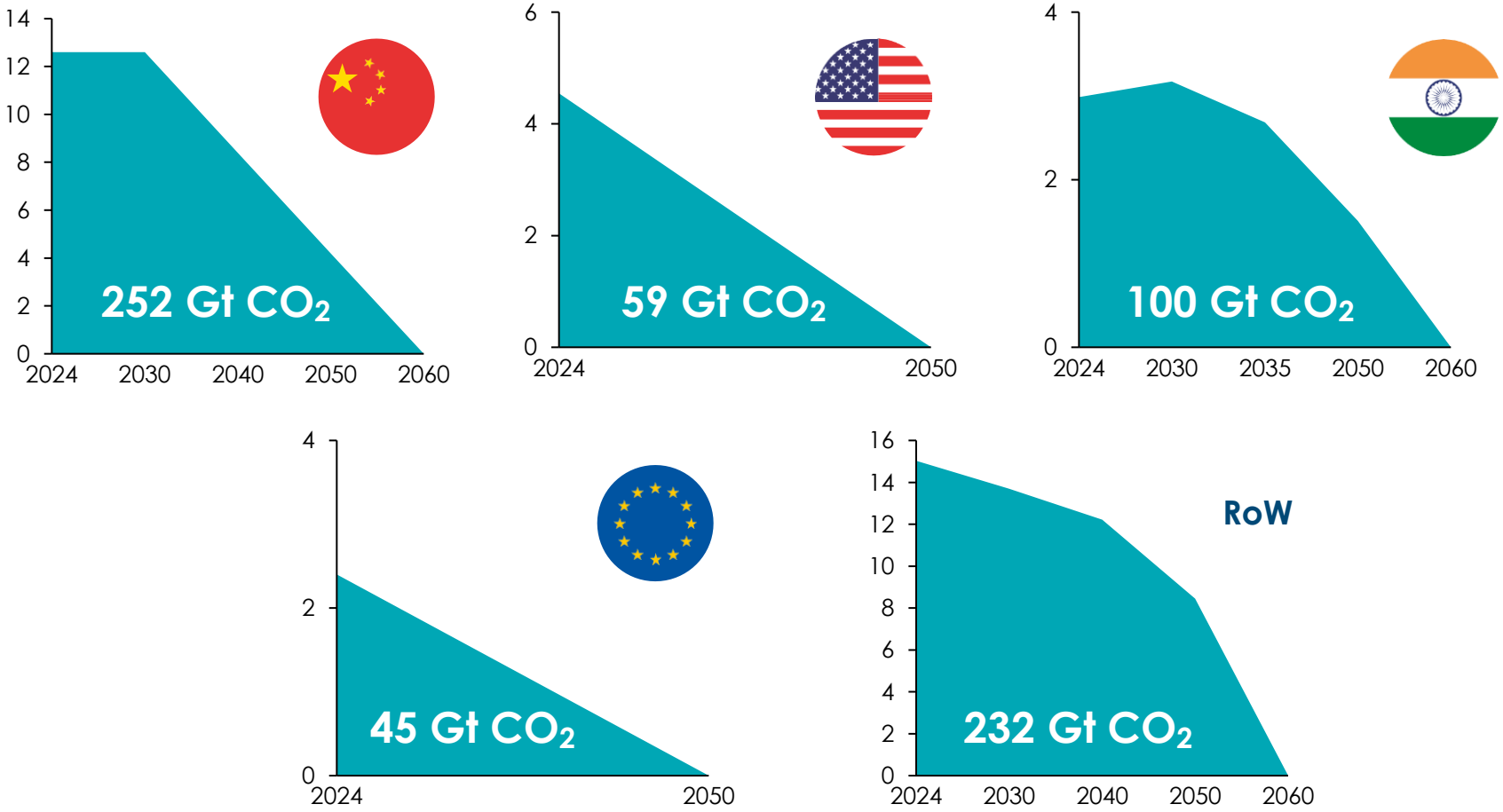
+ effect of complexity and uncertainty in sectors that require strong policy is likely a brake on the transition

Overall pace of transition determined by the interactions between these two

Even if all countries implement their pledges (from NDCs 2.0), the world is halfway between 1.5-2.0°C

Cumulative CO_2 emissions*, 2024-2060

$GtCO_2$



Remaining carbon budget at the start of 2025 for a 50% likelihood

1075 Gt CO_2
for < 2°C

650 Gt CO_2
Current estimate of global cumulative emissions between 2025-2060

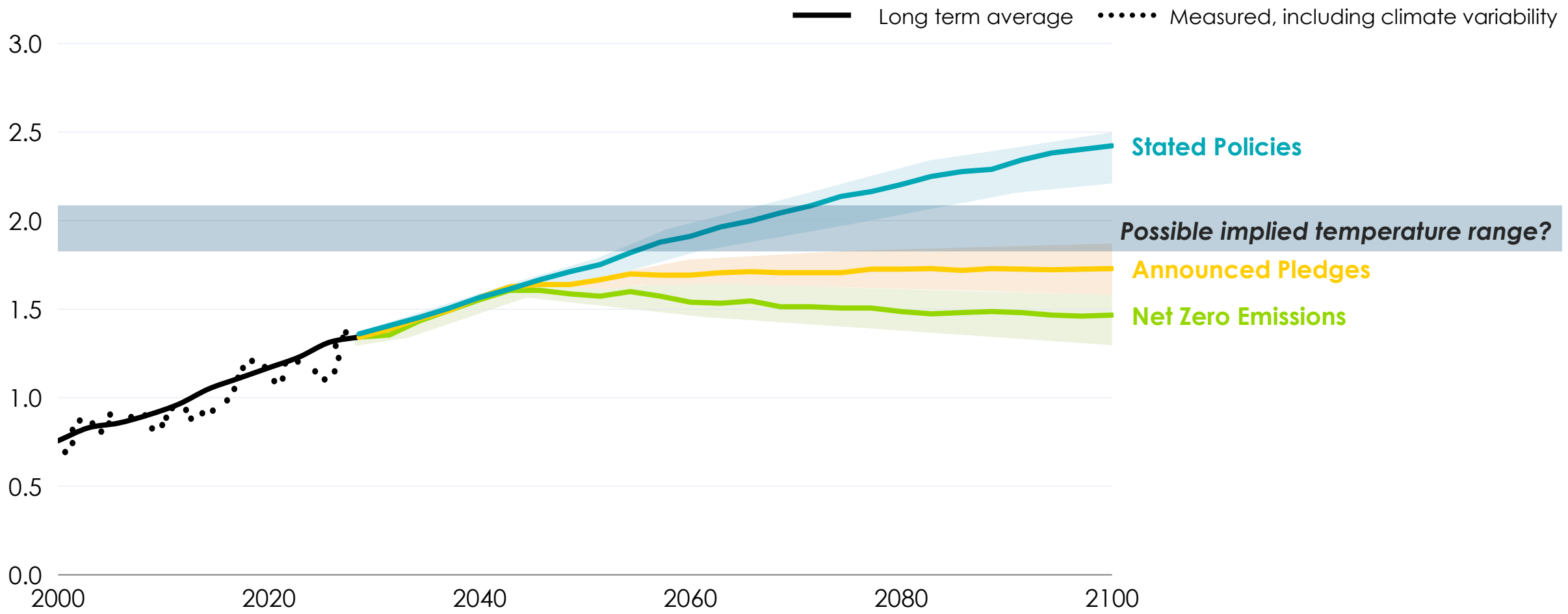
175 Gt CO_2
for < 1.5°C

Source: IEA (2025) World Energy Review; IEA (2024) World Energy Outlook; ETC (2023) Fossil Fuel in Transition

The US slowdown and the 'implementation gap' between stated policies and announced pledges suggest temperatures towards 2C or above

IEA scenarios for global temperature increase vs preindustrial level

°C



Notes: IEA STEPS scenario projects what will happen under current stated policies and trends; APS projects what will happen under all announced policies and net-zero commitments; NZS describes what needs to happen to limit warming to levels consistent with 1.5°C of warming.
Sources: IEA (2024), World Energy Outlook

COP30 wants global "mutirão" – though expectations are muted

1. **NDCs 3.0:** Delivery of new ratchet of national climate targets.
2. **Climate Adaptation:** Develop a collective vision and prioritisation for adaptation based on NDCs and National Adaption Plans, advancing "Baku Adaptation Road Map".
3. **Climate and Nature Finance:** Commitment to "Baku to Belem Roadmap" to unleash 1.3 trillion dollars per year as set out in the NCQG.
4. **Deforestation and Forest Protection:** Shift to investment-driven solutions, with the **Tropical Forest Forever Facility (TFFF)** as a flagship initiative.
5. **Renewable energy:** Triple capacity globally.
6. **Energy Efficiency:** Double the global average annual rate of improvements.
7. **Fossil Fuels:** Transition away from fossil fuels in energy systems in a just, orderly, and equitable manner.
8. **Loss & Damage:** Strengthen the institutionalisation and connection between L&D mechanisms.
9. **Just Transition:** Demonstrate ambition to agree on the scope and focus of the work programme.

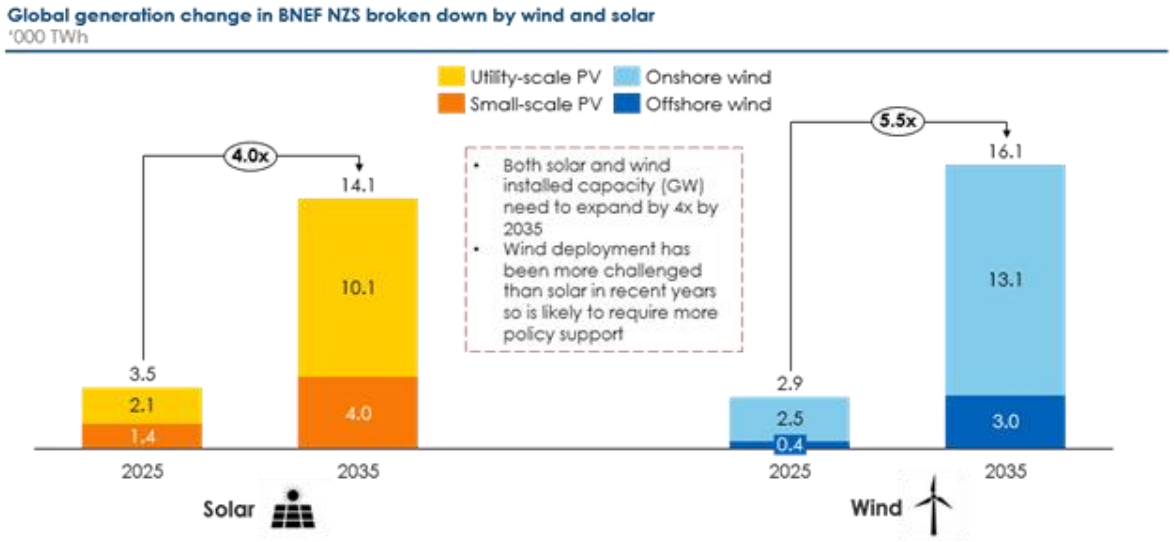
Likely that NDC ratchet and progress on finance continue to fall below expectations?

Source: UNFCCC (2025), *Federative Republic of Brazil COP30 President-Designate, March 10th, 2025;* UNFCCC (2025), *Third CPD Letter.*

What should the ETC's asks be for COP30?

Build more renewables: Advance the global 'tripling' (2030) target towards a 4-5x increase by 2035

Policy should target 4x solar and 5.5x wind generation by 2035 to align with net zero buildout rates; the latter is likely to require stronger support



+ expanded grids, storage and interconnection

Build overall ambition and use this as a platform to fill in policy gaps

- **NDCs – opportunity for new NDCs** to reflect existing commitments**, tripling overall ambition**
- **NDCs – consistent and comprehensive format, as well as clear sectoral roadmaps & policies** to ensure they are 'investable'
- Recommit to **fossil fuel phase down**
- **Build Clean Now:** industrial decarbonisation