The Inevitable Policy Response Forecast Policy Scenario 2023 (IPR FPS 2023)

Detailed energy system results

September 2023

INEVITABLE POLICY RESPONSE

IPR was commissioned by the PRI[1] and is supported by world class research partners and leading philanthropies, financial institutions, & NGOs

Commissioned by PRI

In 2018, the Inevitable Policy Response was commissioned by PRI to advance the finance industry's knowledge of climate transition risk & support investor efforts to incorporate climate risk & opportunities in portfolio assessment

A Climate Research Consortium

This report was produced by Energy Transition Advisers and Theia Finance Labs[2] with support and analysis from Vivid Economics.

NGO partners include Carbon Tracker, Climate Bonds & Planet Tracker

Strategic Partners

In 2021, leading financial institutions joined the IPR as Strategic Partners to provide more in-depth industry input, and to further strengthen its relevance to the financial industry

Core philanthropic support

The IPR is funded in part by the Gordon and Betty Moore Foundation through The Finance Hub, which was created to advance sustainable finance, and the ClimateWorks Foundation striving to innovate and accelerate climate solutions at scale

1. Principles for Responsible Investment
2. The conclusions of the report are solely those of Energy Transition Advisers and Theia Finance Labs

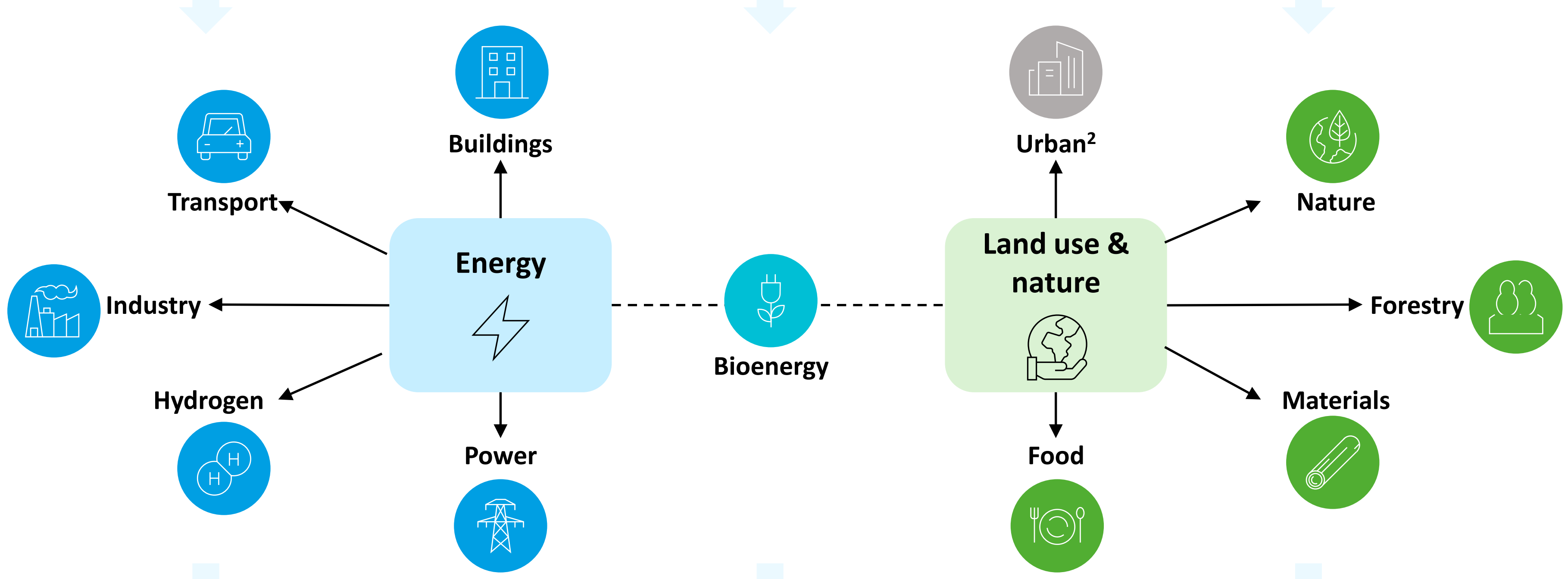
IPR offers a range of applications to help financial institutions navigate the climate transition

Policy forecast

IPR produces **>300 high-conviction policy forecasts** covering 21 countries and 10 policy areas across energy and land use

Policy forecasts feed into a fully **integrated climate and nature scenario model** that elicits the impact of the forecasted policies on the energy, land use, and nature systems up to 2050, tracing detailed effects on all emitting sectors[1]

Modeling



Value drivers

IPR's integrated scenario model outputs detail value drivers across energy and land use. See Value Driver Visualizer

Applications

Fitch Ratings, Morning Star, Paris Agreement Capital Transition Assessment (PACTA), Planetrics, *tilt* (Climate data for SMEs)

1. IPR also develops a '1.5°C Required Policy Scenario'(1.5°C RPS) building on the IEA NZE by deepening analysis on policy, land use, emerging economies, NETs and value drivers. The RPS scenario is also run through the model and can be used by those looking to align to 1.5°C. 2. Urban areas are not modelled in detail in IPR

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IPR has developed global, policy-based forecasts of forceful policy responses to climate change and implications for energy, agriculture and land use

Please see the IPR Home Page for further details

Scenario	Policy Forecast Details	Open Access Database
IPR 2023 Forecast Policy Scenario (FPS) • Models impact of forecasted policies on the real economy	IPR FPS 2023 Summary Report IPR 2023 Policy Forecast IPR FPS 2023 Detailed Energy Results IPR FPS 2023 Detailed Land Use and Nature Results IPR 2023 Bioenergy Report	IPR FPS 2023 Value Drivers IPR Scenario Explorer
IPR 1.5°C Required Policy Scenario (RPS) • Required policies to align to a **1.5°C objective** building on the IEA's Net Zero scenario and deepening analysis on policy, land use, emerging economies and value drivers	IPR 1.5°C RPS Energy and Land Use System Results including Policy Details	IPR RPS 2021 Value Drivers
IPR Forecast Policy Scenario + Nature (FPS + Nature) • First integrated climate and nature scenario for use by investors	IPR 2022 FPS + Nature detailed results	IPR FPS + Nature Value Drivers

IPR has published a set of publicly available outputs from the FPS and 1.5°C RPS that offer significant granularity at the sector/country level, allowing investors to assess their own climate risk across 4,000+ variables

Disclaimer: This is not intended to constitute policy advice, financial advice or any specific advice.

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IPR 2023 forecasts higher climate policy ambition across 10 policy levers covering energy, land use, and nature

Net zero
- Interim emissions target
- Net zero CO2 long-term target

Carbon pricing
- Carbon taxes
- Emission trading systems
- Carbon border adjustment mechanisms (CBAMs)

Clean power
- Targets for a fully decarbonised electricity system
- Renewable capacity auctions
- Renewable subsidies
- Nuclear power targets and and strategies

Low-carbon buildings
- Prohibiting regulations for fossil heating systems
- Purchase subsidies for low-carbon heating systems
- Thermal efficiency regulations for buildings
- Minimum energy performance standards for new appliances

Low-carbon agriculture
- Subsidies for low-emissions practices and technologies
- Emissions regulation including via tax or cap-and-trade systems
- Farmer education and technical assistance programs

Coal phase-out
- Regulations prohibiting coal build
- Emissions performance standards
- Electricity market reforms

Zero emissions vehicles
- ZEV consumer subsidies Targets to fully decarbonise the new sales of road vehicles
- Manufacturer ZEV obligations

Clean industry
- Emissions performance standards for industrial plants
- Subsidies for new or retrofit clean industrial processes

Forestry
- Incentives for reforestation and afforestation
- Penalties for deforestation, supported by consumer pressure
- Mandates to ensure deforestation free supply chains

Nature-based solutions
- Land protection and restoration policy
- Nature incentives for landowners to protect biodiversity hotspots and habitats
- Voluntary biodiversity credit markets

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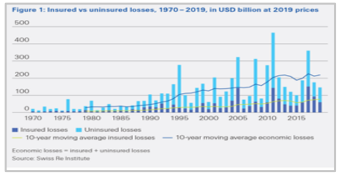
The drivers of policy momentum make an inevitable and forceful policy response more likely…social tipping points are key

Changes in physical & monetary costs

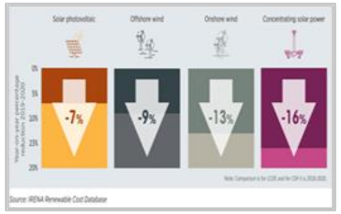
Extreme weather events

Increase in wet-bulb globe temperature

Uninsurable world



Cheaper renewable energy



Increased pressure from society, markets & regulators

Financial markets pressure for net zero

Civil society advocating for 1.5C

Financial regulator interventions

Pressure for global institutions to support EDMEs transition

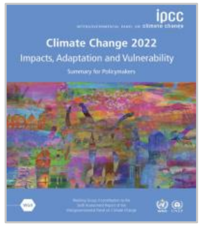
Changes in geopolitics, energy security and research

US IRA impact on industrial policy

Impacts on security

Improved climate collaboration

New climate research



Ratchet pressures increase the likelihood that governments will strengthen policy by 2025, and again to 2030 and beyond

Paris Ratchet process triggers a cumulating policy response into 2025, 2030, and beyond

2021	2023	2025	2028	2030
Countries communicate their updated or 2nd round of climate pledges	Global Stocktake (GST) on climate, mitigation, and finance	**2025 Ratchet** Countries submit their 3rd round of climate pledges (NDCs)	Second Global Stocktake (GST) on climate, mitigation, and finance	**2030 Rachet** Countries submit their 4th round of climate pledges (NDCs)

Policy announcements are expected to continue in 2023 -2025, with continued acceleration in 2028-2030. Recognition of Overshoot grows from 2025

COP28 UAE

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Energy system executive summary (1/2)

System-level results and key findings

- Energy system emissions plateau in the early 2020s and fall about 75% by 2050 in the Forecast Policy Scenario (FPS)
- Advanced Economies (AEs) reach near-zero emissions by 2050 while emissions fall by 60% in Emerging and Developing Economies (EMDEs)
- Clean sources grow to over 60% of the energy mix by 2050 and global peak oil occurs in the mid 2020s. Demand for oil as a fuel declines significantly from 2030 but, the use of oil as a feedstock for chemicals continues
- Energy system policies have remained similar to those in FPS 2021 – none have changed in a way that shifts our projected timeline by more than 5 years
- Power and transport drive 76% (21GtCO_2) of emission reductions to 2050 while industry is latest to decarbonize. In the FPS, zero-emission vehicles (ZEVs) reach almost 90% of the car fleet by 2050
- ~5 GtCO_2 are captured by 2050 in FPS23, a third of which is from negative emissions technologies
- Clean hydrogen becomes a major energy source, with demand from steel and chemicals, synfuels for shipping and aviation, and flexible power generation
- Bioenergy grows moderately to 2050, with a shift toward sustainable feedstocks fulfilling demand in aviation and biomass energy with carbon capture and storage (BECCS)
- A range of other highly uncertain but disruptive trends could shift the world to a future unlike that modelled in the FPS

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Energy system executive summary (2/2)

Power

- Decarbonization of power generation, led by Advanced Economies, is a critical enabler of lower emissions in final energy consumption
- In the FPS, the remaining fossil fuel generation is dominated by emerging markets and developing economies (EMDEs), where policy trajectories result in slower phase down relative to Advanced Economies (AEs)
- By 2045, China retires 60% (800GW) of its unabated coal fleet, fits 100GW with carbon capture and storage (CCS) and keeps the “economically stranded” remainder in reserve
- Wind and solar account for around 70% of global electricity generation by 2050. They are complemented by nuclear and hydropower which generate over 15% of electricity
- In the FPS, most AEs achieve clean power by 2040, while unabated fossil remains in some EMDEs in 2050

Transport

- In the FPS, road transport decarbonises 90%, while shipping & aviation account for 70% of sector emissions by 2050 despite having shifted to 50% zero carbon fuels
- China and Advanced Economies currently dominate zero-emission vehicle (ZEV) sales, but by the mid-century Sub-Saharan Africa (SSA), India and other EMDEs make up 45% of sales
- In the FPS, ZEVs therefore reach almost 90% of the car fleet by 2050

Industry

- Scrap becomes the crucial decarbonisation lever in steel, while virgin steel is increasingly produced with hydrogen (H_2). Cement begins to decarbonize at scale in the 2030s, with a combination of zero carbon clinker and CCS
- Fossil fuels remain a core feedstock for chemical production, although electrification and hydrogen help to decarbonize industrial heating
- Policy support enables green H_2 build-out, with blue H_2 only competitive in certain regions with favourable conditions

Buildings

- In the FPS, increased efficiency of both building envelopes and electrical heat pumps reduce emissions from 2030
- New net zero buildings only account for around 30% of 2050 stock as large scale retrofitting of existing buildings takes place steadily to 2050
- Efficient electric heat pumps replace fossil heating systems from the 2020s to provide 60% of building heat by 2050, with bioenergy and hydrogen playing a role

Bioenergy & Removals

- FPS23 covers bioenergy used in transport and buildings, as well as bioenergy with carbon capture and storage (BECCS) used in power and industry to provide negative emissions
- Bioenergy is a long-term decarbonisation option in aviation and some niches uses, while the need for removals in the FPS justifies expensive bioenergy with carbon capture and storage (BECCS)
- The FPS includes 0.6 Gt of direct air carbon capture and storage (DACCS) by 2050, predicated on a significant cost reduction as removals ramps up

The FPS 2023 is driven by IPR's high-conviction policy forecast, to provide high-conviction forecasts on the speed and scale of the energy and land transition compared to a stated policy baseline

	IEA STEPS (from WEO 2022)	IPR Forecast Policy Scenario (FPS) 2023
Objective of modelling	To provide a benchmark to assess the potential **achievements and limitations of recent developments** in energy and climate policy.	To assess portfolio risks and opportunities associated with the **policies that are driving and are likely to drive** the energy transition.
Approach to modelling	STEPS is the **Stated Policies Scenario**, which reflects **current policy and any under development** across sectors and countries, considering what is likely to be achieved. For time-limited policies, **no future change in stringency is considered** and STEPS **does not take a long-term view** on these policies.	FPS 2023 uses an **evidence- and data-driven policy forecasting method** to **explicitly model government behaviour** on key policy levers across sectors. **Policies change over time** at rates consistent with the evidence base. This aims to model a **realistic and investible view of the world** rather than a cost-optimal view (see policy report for further details)
Illustrative example	Existing **bioenergy policies would not change in stringency or direction in the long-run.** This leads to progressively higher bioenergy take-up, as **policies do not create cheaper alternatives**, such as reductions in DACCS costs which substitutes for BECCS.	Governments become **better informed about the energy and land system trade-offs** associated with the use of bioenergy, and **change direction away from bioenergy in the long-run,** including via DACCS for removals and other renewables in the energy mix.

Source: IEA World Energy Outlook 2022, IEA Global Energy and Climate Model documentation

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Overview

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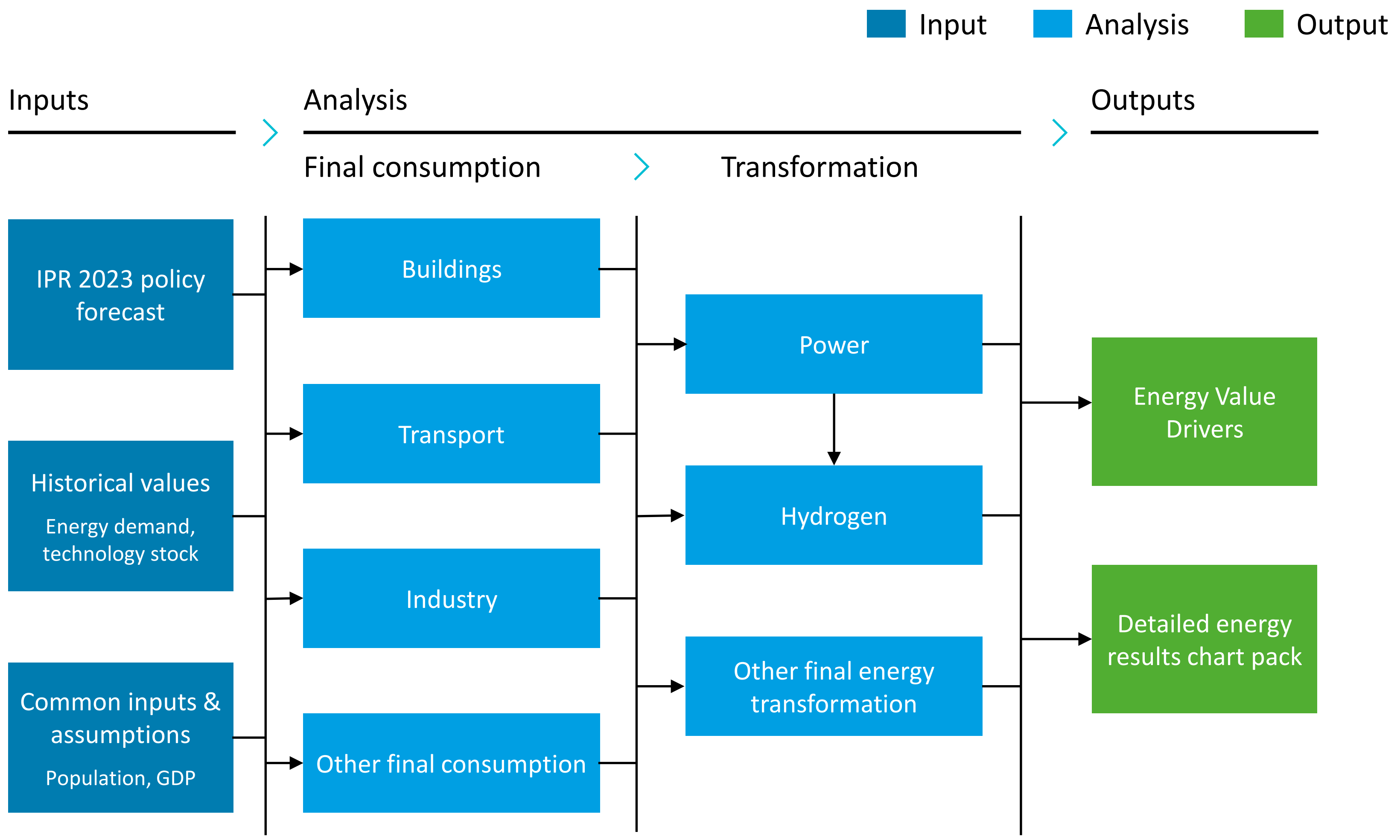
The IPR energy system model covers 7 sectors, 21 regions, 30 years and 20+ variables



- The IPR 2023 policy forecast constrains the energy system analysis
- Population and GDP determine sector demand
- The technology mix is informed by least cost optimisation models and considers both stocks and flows based on historical values
- Outputs cover 21 regions, 30 years and 20+ variables including energy demand, emissions, deployment, capacity and production

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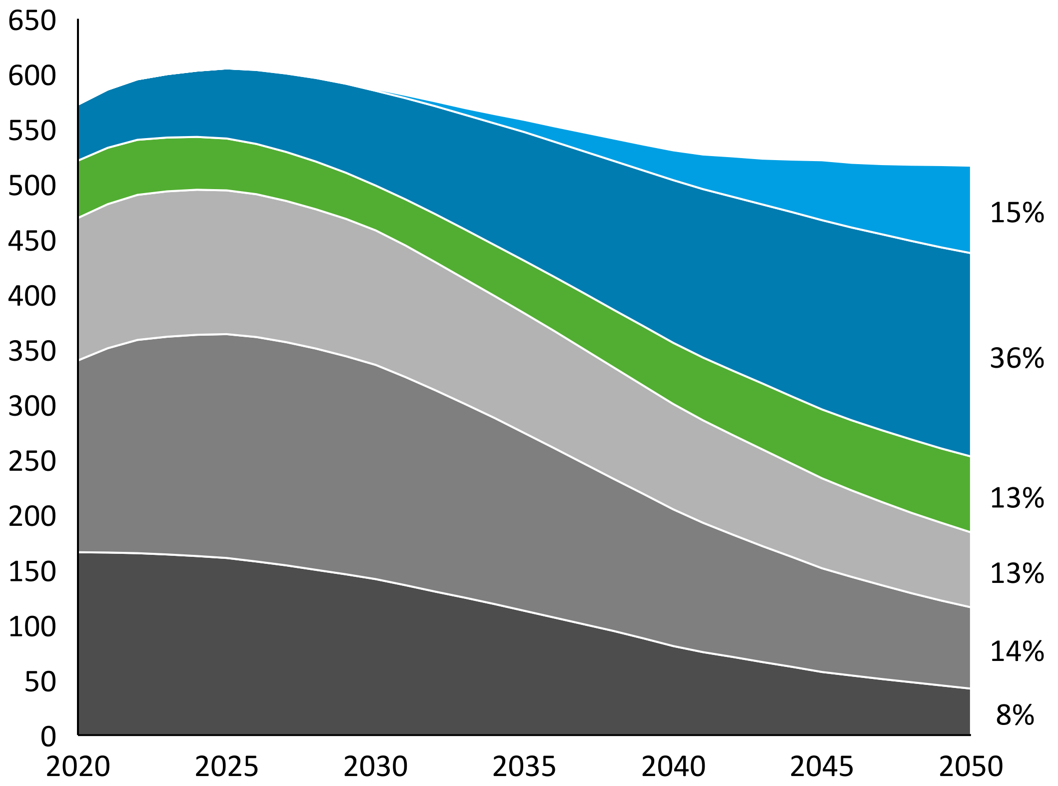
Energy demand in FPS 2023 is similar to FPS 2021 but has slightly more renewables and slightly less bioenergy and hydrogen

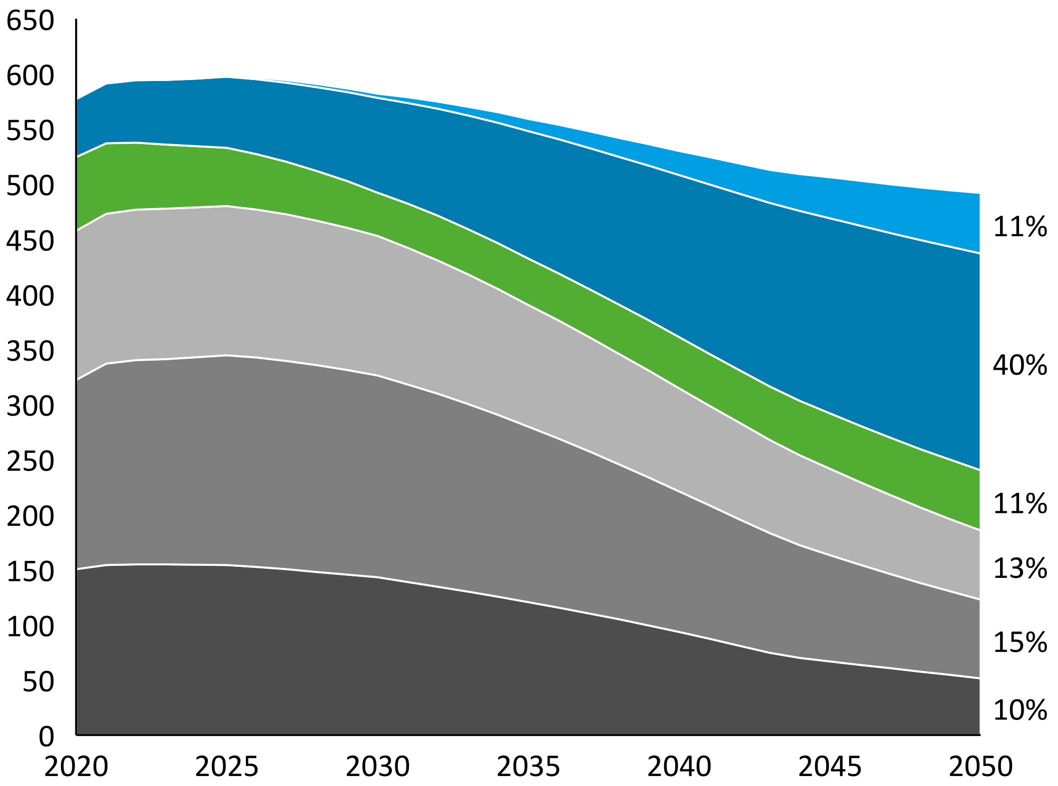
Global primary energy demand, EJ

Coal | Oil | Natural gas | Bioenergy | Renewables & Nuclear | of which hydrogen production

FPS 2021



FPS 2023



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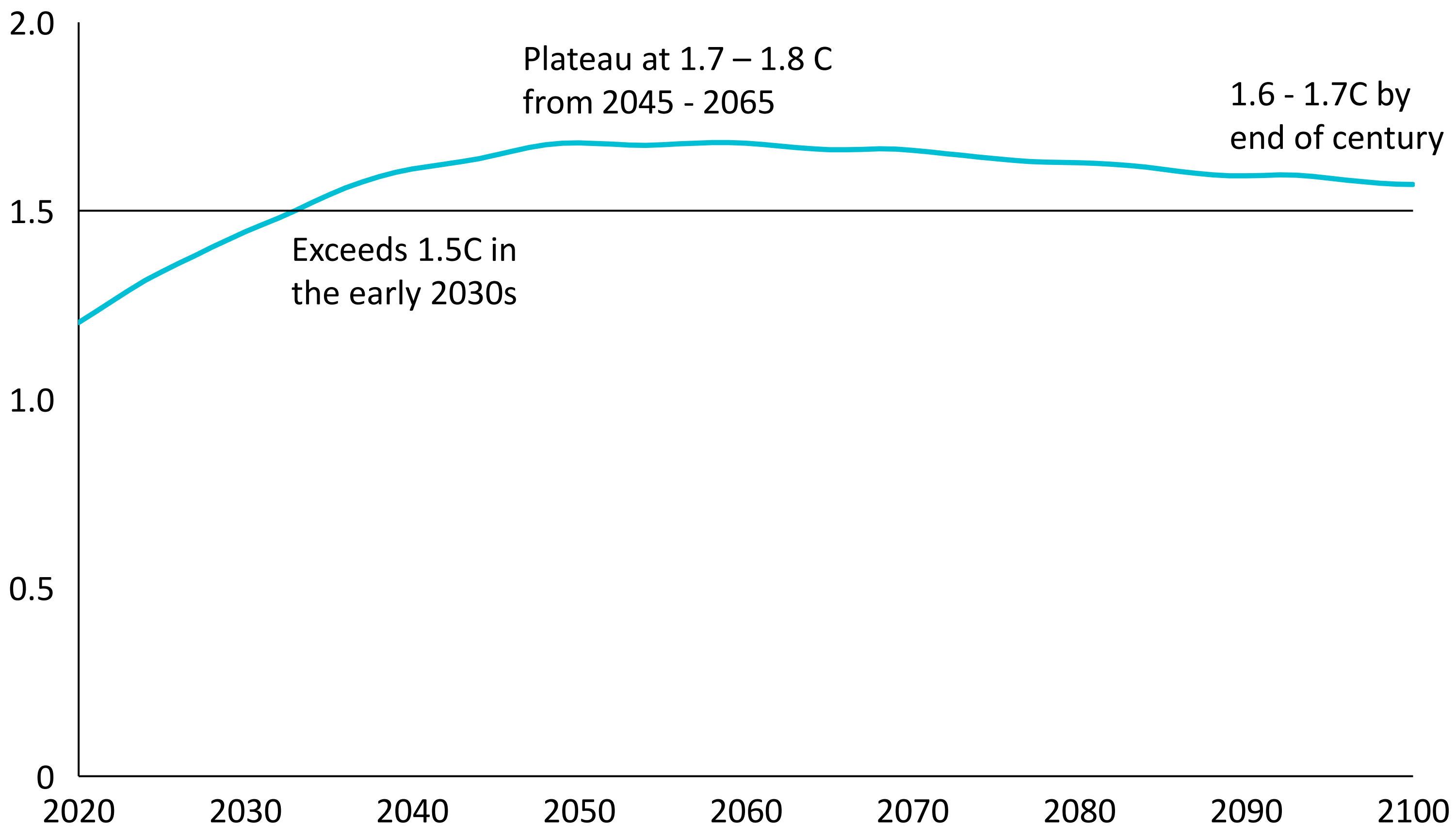
FPS 2023 forecasts peak temperatures of 1.7-1.8C around 2045, dropping to 1.6-1.7 C by 2100 if DACCS continues

Surface temperature anomaly, degrees C above pre-industrial reference period[1]



1. The pre-industrial reference period is 1850 to 1900, defined in Kelvin. Temperature anomalies in Kelvin and Celsius are equivalent.
2. Based on MAGICC 7
3. Assuming only impact of continuation of DACCS levels

IPR FPS 2023 forecasts[2]

- An exceedance of 1.5C in the early 2030s
- Peak temperatures of 1.7 - 1.8C around 2045 - 2065
- A decline to 1.6 – 1.7C by 2100 and 1.5C by 2130[3], based on direct air carbon capture and storage (DACCS) deployment estimates
- Net-zero CO_2 emissions around 2060 and net-zero GHG emissions around 2080
- Overall likelihood of staying below 2°C warming is at >90%

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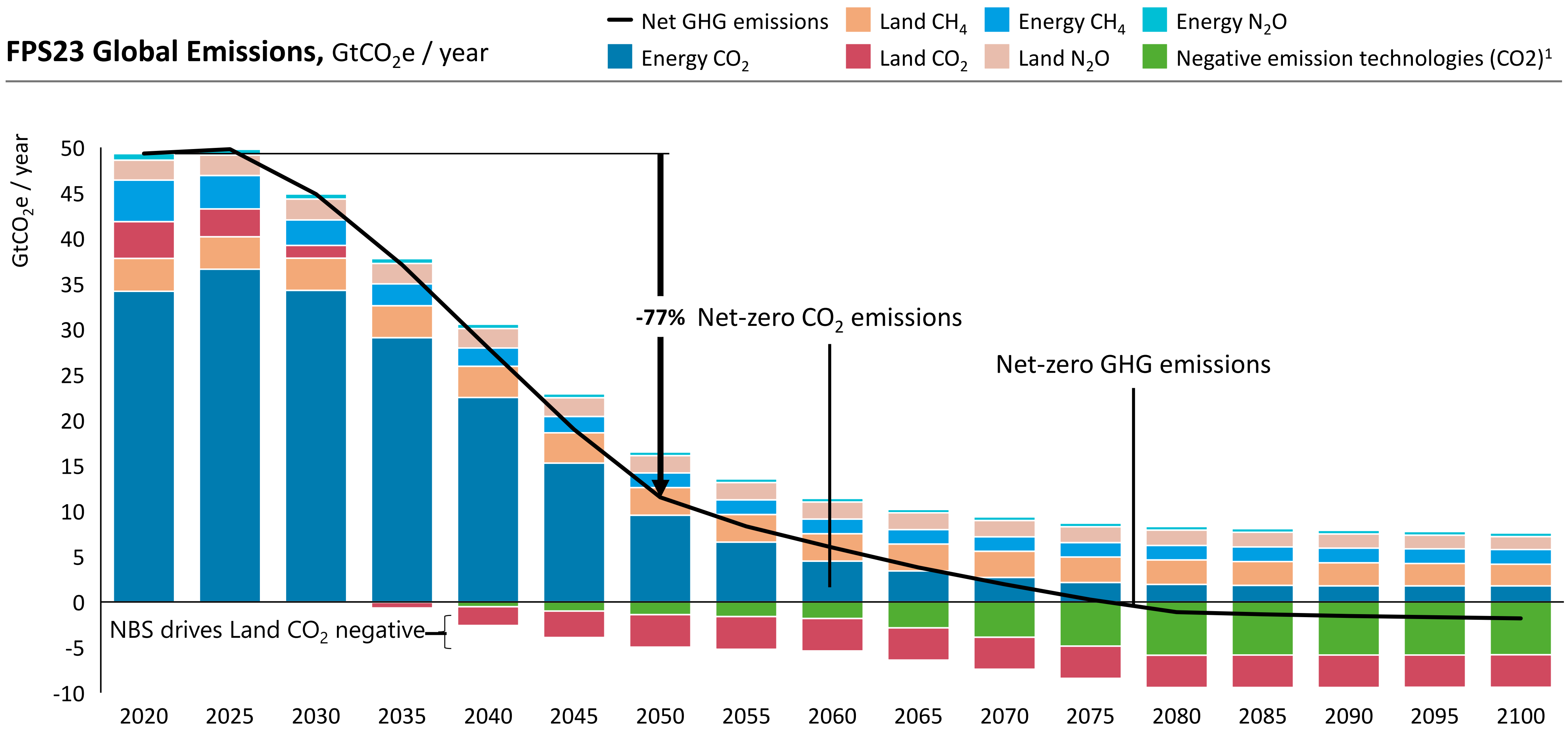
Greenhouse gas emissions drop 80% by 2050 and reach net-zero by 2080, but only because negative emissions technologies remove 6 $GtCO_2$ per year by 2080

FPS23 Global Emissions, $GtCO_2e$ / year



1. Direct air carbon capture and storage (DACCS) and Bioenergy with carbon capture and storage (BECCS)

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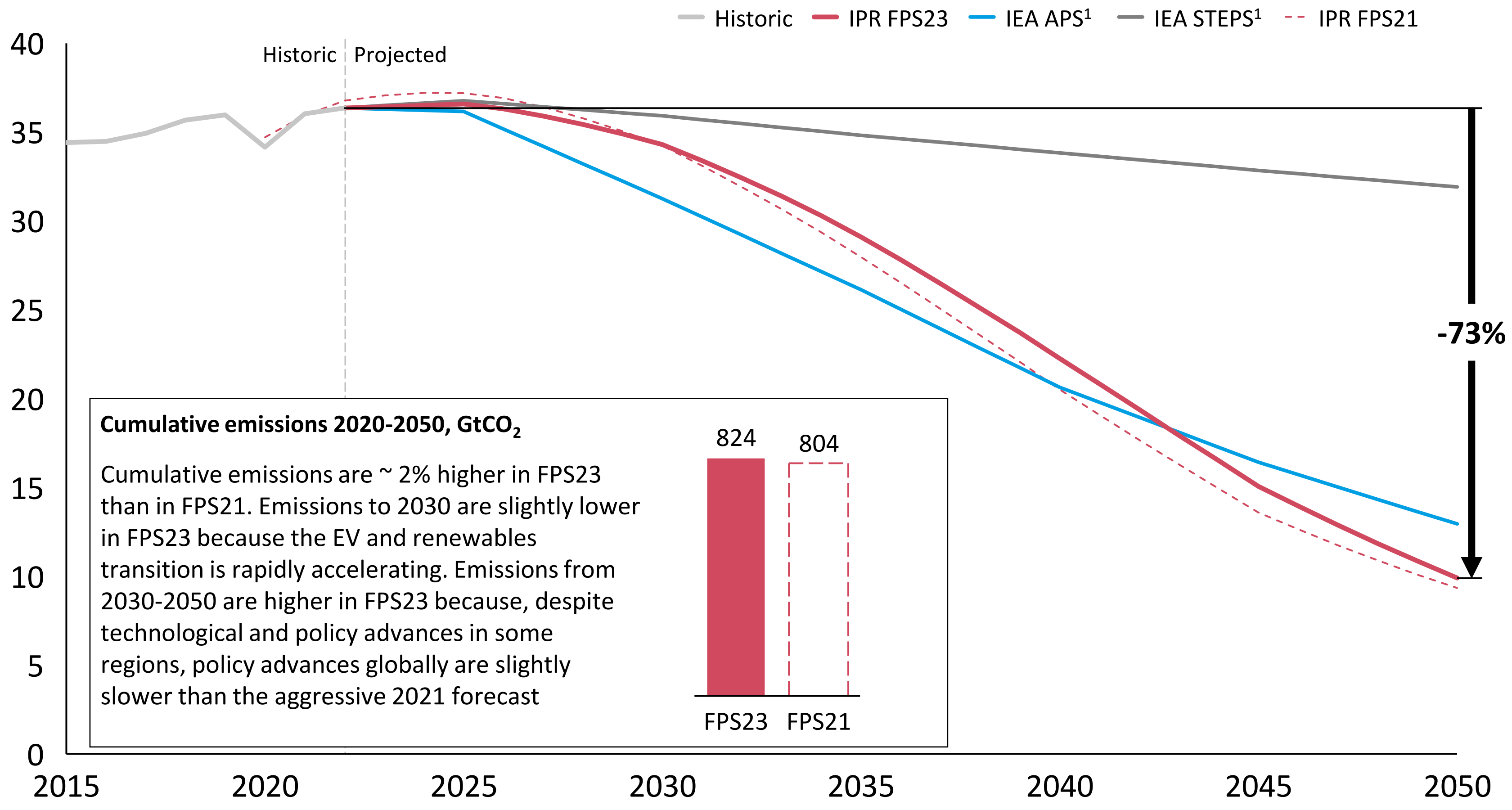
Energy system emissions plateau in the early 2020s but fall about 75% by 2050 in the FPS 2023

Global energy-related CO_2 emissions, $GtCO_2$/year



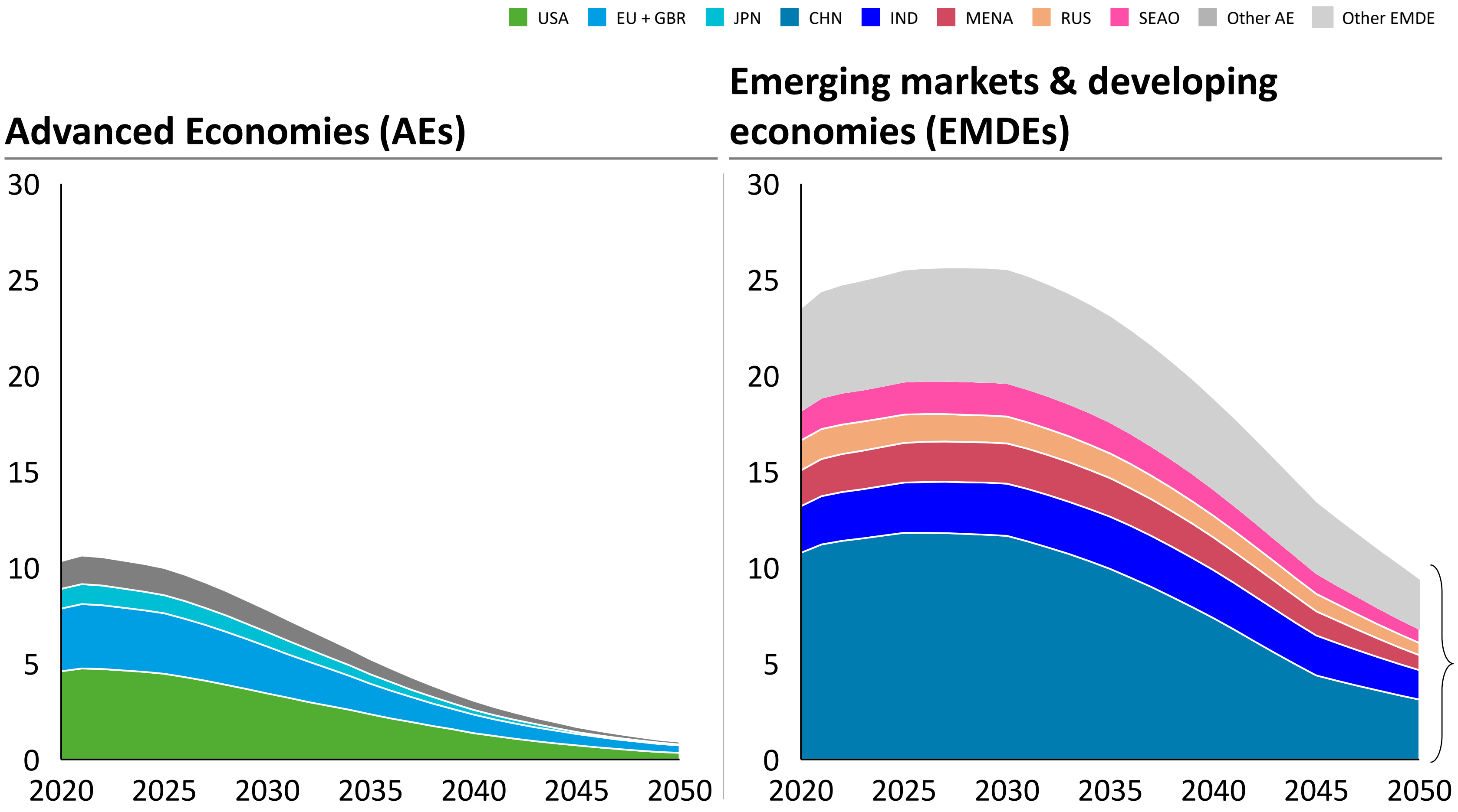
1. IEA data published in 5-year intervals and 2025 data unavailable, linear interpolation may not reflect differences with IPR

Source: IEA World Energy Outlook (WEO) 2022

- In the early 2020s, **energy-related CO_2 emissions in the FPS plateau**, following a similar pathway to IEA scenarios
- Although emissions are higher than APS through the 2030s, FPS23 is a slightly lower temperature scenario than APS. Decarbonization policies push the FPS23 trajectory lower then APS by the 2040s and FPS 2023 may also have higher land carbon sequestration from land
- As **policies ratchet up further, emissions fall below the IEA APS** level in the early 2040s, driven in part by a significant ramp up in emissions removals to around 5Gt p.a. by 2050. Emissions fall a total of 73% between 2022 and 2050

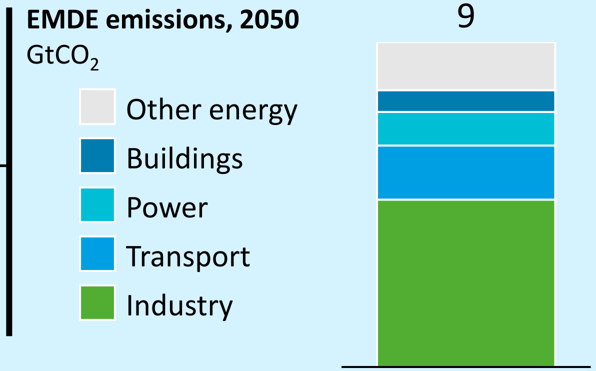
Advanced Economies reach near-zero CO_2 emissions by 2050 with substantial emissions in Emerging and Developing economies

Energy-related CO_2 emissions[1] by region, $GtCO_2$/year



1. Emissions on a production basis. Includes carbon removals from BECCS but not DACCS

- Except for the uptick in emissions following the recovery in activity post-COVID, **AEs see CO_2 emissions fall rapidly** to near-zero by 2050. **AEs could reach net-zero energy** emissions with CO_2 removals from DACCS (not shown)
- In EMDEs, **emissions continue to grow throughout the 2020s** due to growing population and incomes. **They still emit 9 $GtCO_2$ in 2050** mainly from industry. Even easier-to-decarbonize sectors like power and transport do not do so fully



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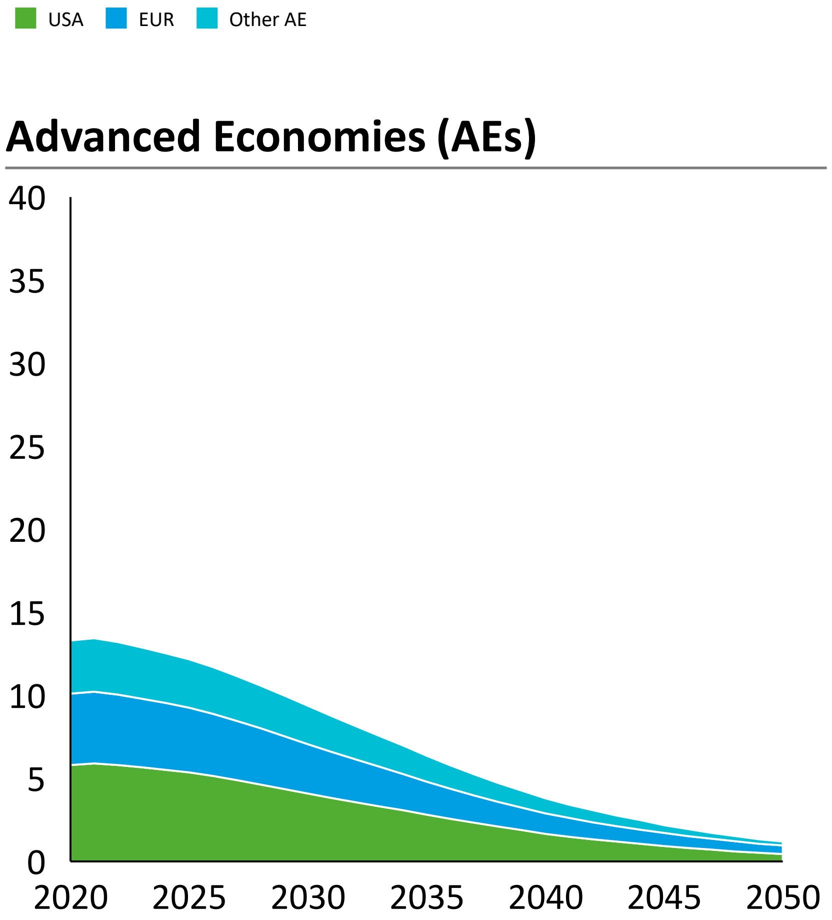
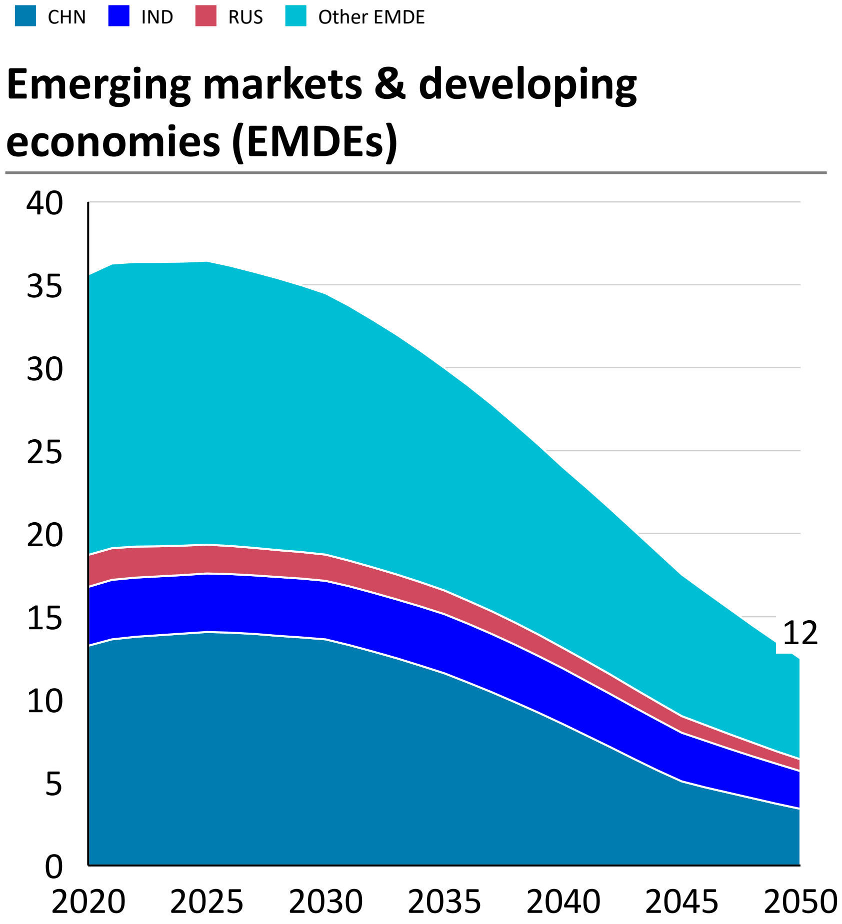
Advanced Economies reach near-zero GHG emissions by 2050, with substantial emissions in Emerging and Developing economies

Energy and Land GHG emissions[1] by region, $GtCO_2e$/year

Advanced Economies (AEs)



Emerging markets & developing economies (EMDEs)



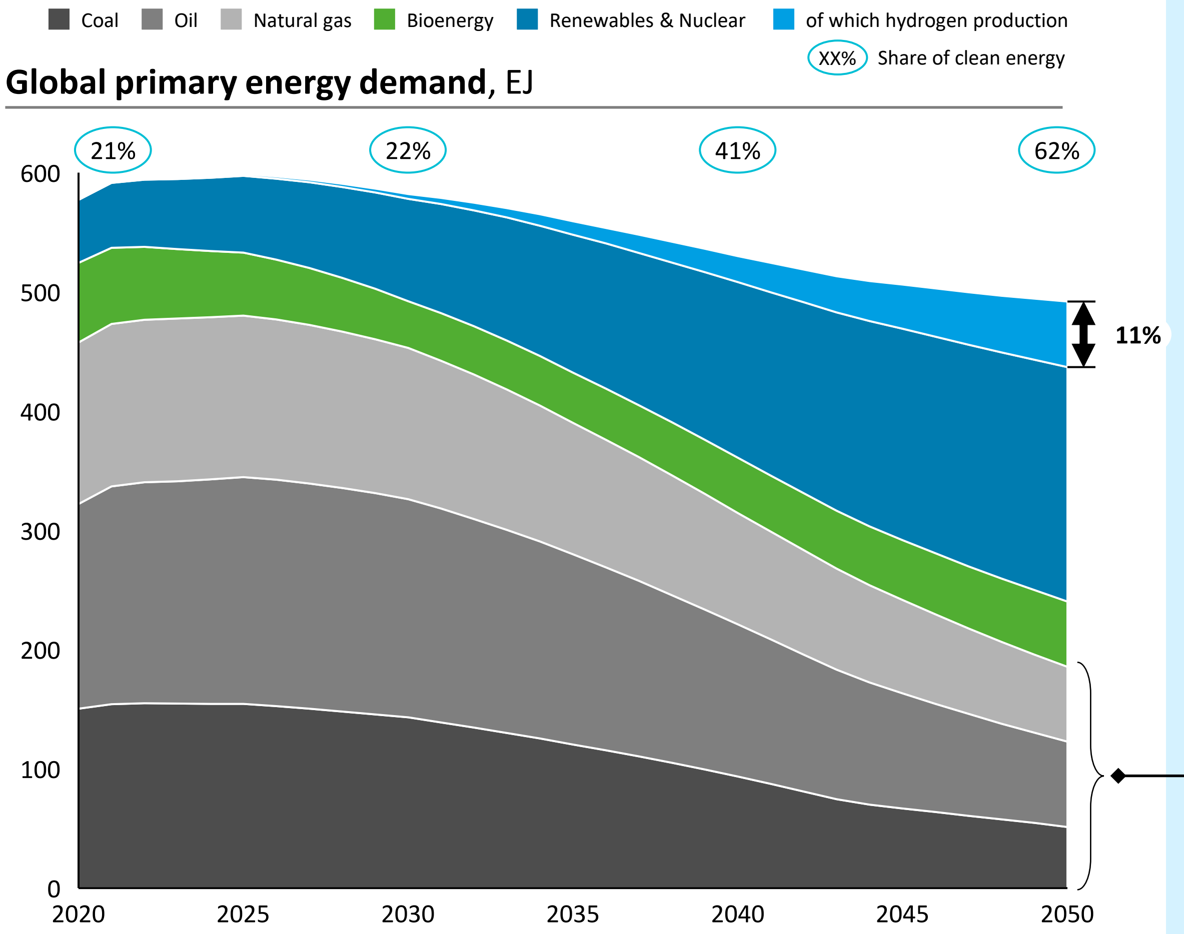
1. Emissions on a production basis. Includes carbon removals from BECCS but not DACCS

- Except for the uptick in emissions following the recovery in activity post-COVID, **AEs see GHG emissions fall rapidly** to near-zero by 2050. **AEs could reach net-zero energy** emissions with CO_2 removals from DACCS (not shown)
- In EMDEs, **emissions continue to grow throughout the 2020s** due to growing population and incomes. **They still emit 12 $GtCO_2e$ in 2050** mainly from industry. Even easier-to-decarbonize sectors like power and transport do not do so fully
- Emissions reductions in both AE and EDME land systems are driven by NBS

Clean sources grow to over 60% of primary energy demand by 2050…

~ 10% of primary energy is used to produce green hydrogen

Global primary energy demand, EJ

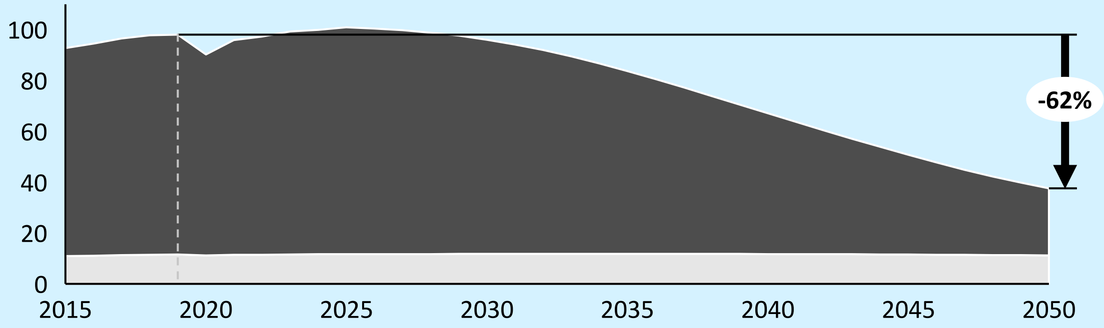


…while global peak oil could occur as soon as 2025

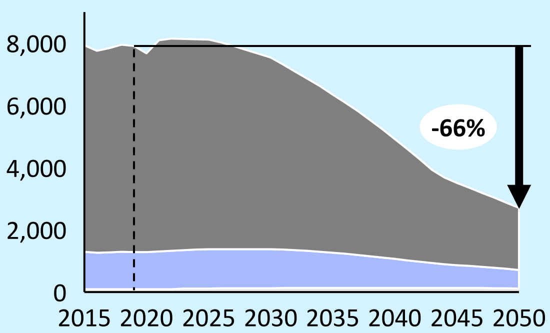
All fossil fuels decline following a mid-2020s plateau

XX% % change 2019-50 | Energy use | Non-energy use | Metallurgical coal[1]

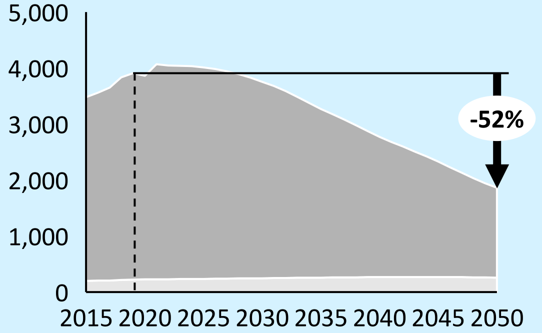
Global oil demand, million barrels per day



Global coal demand, Mt



Global natural gas demand, bcm



1. Metallurgical – or coking – coal is used in the production of steel, and acts as both a fuel for high temperature process heat and as a reactant in the reduction of iron ore

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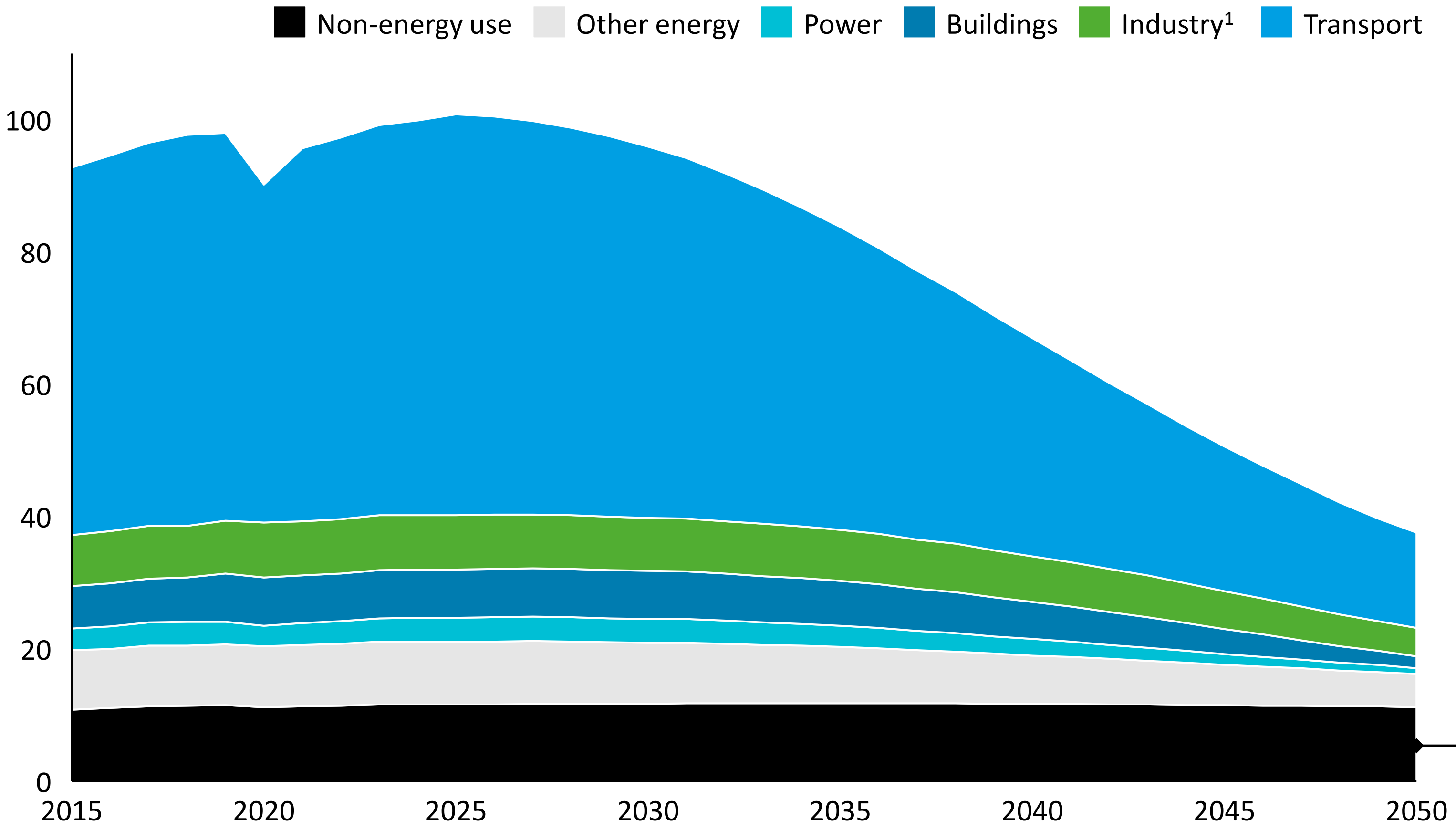
Oil demand declines significantly from 2030, but the use of oil as a feedstock for chemicals continues

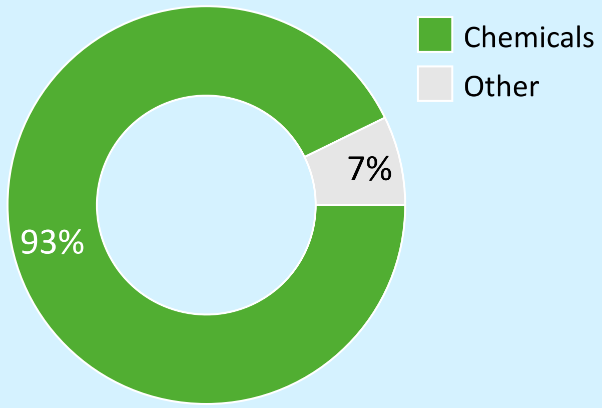
Non-energy use accounts for 10% of demand in 2020 but almost 30% in 2050

Global oil demand, million barrels per day



- The rise of EVs reduces oil demand for transport by over 70% from 2020 – 2050. By 2050, oil is still used for aviation and shipping
- However, because industrial decarbonization is slow, oil remains the main feedstock used for chemicals

Non-energy oil demand, 2050
million barrels per day

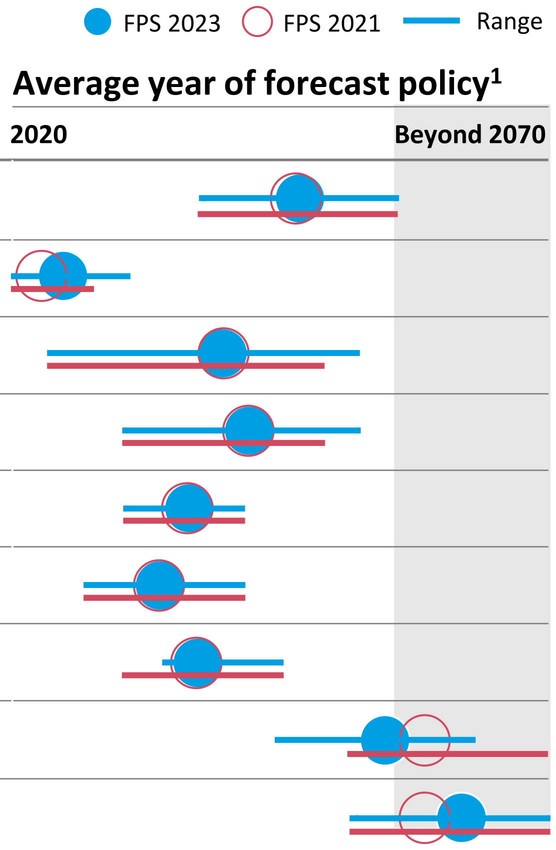


1. Oil used as a fuel to heat industrial processes: "energy use". Excludes "non-energy" use of oil as a feedstock

Energy system policies have remained similar to those in FPS 2021 – none have changed in a way that shifts our projected timeline by more than 5 years

Industry and new coal are the policy areas with the largest changes compared to FPS 2021

Policy Area	Policy Lever	Key Policy Changes relative to FPS 2021
CO_2 emissions	Net Zero CO_2	India decelerated to a net zero target of 2065[3]
Power	New coal	China continues to build new coal until 2030
	All coal	EU ends coal generation slightly sooner
	Clean power	UK and Indonesia accelerated relative to FPS 2021, South-East Asia and South Africa decelerated
Buildings	Heating	Central & South America and South Africa decelerated to 2045 and 2050 respectively
Transport	LDVs	Gulf States accelerated ICE phase out for both LDV and HDV, while Russia, Eurasia and Indonesia all decelerated. UK HDV target has been decelerated to be in line with other AEs and Brazil also decelerated
	HDVs	
Industry	Fuel	The decarbonisation of industry fuel emissions has been brought forward relative to process emissions, but industry remains the latest sector for forecast policies to decarbonize
	Process	



1. Average year policy of forecast to be achieved, weighted by current sectoral emissions for each modelled region
2. Including direct air carbon capture and storage (DACCS) negative emissions
3. Only USA, India and Australia net zero announcements were forecast in FPS 2021

Note: See appendix for further detail on policy forecasts by modelled region

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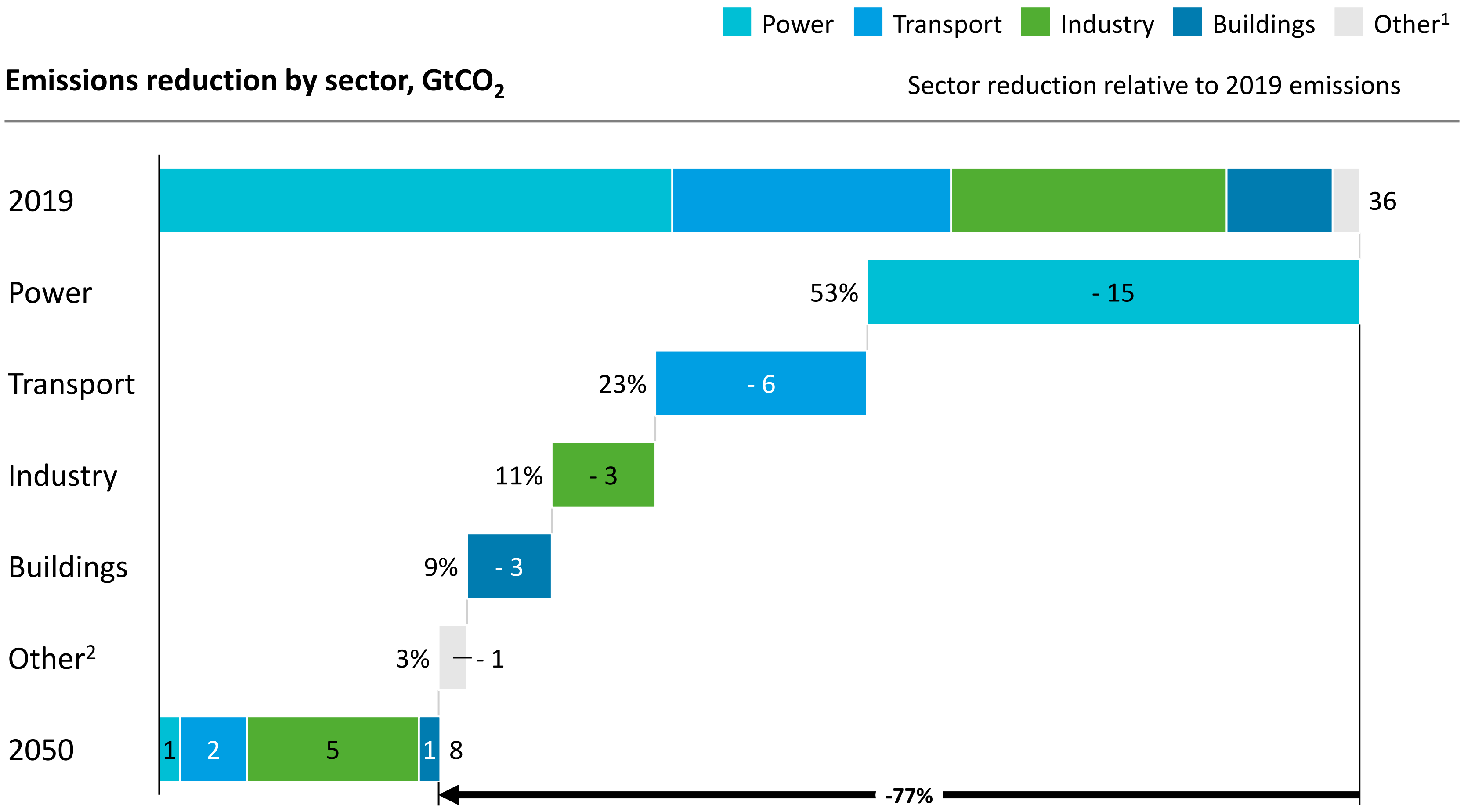
75% (21GtCO_2) of emission reductions to 2050 come from power and transport, while industry is latest to decarbonize

Power and transport are the first sectors to decarbonize in FPS 2023

Emissions reduction by sector, GtCO_2

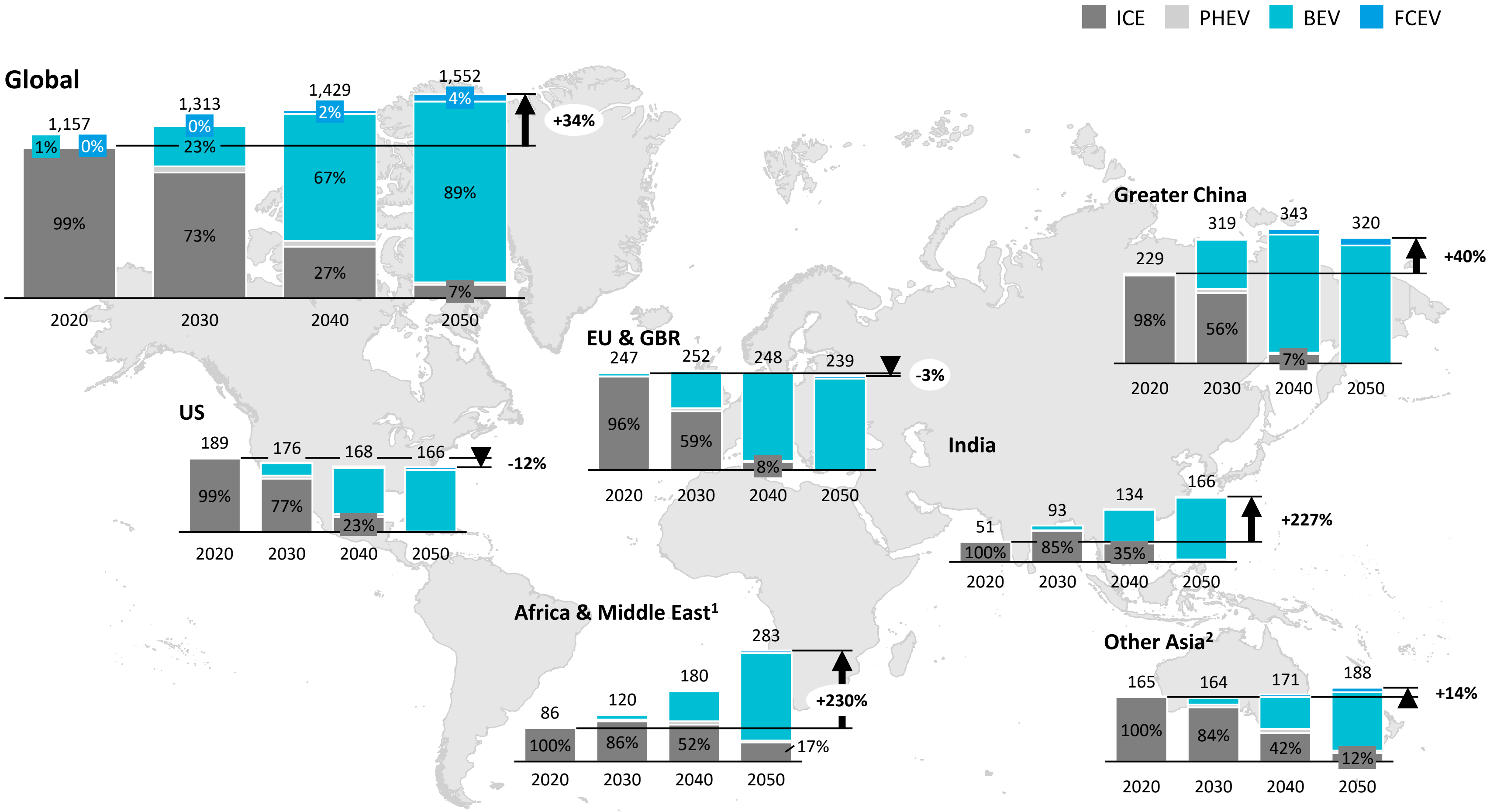


- The decarbonisation of power enables other sectors to then abate emissions through higher electrification
- The transport sectors also decarbonises quickly and significantly with AEs already reducing emissions today
- Harder-to-abate emissions in industry and buildings are tackled through a mix of policy support, emerging technologies, and improved efficiencies

1. Includes removals from DACCS

In the FPS, zero-emission vehicles (ZEVs) reach over 90% of the car fleet by 2050

Passenger car fleet, millions



1. SSA, SAF, MENA
2. AUS, JPN, KOR, IDN, SEAO, SA, EURA

- **Car numbers in Africa and India more than triple** to 2050, while absolute numbers fall in the US and Europe
- China and Europe are almost fully decarbonised by 2040, after which the **majority of remaining ICE vehicles are in EMDEs**
- Pure **battery electric vehicles are the dominant technology,** however plug-in hybrid vehicles initially and later hydrogen fuel cell vehicles gain a small share in market segments with large travel distances

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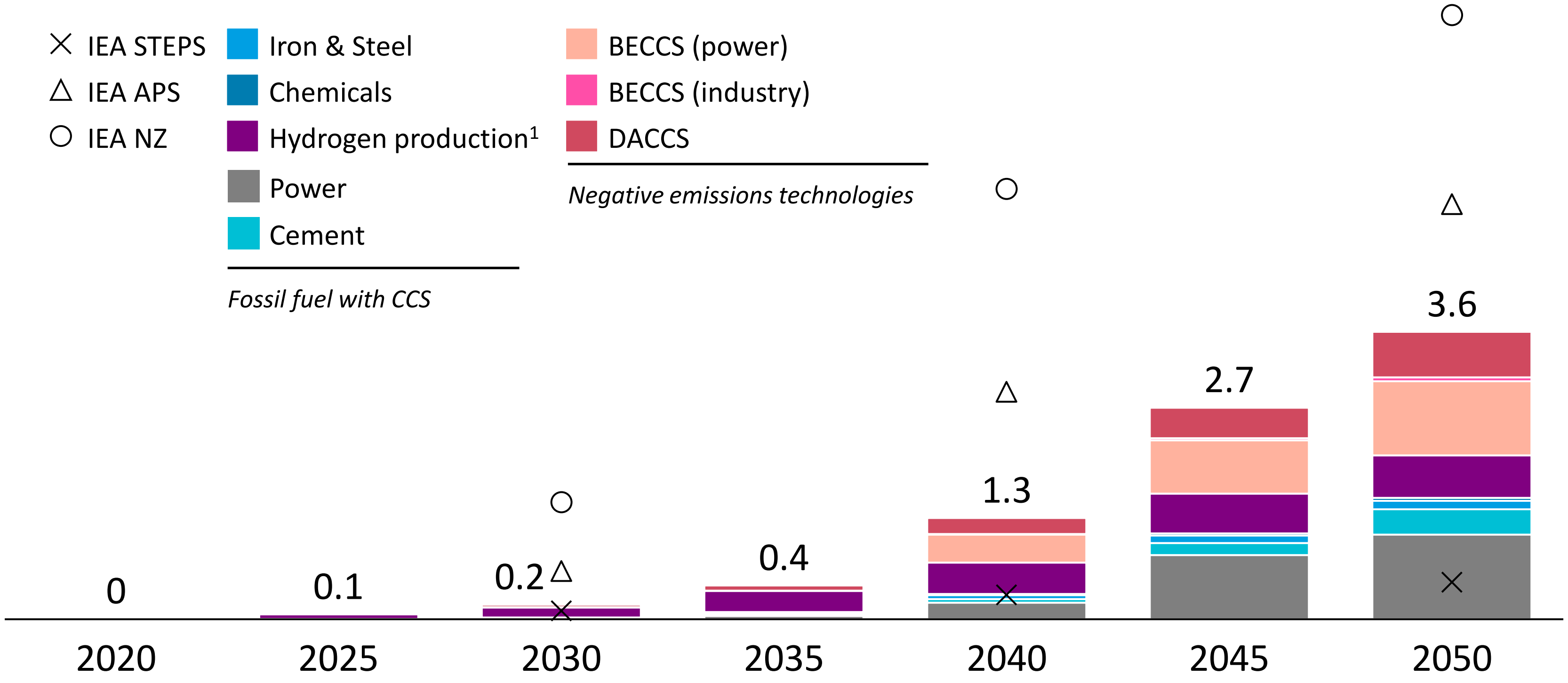
Over 3 $GtCO_2$ are captured by 2050 in FPS 2023, a third of which is from negative emissions technologies

Carbon dioxide captured by CCS removed by BECCS and DACCS, $GtCO_2$



1. Not including that used in ammonia and methanol production

Source: IEA WEO (2022)

- Carbon capture and storage (CCS) and removals in the FPS is comparable to the IEA APS, where policy requires hard-to-abate sectors to reduce their emissions
- In FPS, a larger uptake of Direct Air Carbon Capture & Storage (DACCS) happens in the 2040s when stakeholders act to accelerate towards net negative emissions, even while industrial sources are slower to decarbonize

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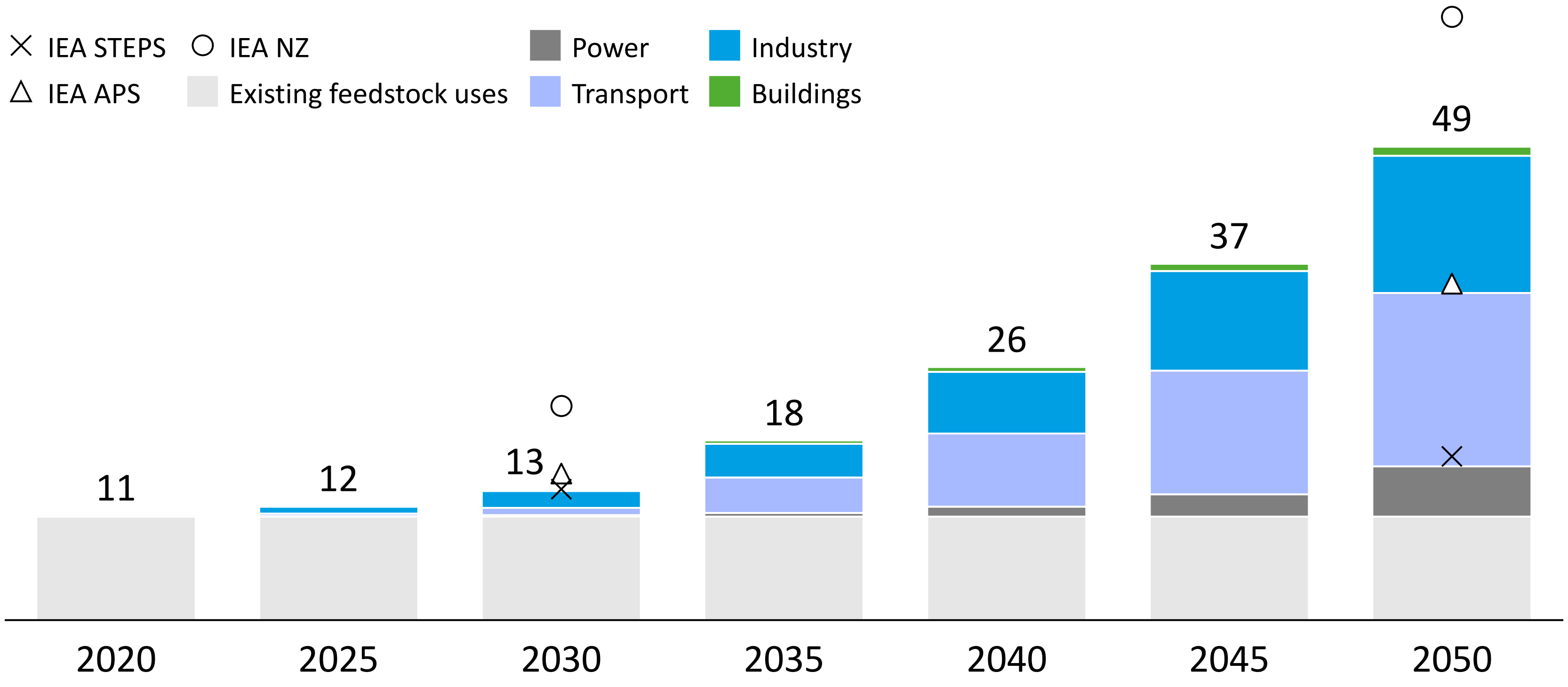
Clean hydrogen demand comes from synfuels for aviation and shipping, steel production and flexible power generation

Hydrogen demand by sector, EJ



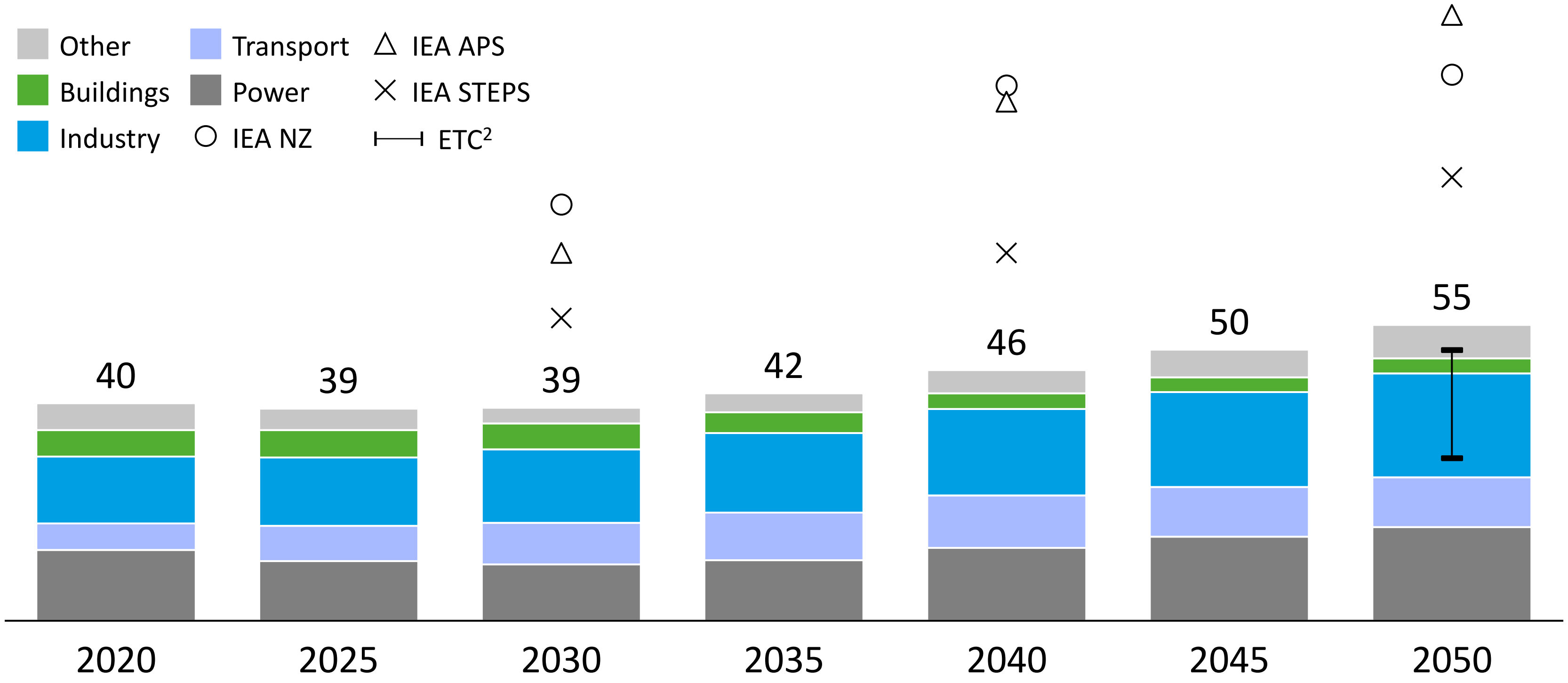
Source: IEA WEO (2022)

- Before the 2030s the FPS sees limited growth in H_2 demand, mainly in the 'traditional' chemicals sector
- More meaningful growth occurs when new industrial uses, and particularly synthetic non-road transport fuels begin to scale
- Compared to IEA scenarios, FPS sees more synfuels (as an alternative to more biofuels), and a marginally greater role in the power mix

INEVITABLE POLICY RESPONSE

Biofuels in aviation and biomass power transitioning to BECCS moderately increase bioenergy use from 2020 to 2050

Modern[1] primary bioenergy demand by sector, EJ



1. Traditional biomass used in cooking and heating is not included, and assumed to phase out by 2030 in line with SDG
2. An estimate of the global supply of sustainable biomass that could be available to the energy system. This range reflects a 'prudent' estimate, achievable without major changes to land use, technology or behaviour. ETC's 'maximum potential' case, with extremely ambitious systems change leads to a supply of c.100EJ – just enough to satisfy IEA NZ demand

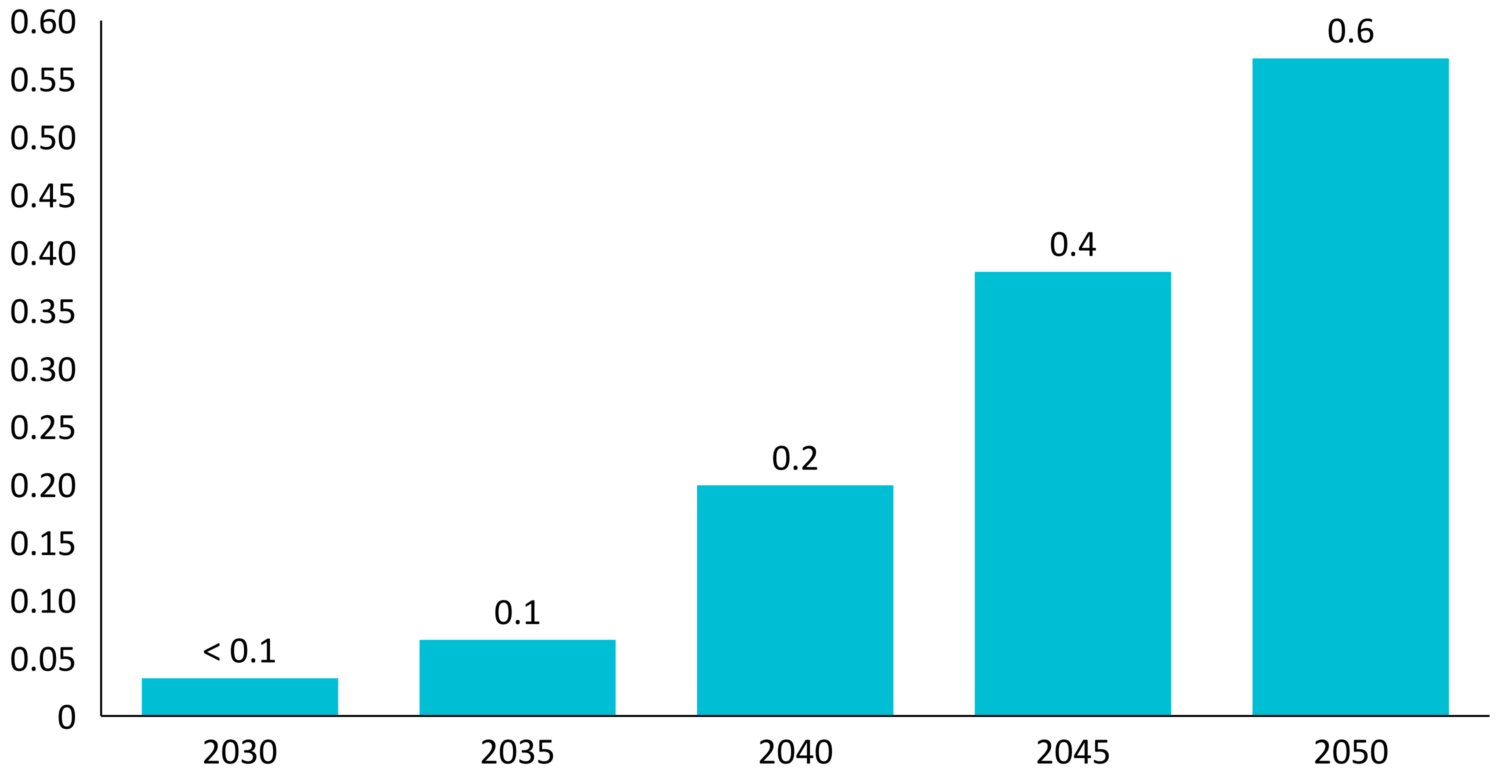
Source: IEA WEO (2022); Energy Transition Commission (2021), Bioresources within a Net-Zero Emissions Economy

- Energy system scenarios like the IEA's are often predicated on ambitious availability of sustainable biomass
- The FPS limits long-term demand primarily to use cases with few green alternatives, given the competition for land and biomass across both land & energy systems
- More details on the role of bioenergy are available in the bioenergy report

INEVITABLE POLICY RESPONSE

FPS 2023 includes 0.6Gt of DACCS by 2050, predicated on a significant cost reduction as removals ramps up

Global DACCS carbon removals, 2030-2050, $GtCO_2$/year



- **FPS 2023 sees DACCS reach 0.6 $GtCO_2$/year by 2050**, predicated on near-term demonstration DACCS sites, which move the technology along the learning curve in the 2030s and **reduce costs to as low as $150/$tCO_2$**
- By the 2040s, **growing demand for removals and lower costs drives rapid uptake**
- Removing 0.6 $GtCO_2$ in 2050 would require 2 - 5 EJ of power, or an **additional 1-2% of FPS 2023 global power demand**[2]
- At the lower end of the cost range, DACCS removals would **cost around $100 billion annually by 2050**
- **DACCS wins over BECCS in the long run once land costs are taken into consideration**

1. Value for energy demand per tCO2 captured taken at the lower bound of values reported by the National Academy for Sciences

Source: IEA, National Academy for Sciences

INEVITABLE POLICY RESPONSE

There are a range of other highly uncertain but disruptive trends which are not explicitly modelled

Transformative technologies and behaviour present uncertainty in future demand and supply within the global energy system. Four trends with high disruption potential are:

IILLUSTRATIVE, NOT EXHAUSTIVE

Generative AI & Automation

Rethinking work

- Artificial intelligence has the potential to reshape how work is done, with significant implications on society and energy systems
- For example, **AI-powered grids** could optimize power grids and boost renewable penetration, while **automation** could lead to increased leisure time, with impacts on energy consumption

A changing social order

Rethinking social structures

- The increasing importance of critical minerals to the energy transition is leading to **shifting global supply chains**, with potential geopolitical implications
- A potential realignment towards **multipolar blocs** could change demand and trade patterns, as well as impact the ability of global and local institutions to enact a just transition

Behavioral shifts

Rethinking mobility & consumption

- **Mobility-as-a-service** and **connected autonomous vehicles** could transform road transport and upend ownership models
- Consumer-led demand changes could drive shifting energy consumption – for example the rise of **remote working** and the resurgence of '**flight shaming**' following a period of post-COVID 'revenge travel'

Enhanced geothermal

Rethinking clean power

- **Enhanced geothermal power could provide clean baseload power** to complement intermittent renewables. According to the National Renewable Energy Laboratory, it could generate ~ 10% of US electricity by 2050[1]
- However, to become a viable solution, it still needs further technology innovation, and market and policy support

1. National Renewable Energy Laboratory, 2023, Enhanced Geothermal Shot Analysis for the Geothermal Technologies Office

Source: McKinsey Global Institute (2022) 'On the cusp of a new world order?'

INEVITABLE POLICY RESPONSE

Overview

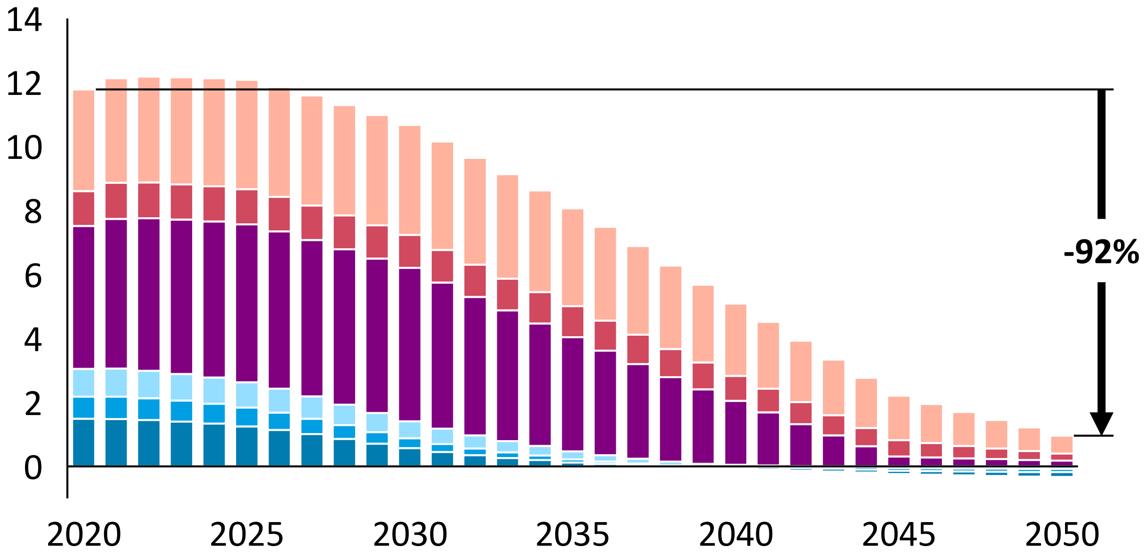
Decarbonization of power generation, led by Advanced Economies…

FPS sees power emissions reduce over 90% by 2050, with Advanced Economies net negative emission by 2040

USA | EU & GBR | Other AE | CHN | IND | Other EMDE

Global power sector emissions by region, $GtCO_2$

Policies to phase out unabated fossil fuel generation, combined with a ramp up of BECCS from around 2035 means that AE power is net negative by 2040. In EMDEs, policy allows unabated fossil generation until 2060 or beyond in some cases



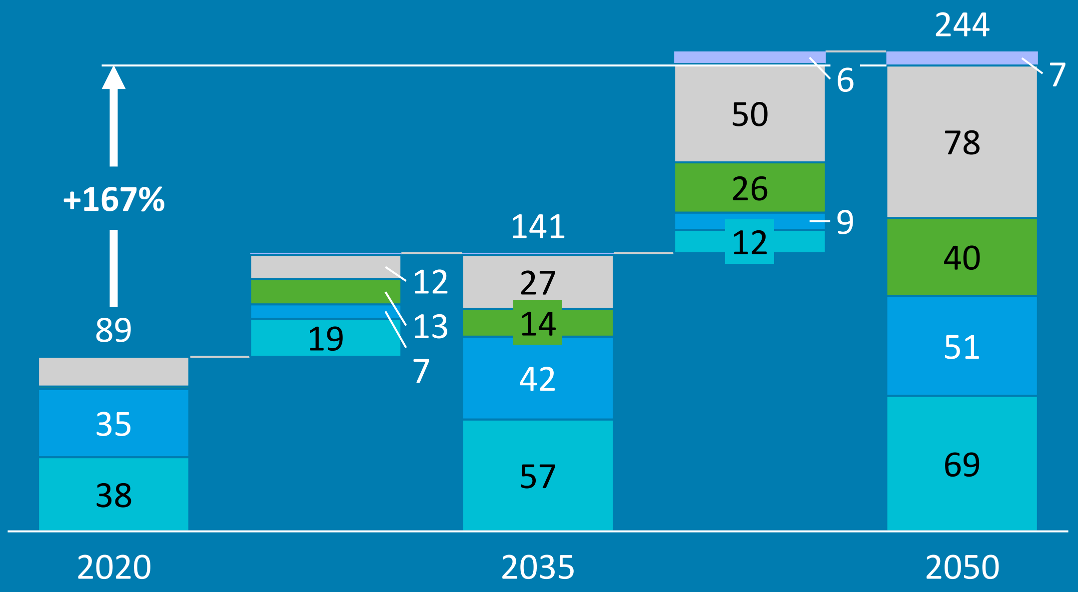
…is a critical enabler of lower emissions in final energy consumption

Power demand almost triples by 2050 as each final energy sector moves towards electrification

Buildings | Industry | Transport | Other | DACCS

Global electricity demand by sector, EJ

Before 2035, increasing electricity demand is driven by both growing activity (i.e. expanding economies and populations) and a switch towards electric heat pumps in buildings and EVs in transport. Beyond 2035, the FPS sees hydrogen production drive a significant portion of further electricity demand. Implementing DACCS at scale could increase the 2050 global electricity demand by 3%.



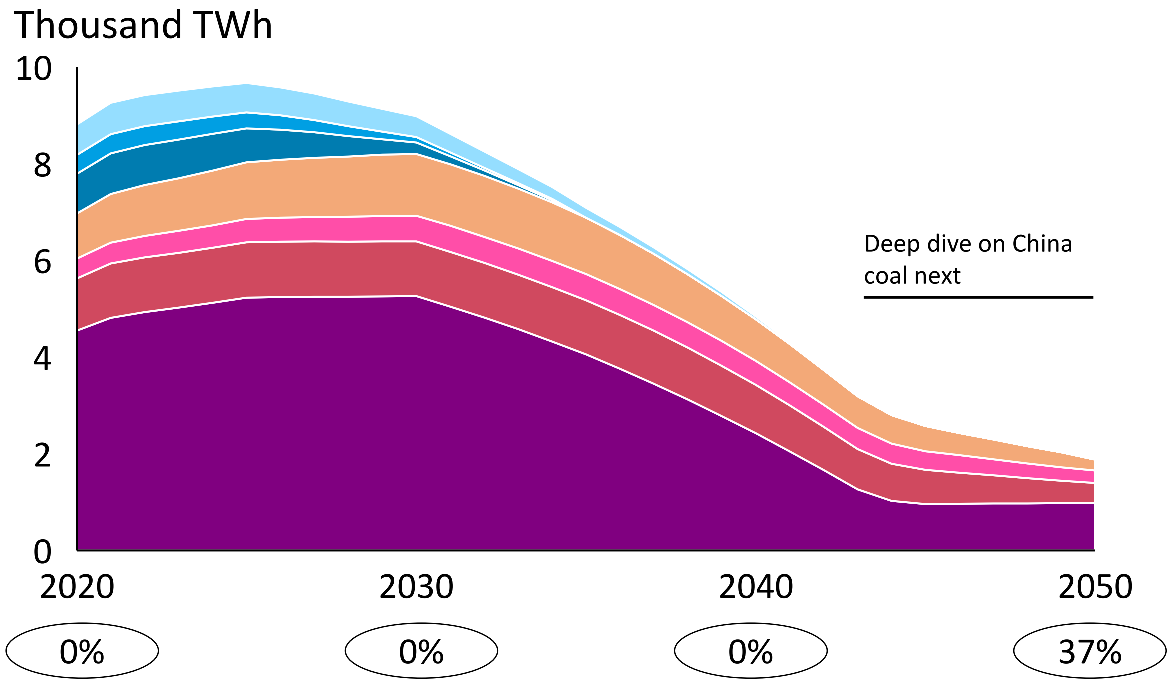
INEVITABLE POLICY RESPONSE

In the FPS, the remaining fossil fuel generation is dominated by EMDEs, where policy trajectories result in slower phase down relative to AEs

% Share of CCS in generation | CHN | IND | SEAO | Other EMDE | USA | EU + UK | Other AE

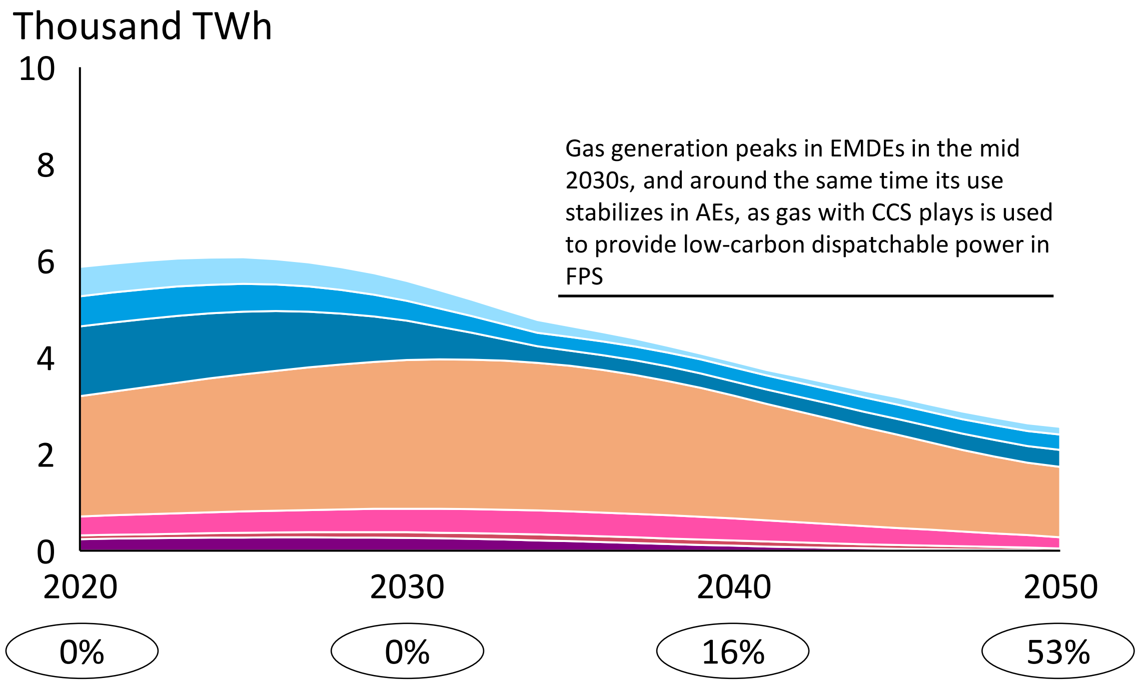
EMDEs account for all coal generation post-2040…

While most AEs phase out coal rapidly due to early policies on end of new coal and end of coal generation, coal remains a more important part of the generation mix in EMDEs for longer. India and China, the two largest users of coal for power generation today, represent together around 70% of coal generation by 2050.



…while natural gas with increasing levels of CCS continues to feature

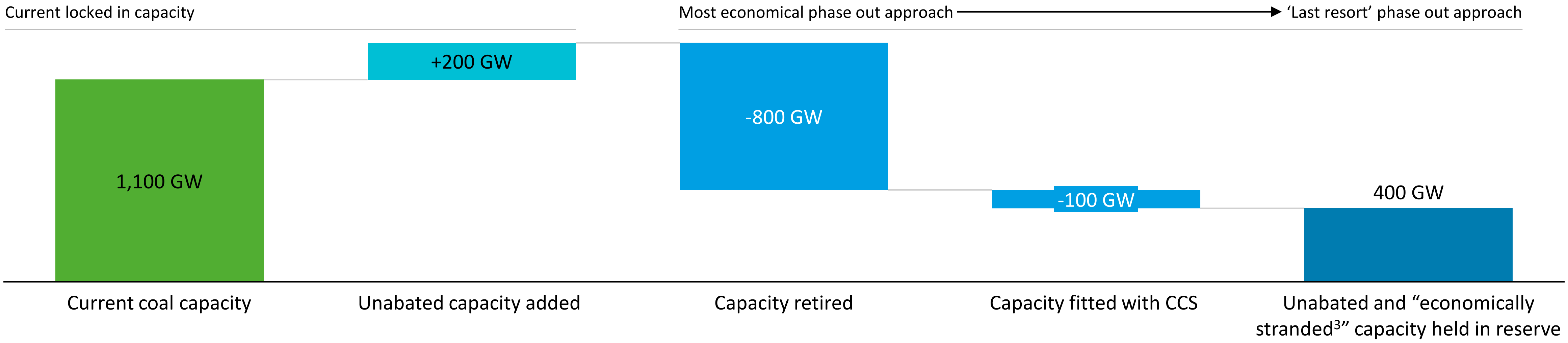
Gas declines more slowly than coal in power, as phase-out policies are implemented later. This avoids stranding gas assets and keeps this source of dispatchable power, helping the system to stay flexible as the share of renewables ramps up. By 2050, around 50% of gas is retrofitted with CCS worldwide, and 100% in AEs.



INEVITABLE POLICY RESPONSE

In the FPS, China retires 60% (800GW) of its unabated coal fleet by 2045, fits 100GW with CCS and keeps the “economically stranded” remainder in reserve

IPR’s pathway for China’s unabated coal fleet from 2020-45, GW



China currently has ~1100 GW of coal fired generation capacity – all of which is unabated.

China has 366 GW of new unabated coal in the pipeline.

FPS forecasts that the 116 GW under construction, and half of the 167 GW of permitted capacity is built by 2030. The remaining ~165 GW pipeline is cancelled.

In FPS, Chinese coal plants are retired, on average, after 30 years.

This is a 5-10 years increase in the historical lifetime of Chinese coal plants[2].

Policy supports the build out ~100GW of CCS in FPS.

China is already running large scale CCS pilot projects, for example starting constructing on the country’s first 1.5Mt coal CCS site in 2022

China places 100s of GW of unabated coal in reserve in FPS.

China can run up to 400 GW of reserves at an average aggregate capacity factor of ~10% and be in line with the coal phase out policies[1].

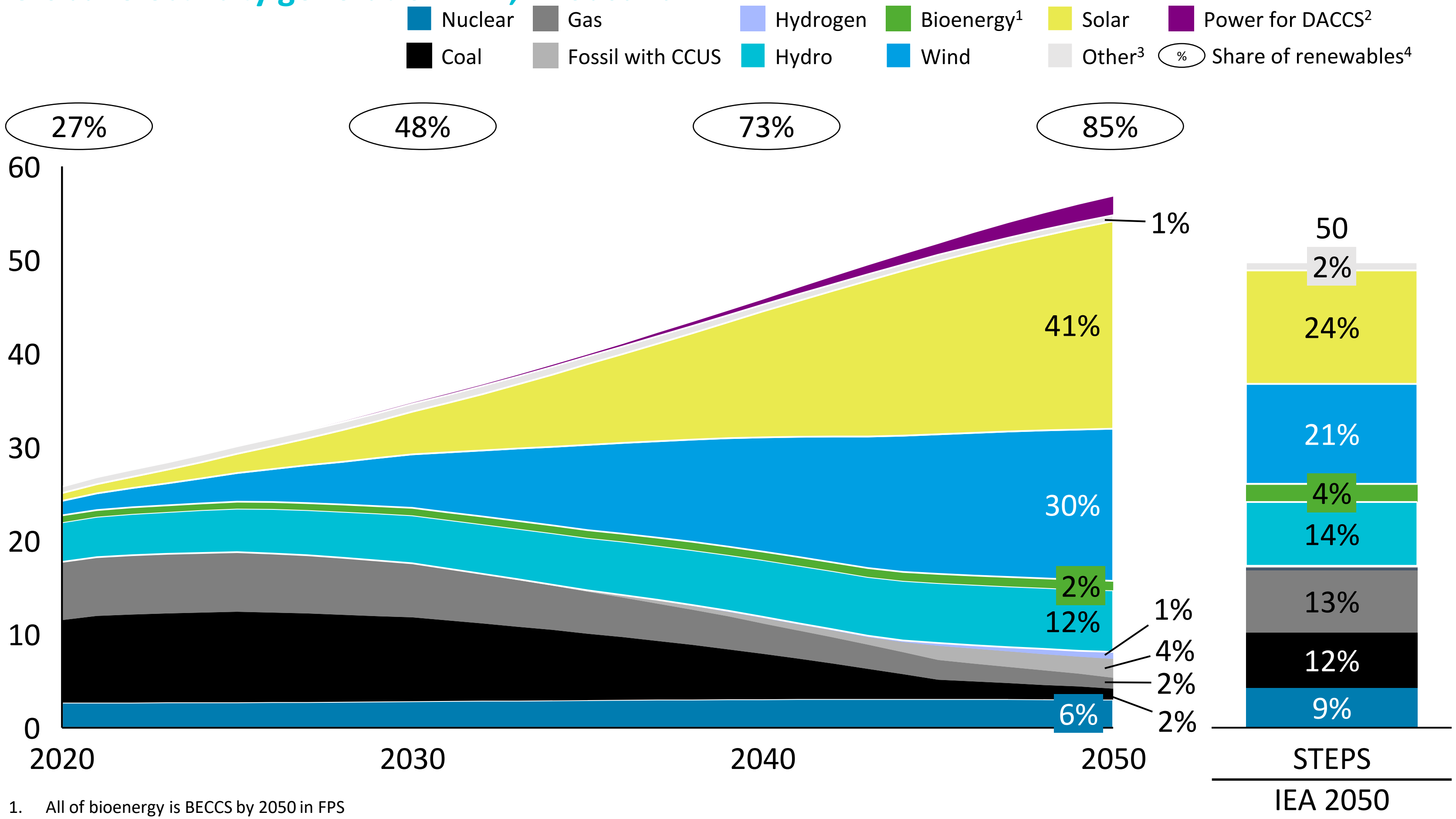
1. IPR coal phase out definition: 97% of dispatched power generation comes from sources other than unabated coal. Coal is considered abated when installed with CCS with a capture rate of 90% or equivalent.
2. Historical retirement age of coal plants has been 20-25 years. Future Chinese coal plant lifetime is modelled to be longer given the higher efficiency of China’s existing coal fleet, compared with historically retired plants.
3. Plants which would no longer be economic and would otherwise shut-down without policy incentives to keep them in reserve

Sources: China coal pipeline: GEM, China coal plant lifetime: source, Distribution of China coal plant age: GEM, China modelled reserve capacity in 2050: source, UK coal capacity factor: DUKES, China CCS suitability: IEA, China coal spatial location: IEA, China CCS pilots: CHN Energy

INEVITABLE POLICY RESPONSE

In the FPS, renewables account for around 85% of global electricity generation by 2050

Global electricity generation mix, Thousand TWh



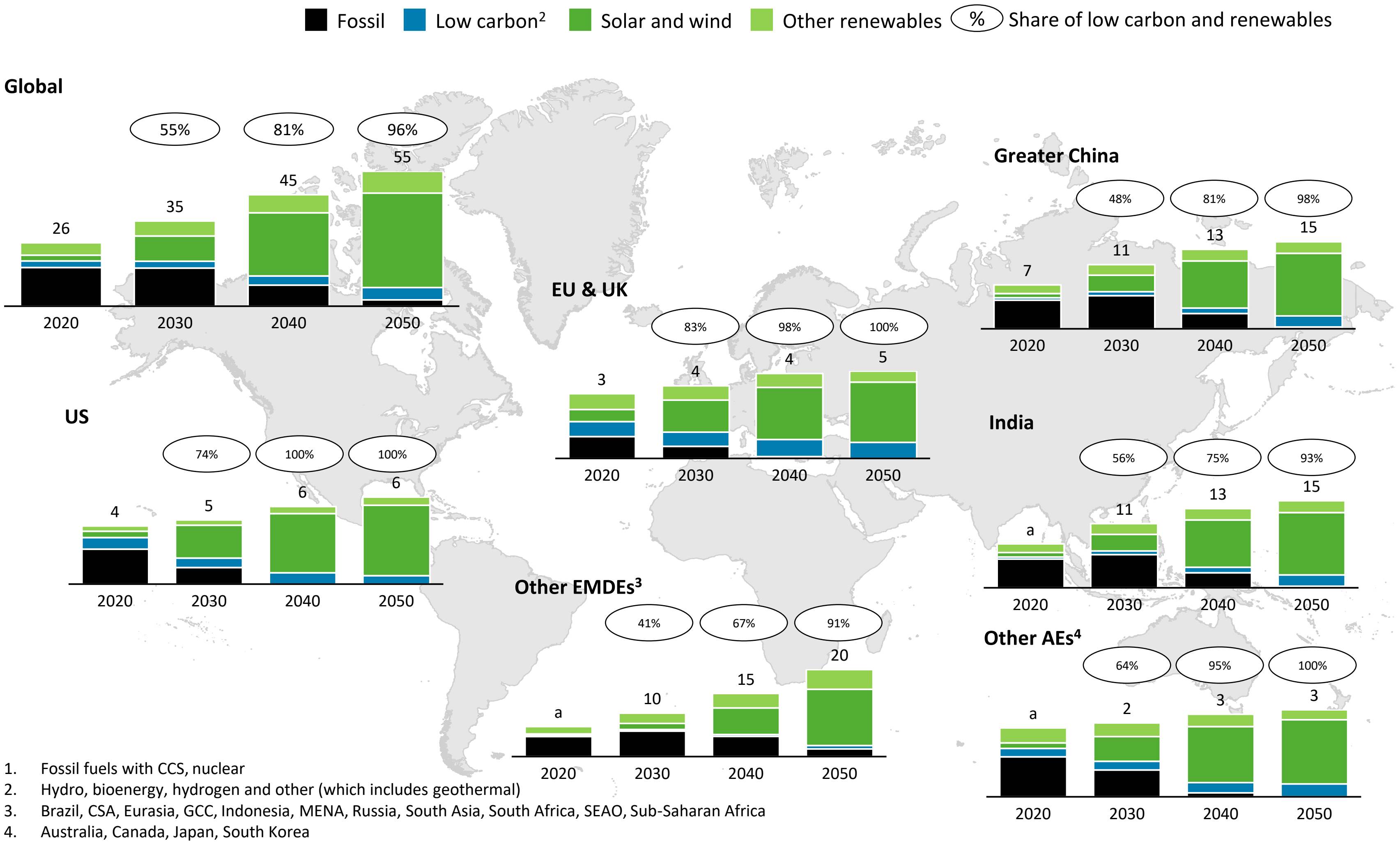
1. All of bioenergy is BECCS by 2050 in FPS
2. Energy demand unassigned to regions or power sources in FPS modelling. Not included in percentage shares
3. Other includes oil and geothermal
4. Solar, wind, hydro, bioenergy, hydrogen and other (not including oil)

Source: IEA WEO (2022)

- Increased electrification means the FPS sees 10% more generation compared to IEA STEPS by 2050
- Fossil generation falls from around 65% of the mix in 2020 to 30% in 2035 and less than 10% by 2050
- Wind and solar grow to over 70% of the mix by 2050, an increase of roughly 15% p.a.
- Gas with CCS still plays an important role as dispatchable power, comprising ~3% of global generation in 2050. By contrast, green hydrogen for power does not play a significant role, as it requires multiple stages of conversion
- Bioenergy transitions fully to BECCS by 2050 to provide carbon removals and accounts for around 2% of the global power mix in 2050
- To implement 0.6 $GtCO_2$ of DACCS would require an additional 1-2% of global electricity generation[2]

In the FPS, most AEs achieve clean power by 2040, while unabated fossil remains in some EMDEs in 2050

Regional electricity generation mix, Thousand TWh



1. Fossil fuels with CCS, nuclear
2. Hydro, bioenergy, hydrogen and other (which includes geothermal)
3. Brazil, CSA, Eurasia, GCC, Indonesia, MENA, Russia, South Asia, South Africa, SEAO, Sub-Saharan Africa
4. Australia, Canada, Japan, South Korea

- By 2040, AEs have phased out close to all unabated fossil fuels for power generation. Due to later policies, EMDEs reach this level of decarbonisation after 2050
- The most rapid solar and wind growth occurs in areas with the fastest unabated fossil decline and best resource endowments – primarily USA, EU & UK, India, Greater China, MENA (other EMDEs) and Australia (other AEs)
- While most regions rely mostly on gas CCS as a source of fast dispatchable power, some regions with high gas prices and limited gas infrastructures such as India could also use hydrogen in similar amounts
- By 2050, all of bioenergy is BECCS. It is located mostly in regions with both demand carbon removals and a source of sustainable local biomass supply. The largest sources of BECCS for power by 2050 are thus the USA, China and Brazil

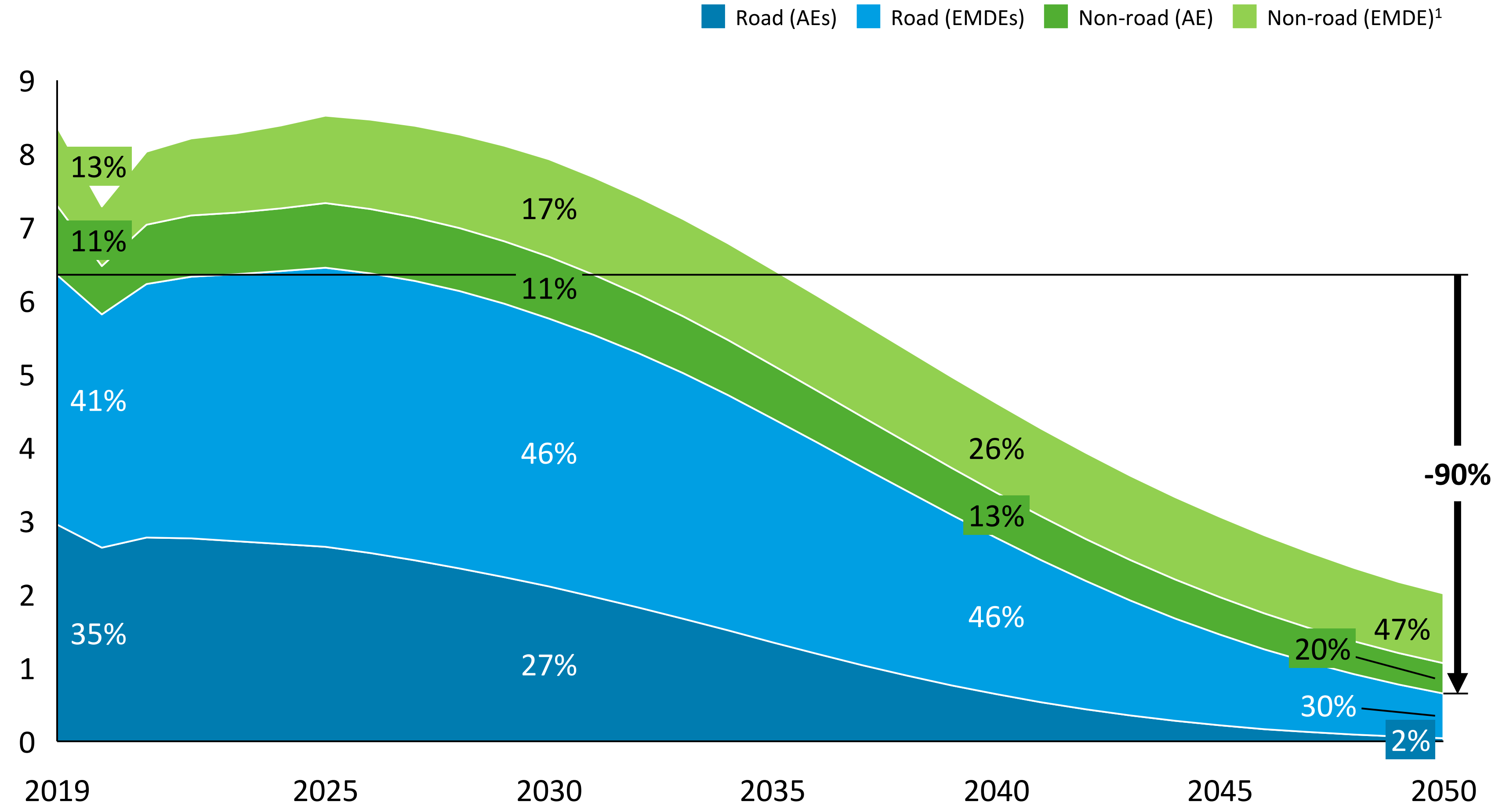
INEVITABLE POLICY RESPONSE

Overview

INEVITABLE POLICY RESPONSE

In the FPS, road transport decarbonises 90%, while non-road accounts for 70% of sector emissions by 2050

Global transport emissions by subsector, 2019-2050, $GtCO_2$/year



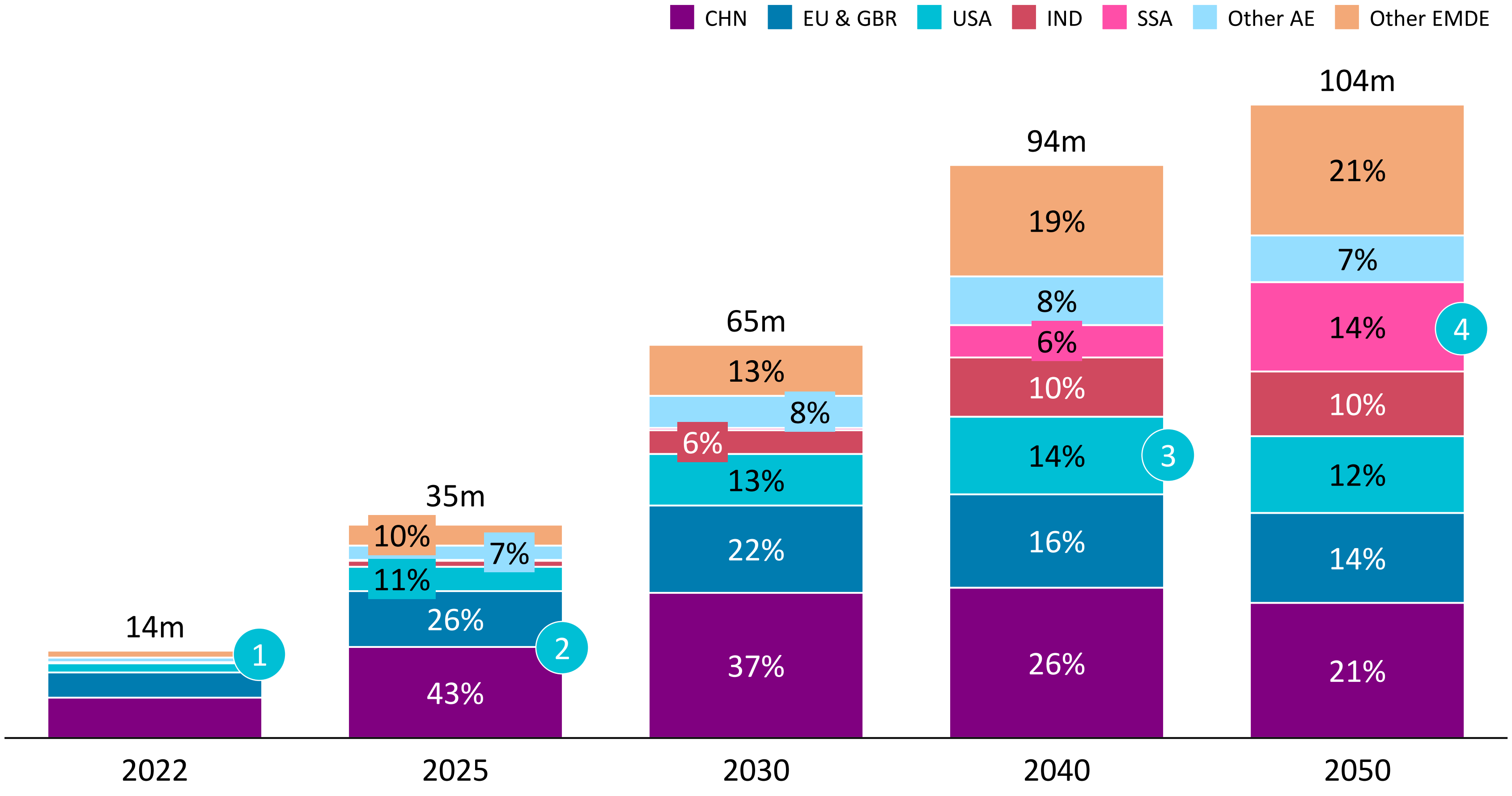
1. Non-road transport covers aviation, shipping and rail. Rail emissions account for less than 100Mt CO_2 throughout the period

- AEs have begun a **rapid transition away from ICE road vehicles**, meaning emissions are already falling, and account for only 2% of transport emissions by 2050
- Road transport is **slower to decarbonize in EMDEs**, due to growing economies and a later transition to zero emissions vehicles (ZEVs), particularly trucks
- Non-road emissions, mostly from **shipping & aviation prove difficult to decarbonize** – growing demand in EMDEs and limited abatement options before synthetic and biofuels scale in the 2030s mean emissions fall around 30% to 2050 compared to pre-COVID levels

INEVITABLE POLICY RESPONSE

China and AEs currently dominate ZEV sales, but by the mid-century SSA, India and other EMDEs make up 45% of sales

Sales of ZEV cars[1] by region, million vehicles and %



1. Zero Emissions Vehicles include battery (BEV), fuel cell (FCEV), and plug-in hybrid electric vehicles (PHEV)

1. The market for ZEVs has been **rapidly expanding in recent years**, and now accounts for 14% of total car sales

2. As early movers with ambition to ban ICE sales by 2035, **China and Europe make up about 70% of the ZEV car market in 2025**

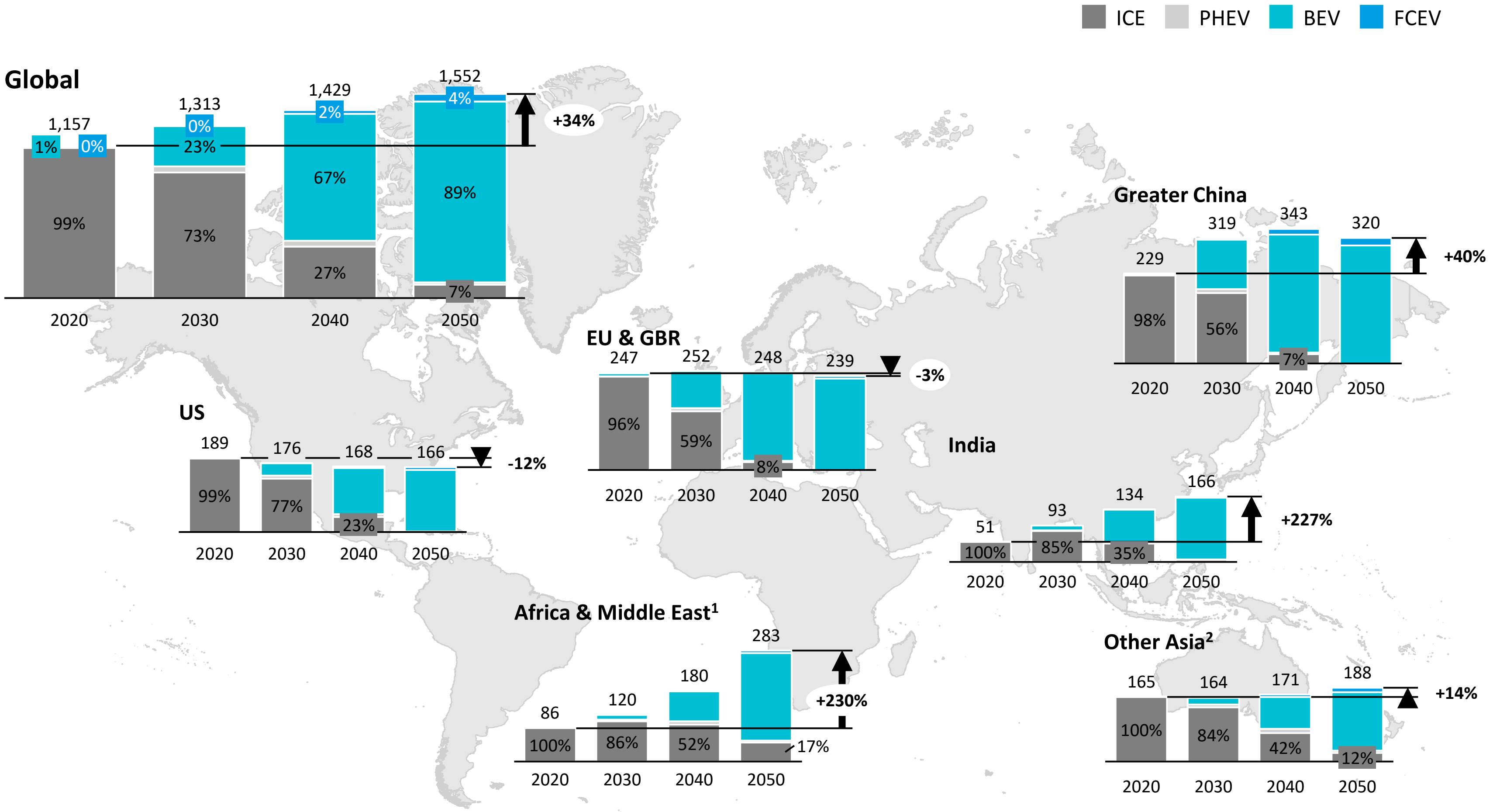
3. Along with the bulk of regions, the **USA has fully ZEV sales by 2040**, and the size of the market means it drives 10-15% of global ZEV sales across the period

4. **By 2050, EMDEs excluding China make up 45% of global sales.** In Sub-Saharan Africa in particular a growing, more affluent population coupled with more stringent policy sees a boom in sales from the mid-2030s

INEVITABLE POLICY RESPONSE

In the FPS, ZEVs therefore reach over 90% of the car fleet by 2050

Passenger car fleet, millions



1. SSA, SAF, MENA
2. AUS, JPN, KOR, IDN, SEAO, SA, EURA

- **Car numbers in Africa and India more than triple** to 2050, while absolute numbers fall in the US and Europe
- China and Europe are almost fully decarbonised by 2040, after which the **majority of remaining ICE vehicles are in EMDEs**
- Pure **battery electric vehicles are the dominant technology,** however plug-in hybrid vehicles initially and later hydrogen fuel cell vehicles gain a small share in market segments with large travel distances

INEVITABLE POLICY RESPONSE

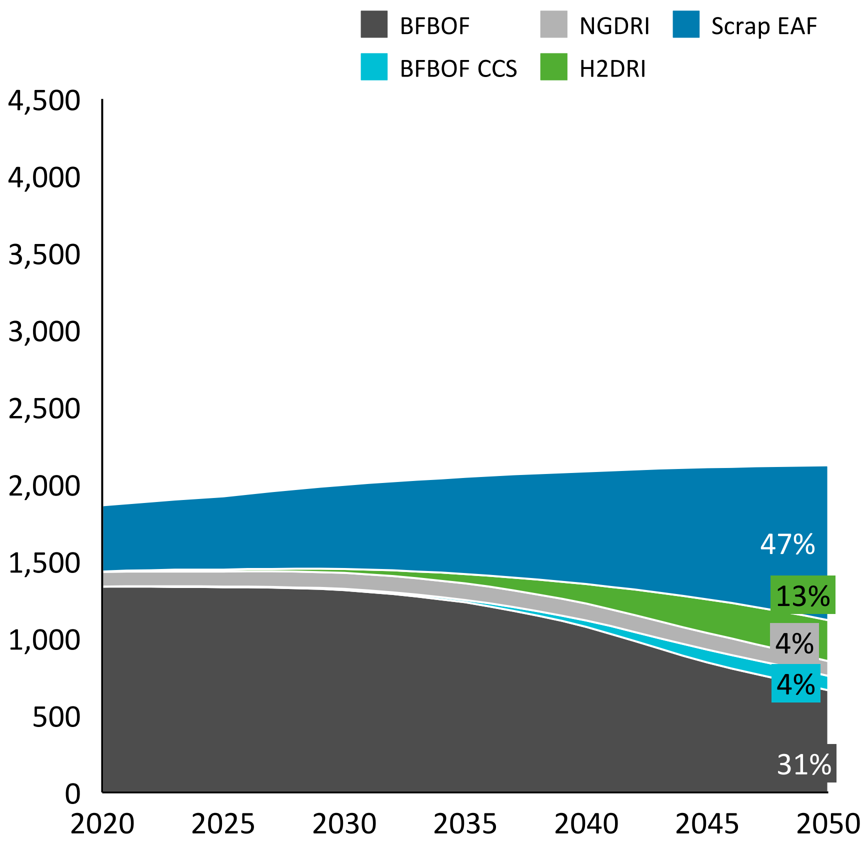
Overview

INEVITABLE POLICY RESPONSE

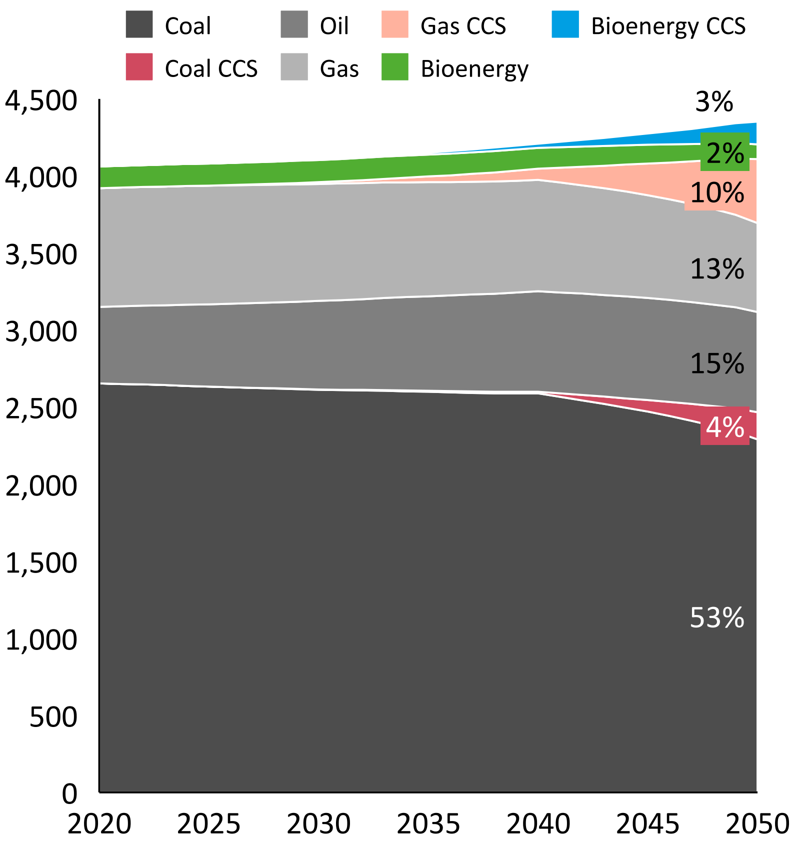
Scrap and H_2 decarbonise most steel production, whereas cement decarbonisation remains slow, driven mostly by CCS

Production by technology, Mt

Iron & Steel



Cement & other non-metallic minerals



Note: BFBOF: Blast Furnace - Basic Oxygen Furnace; CCS: Carbon Capture and Storage; NGDRI - Natural Gas Direct Reduced Iron; H2DRI - Hydrogen Direct Reduced Iron; EAF - Electric Arc Furnace

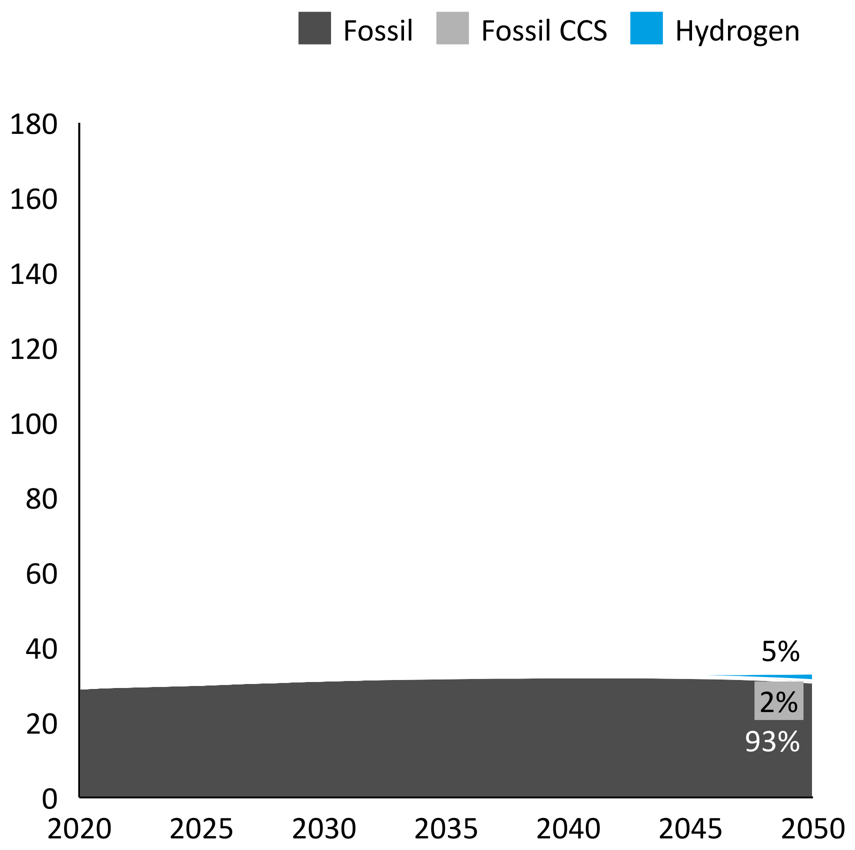
- Growing use of scrap steel allows **scrap EAF to become the largest steel production method** by 2050, at 47%
- **For virgin steel, decarbonisation mainly takes place through H2DRI (13%)**, which begins to be built out at scale from 2030 - BFBOF CCS also plays a role (4%) in regions where newer plants make retrofits more likely
- Based on the current policy forecast, **cement sees little decarbonisation by 2050**, with some CCS for coal (4%) and natural gas (13%), although clinker substitutes could play a further role to reduce cement's carbon footprint
- **Bioenergy plays only a limited role** in cement kilns at 2%, most of which is BECCS by 2050
- Forecast policy ambition means that industry decarbonizes in the 2070s globally, but the US and Europe are leading regions

INEVITABLE POLICY RESPONSE

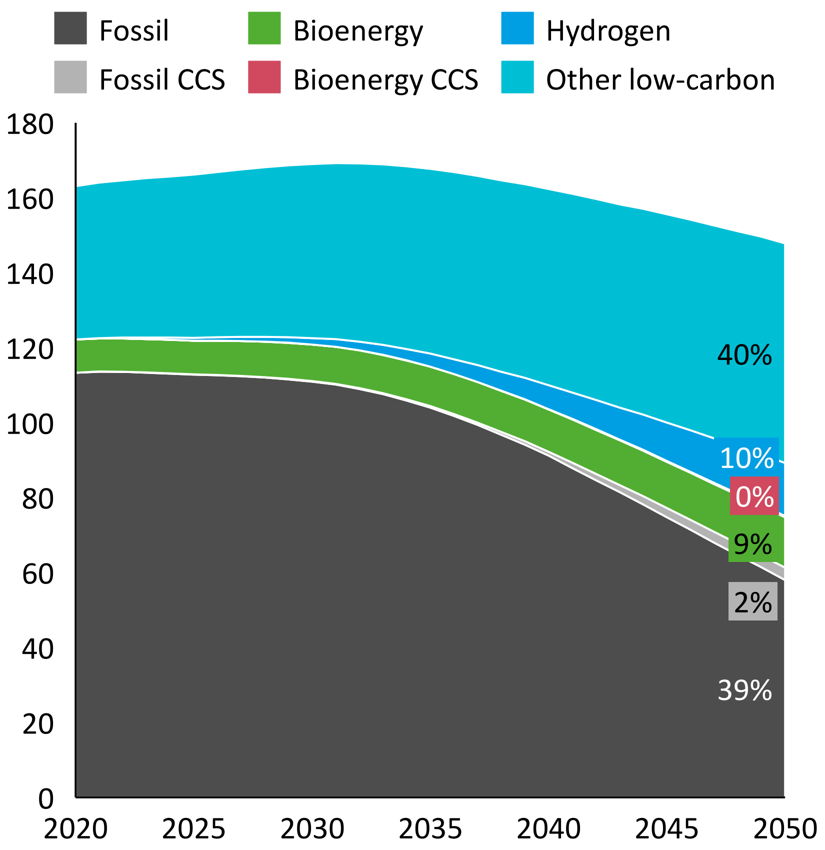
Fossil fuels remain a core feedstock for chemicals, although electrification and H_2 help to decarbonize industrial heating

Chemical subsector energy demand, EJ

Feedstock



Fuel

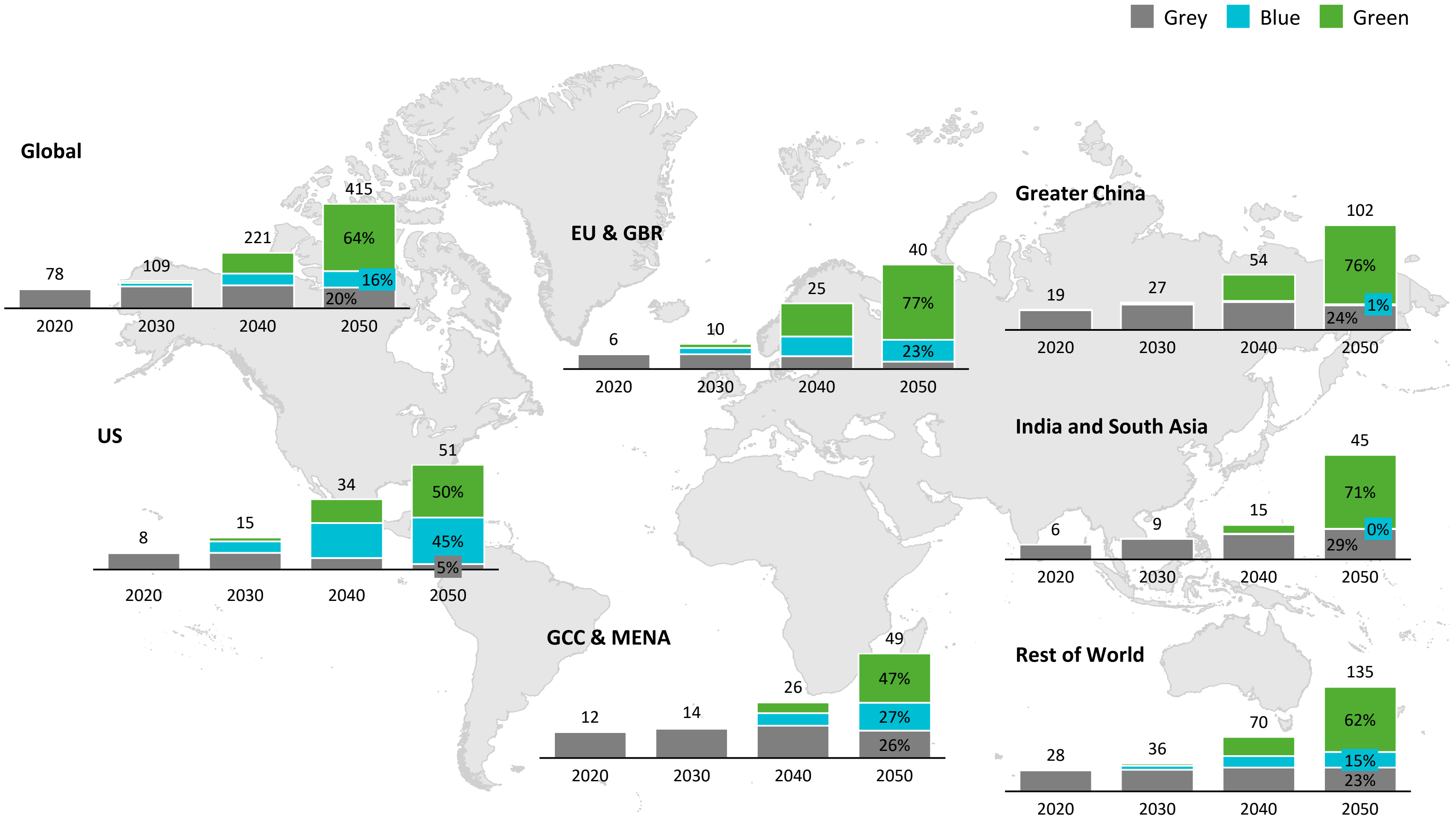


- **Fossil feedstocks remain persistent in 2050**. High-value chemicals are slow to switch to hydrogen or CCS for feedstocks. They make up only 5% and 2% of the feedstock mix, respectively
- **Hydrogen and industrial heat pumps** replace some of the fossil fuels used for low temperature heating by 2050, with low-carbon fuels reaching 50% of fuel demand by 2050, and a further 2% in fossil CCS
- **Late net zero targets** mean shifts are only gradual

INEVITABLE POLICY RESPONSE

Policy support enables green H2 build-out, with blue H2 only competitive in certain regions with favourable conditions

Hydrogen production, Mt



- **Green hydrogen grows to dominate hydrogen production by 2050 (64%)**, supported by policies such as the US's IRA, the EU's GDIP, and India's hydrogen strategy
- **Blue hydrogen is mostly used in regions with particularly favourable conditions**, such as MENA and the US where gas prices is lower
- **Grey hydrogen production also grows** towards 2040, but reduce by 2050, due to industrial decarbonisation and carbon pricing

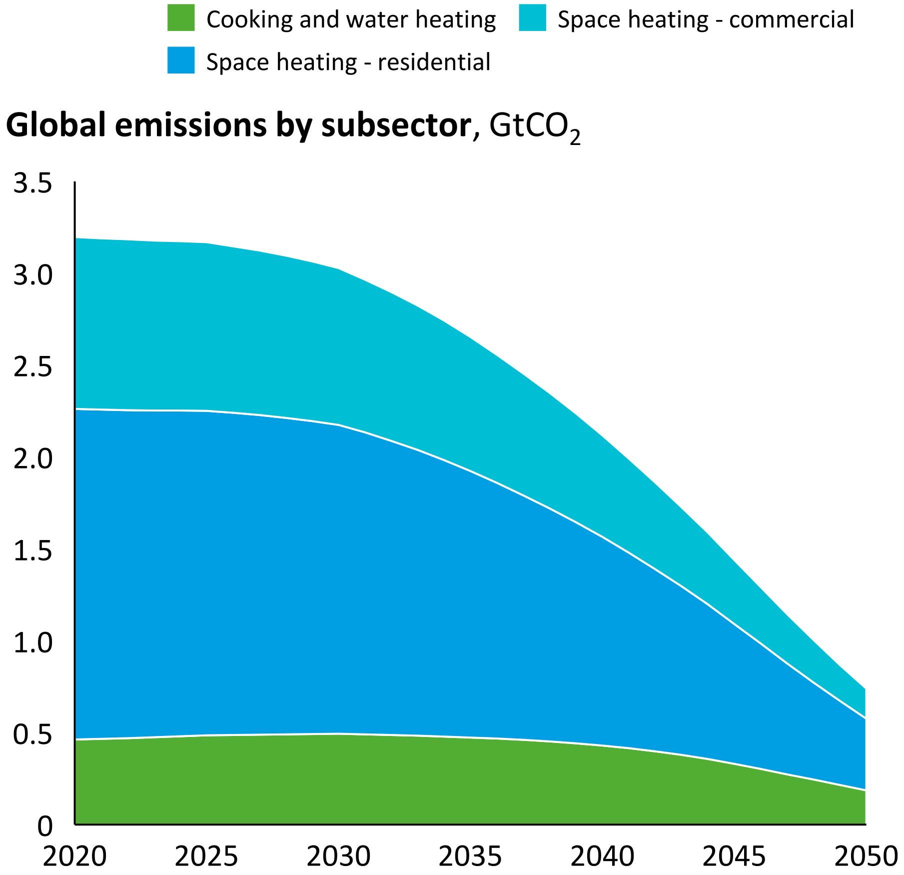
INEVITABLE POLICY RESPONSE

Overview

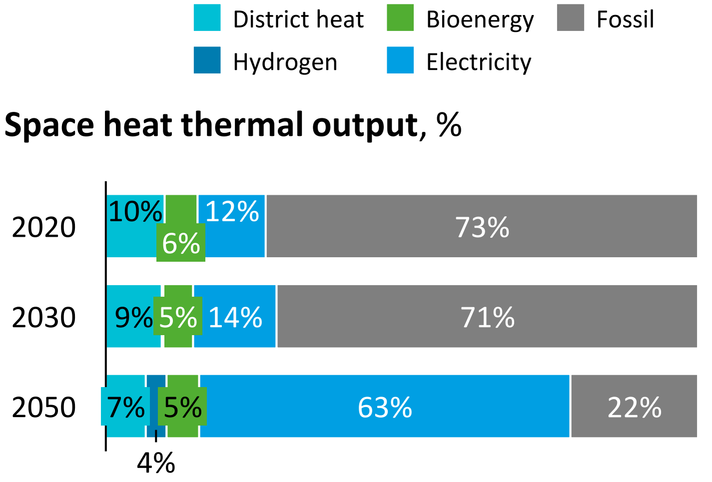
INEVITABLE POLICY RESPONSE

In the FPS, increased efficiency of both building envelopes and electrical heat pumps reduce emissions from 2030

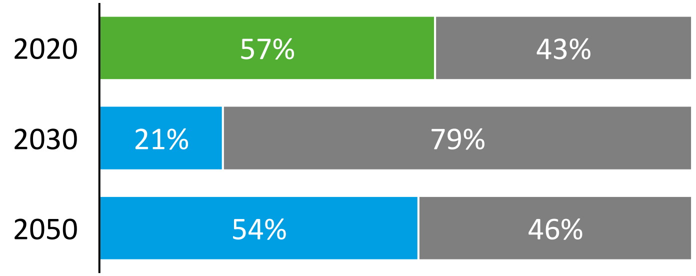
Global emissions by subsector, $GtCO_2$



Space heat thermal output, %



Cooking and water heat fuel share, %

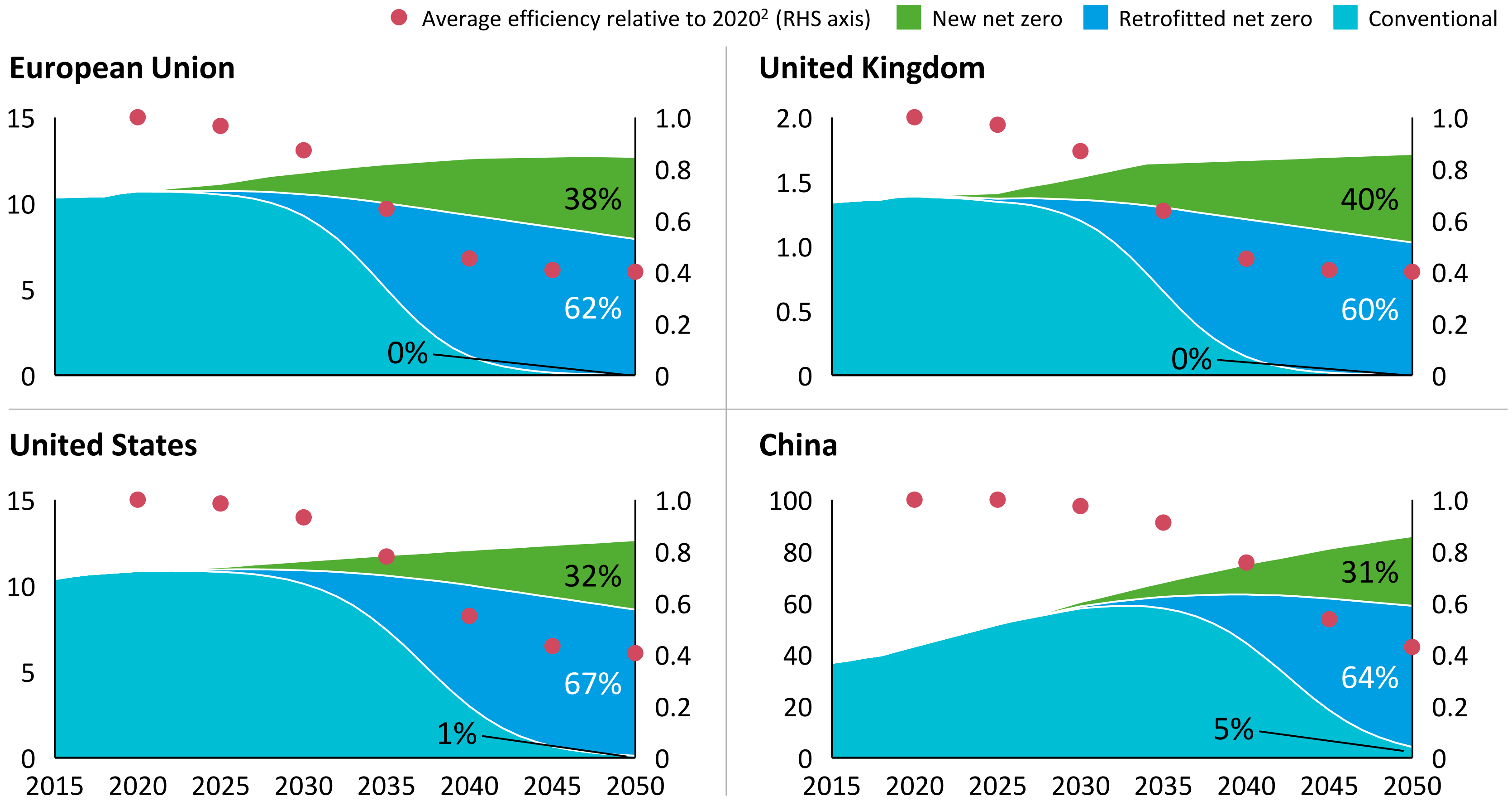


- **Overall emissions from buildings fall 77%** from 2019 to 2050
- As fossil remains a significant part of the space heating fuel mix by 2050, **demand reductions through efficiency retrofits become critical** for decarbonisation
- **Policy helps drive electric heat pump uptake**, displacing fossil boiler systems towards 2050
- In cooking and water heating, **traditional biomass is phased out before 2030**

INEVITABLE POLICY RESPONSE

Retrofits are critical to decarbonisation as new net zero buildings account for only around 30% of global stock by 2050

Floorspace by envelope[1] in selected regions, billion m²



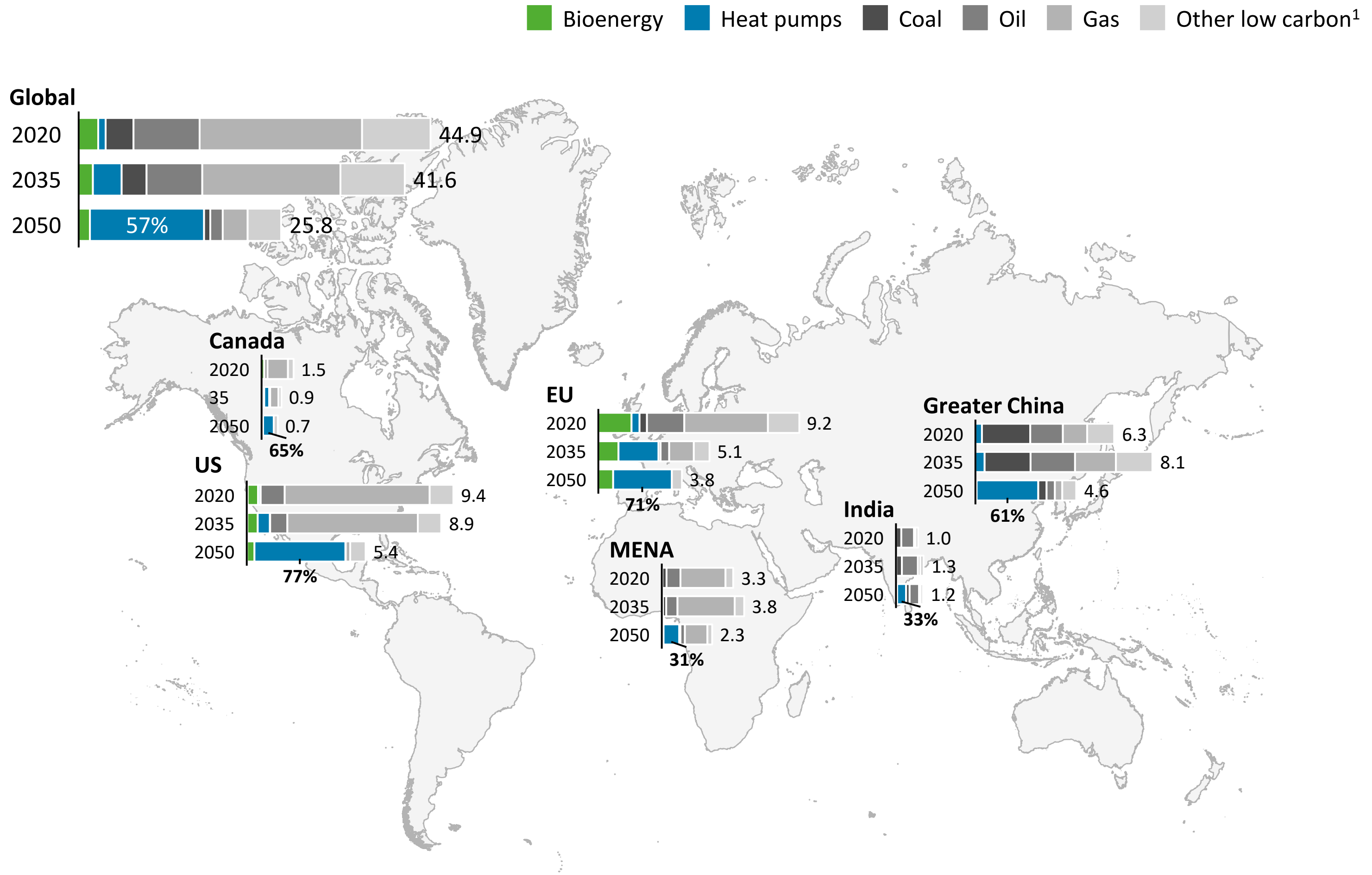
1. A new net-zero building is a new building that is 60% more efficient than the average building in 2020 in a particular region. A retrofitted net-zero building is an existing building that is retrofitted to be 60% more efficient than the average building in 2020 in a particular region. A conventional building is an existing or new building that has the same energy efficiency as the average building in 2020 in a particular region.
2. Ratio where 1 equals the amount of energy required to supply a unit of 'thermal comfort' to a building with 2020 specifications

- Buildings with deep retrofits can be **60% more efficient** than a conventional home
- In early-mover regions, there is a significant rate of retrofit, with **>50% of the building stock in retrofitted net-zero buildings**
- Regions like the UK need to **overcome regulatory constraints** to meet floorspace demand, but if they do, many of these **new buildings become net-zero ready, e.g., 40% in UK, 38% in EU by 2050**
- In the FPS, regions with later policy targets see slower improvement in building efficiency – e.g., **in China, buildings in 2050 on average require 53% of the energy needed** to achieve the same level of thermal comfort in 2020, vs. 40% in the EU

INEVITABLE POLICY RESPONSE

Efficient electric heat pumps replace fossil heating systems, with bioenergy and hydrogen playing a role

Thermal output by technology, 2020-2050, TW/year



1. Includes electric resistive heating, hydrogen and district heating

Source: IEA, European Commission

- Globally and in most regions, improving **envelope efficiency reduces demand for heating** over time
- **Heat pumps are the key decarbonization lever** for space heating, reaching 57% globally by 2050
- The **EU leads on heat pump deployment**, but there is strong **growth from 2035-2050 in the US and China**
- **Coal, oil and gas are mostly phased out** by 2050, with the last of these replaced by hydrogen in some regions

INEVITABLE POLICY RESPONSE

Overview

Most end uses of biomass simply provide energy, but adding CCS can also provide negative emissions in power and industry

A detailed analysis of the role bioenergy across the energy and land systems is available in the bioenergy report

Energy provision

Bioenergy has a similar chemical composition to fossil fuels so releases a similar amount of energy. However, the carbon sequestered by growing biomass means the **lifecycle emissions are lower than fossil fuels**. Because they are similar, bioenergy can often be used with **existing fossil infrastructure**

End-uses for which biomass can only provide energy include:

- Road transport
- Shipping
- Aviation
- Buildings

These end-uses cannot be used for negative emissions because sources are not sufficiently concentrated for CCS

Carbon removals (Negative emissions)

For end-uses with concentrated sources of CO_2 emissions, **CCS can be added to provide net-negative emissions**. This is bioenergy with carbon capture and storage: BECCS. Because CCS captures most “tail-pipe” emissions, the amount of carbon sequestered by growing biomass is greater than the amount emitted during combustion.

End-uses for which biomass can provide negative emissions in addition to energy include:

- Power
- Industry

INEVITABLE POLICY RESPONSE

Bioenergy is a long-term decarbonisation option in aviation and some niche uses, while the need for removals in the FPS justifies expensive BECCS

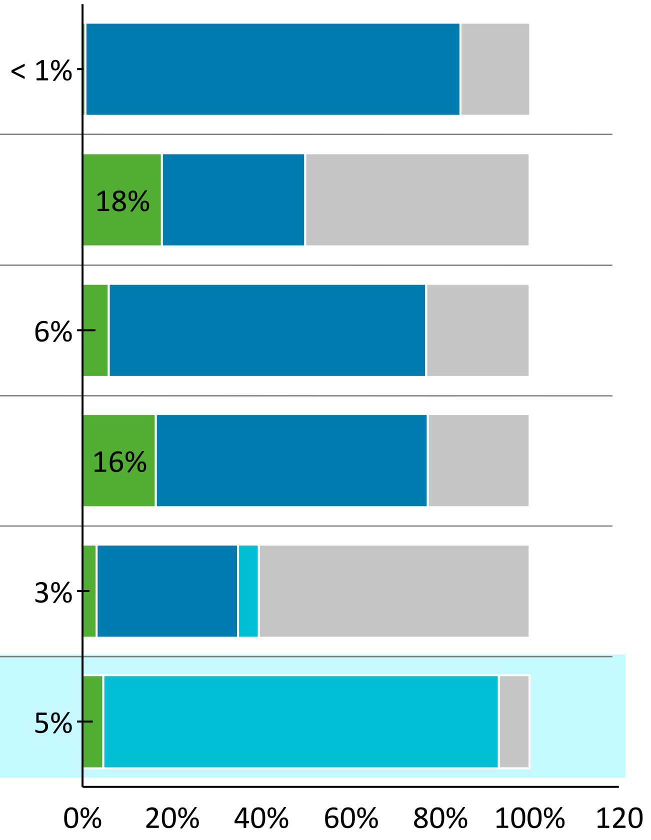
A detailed analysis of the role bioenergy across the energy and land systems is available in the bioenergy report

Deep dive to follow | Bioenergy | Electricity or Hydrogen | Other low carbon | Unabated fossil fuel

SELECTED END USES, NON-EXHAUSTIVE

Sector	End use	Likely technological and policy development
Transport	Road	BEVs (and possibly FCEVs) are the cheapest decarbonization options, even for heavy trucks. Countries with ambitious blending policies continue to support biofuels but probably not beyond 2050
	Aviation & Shipping	Hydrogen based fuels (synfuels or ammonia) likely becomes the preferred option in the long-term but are not yet widely available. Bioenergy has a role to play because it can be used from today, especially in aviation
Buildings	Space heating[1]	Almost all modern bioenergy used in buildings (excluding traditional biomass) is wood pellets which are likely replaced by heat pumps. Renewable natural gas could play a minor role
Industry	Low T process heating	Electrification is the greenest and cheapest option in most low temperature heating processes. Biomass becomes competitive in the pulp and paper, and sugar, industries which use cheap self-supplied residues (e.g., bark)
	High T process heating	Hydrogen and CCS are usually the greenest options (CCS in cement to capture process emissions). CCS could be combined with bioenergy if there is a strong incentive for removals. Iron and steel likely switch to scrap and H2DRI EAF
Power	Power generation	Bioenergy likely only makes sense if it is combined with CCS: BECCS. Without an incentive for carbon removals, it probably cannot compete with intermittent renewables or with dispatchable technologies such as Gas CCS

% of energy demand by fuel in 2050

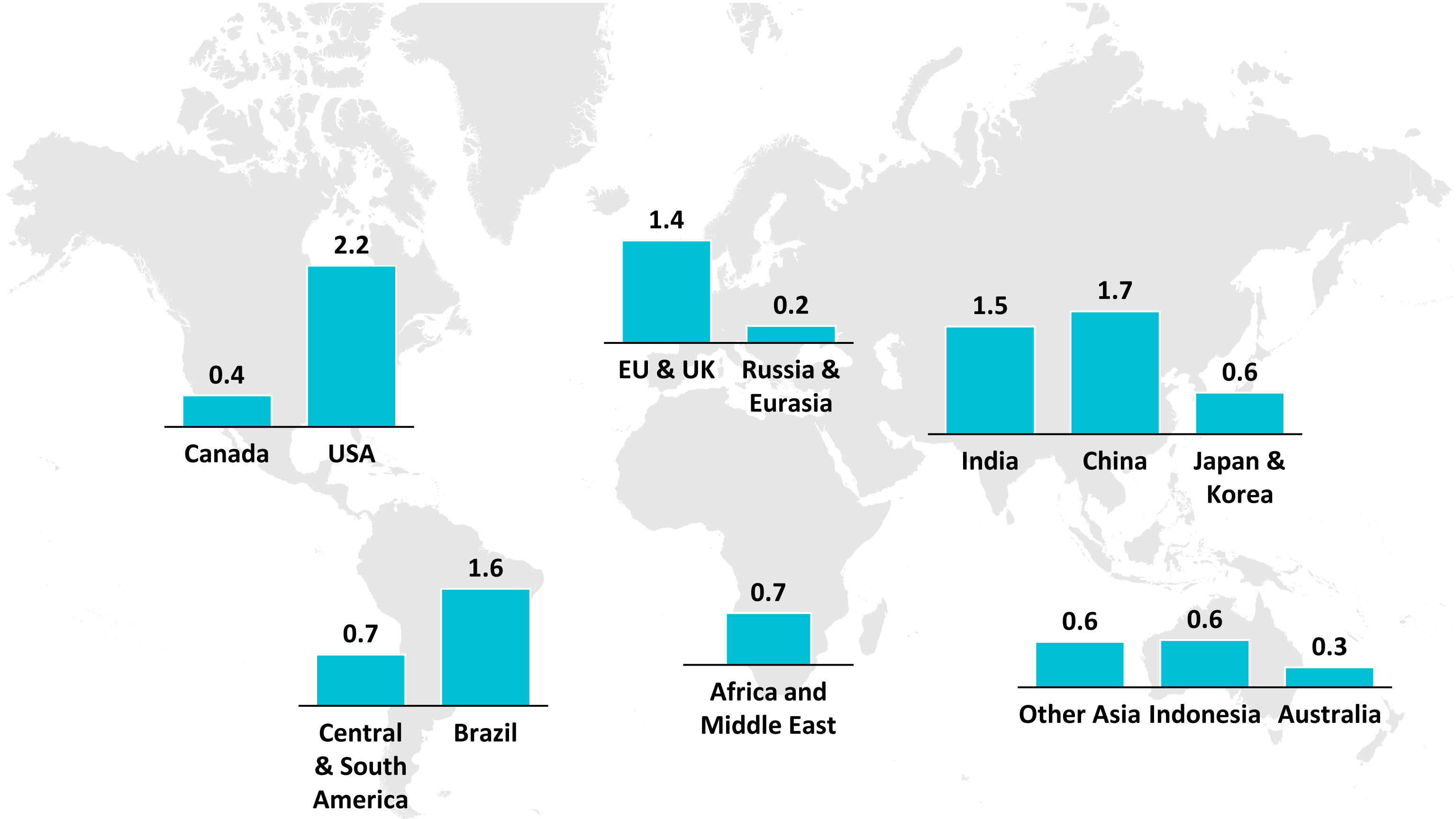


1. Converted to thermal output to account for the increased efficiency of heat pumps compared to other technologies

BECCS plays a role in power where removals are valued by policymakers and supply is available; FPS 2023 sees ~1Gt by 2050

A detailed analysis of the role bioenergy across the energy and land systems is available in the bioenergy report

FPS 2023 bioenergy demanded for BECCS power generation in 2050, EJ



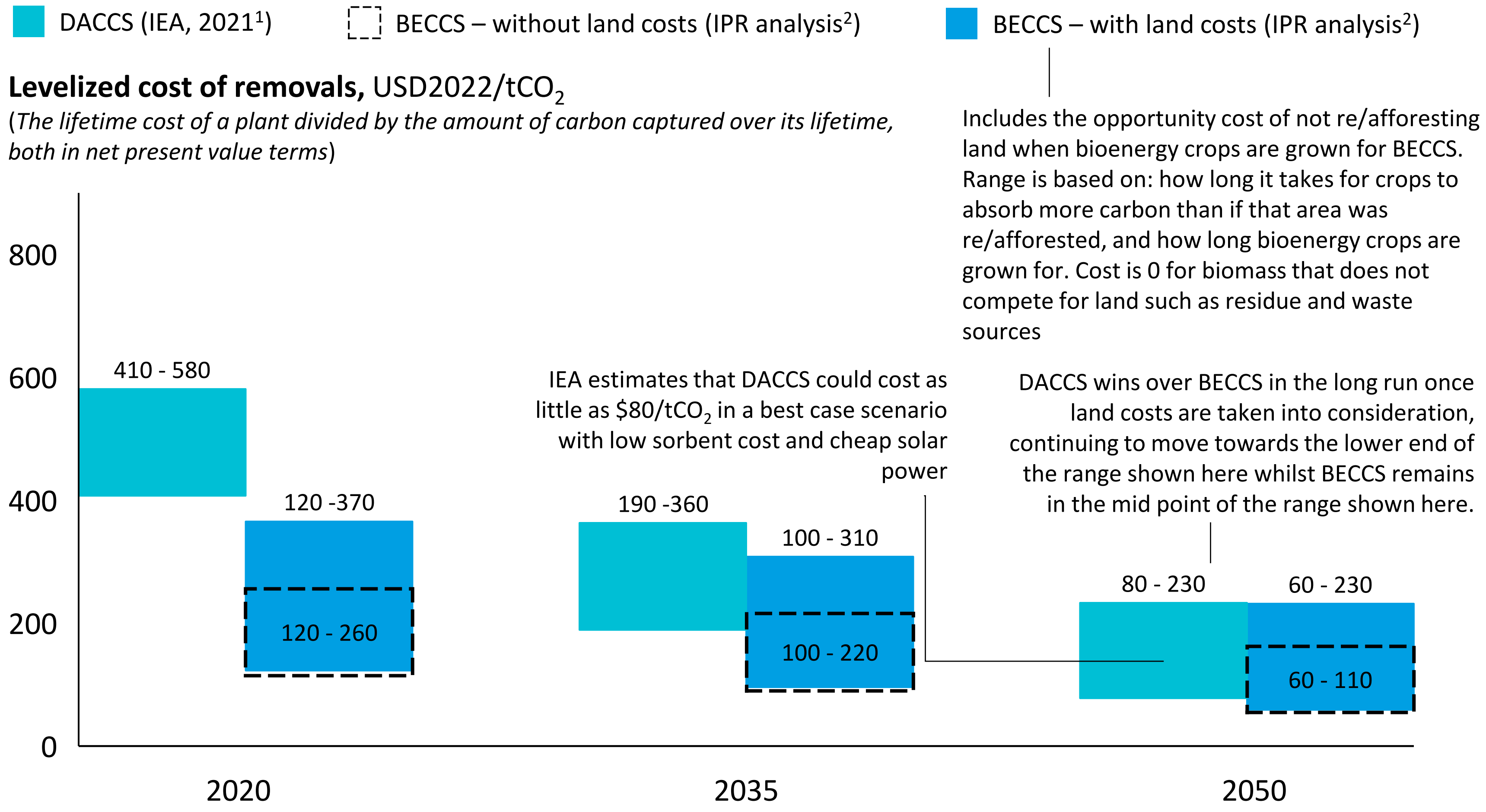
In the FPS, all bioenergy use in power is BECCS by 2050. Unabated biomass power cannot compete with renewable, baseload or dispatchable generation

BECCS is used to provide baseload power and seasonal flexibility under particular policy conditions

BECCS are incentivised where removals are most valued and where supply is readily available. It removes around **1GtCO_2/year by 2050**

INEVITABLE POLICY RESPONSE

Demand: Once land-based costs are considered, DACCS is expected to be more attractive than BECCS by 2050



1. Primarily based on IEAGHG Technical Report, 2021, Global Assessment of Direct Air Capture Costs. Assumes FOAK is 2020 and NOAK is 2050. Range is from base case (lower) to very ambitious (upper)
2. No land cost estimates in line with Fuss et al, 2018, Negative emissions—Part 2: Costs, potentials and side effects. Land costs calculated based on how long it takes for crops to absorb more carbon than if that area was re/afforested: the carbon payback period (CPP), and how long bioenergy crops are grown for: the removal period . Lower bound = 75-year removal period with 5-year CPP, upper bound = 50-year removal period with 15-year CPP
3. BECCS and DACCS represent two of the most often discussed technology-based removals, however other approaches such as biochar or enhanced weathering also offer potential for removals.

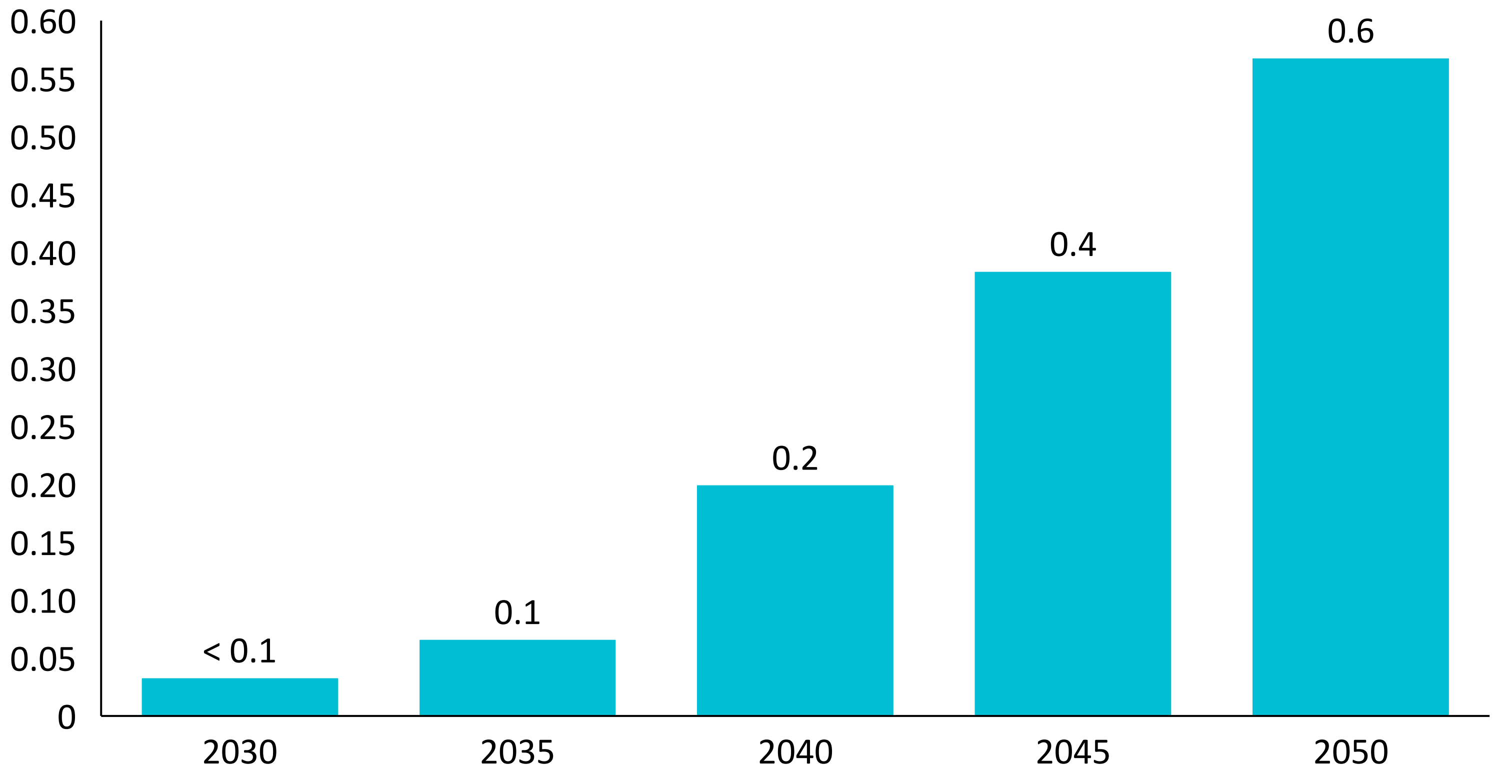
There are multiple considerations in estimating the true levelized cost of removals for BECCS. In particular, land costs are considered explicitly in the modeling for FPS 2023 (see footnote 2), whilst others' estimates typically may not

BECCS applies a relatively mature technology and so is unlikely to experience significant cost reductions. BECCS costs increase if the land impact of growing biomass is considered

Direct Air Carbon Capture and Storage (DACCS) removes carbon from ambient air and has the benefit of limited land constraints[3]. While it starts from a high baseline, it could see rapid cost reductions as today's demonstrator plants scale, and with access to low-cost renewable energy

FPS 2023 includes 0.6Gt of DACCS by 2050, predicated on a significant cost reduction as removals ramps up

Global DACCS carbon removals, 2030-2050, $GtCO_2$/year



1. Cost trajectory from McKinsey Voluntary Carbon Markets modelling
2. Value for energy demand per tCO2 captured taken at the lower bound of values reported by the National Academy for Sciences

Source: IEA, National Academy for Sciences, McKinsey Voluntary Carbon Markets modelling

- **FPS 2023 sees DACCS reach 0.6 $GtCO_2$/year by 2050**, predicated on near-term demonstration DACCS sites, which move the technology along the learning curve in the 2030s and **reduce costs to as low as \$150/tCO_2**[1]
- By the 2040s, **growing demand for removals and lower costs drives rapid uptake**
- Removing 0.6 $GtCO_2$ in 2050 would require 2 - 5 EJ of power, or an **additional 1-2% of FPS 2023 global power demand**[2]
- At the lower end of the cost range, DACCS removals would **cost around \$100 billion annually by 2050**
- **DACCS wins over BECCS in the long run once land costs are taken into consideration**

INEVITABLE POLICY RESPONSE

The energy system modelling captures both policy- and technoeconomic-driven effects

ILLUSTRATIVE

01 Forecast policy
Detailed assessment at country level across the policy areas determine the IPR view on likely policy outcomes

02 Specify detailed constraints
FPS policies are translated to specific modelling constraints and parameters across energy sectors and IPR modelling regions

03 System optimisation
Core elements of energy system are assessed through optimizing energy system model to gain insight on the pathway of key parameters. Bioenergy analysis provides key link to land modelling

04 Smoothing & refinement
Policy-constraint optimized pathways smoothed and expanded through process of expert insight to ensure realistic outcomes

05 Produce value drivers
Once run through sector calculators to smooth, granular and realistic value drivers are produced

INEVITABLE POLICY RESPONSE

IPR's climate policy forecast shows more deceleration than acceleration across sectors, but the forecast is broadly unchanged relative to FPS 2021

Policy forecast for modelled regions

Change in forecast relative to IPR 2021[1]: Deceleration | No change | Acceleration | New forecast

Country	Total CO_2 Emissions 2021, %	CO_2 emissions: Net Zero CO_2	CO_2 emissions: "Carbon price"	Power: New coal	Power: All coal	Power: Clean power	Buildings: Heating	Transport: Light duty	Transport: Heavy duty	Industry: Fuel	Industry: Processes[3]
CHN	32%	2060	$50/tCO_2$	2030	2045	2050	2045	2035	2040	2070	Beyond 2070
USA	14%	2050	$30/tCO_2$	Before 2023	2035	2040	2040	2040	2045	2055	2065
IND	7%	2065	$50/tCO_2$	2025	2060	2060	N/A	2040	2045	Beyond 2070	Beyond 2070
WEU[2]	7%	2045	$120/tCO_2$	Before 2023	2035	2045	2035	2035	2040	2050	2070
MENA[2]	6%	2060	$30/tCO_2$	2030	2060	2060	2050	2040	2045	2070	Beyond 2070
SEAO[2]	5%	2060	$50/tCO_2$	2025	2050	2065	N/A	2040	2045	2070	Beyond 2070
RUS	4%	Beyond 2065	$0/tCO_2$	2030	2060	2060	2050	2050	2055	Beyond 2070	Beyond 2070
CSA[2]	3%	Beyond 2065	$30/tCO_2$	2025	2045	2050	2045	2040	2045	Beyond 2070	Beyond 2070
GCC[2]	3%	2060	$20/tCO_2$	N/A	N/A	2060	N/A	2040	2045	2070	Beyond 2070
JPN	3%	2050	$70/tCO_2$	2025	2045	2045	2040	2040	2040	2055	2065
EURA[2]	2%	Beyond 2065	$0/tCO_2$	2030	2060	2060	2050	2050	2055	Beyond 2070	Beyond 2070
EEU[2]	2%	2045	$120/tCO_2$	Before 2023	2035	2045	2035	2035	2040	2050	2070
IDN	2%	2060	$50/tCO_2$	2025	2050	2050	N/A	2045	2050	2070	Beyond 2070
KOR	2%	2050	$70/tCO_2$	2025	2045	2045	2040	2035	2040	2055	2065
CAN	2%	2050	$100/tCO_2$	Before 2023	2030	2035	2035	2035	2040	2055	2065
BRA	1%	2050	$50/tCO_2$	2025	2045	2050	N/A	2045	2050	2060	2070
SAF[2]	1%	Beyond 2065	$30/tCO_2$	2025	2050	2050	2050	2040	2045	Beyond 2070	Beyond 2070
SA[2]	1%	2065	$50/tCO_2$	2035	2060	2060	N/A	2050	2055	Beyond 2070	Beyond 2070
GBR	1%	2050	$120/tCO_2$	Before 2023	Before 2030	2035	2035	2030	2040	2055	2065
AUS	1%	2050	$70/tCO_2$	From 2023	2038-40	2045	2035	2040	2045	2055	2065
SSA[2]	1%	Beyond 2065	$20/tCO_2$	2030	2060	2050	N/A	2050	2055	Beyond 2070	Beyond 2070

1. Based on policy announcements tracked in IPR 2021 Policy Forecast Detailed resource (March 2021) and in 2022 & 2023 live regulatory tracking (QFTs). Deceleration – forecast has been decelerated relative to IPR 2021; No change – forecast remains the same as IPR 2021, Acceleration – forecast has been accelerated relative to IPR 2021. The policy report discusses these findings in greater detail.; 2. Multi-country region (flag represents the country within the region with the largest emissions); 3. Industrial processes were previously forecasted as 'Beyond 2060' for all regions, hence a designation of 'No change'

The global energy system is split into 21 distinct regions and countries covering the whole of the globe

Code	Region name	Mapping to IPR policy forecast countries	Category
AUS	Australia		Advanced Economies (AE)
CAN	Canada		
EEU	Eastern European Union	Lowest ambition of Italy, France, Germany	
JPN	Japan		
KOR	South Korea		
GBR	United Kingdom		
USA	United States of America		
WEU	West European Union	Lowest ambition of Italy, France, Germany	
BRA	Brazil		Emerging Markets & Developing Economies (EMDE)
CHN	Greater China		
CSA	Central & South America	Lowest ambition of Argentina, Mexico	
EURA	Eurasia		
GCC	Gulf Coordination Council	Saudi Arabia	
IND	India		
IDN	Indonesia		
MENA	Middle East & North Africa	Turkey	
RUS	Russia	Russia	
SA	South Asia	India	
SAF	Southern Africa[1]	South Africa	
SEAO	South East Asia & Oceania	Vietnam	
SSA	Sub-Saharan Africa	Nigeria	

1. South Africa, Lesotho, Eswatini

Note: Where region includes multiple regions, the flag reflects the country with the largest current energy system emissions

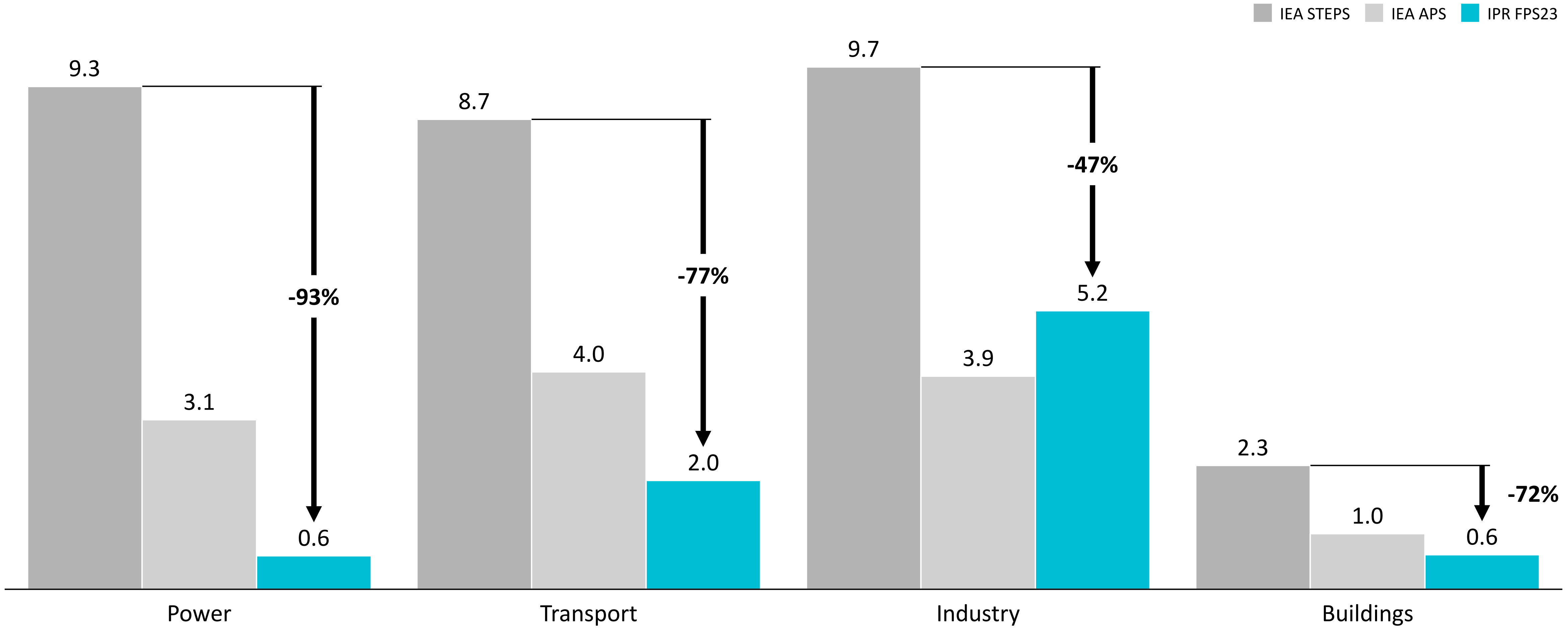
INEVITABLE POLICY RESPONSE

Overview

INEVITABLE POLICY RESPONSE

FPS 2023 sees 47-93% fewer sectoral emissions compared to IEA STEPS in 2050, industry emissions being closest to business as usual

Global CO_2 emissions by sector in 2050, $GtCO_2$

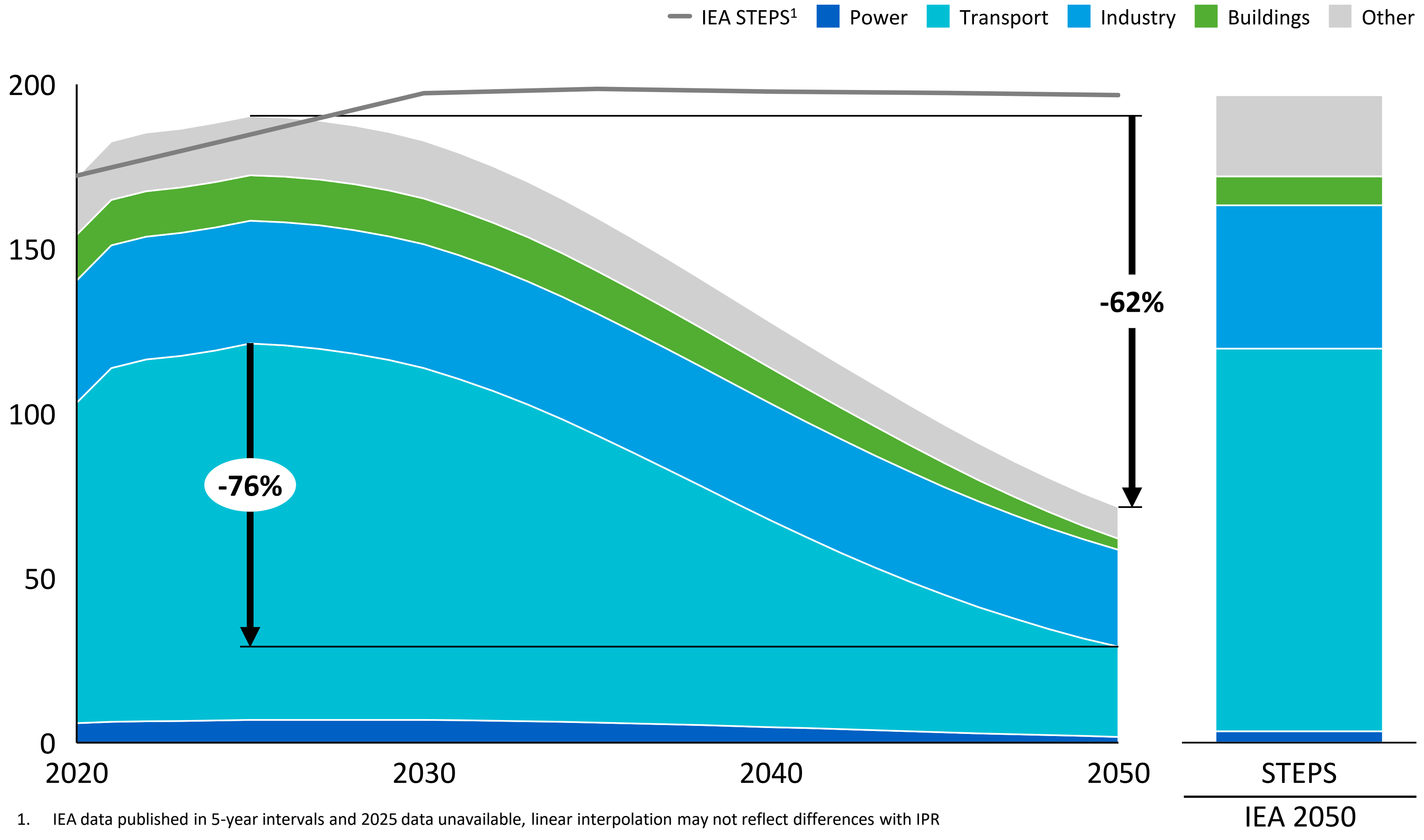


Source: IEA WEO 2022

INEVITABLE POLICY RESPONSE

Oil demand peaks around 2025 and then declines around 60% to 2050, driven by a rapid electrification of transport

Oil demand by sector, EJ



1. IEA data published in 5-year intervals and 2025 data unavailable, linear interpolation may not reflect differences with IPR

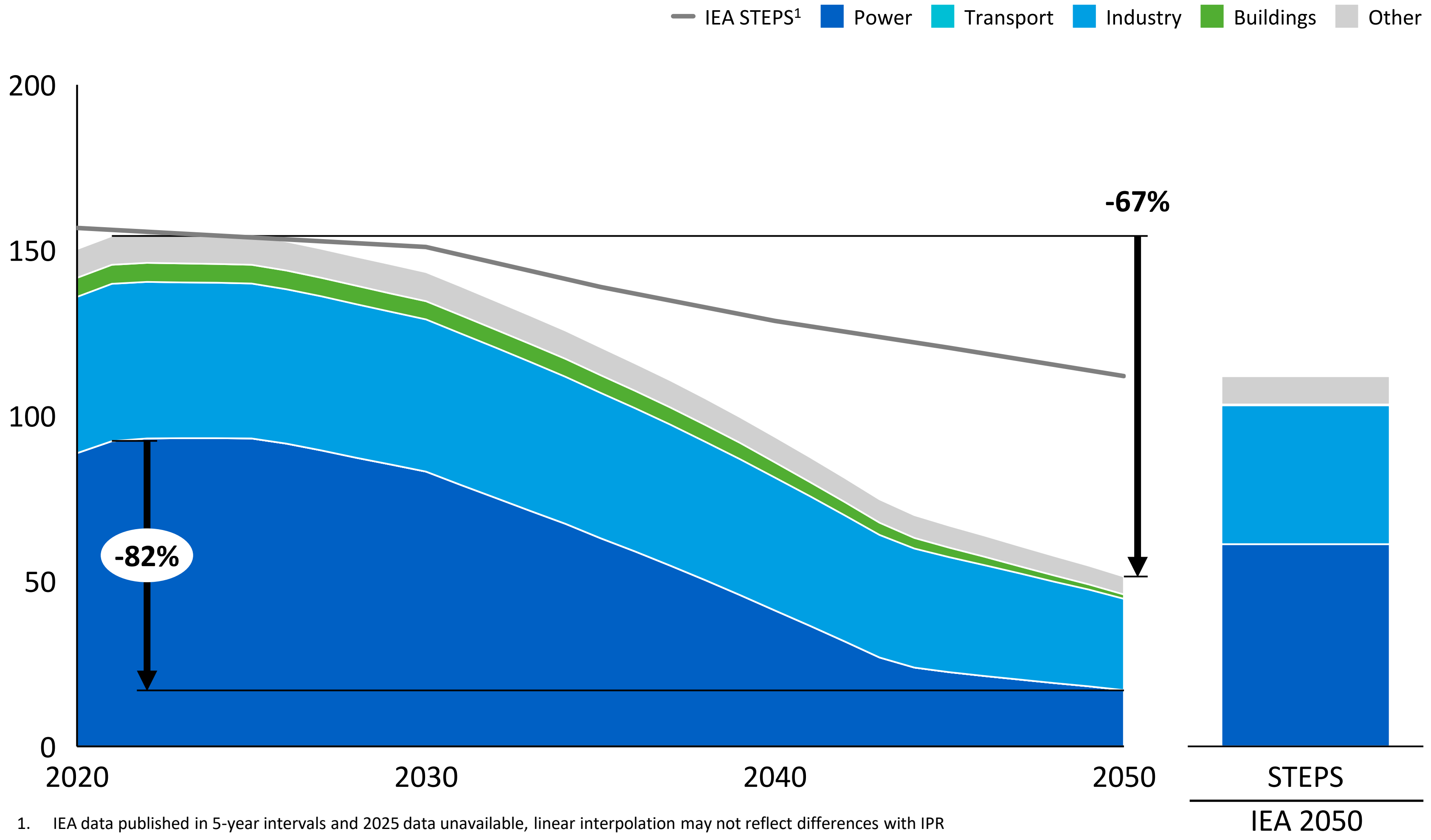
Source: IEA WEO 2022

- Oil demand peaks in the mid 2020s, seeing an uptick during the post-COVID-19 recovery and some growth across all sectors
- Transport is the most significant driver of falling oil demand, with sectoral demand 76% from 2025 to 2050 – this is largely due to a shift from ICE vehicles to EVs
- Industry and buildings also contribute to falling demand, but the use of petrochemical feedstocks mean that oil demand for industry persists
- The largest difference compared to the 'business-as-usual' IEA STEPS scenario is in transport

INEVITABLE POLICY RESPONSE

Coal demand falls by around 70%, driven primarily by a reduction in in power sector demand

Coal demand by sector, EJ



1. IEA data published in 5-year intervals and 2025 data unavailable, linear interpolation may not reflect differences with IPR

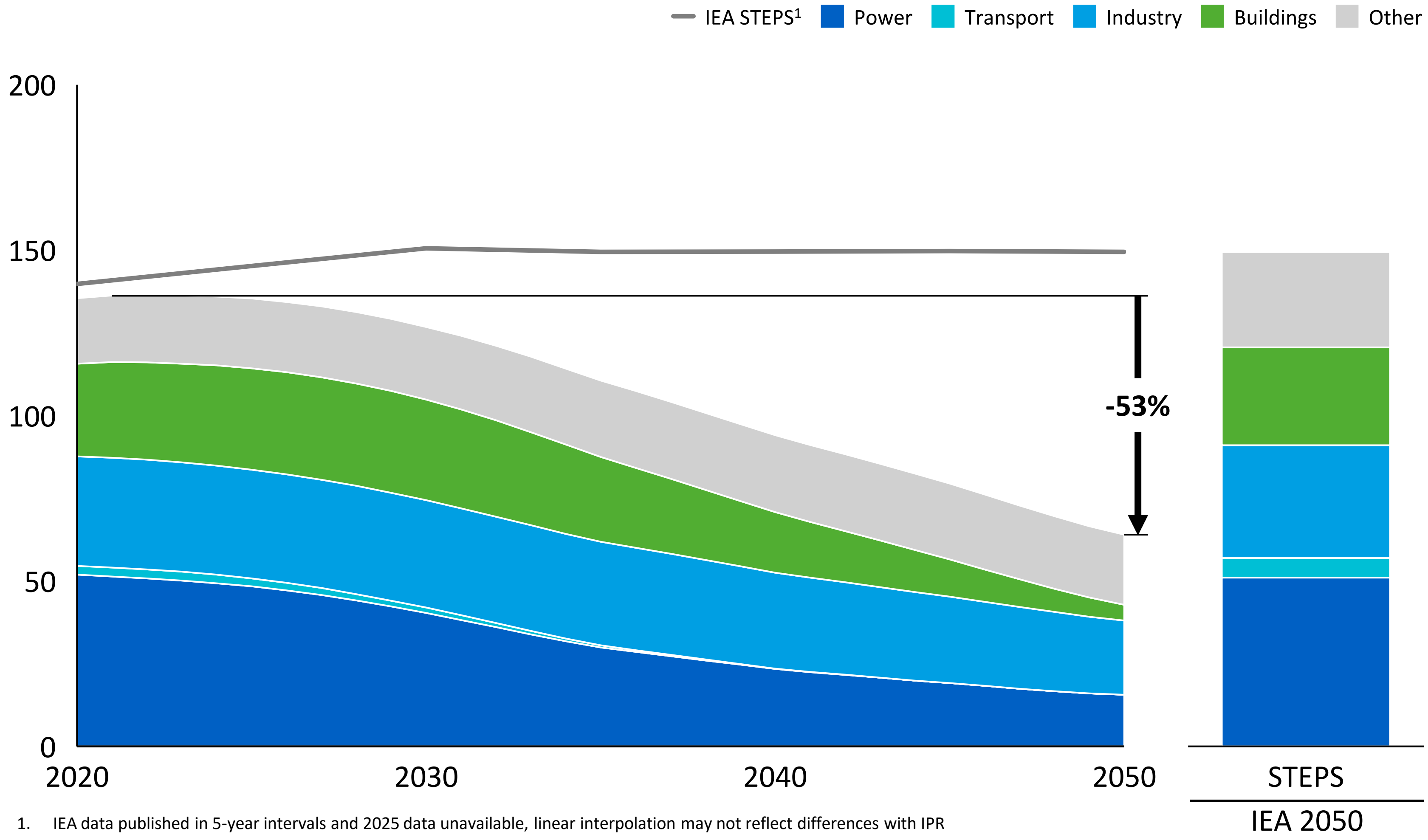
Source: IEA WEO 2022

- Coal demand falls by 67% by 2050
- The power sector shifts quickly away from coal, with a steep decrease in coal demand until 2040, reaching a total 82% reduction from 2021 to 2050
- Coal use is most persistent in industry, which decarbonises slower and is harder to abate – half of 2050 coal demand is for industrial uses such as steel production

INEVITABLE POLICY RESPONSE

Gas demand halves by 2050, driven by the power and buildings sectors

Natural gas demand by sector, EJ



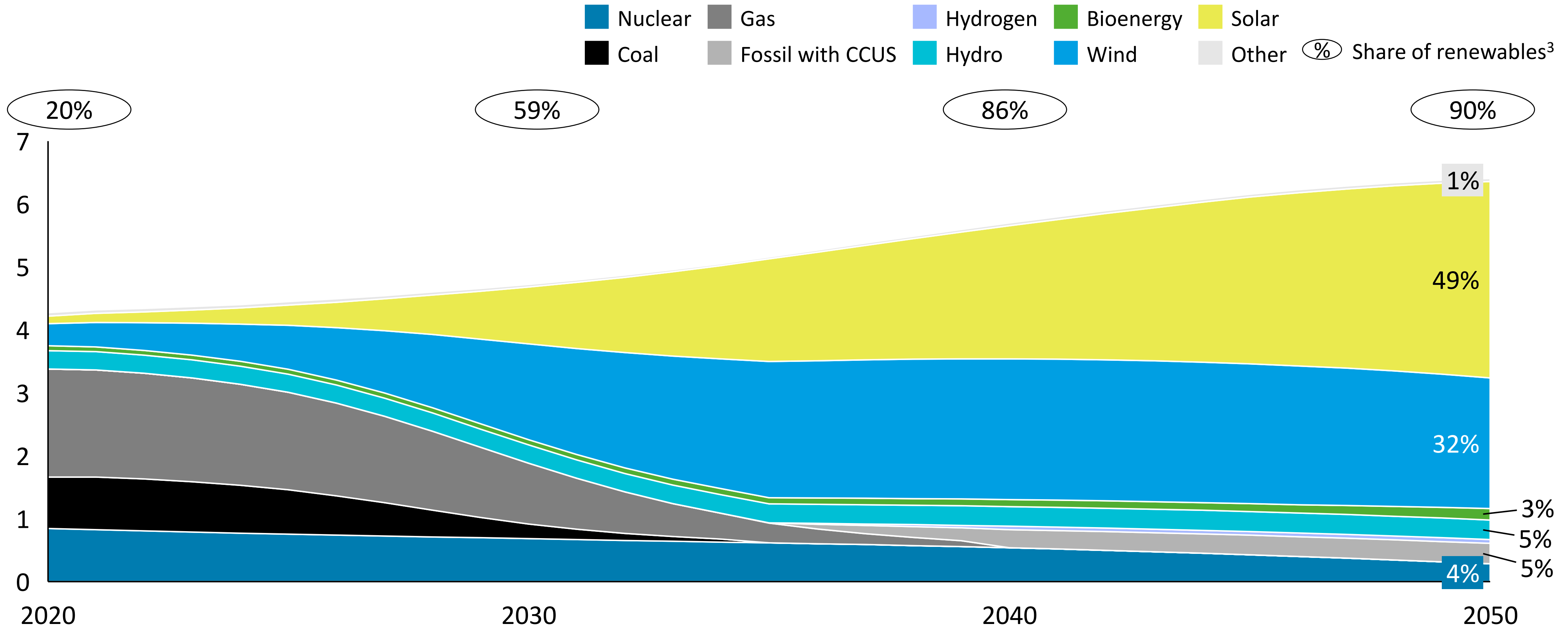
1. IEA data published in 5-year intervals and 2025 data unavailable, linear interpolation may not reflect differences with IPR

Source: IEA WEO 2022

- In the near-term, gas demand plateaus, and then reduces by 53% by 2050
- Falling gas demand is driven mostly by the decarbonisation of power and buildings
- Power switches from gas to renewables, as many countries implement 100% clean power policies
- Buildings electrifies, with heat pumps replacing gas as the primary provider of space heating

In FPS 2023, the United States achieves 100% clean power by 2040, with wind and solar already providing more than 60% of power by 2030

United States electricity generation mix, Thousand TWh

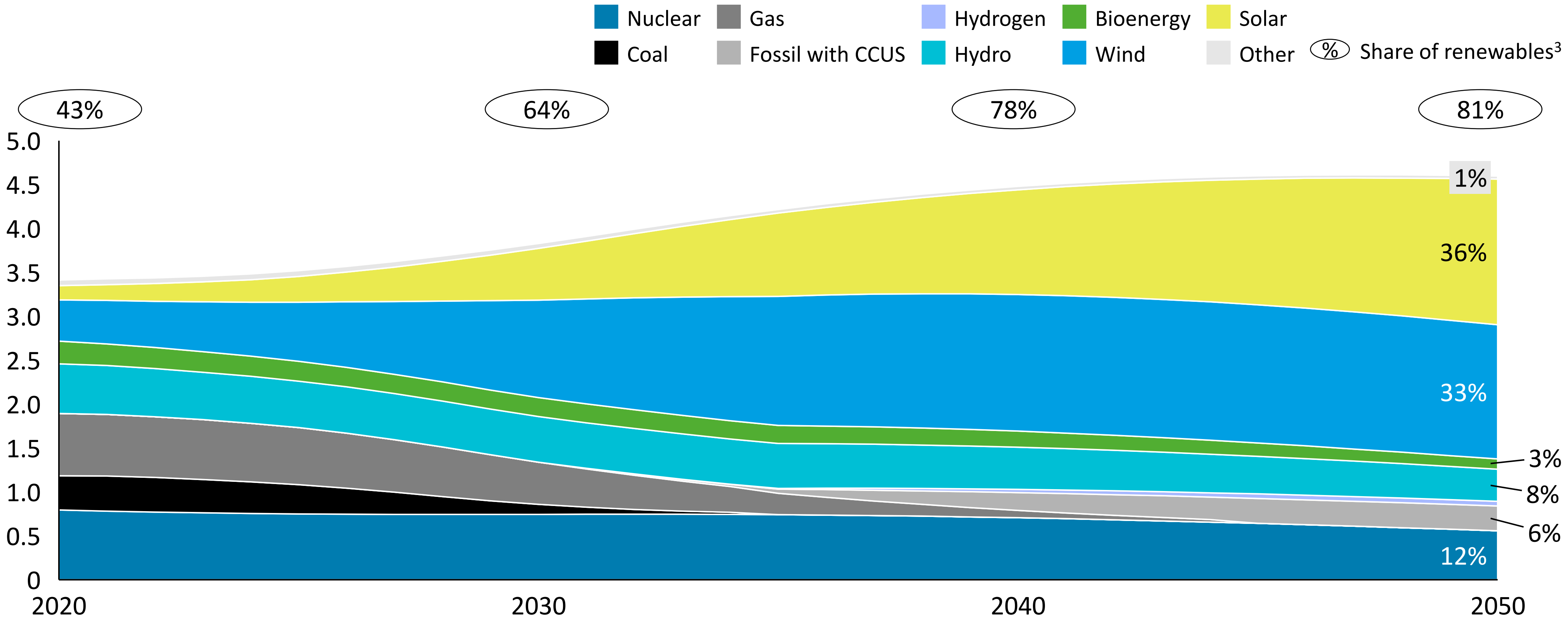


1. All of bioenergy is BECCS by 2050 in FPS
2. Other includes oil and geothermal
3. Solar, wind, hydro, bioenergy, hydrogen and other (not including oil)

INEVITABLE POLICY RESPONSE

The European Union and United Kingdom reach 100% clean power by 2045 in FPS 2023 through a portfolio of low-carbon generation technologies

EU27 and Great Britain electricity generation mix, Thousand TWh

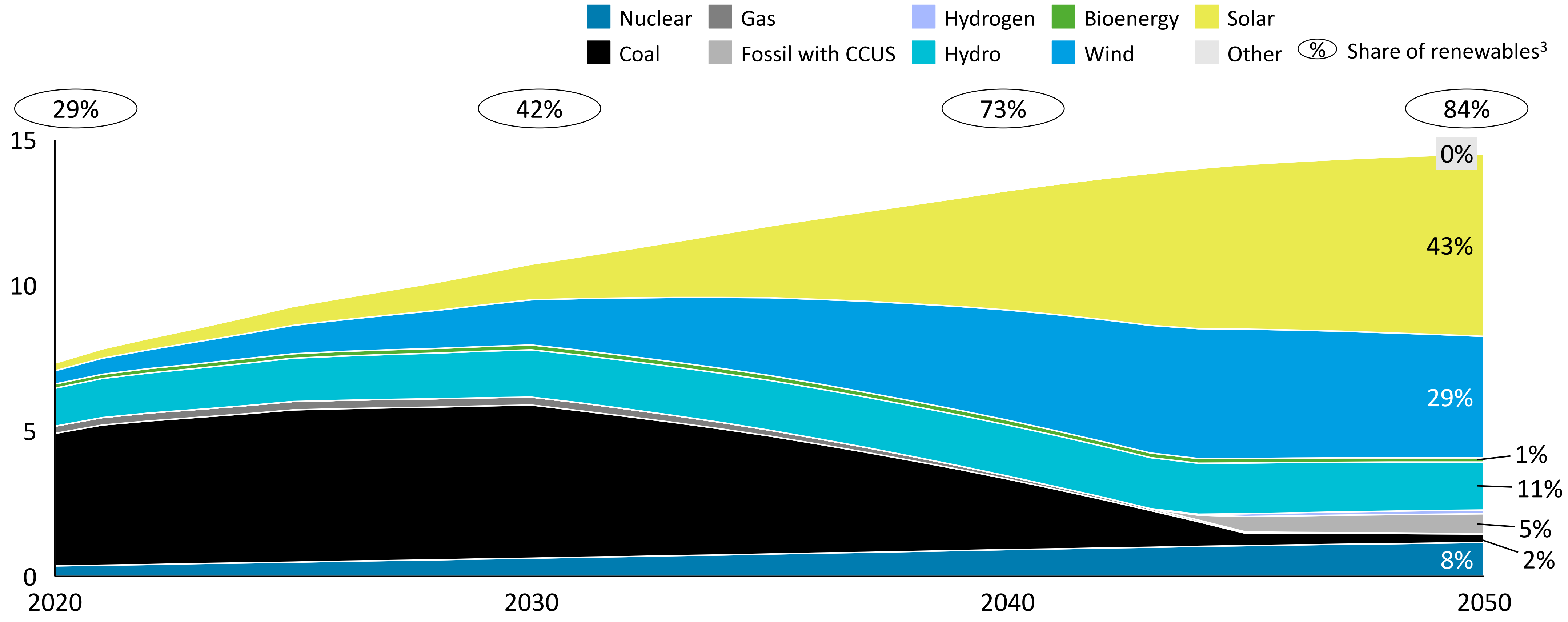


1. All of bioenergy is BECCS by 2050 in FPS
2. Other includes oil and geothermal
3. Solar, wind, hydro, bioenergy, hydrogen and other (not including oil)

INEVITABLE POLICY RESPONSE

In FPS 2023, China achieves clean power by 2050, with CCS retrofit used to decarbonize a large share of coal generation left after 2045

Greater China electricity generation mix, Thousand TWh

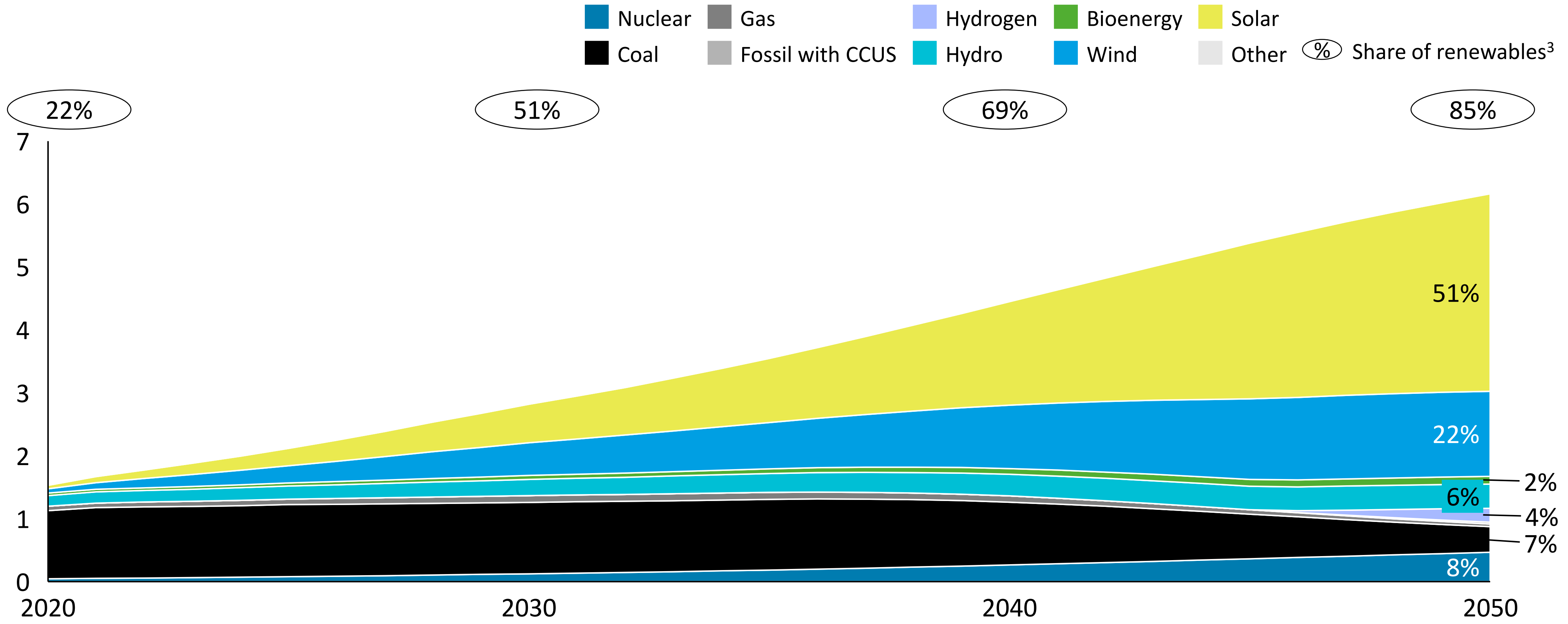


1. All of bioenergy is BECCS by 2050 in FPS
2. Other includes oil and geothermal
3. Solar, wind, hydro, bioenergy, hydrogen and other (not including oil)

INEVITABLE POLICY RESPONSE

In FPS 2023, India's power mix decarbonises substantially with a strong increase in solar, though unabated fossil generation remains well past 2050

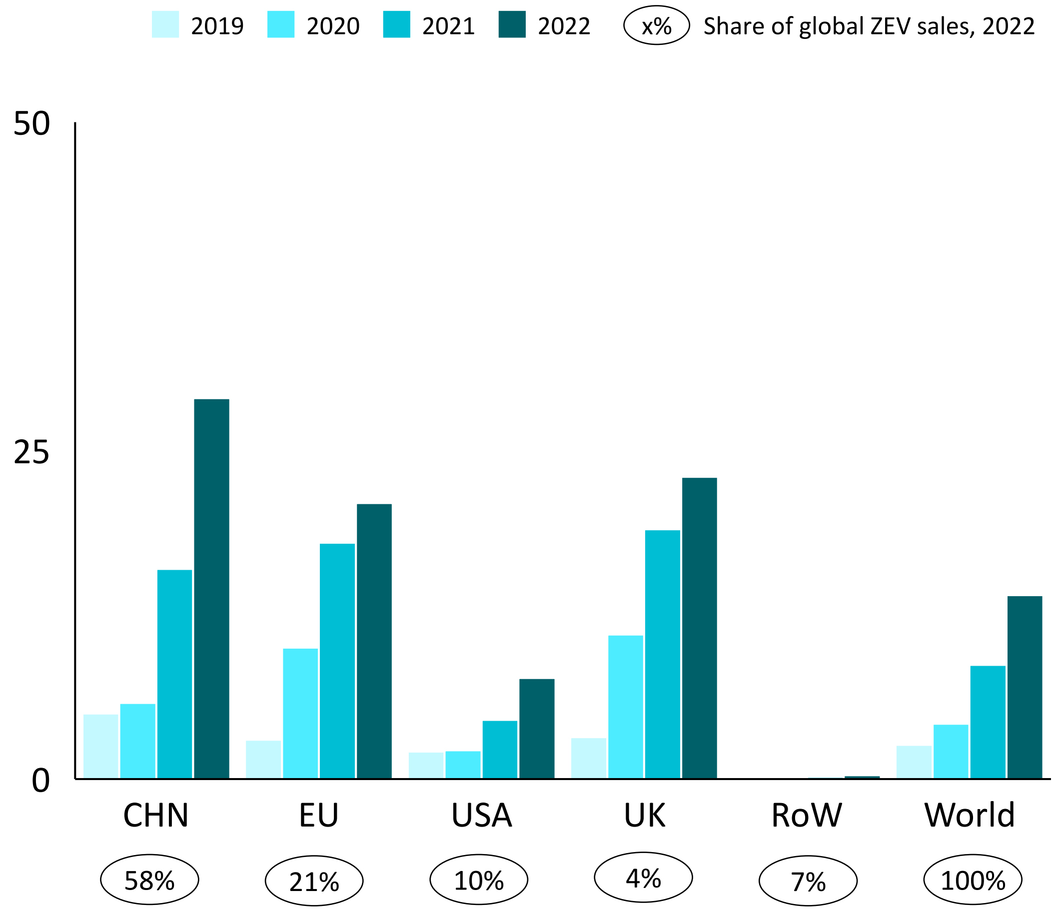
India electricity generation mix, Thousand TWh



1. All of bioenergy is BECCS by 2050 in FPS
2. Other includes oil and geothermal
3. Solar, wind, hydro, bioenergy, hydrogen and other (not including oil)

The market for ZEVs has continued to expand rapidly in major markets…

Share of ZEVs[1] in vehicle sales by region, %



1. Zero Emissions Vehicles include battery (BEV), fuel cell (FCEV), and plug-in hybrid electric vehicles (PHEV)

Source: IEA Global EV Outlook (2023), McKinsey Center for Future Mobility

…with most enabling factors shifting in favour of ZEVs in recent years

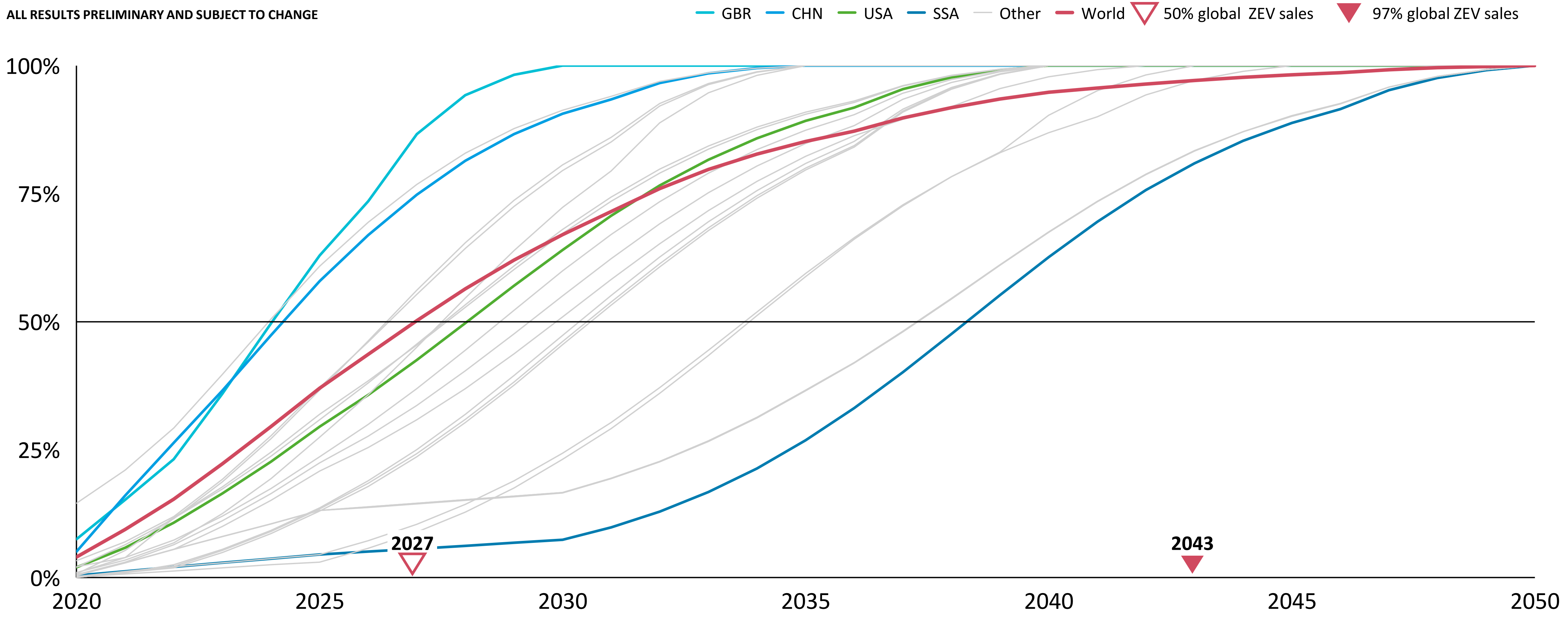
1	Regulation and incentives	**New EU Fit-for-55 targets** announced and approved for 2030 and 100% ZEV target by 2035	-55%	New car emissions in 2030 vs. 2021
		US passes IRA to boost EV production and EPA finalized 2026 emission standards	-30%	New car emissions in 2026 vs 2021
2	Technology and charging infrastructure	**Battery prices** spike in 2022 and reaching 100 USD/kWh milestone moved post 2025	132	2021 average battery price per kWh (BNEF)
		Most major OEMs have announced aggressive EV targets by 2030, including ICE phaseouts	13	Of the 15 top OEMs by 2021 sales volume target >25% EV by 2030
		Governments have accelerated charging infrastructure ramp up and incentives	2	Trillion USD to build s US national EV charging system by Biden govt.
3	Consumer preferences	**EV adoption** continues to grow globally beyond regulatory targets driven by consumer demand	26	Million EVs sold in 2022 globally
		New model launches to continue growing across segments in Europe, China and the US	45	New European BEV+PHEV model launches in 2022

INEVITABLE POLICY RESPONSE

IPR's policy forecast leads half of global car sales to be ZEVs by 2027, with almost no ICE sales by the 2040s…

Share of ZEVs[1] in car sales by region, %

ALL RESULTS PRELIMINARY AND SUBJECT TO CHANGE



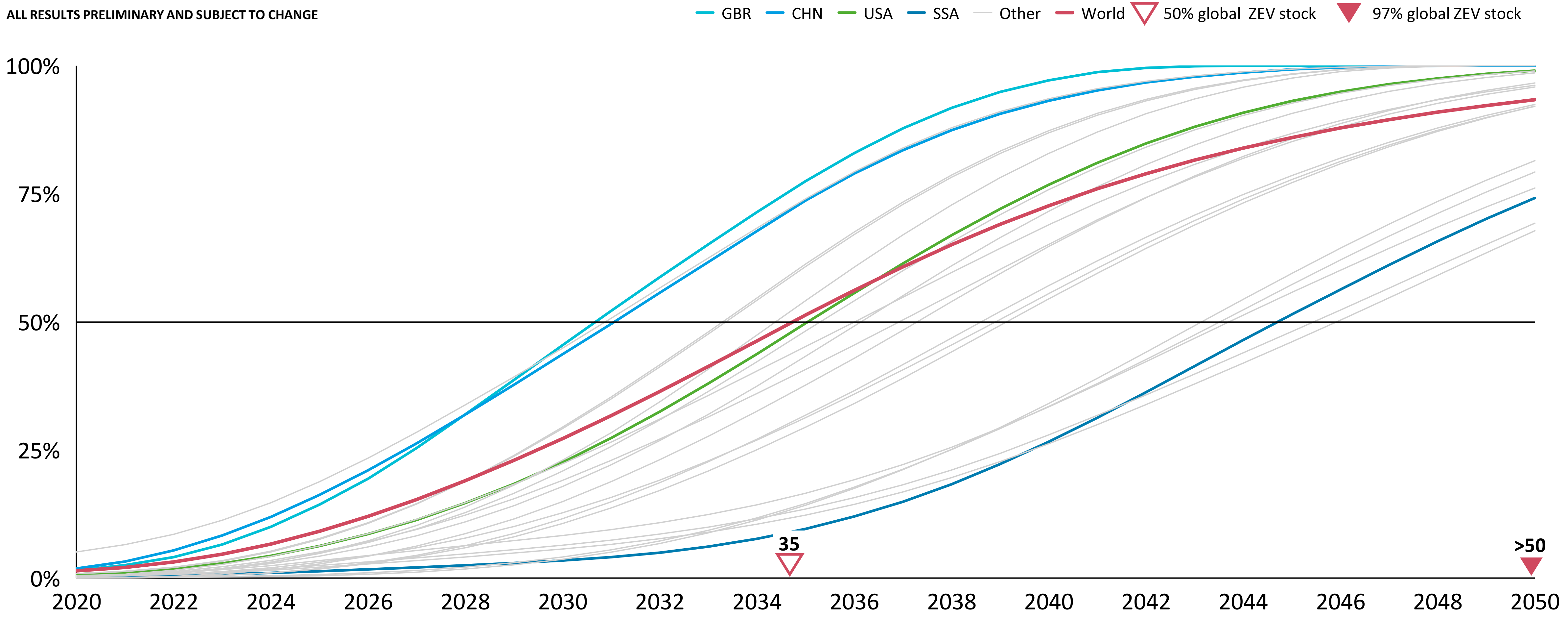
1. Zero Emissions Vehicles include battery (BEV), fuel cell (FCEV), and plug-in hybrid electric vehicles (PHEV)

INEVITABLE POLICY RESPONSE

…leading to electric cars dominating the global fleet from the mid-2030s

Share of ZEVs[1] in car stock by region, %

ALL RESULTS PRELIMINARY AND SUBJECT TO CHANGE

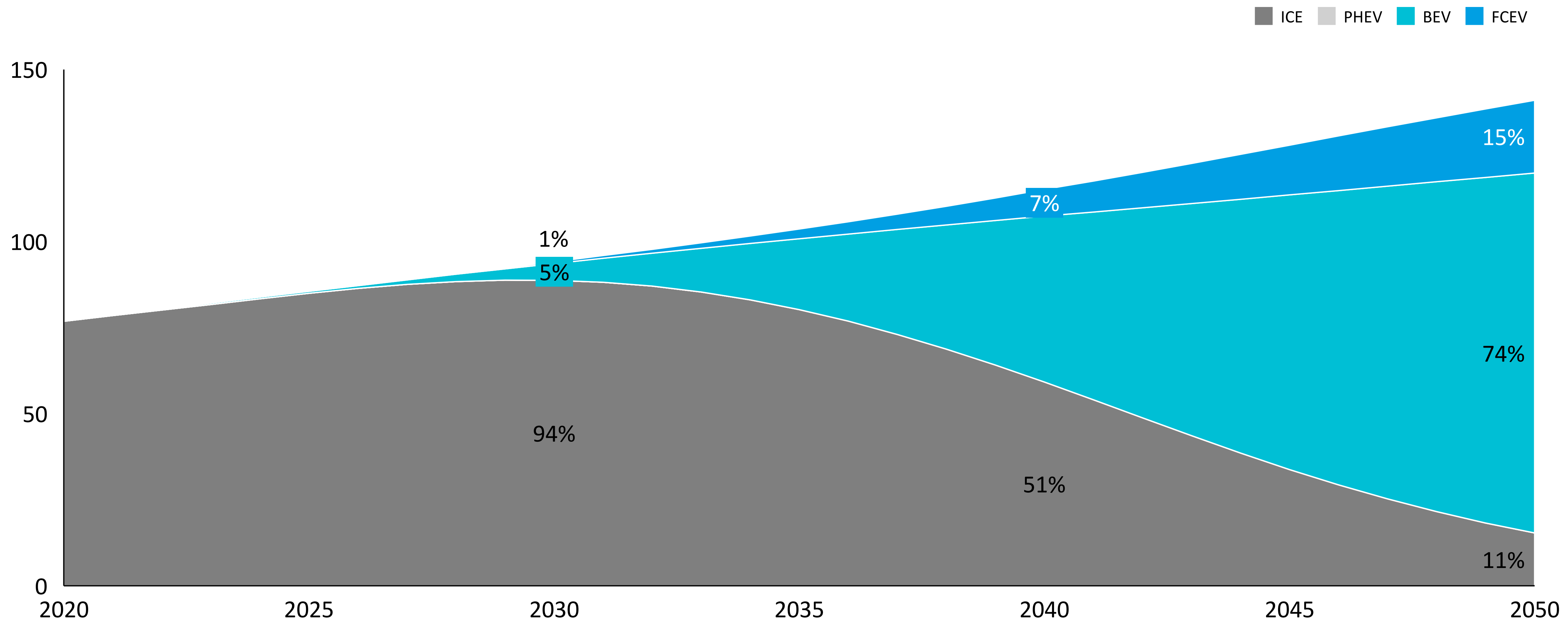


1. Zero Emissions Vehicles include battery (BEV), fuel cell (FCEV), and plug-in hybrid electric vehicles (PHEV)

INEVITABLE POLICY RESPONSE

Zero emissions trucks emerge slightly later than light duty vehicles, though grow to dominate the fleet by 2040

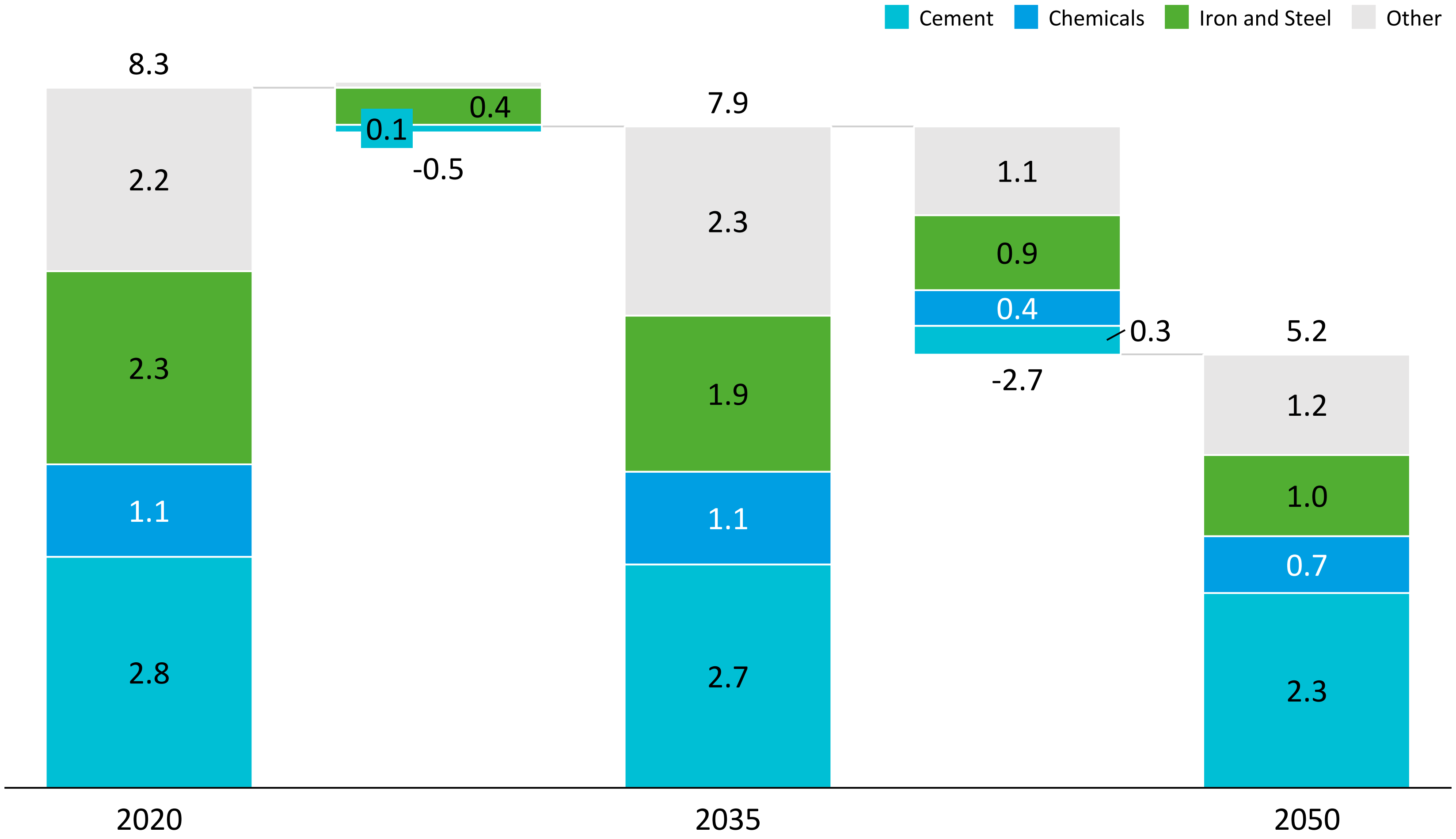
Global truck fleet by powertrain, millions



INEVITABLE POLICY RESPONSE

In the FPS, industrial abatement is limited until CCS and hydrogen mature from around 2035

Net industrial emissions by subsector, $GtCO_2$

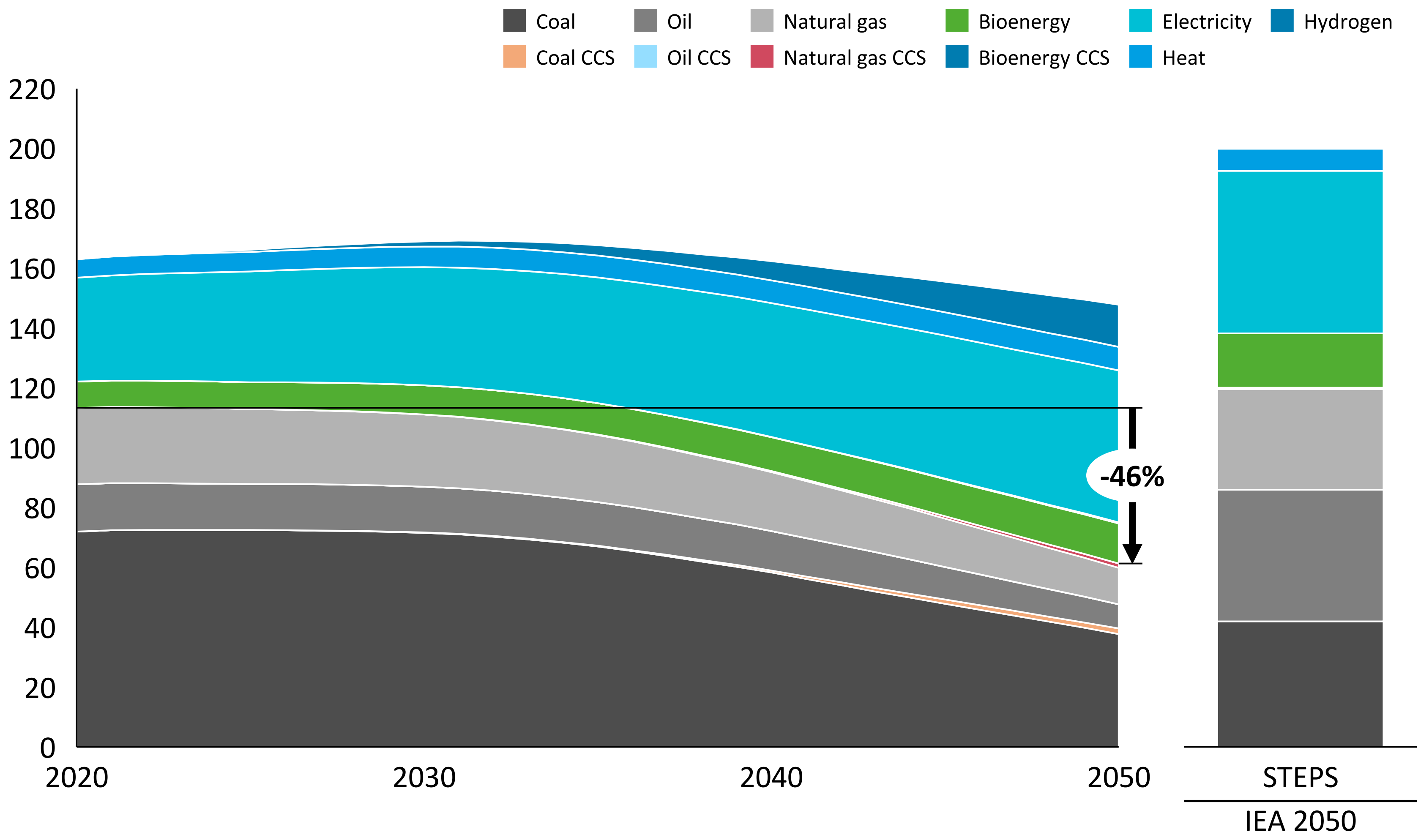


- The FPS 2023 policy forecast considers industrial fuels and industrial processes separately, leading to a **broad deceleration in policy ambition** relative to FPS 2021
- **Growing demand** for industrial goods and **low near-term policy ambition** mean that emissions only fall 0.5 $GtCO_2$ from 2020 to 2035
- **Policy requirements begin to bite from 2035** to 2050, leading to **2.7 $GtCO_2$ of abatement**, but the industry sector remains far from net zero

INEVITABLE POLICY RESPONSE

In industry, fossil fuel use falls by 46%, with limited CCS take-up

Industry energy mix, EJ



Source: IEA WEO 2022

- Long asset lifetimes, high-cost of low-carbon technologies, and low policy ambition means that total fossil fuel use declines relatively slowly
- Coal use falls 45% from 2020 to 2050, and only 5% of total coal in 2050 operating with CCS
- Demand for oil falls 49% by 2050, with no uptake of CCS
- In natural gas, demand falls 47% and CCS take-up makes up 11% of overall gas in 2050
- Electricity demand increase 46% as electrification takes place in light industry
- Hydrogen becomes an important part of steel production, growing more than doubles.

INEVITABLE POLICY RESPONSE

Fossil demand falls in all industrial sectors, but remain persistent in 2050, due to low decarbonisation rates and feedstock demand

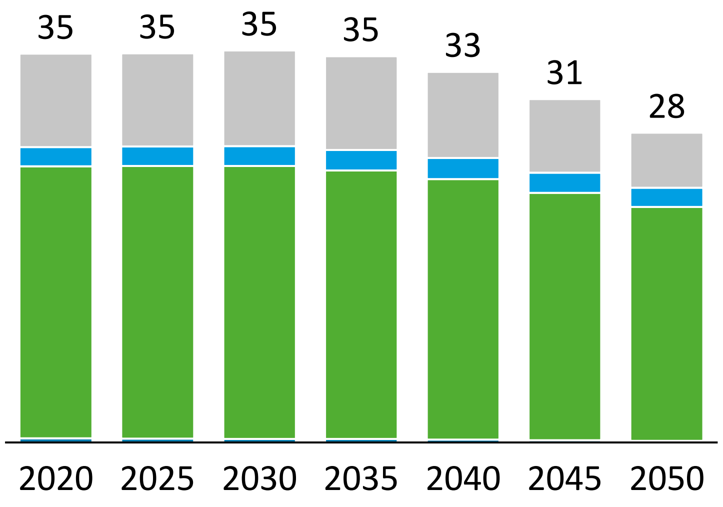
Fossil fuel demand by industry sector

Other industries | Cement CCS | Chemicals CCS | Iron & steel CCS | Cement | Chemicals | Iron & steel

Oil demand, EJ

Fuel: From 2020-2050, demand falls in other industries due to faster decarbonisation

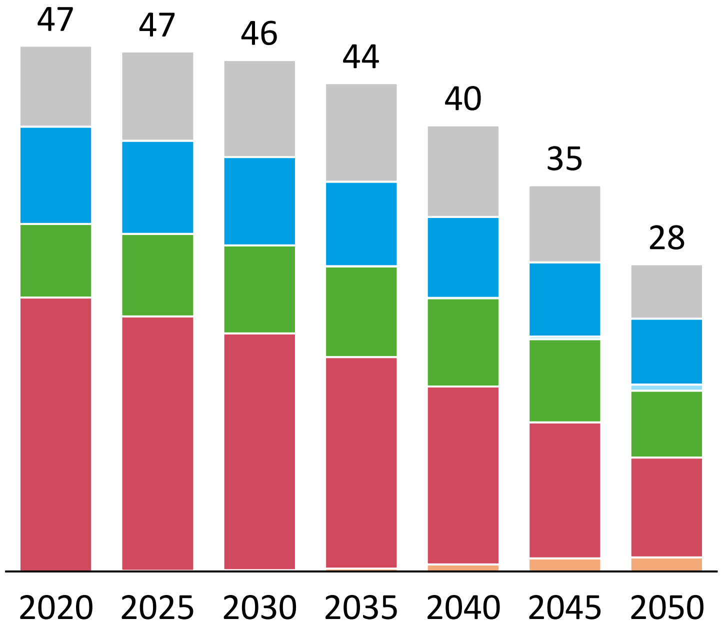
Feedstock: Use of oil for chemical feedstocks remain persistent to 2050



Coal demand, EJ

Fuel: Coal remains a significant part of fuel use across all industrial sectors by 2050

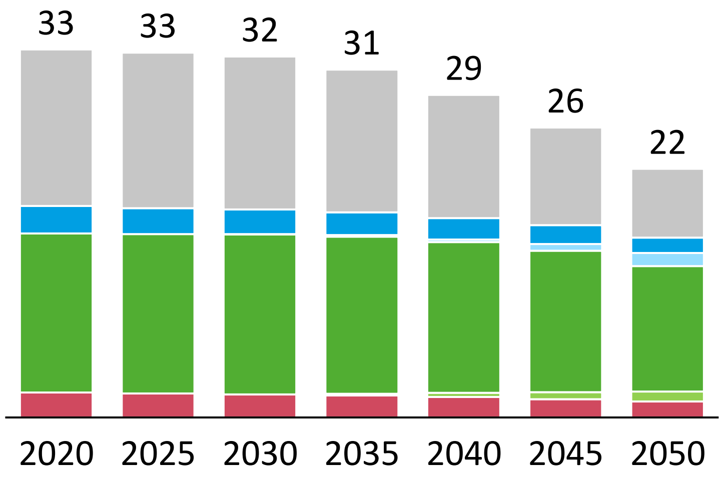
Feedstock: In iron and steel, an increase in the use of scrap reduces the need for metallurgical coal



Natural gas demand, EJ

Fuel: decarbonisation in other industries drives the majority of the decrease in natural gas by 2050

Feedstock: Gas continues to be used as a feedstock for chemicals, but CCS drives some decarbonisation



Disclaimer

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