INEVITABLE POLICY RESPONSE

- The Inevitable Policy Response Forecast Policy Scenario 2021 (IPR FPS 2021):
- Detailed energy system results

Preparing financial markets for climate-related policy and regulatory risks

December 2021

IPR is commissioned by the Principles for Responsible Investment (PRI), supported by world class research partners and joined by leading financial institutions

PRI Principles for Responsible Investment

PRI commissioned the Inevitable Policy Response in 2018 to advance the industry's knowledge of climate transition risk, and to support investors' efforts to incorporate climate risk into their portfolio assessments

:vivideconomics putting economics to good use

Energy Transition Advisors ETA

A research partnership led by Energy Transition Advisors and Vivid Economics conducts the initiative's policy research and scenario modelling and includes 2Dii, Carbon Tracker Initiative, Climate Bonds Initiative, Quinbrook Infrastructure Partners and Planet Tracker

The consortium was given the mandate to bring leading analytic tools and an independent perspective to assess the drivers of likely policy action and their implications on the market

Planet Tracker

quinbrook infrastructure PARTNERS

2° Investing Initiative

Carbon Tracker Initiative

Climate Bonds Initiative

Who supports the Inevitable Policy Response ?

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

BLACKROCK · FitchRatings · nuveen A TIAA Company · ROBECO The Investment Engineers · BNP PARIBAS ASSET MANAGEMENT · Goldman Sachs Asset Management · NewForests

Core philanthropic support since IPR began in 2018. 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

GORDON AND BETTY MOORE FOUNDATION · THE FINANCE HUB · climateworks FOUNDATION

The IPR helps the financial sector navigate the climate transition

Markets inconsistently price transition risk

- Policies will continue interacting with new technologies to deeply disrupt established industries and economies
- Financial institutions need to deepen their understanding of this unfolding environment to manage their assets effectively
- Yet the scenarios currently available provide limited intelligence about the realistic risks and opportunities most critical to the financial sector, and omit the land sector

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The IPR offers a range of applications

IPR Policy Forecast

A **high-conviction policy-based forecast** of forceful policy response to climate change and implications for energy, agriculture and land use

IPR Forecast Policy Scenario (FPS)

A **fully integrated climate scenario** modelling the impact of the forecasted policies on the real economy up to 2050, tracing detailed effects on all emitting sectors

IPR 1.5°C RPS Scenario

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. This can be used by those looking to align to 1.5°C

IPR value drivers

A set of publicly available **outputs from the FPS and 1.5°C RPS** that offer significant granularity at the sector and country level allowing investors to assess their own climate risk

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IPR's FPS value add

A high conviction policy-based forecast, anchored in realistic policy and technology expectations rather than hypothetical 'optimal' pathways

Fully integrating land-use to examine the full system impacts of policies, and highlight the critical role of land

Transparent on expectations for policy and deployment of key technologies, such as Negative Emission Technologies

Covers all regions of the world, with specific policy forecasts for key countries and regions

Applicable to TCFD reporting and regulatory stress testing

Complete forecast includes macroeconomic, energy and land use models linking crucial aspects of climate across the entire economy

A '**1.5°C Required Policy Scenario**' (1.5°C RPS) has been developed, building on the IEA NZE, deepening analysis on land use, and deriving polices required to reach a rapid net zero 2050 outcome

Note: IPR does not model physical risk

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IPR 2021 reports

A series of new IPR reports have been released in 2021. Please visit the PRI website here for more information

Glossary

- AgTech - Agriculture technology
- BECCS - Bioenergy with carbon capture and storage
- BNEF - Bloomberg New Energy Finance
- CAGR - Compound average growth rate
- CCS - Carbon capture and storage
- CDR - Carbon dioxide removal
- CH_4 - Methane
- CO_2 - Carbon dioxide
- CPS - Current Policies Scenario
- DAC - Direct air capture
- LT-DAC - Low temperature solid sorbent
- EV - Electric vehicle
- FPI - Food Price Index
- FPS - Forecast Policy Scenario
- GHG - Greenhouse gas
- ICE - Internal Combustion Engine
- IEA - International Energy Agency
- IPR - Inevitable Policy Response
- N_2O - Nitrous oxide
- NDC - Nationally determined contributions
- NEO - New Energy Outlook
- NETs - Negative emission technologies
- NPS - New Policies Scenario
- P1 - An IPCC 1.5°C scenario
- P2 - An IPCC 1.5°C scenario
- 1.5°C RPS - 1.5°C Required Policy Scenario
- SDS - Sustainable Development Scenario
- STEPS - Stated Policies Scenario
- TCFD - Task Force on Climate-related Financial Disclosures
- ULEV - Ultra low emission vehicles
- WEO - World Energy Outlook

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Executive summary overview

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Key findings

Sweeping transformation across major sectors

As key regions and countries will be pushed to stock-take and convert commitment into action, every major sector will be transformed, deeply disrupting established industries and economies:

- Rapid transformation of the energy system
- Global use of all fossil fuels (Oil, coal, and natural gas) will fall 60% by 2050
- Oil demand is already near its all-time peak, and will drop after the mid-2020s, driven by the mass transition to electric vehicles and improving vehicle efficiency
- Demand for coal will fall by 75% by 2050, due to less use by the power industry
- CO2 emissions from the power sector will decline rapidly and steadily until 2050
- Wind and solar power will represent over 30% of electricity generation by 2030, and will be the primary power generation sources (accounting for over 60% of the mix) by 2050

Seismic shift in transport within this decade

- Fossil fuel-powered vehicles peak in 2025 , and fall out of production by 2050 as people rapidly switch to zero emission vehicles which account for 30% of all cars on the road by 2030
- Global truck fleet will decarbonise more slowly, but will still be almost fully decarbonised by 2050 as the fleet transitions to electric and hydrogen fuelled vehicles

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CO_2 emissions

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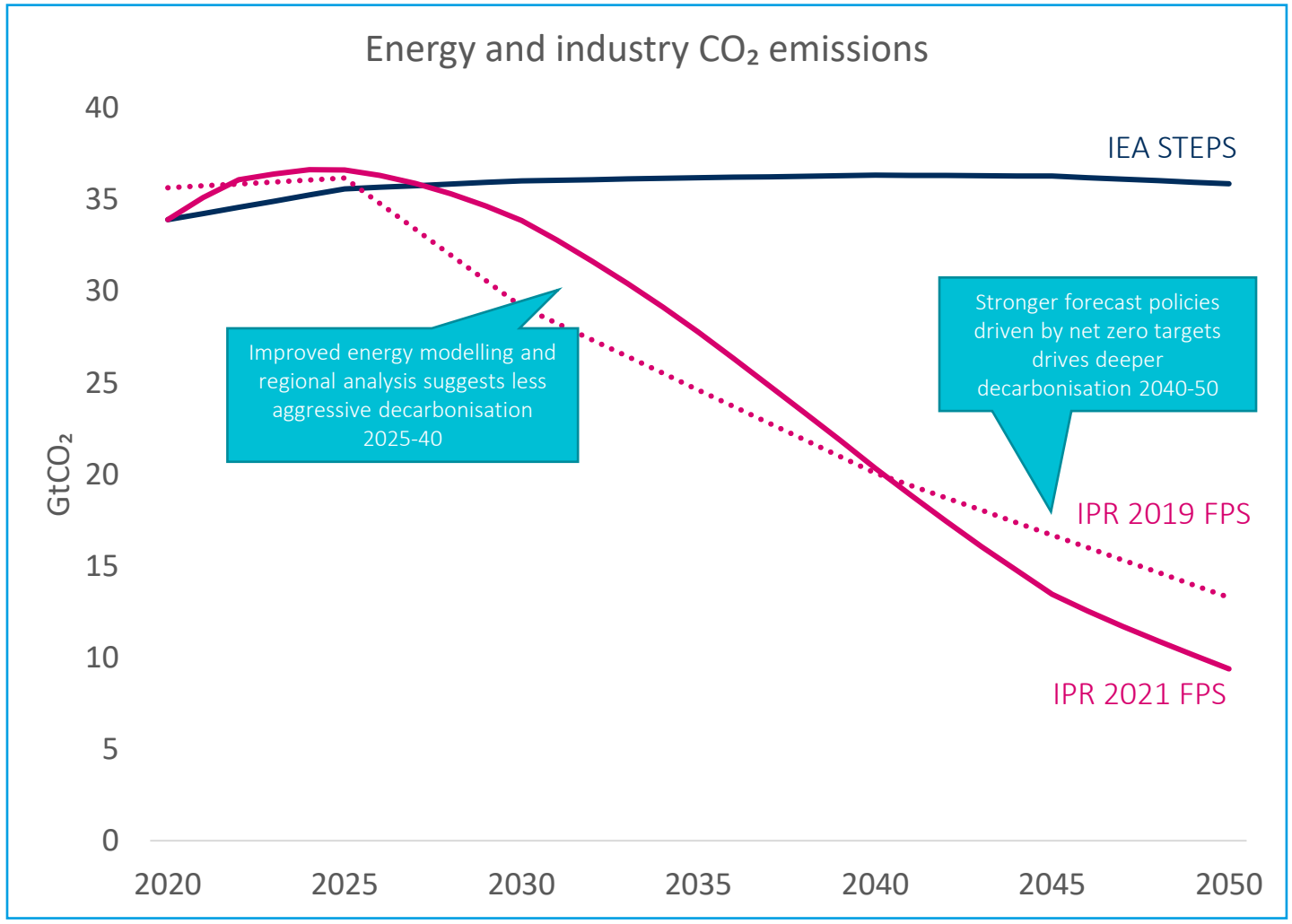
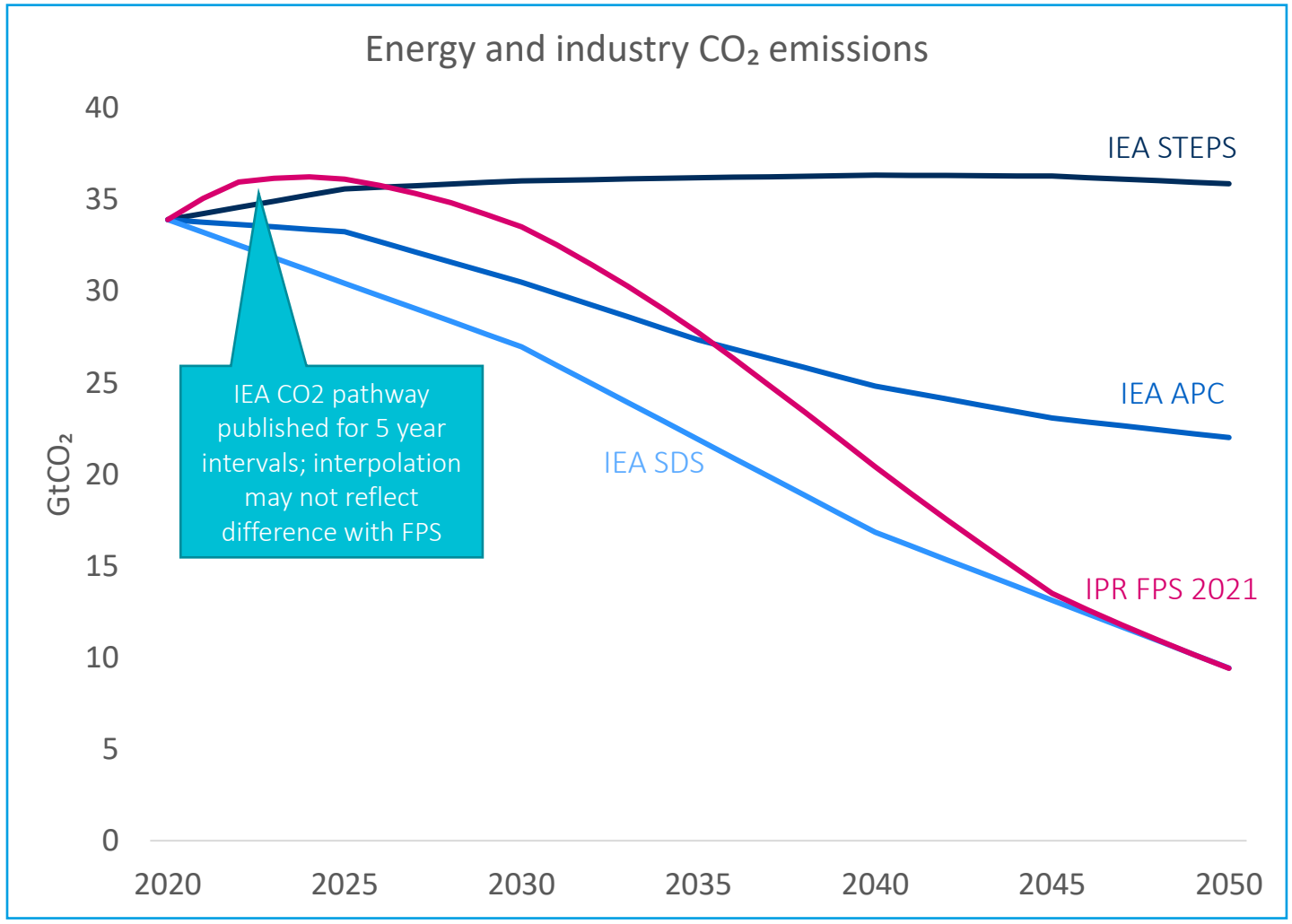
IPR FPS 2021 energy related CO_2 emissions vs IEA STEPS and FPS 2019



- Energy-related CO_2 emissions follow a similar pathway to IEA STEPS to 2025*, before declining to 2050
- Between 2025 and 2040, energy-related CO_2 emissions are above the IPR 2019 forecast.
- Emissions reduction projections have been revised upwards following more detailed modelling at the regional level
- From 2040, energy-related CO_2 emissions fall below the IPR 2019 forecast, as more ambitious IPR 2021 forecast policies take effect

* Data on STEPS CO_2 pathway is only published in 5-year increments

IPR FPS 2021 energy related CO_2 emissions vs IEA APC and IEA SDS



- Between 2020 and 2030, energy-related CO_2 emissions fall only slightly, as new policies begin to take effect
- By 2035 emissions are comparable to the IEA Announced Pledges Case (APC)
- Over this period emissions are well above those in IEA Sustainable Development Scenario (SDS), which represents immediate climate action
- From around 2035, emissions fall well below APC levels as more ambitious IPR 2021 forecast policies take effect
- By around 2045, emissions are line with those in IEA SDS

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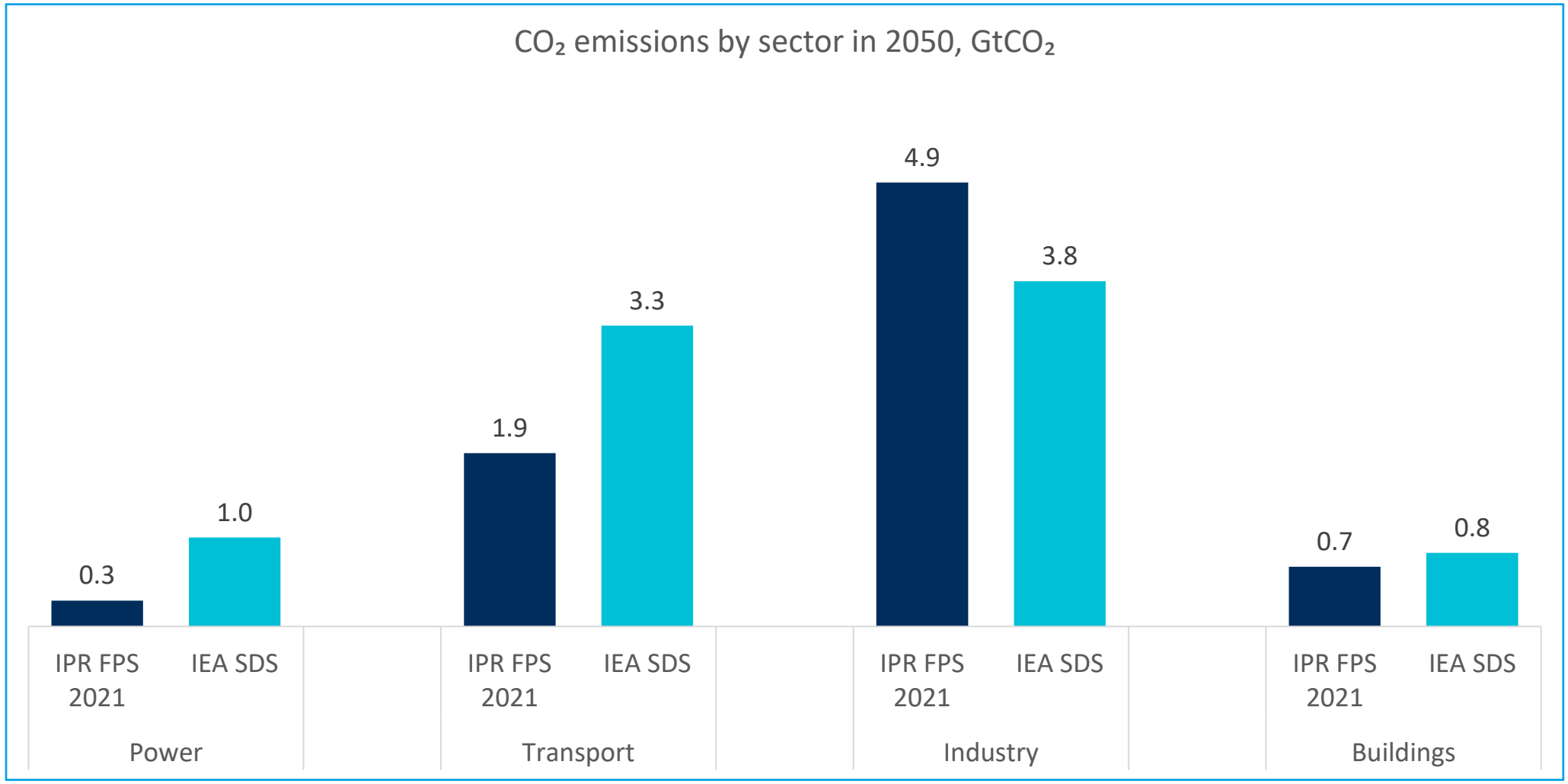
* Data on IEA CO2 pathways are published in 5-year intervals ** IPR FPS 2019 was modelled in 5-year increments
Note: IEA scenario data based on May 2021 Net Zero Emissions report; in WEO2021, IEA APC is renamed Announced Pledges Scenario (APS), with a slightly modified emissions pathway

By 2050, IPR FPS 2021 decarbonises more rapidly than IEA SDS in power and transport, but more slowly in industry



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Fuel demand

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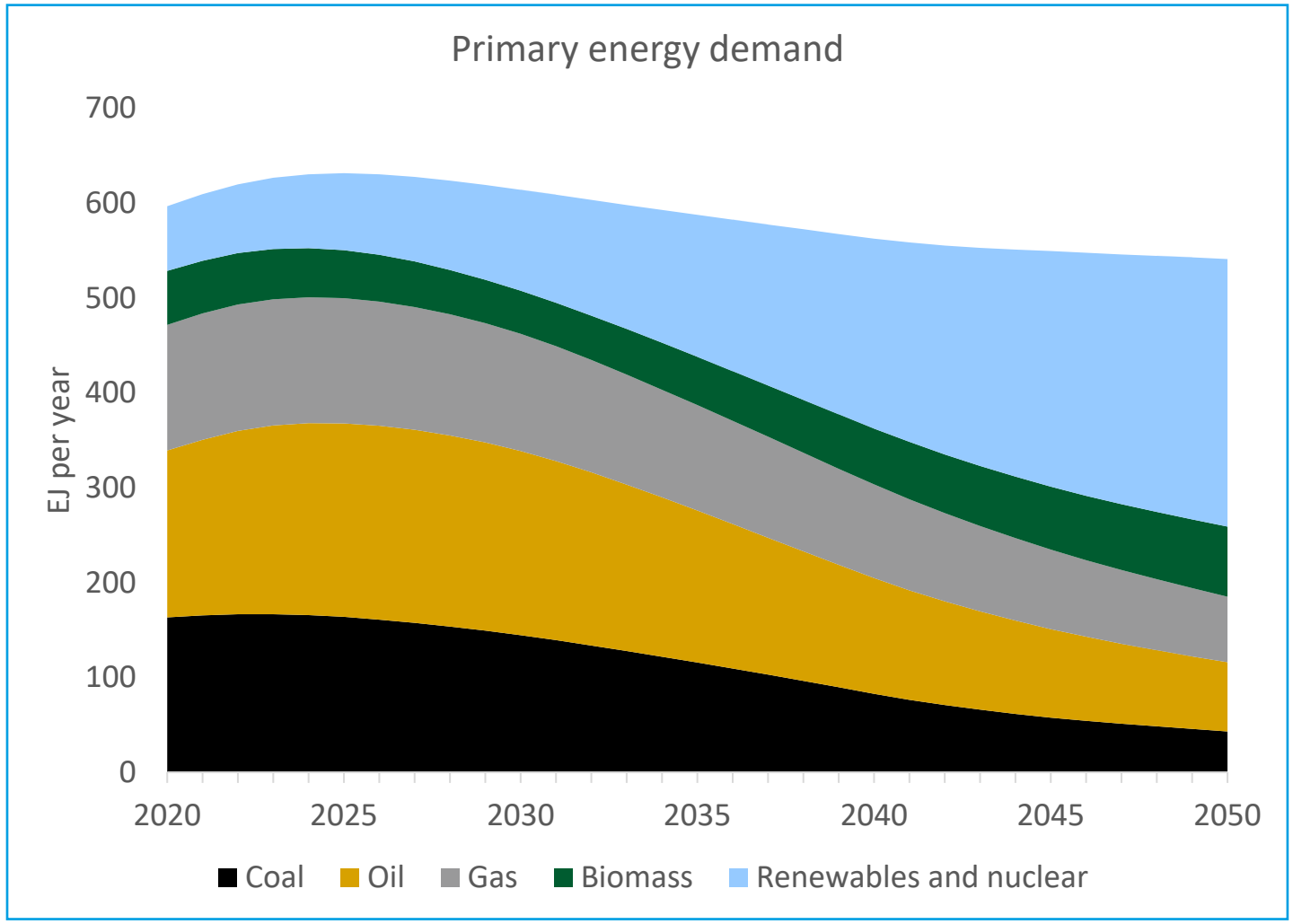
Biomass, renewables and nuclear grow from around 20% of primary energy in 2020 to around 65% in 2050



- The share of fossil fuels in primary energy falls from around 80% in 2020 to below 40% in 2050
- In contrast, the share of biomass, renewables and nuclear rises substantially
- These low-carbon fuels account for the majority of primary energy by the mid-2040s and for around 65% by 2050
- Overall, around 15% of primary energy is used to produce hydrogen

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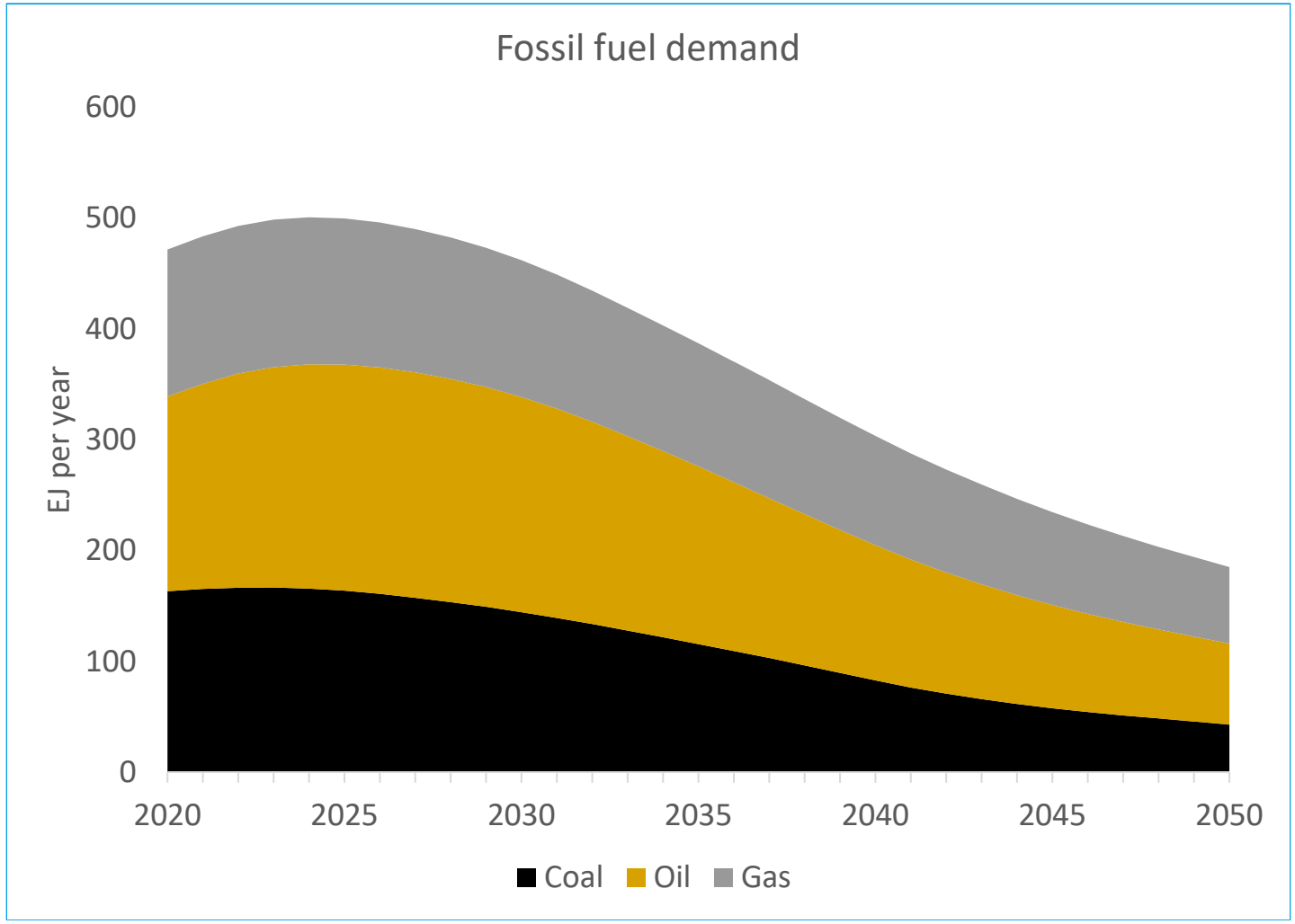
Total fossil fuel demand peaks in the mid-2020s before declining, with coal seeing the fastest fall



- Total coal, oil and gas demand peak in the mid-2020s before declining substantially to 2050
- Coal demand decreases around 10% between 2020 and 2030, driven by early coal phase outs in some regions; between 2020 and 2050 coal demand falls by around 75%
- Oil demand rises in the early 2020s before falling to 2030; between 2020 and 2050 oil demand falls by around 60%
- Gas demand falls around 5% between 2020 and 2030, and then falls further: between 2020 and 2050 gas demand falls by around 50%

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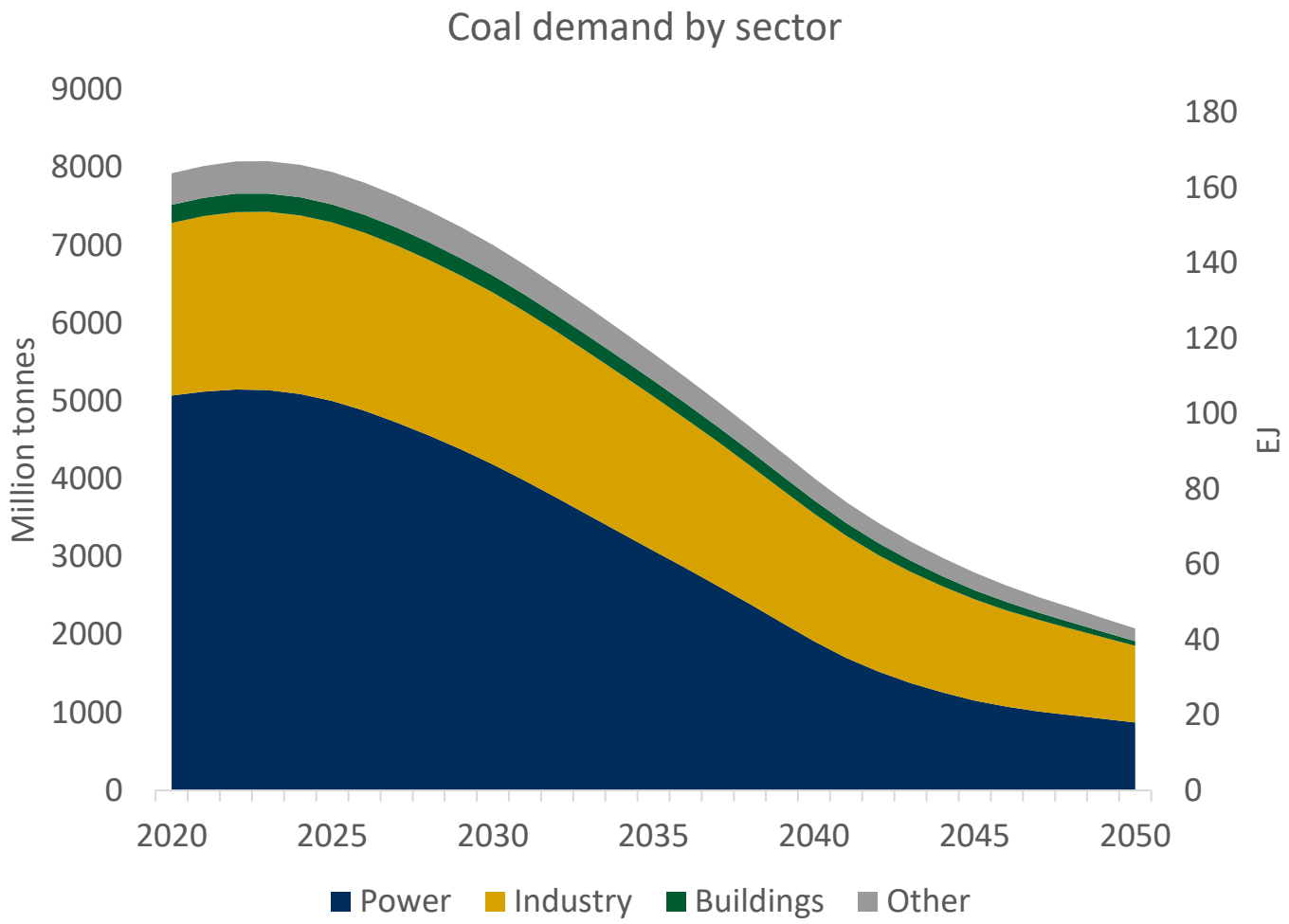
Coal demand falls 70%, driven primarily by a reduction in demand in the power sector; by 2050 industry accounts for the largest share of coal demand



- Coal demand falls around 75% between 2020 and 2050
- Demand from power falls rapidly, with around an 85% reduction 2020-50
- As a result, the share of power in total coal demand falls from over 60% in 2020 to around 40% in 2050
- Demand from industry falls less rapidly, with around a 45% reduction 2020-50
- By 2050 industry accounts for almost half of total coal demand, up from around 30% in 2050

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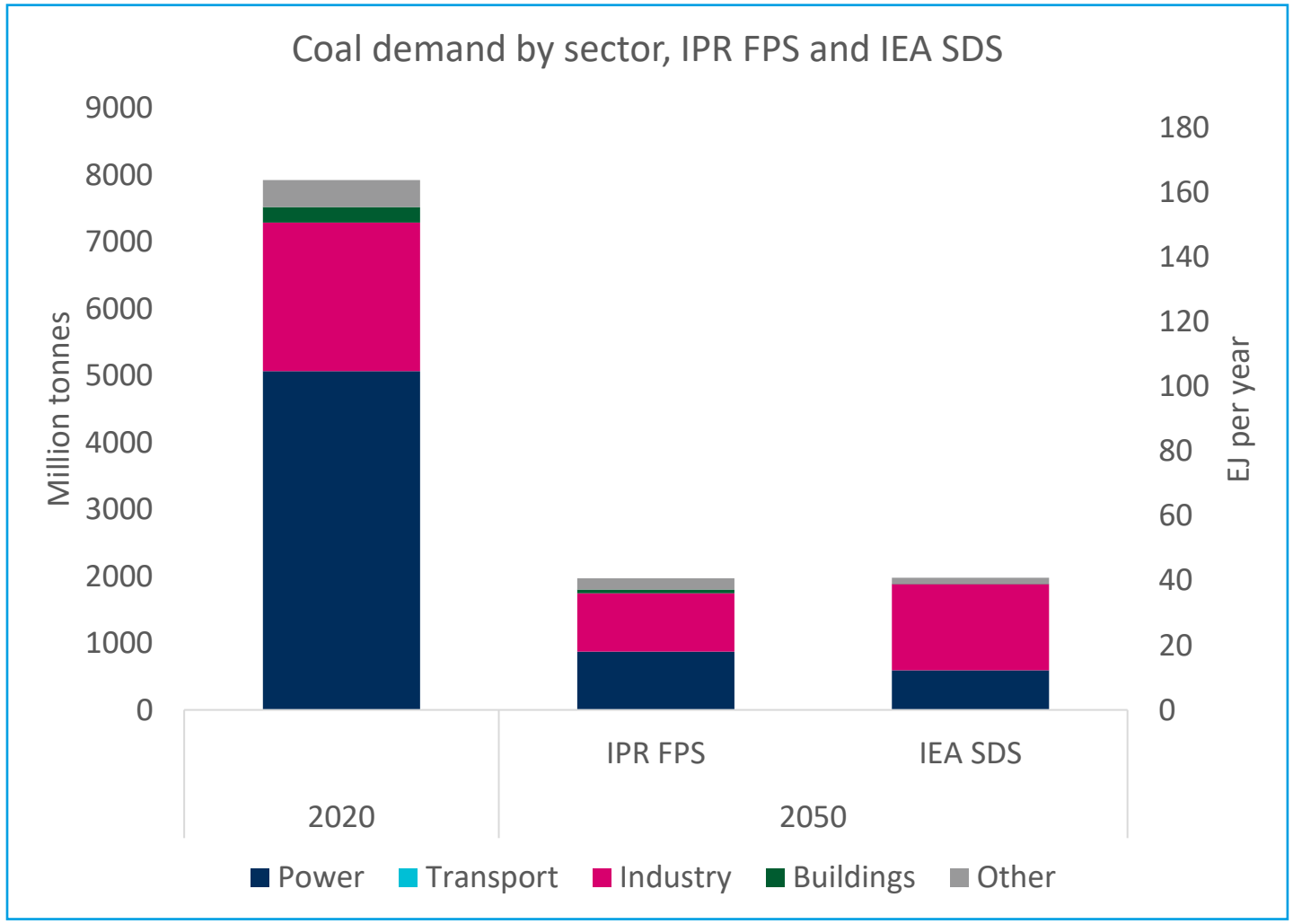
Relative to IEA's Sustainable Development Scenario, coal demand declines to similar levels, but is higher in power and lower in industry



- Sectoral demand for coal is similar to that in IEA SDS by 2050
- Coal is slightly higher in power than under IEA SDS, as a number of regions are forecast to delay phase out of coal
- Conversely, coal is lower in industry than under IEA SDS, as coal is displaced more rapidly by alternative fuels, and particularly by hydrogen in steel production

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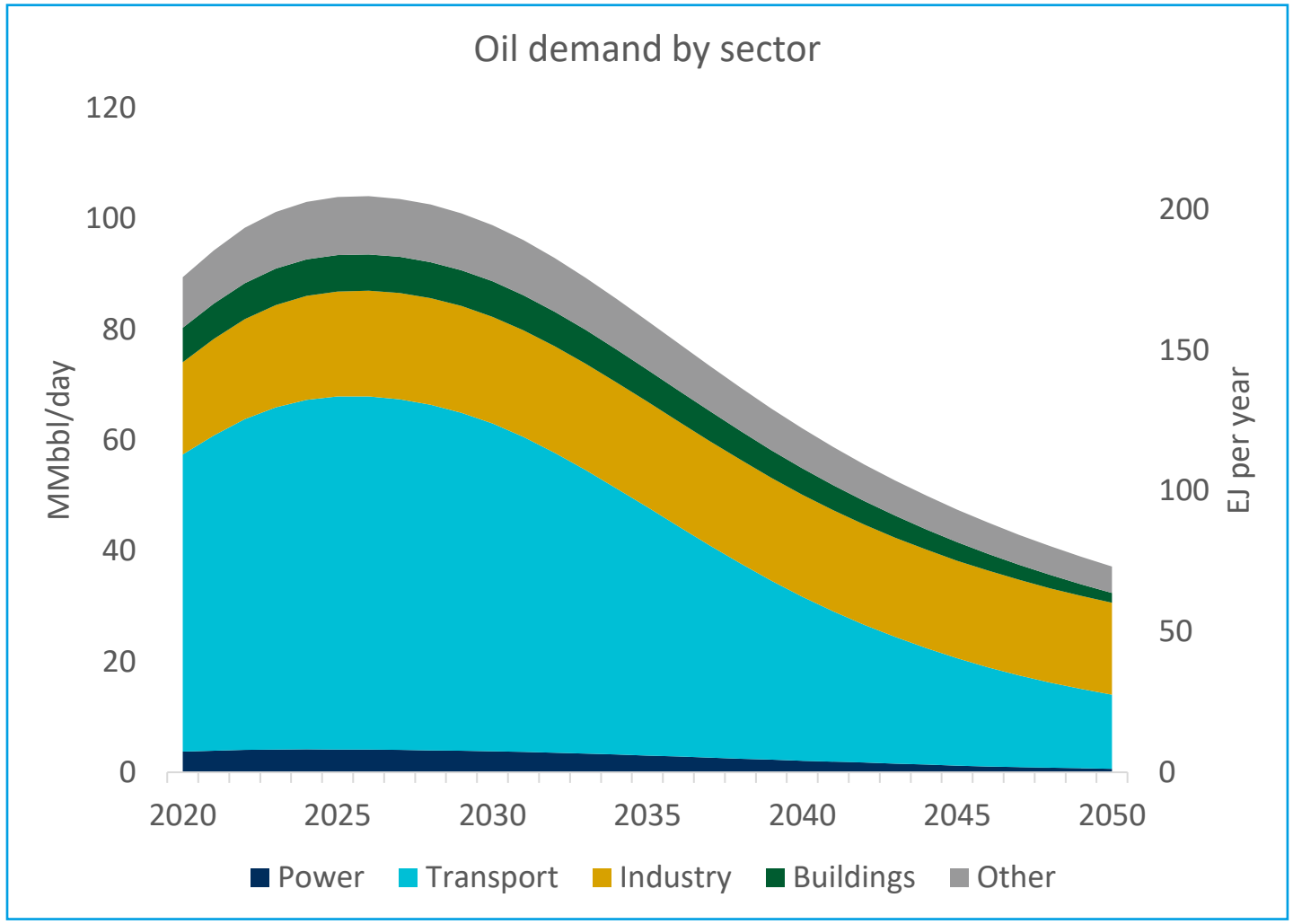
Oil demand peaks in 2025, and falls around 60% between 2020 and 2050



- Oil demand grows until the mid-2020s, driven by recovery from the COVID-19 pandemic and further economic growth
- Oil demand peaks around 2025, as transport and other sectors reduce use of fossil fuels. Overall oil demand falls around 60% between 2020 and 2050 as fossil vehicles exit the fleet
- Transport accounts for the majority of the demand reduction; oil demand in transport falls around 75% between 2020 and 2050. By 2050, transport accounts for under 35% of oil demand
- Demand in industry falls only slightly, due to continued use of oil as a petrochemical feedstock, where the carbon content is largely embedded in the products. By 2050, industry accounts for over 45% of oil demand

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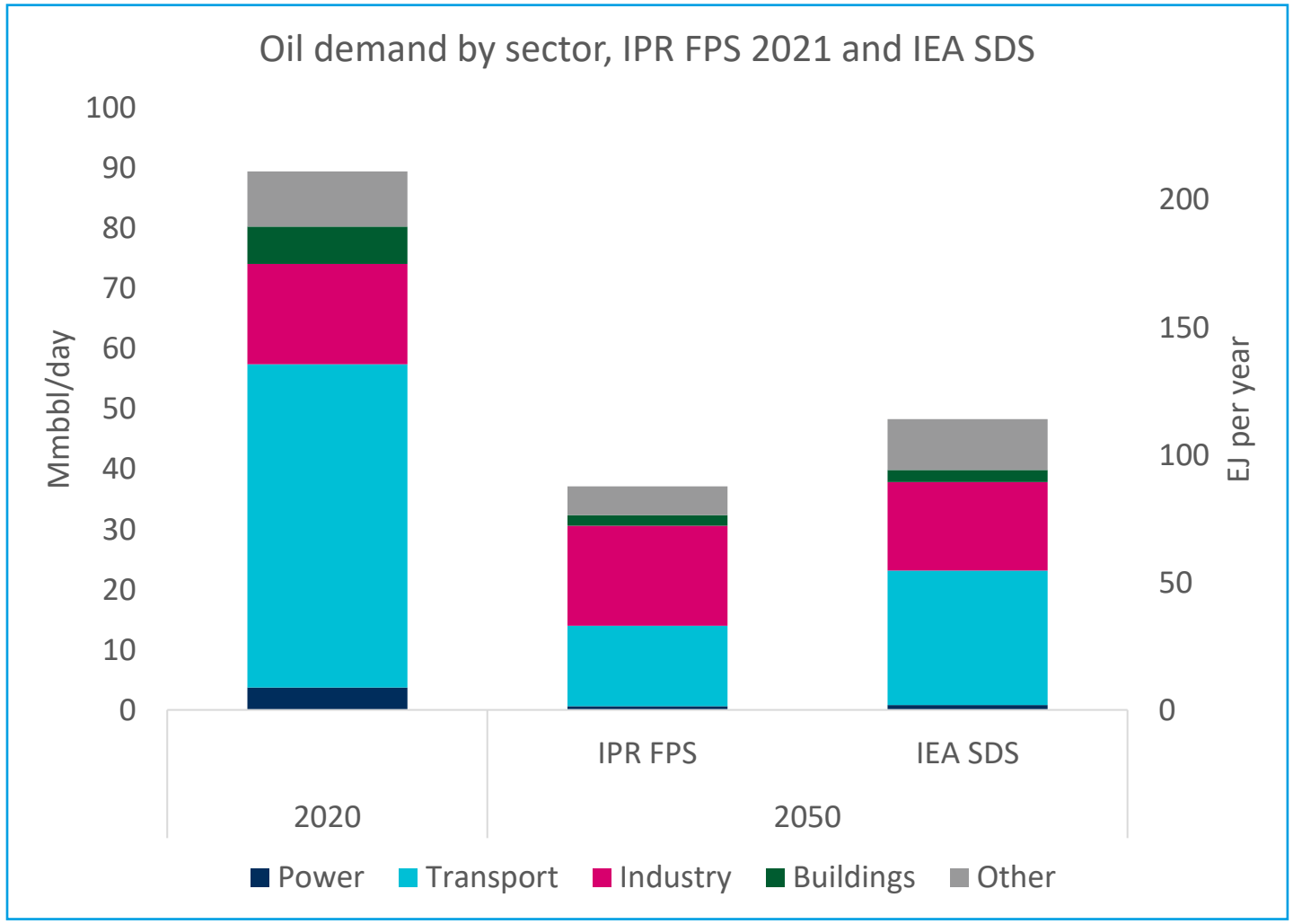
Oil demand declines more rapidly than in IEA's Sustainable Development Scenario, driven by faster electrification of transport



- Oil demand falls 60% to 2050, compared to a 45% decline in IEA SDS
- Oil demand in transport falls to around 40% lower than SDS levels, as electric vehicles rapidly dominate the fleet
- However, oil demand in industry remains around 15% above SDS levels, as industry is slower to decarbonise

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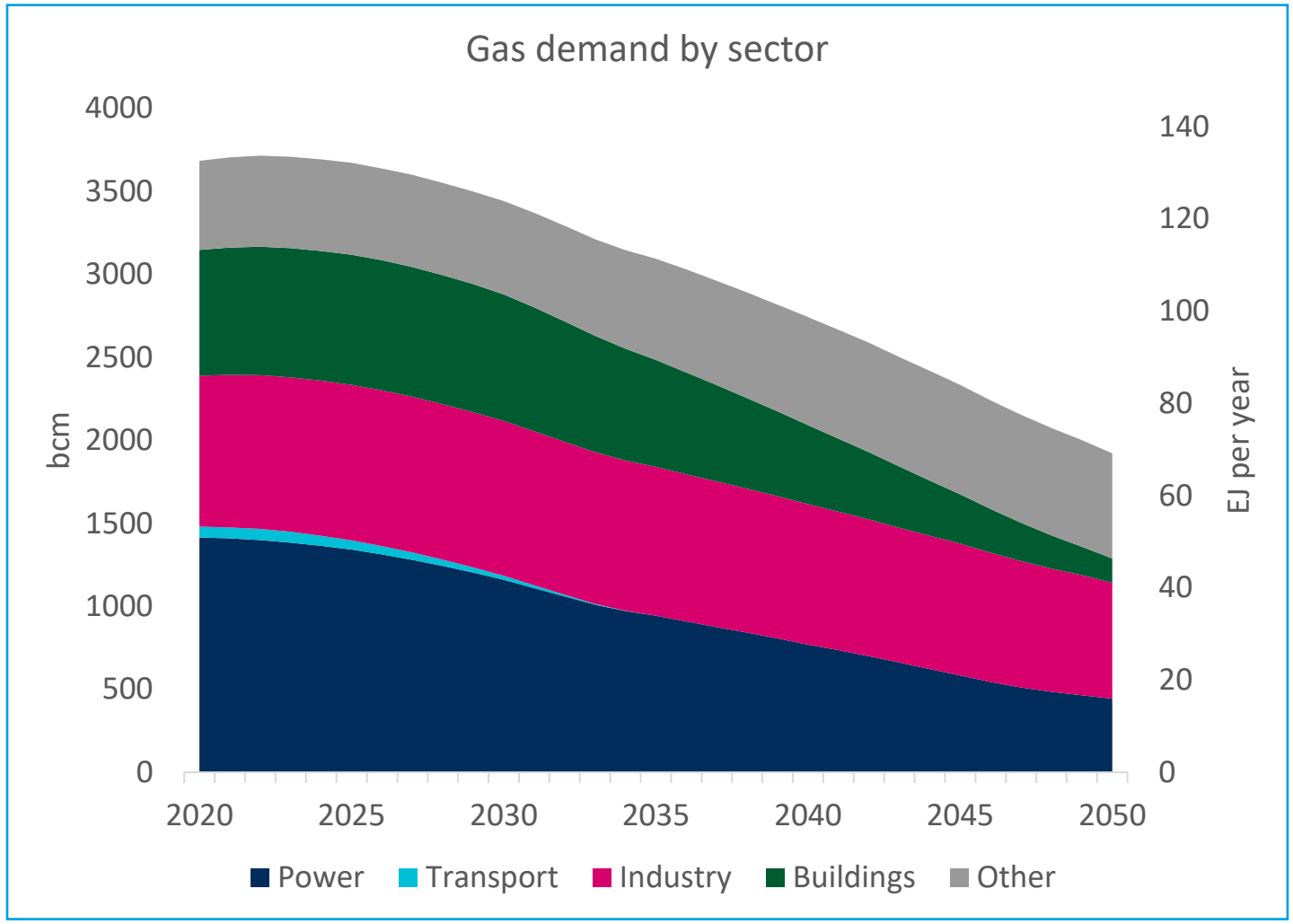
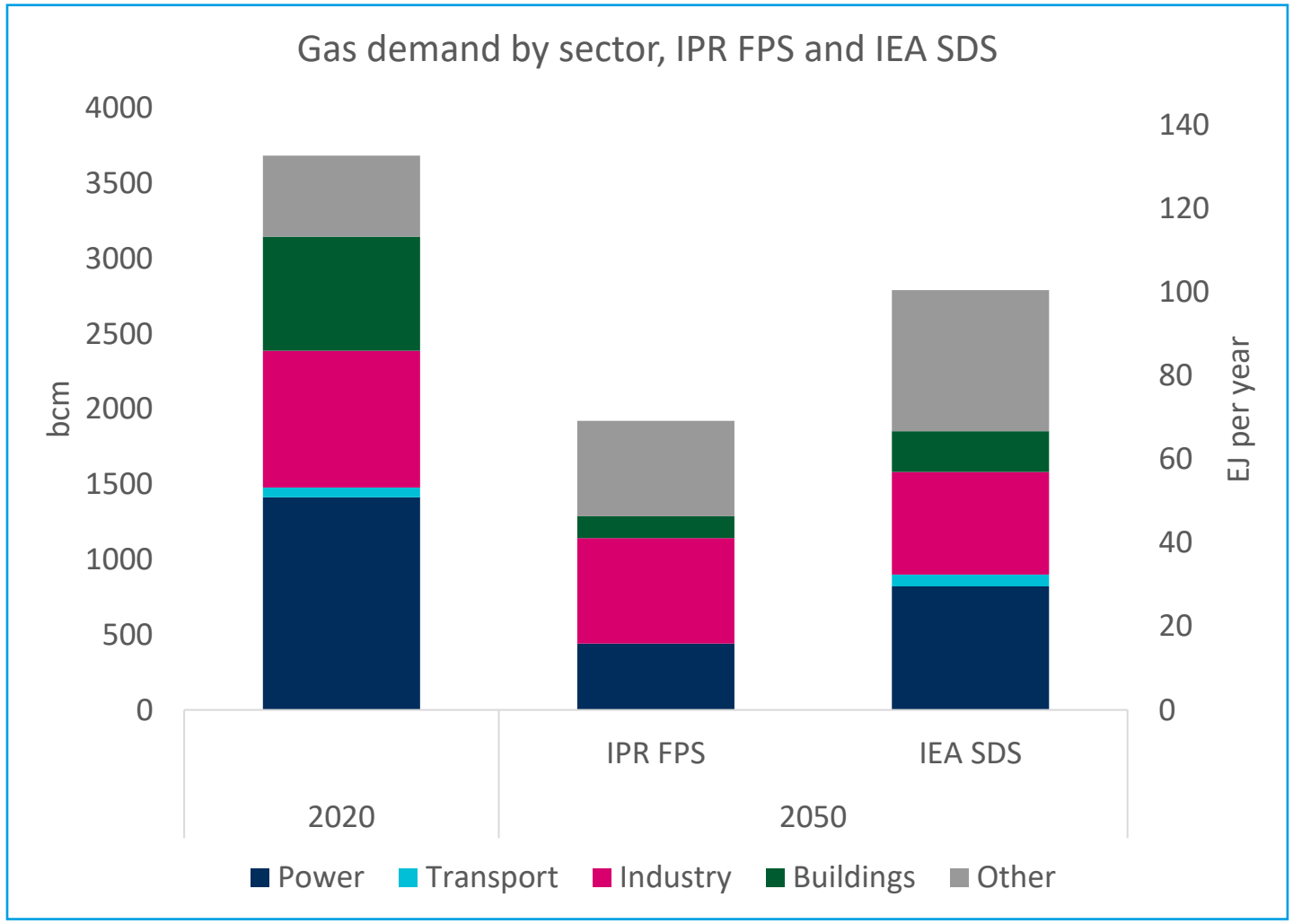
Gas demand falls by half, driven primarily by a reduction in demand in the power and buildings sectors



- Gas demand falls around 50% between 2020 and 2050
- The power sector accounts for the majority of the demand reduction, with demand falling ; gas demand in power falls around 70% between 2020 and 2050
- Buildings also account for over one third of the demand reduction; gas demand in buildings falls 80% to 2030 as heating and cooking are electrified in many countries
- Demand falls more slowly in industry, with around a 25% reduction between 2020 and 2050
- As a result, industry accounts for the largest share (around 35%) of gas demand by 2050, followed by power (around 25%)

INEVITABLE POLICY RESPONSE

Gas demand falls more rapidly than in IEA's Sustainable Development Scenario, due to more rapid transport decarbonisation



- Gas demand falls around 45% to 2050, compared to only around 25% in IEA SDS
- Gas demand in power falls to around half of SDS levels, as 100% clean power policies drive an end to unabated gas in many countries
- Gas demand in other uses falls to around 30% of SDS levels; this category includes hydrogen production, of which around 50% is produced from fossil fuels in SDS but only 20% in IPR FPS

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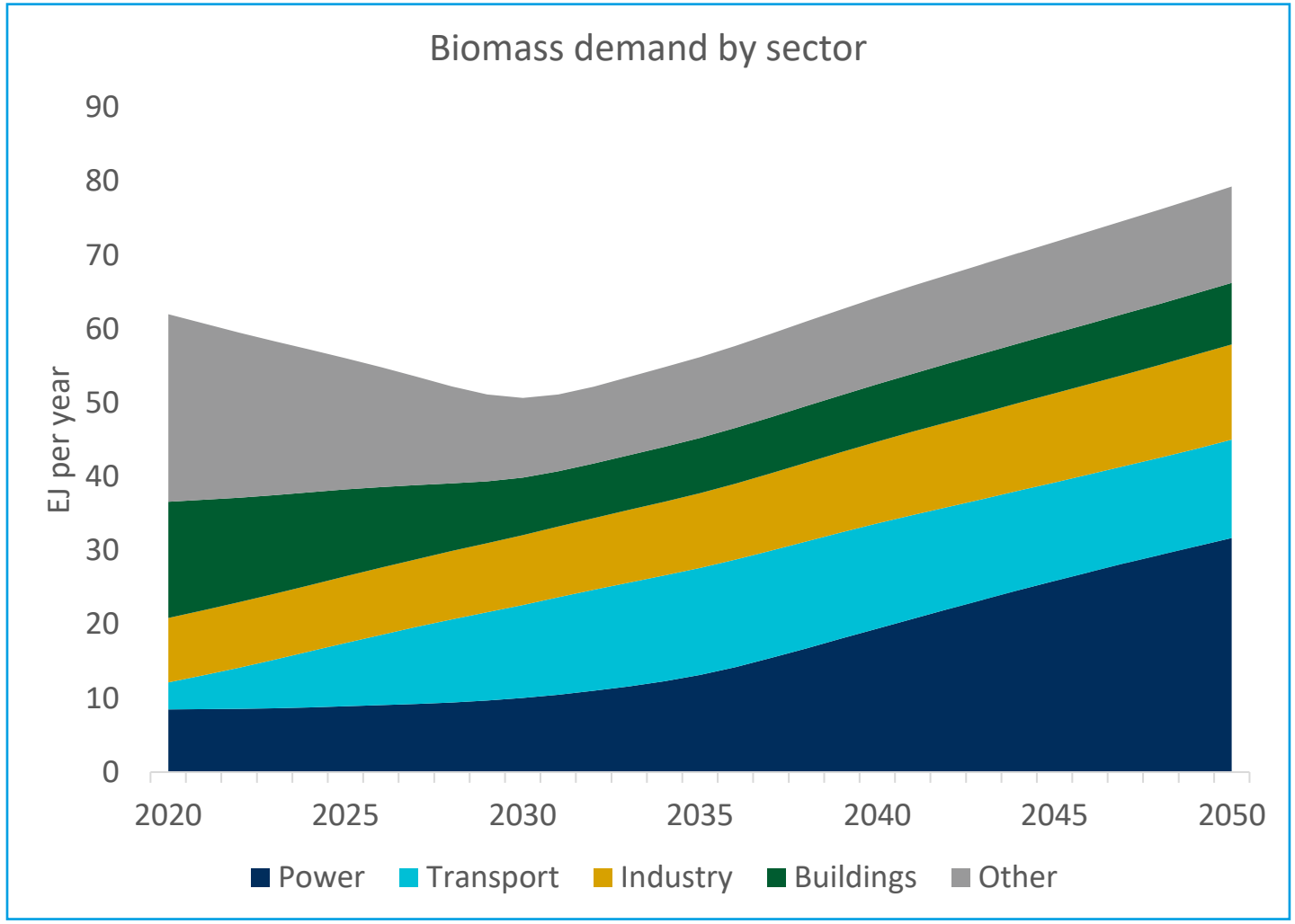
Biomass plays an important role in reducing fossil fuel use across the power, transport and industry sectors



- Biomass is currently used in most sectors. Around half of all biomass use is as traditional biomass for cooking and heating in developing and emerging economies
- Traditional biomass is phased out between 2020 and 2030 as income growth and public health policy drives adoption of modern methods of cooking and water heating
- Between 2030 and 2050, biomass demand rises to almost 80 EJ, reducing fossil fuel use in the power, transport and industry sectors
- The largest growth is in the power sector, where biomass provides baseload generation as well as some opportunities for bioenergy with carbon capture and storage (BECCS)

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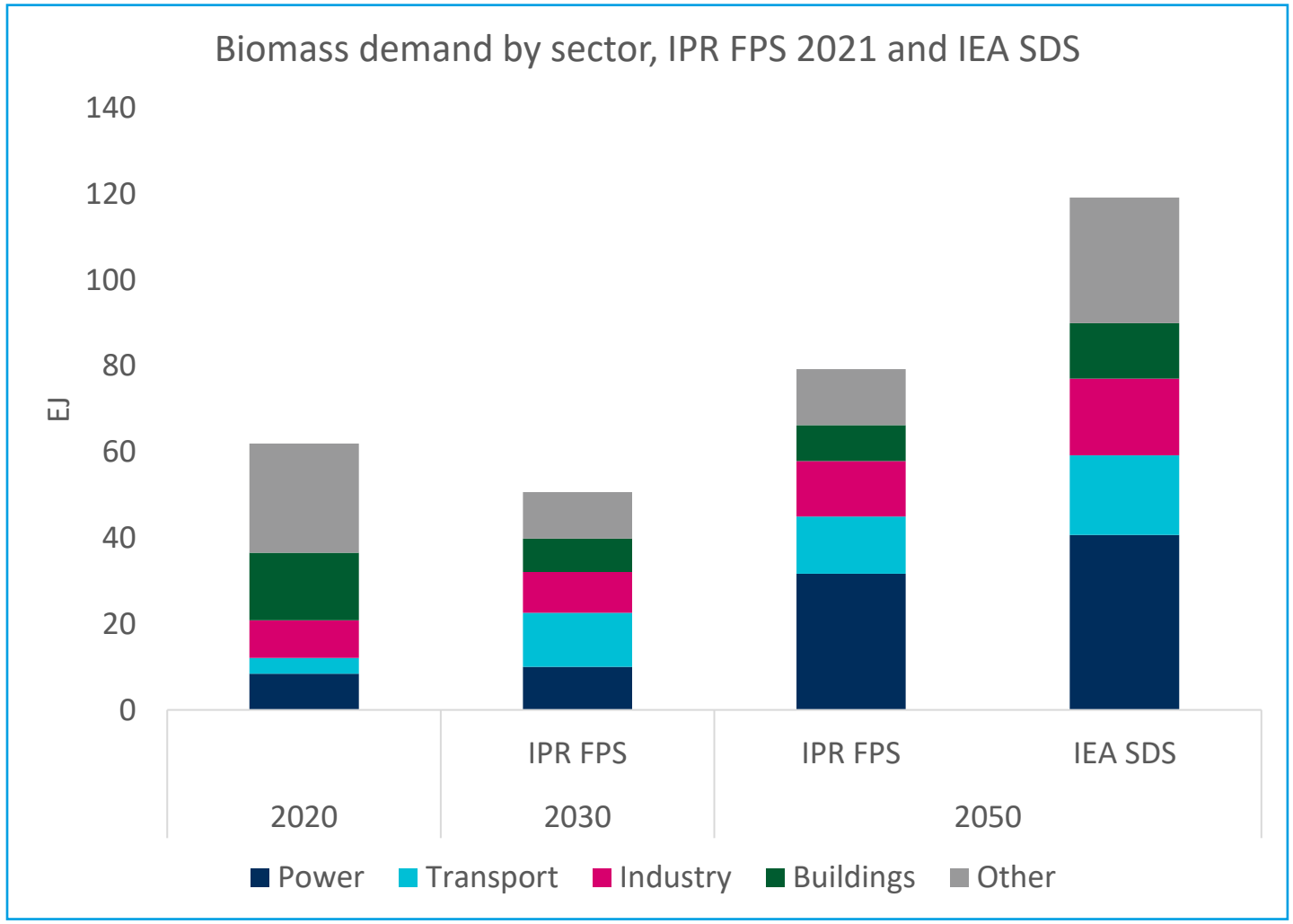
Biomass demand grows substantially, but remains lower than in IEA's Sustainable Development Scenario



- Biomass demand falls to 2030 as traditional biomass is phased out, before growing over 60% to almost 80 EJ between 2030 and 2050
- In contrast, biomass demand in IEA SDS rises to 120 EJ
- Biomass demand plays a comparable role to that in IEA SDS in power, transport, industry and buildings, albeit at somewhat lower overall volumes
- In IEA SDS a substantial share of bioenergy is used in the energy production sector including coal mining and oil and gas extraction; in IPR FPS 2021, energy demand in these sectors is met with a mix of bioenergy, electrification, and fossil fuels

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Power and hydrogen

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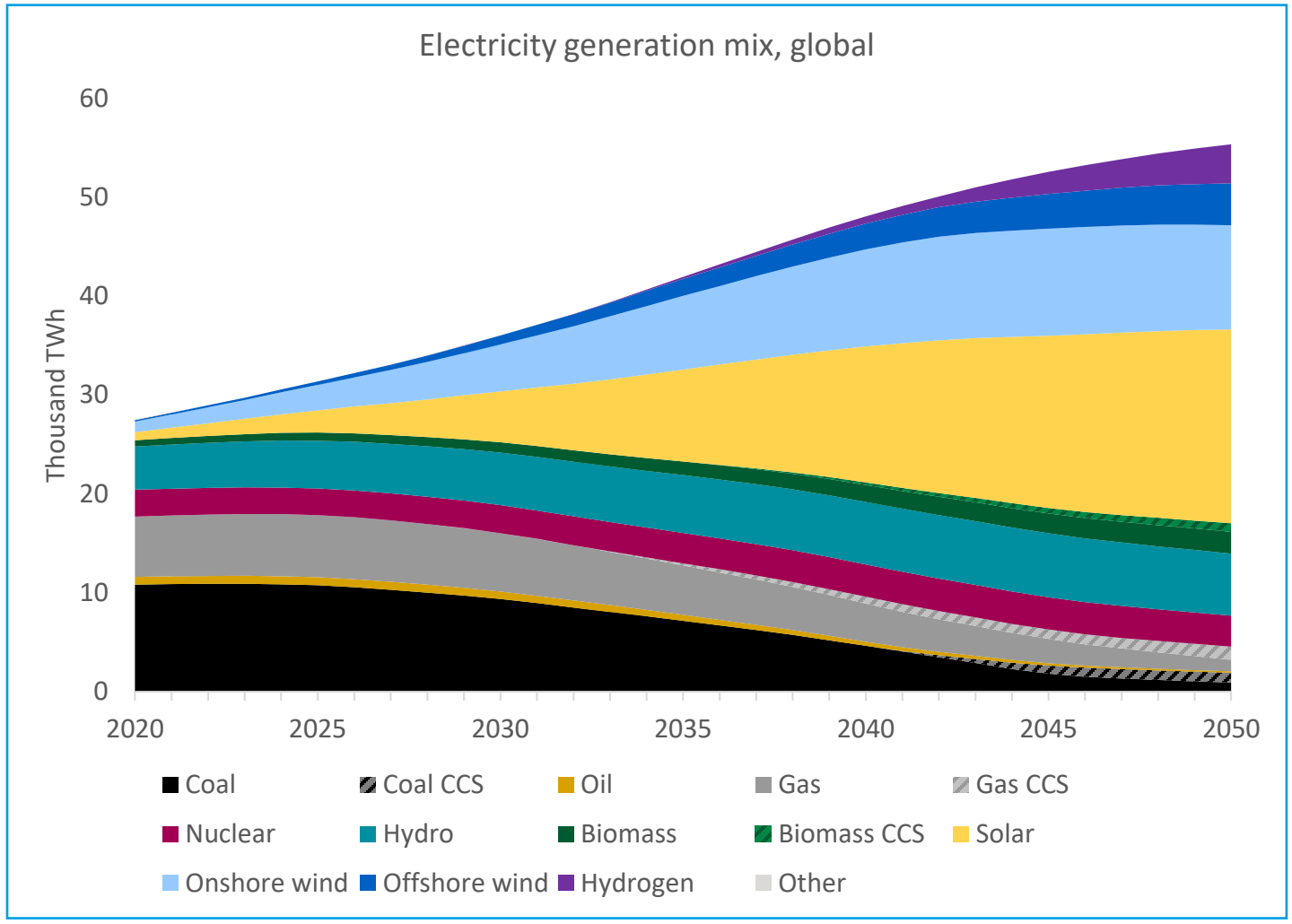
Electricity is almost fully decarbonised by 2050, with renewables accounting for almost 80% of generation



- Fossil generation falls from around 65% of the mix in 2020 to 45% in 2030 and under 10% by 2050. By 2050, CCS accounts for around half of remaining fossil fuel use
- Wind and solar grow from under 10% of the mix in 2020 to over 30% in 2030 and over 60% in 2050
- Including biomass and hydro, renewables account for almost 80% of generation by 2050
- Towards 2050, hydrogen emerges as an important balancing technology
- By 2050, over 95% of generation is low-carbon

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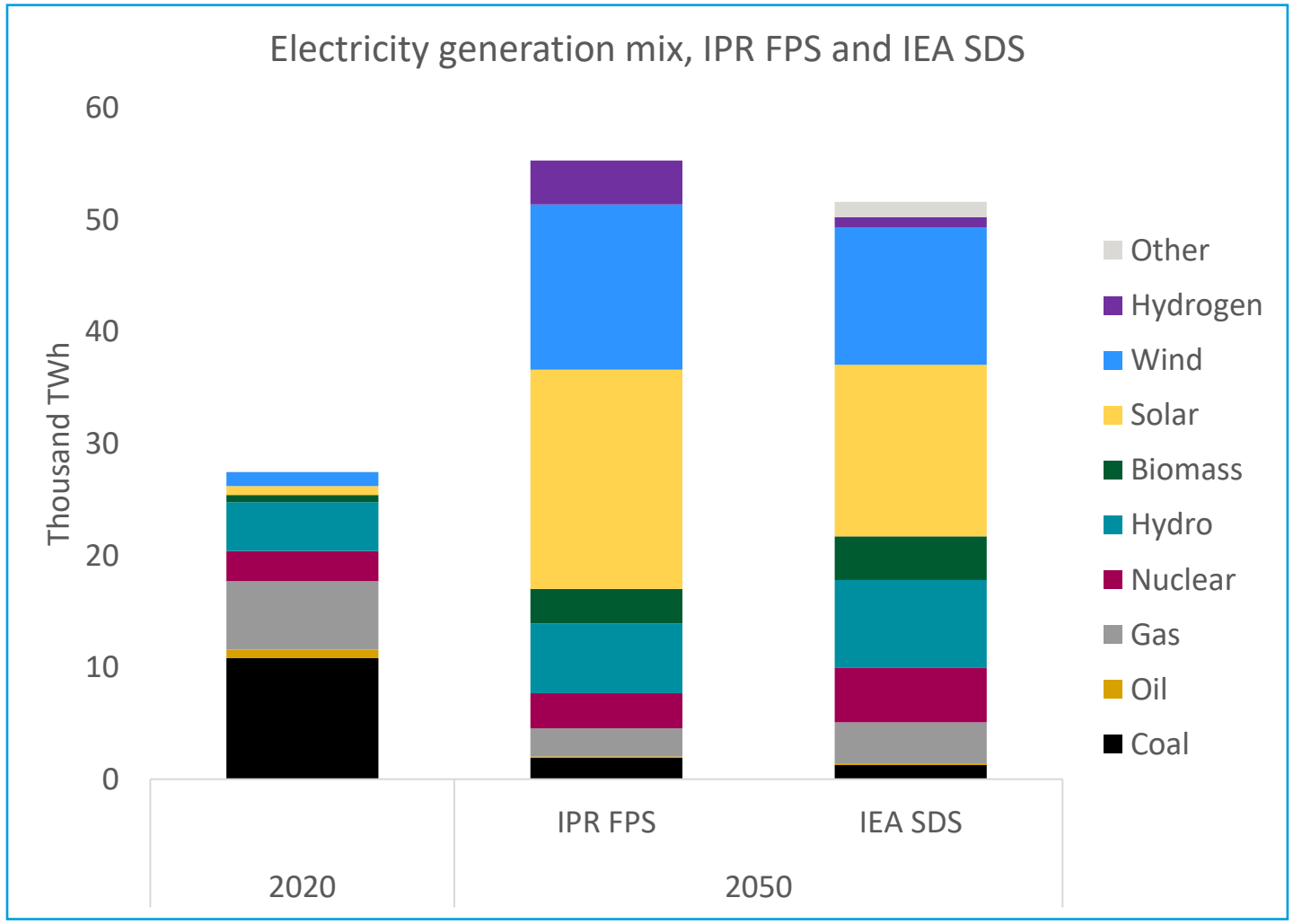
IPR FPS has a similar generation mix to IEA SDS, though with higher levels of solar, wind and hydrogen



- Electricity generation grows substantially in both IPR FPS and IEA SDS, as economic growth and electrification of heat and transport drive greater electricity demand
- The generation mix in both scenarios is comparable, with a large reduction in coal, oil and gas; and a large increase in low-carbon generation
- Wind and solar account for the majority of generation by 2050 in both scenarios. Their share is higher in IPR FPS, at over 60% of the mix compared with around 55% in IEA SDS. Within this, solar accounts for around 55% of variable renewables in both scenarios
- The larger share of wind and solar in IPR FPS is offset by a smaller share of nuclear and hydro relative to IEA SDS
- Hydrogen plays a bigger role in IPR FPS, accounting for 7% of generation

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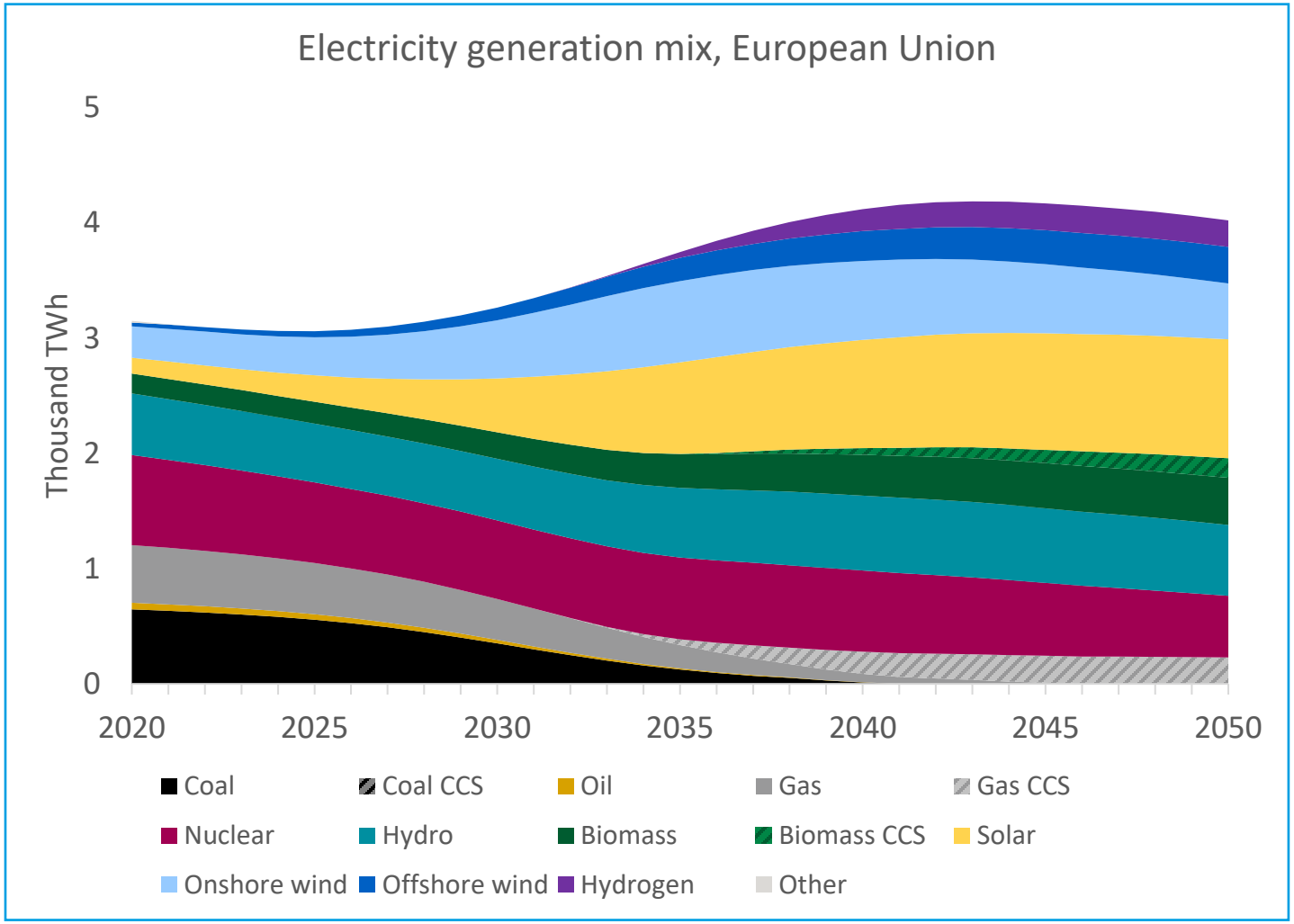
The European Union achieves 100% clean power by 2045 through a portfolio of low-carbon generation technologies



- The EU achieves its FPS policy objective of a coal phase out by 2040 and 100% clean power by 2045
- Fossil generation falls from around 40% of the mix in 2020 to 20% in 2030 and around 5% by 2050; by 2045, gas CCS accounts for all remaining fossil generation
- Wind and solar grow from around 15% of the mix in 2020 to over 30% in 2030 and over 45% in 2050
- The share of hydro and nuclear the declines from around 40% of the mix in 2020 to 30% in 2050, though these technologies continue to play an important role
- Biomass with carbon capture and storage (BECCS) plays a smaller role, offsetting residual emissions in the industry sector to achieve net zero emissions overall

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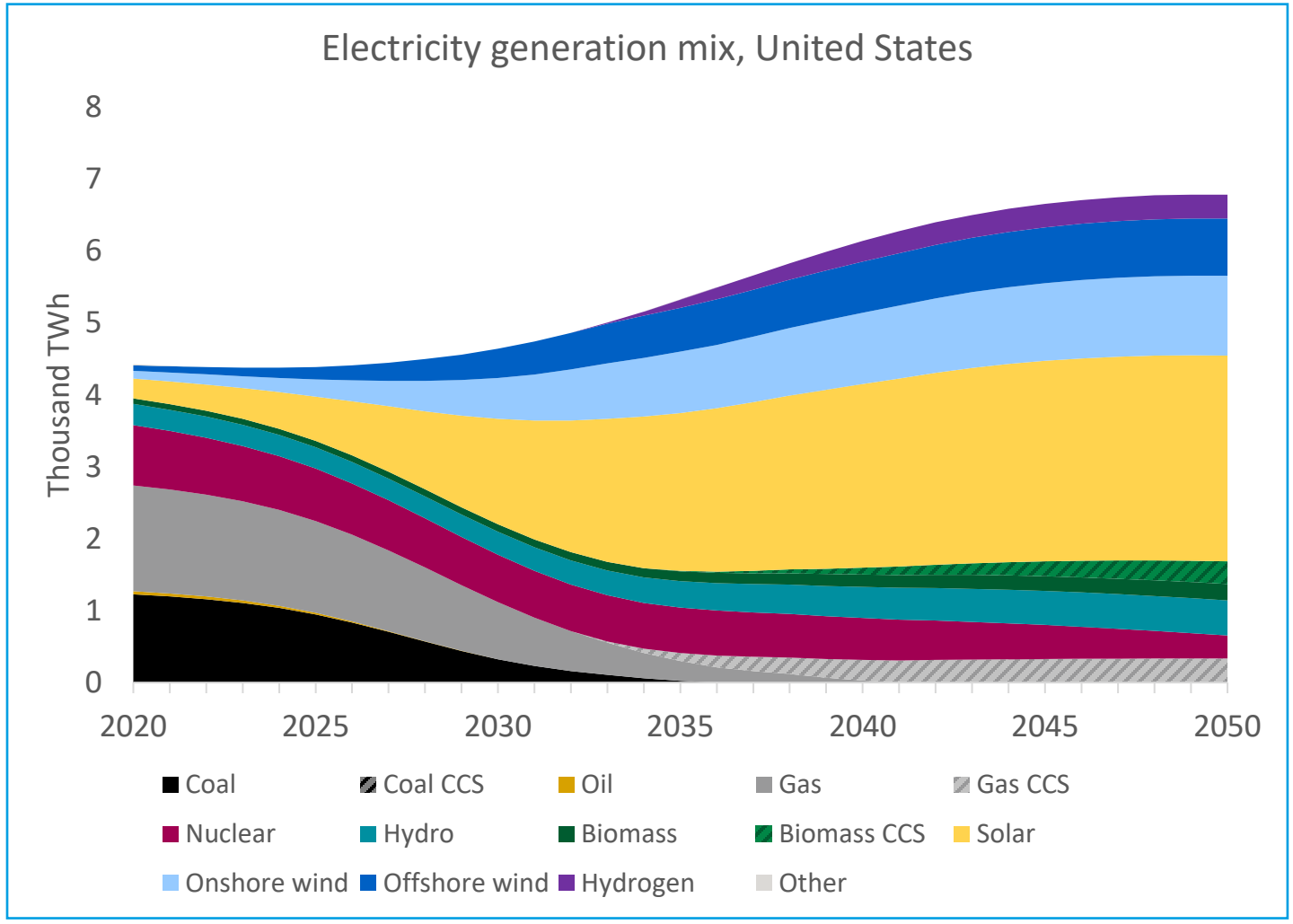
The United States achieves 100% clean power by 2040, with wind and solar providing the majority of power generation from 2030



- The USA phases out coal generation by 2030 and achieves 100% clean power by 2040
- Fossil generation falls from around 60% of the mix in 2020 to 20% in 2030 and around 5% by 2050; by 2040, gas CCS accounts for all remaining fossil generation
- Wind and solar grow from around 10% of the mix in 2020 to over 60% in 2030 and over 70% in 2050
- Biomass with carbon capture and storage (BECCS) accounts for about 5% of generation, offsetting residual emissions in the industry sector to achieve net zero emissions overall

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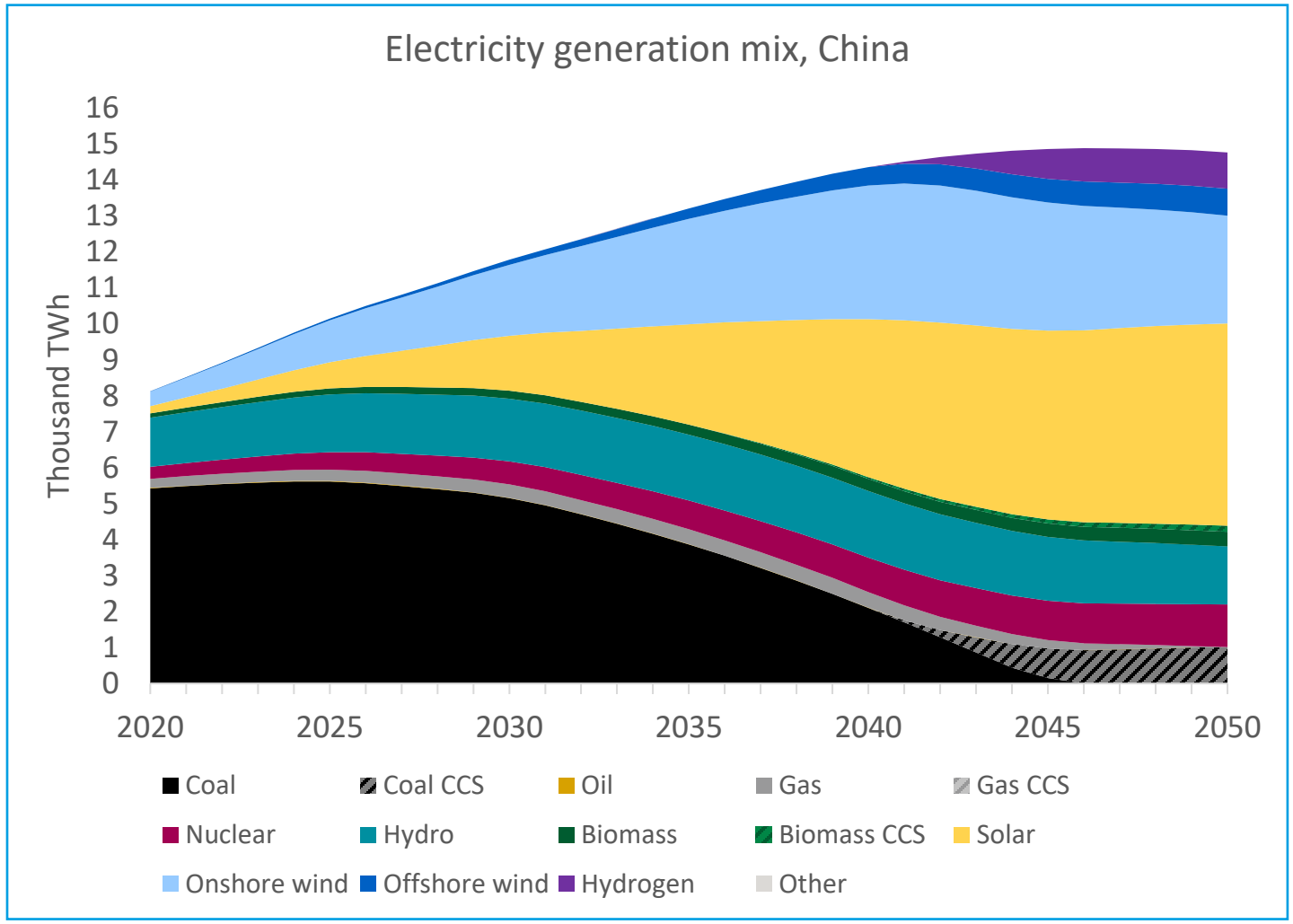
China achieves 100% clean power by 2050, with CCS retrofit used to decarbonise remaining coal generation



- China phases out unabated coal generation by 2045 and achieves 100% clean power by 2050
- Coal generation falls only slightly to 2030 but more rapidly thereafter; coal generation falls from around 70% of the mix in 2020 to less than 10% by 2050
- From 2045, all remaining coal generation is retrofitted with CCS
- Wind and solar grow from under 10% of the mix in 2020 to around 30% in 2030 and over 60% in 2050
- Hydro and nuclear continue to play an important role, accounting for around 20% of the mix between 2020 and 2050

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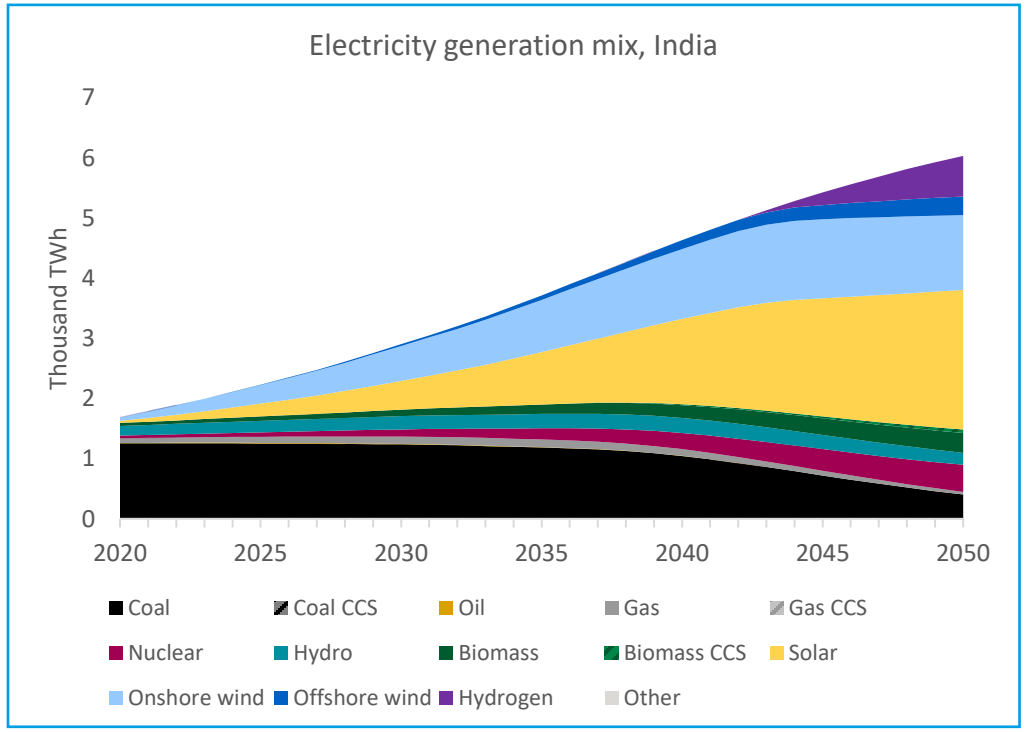
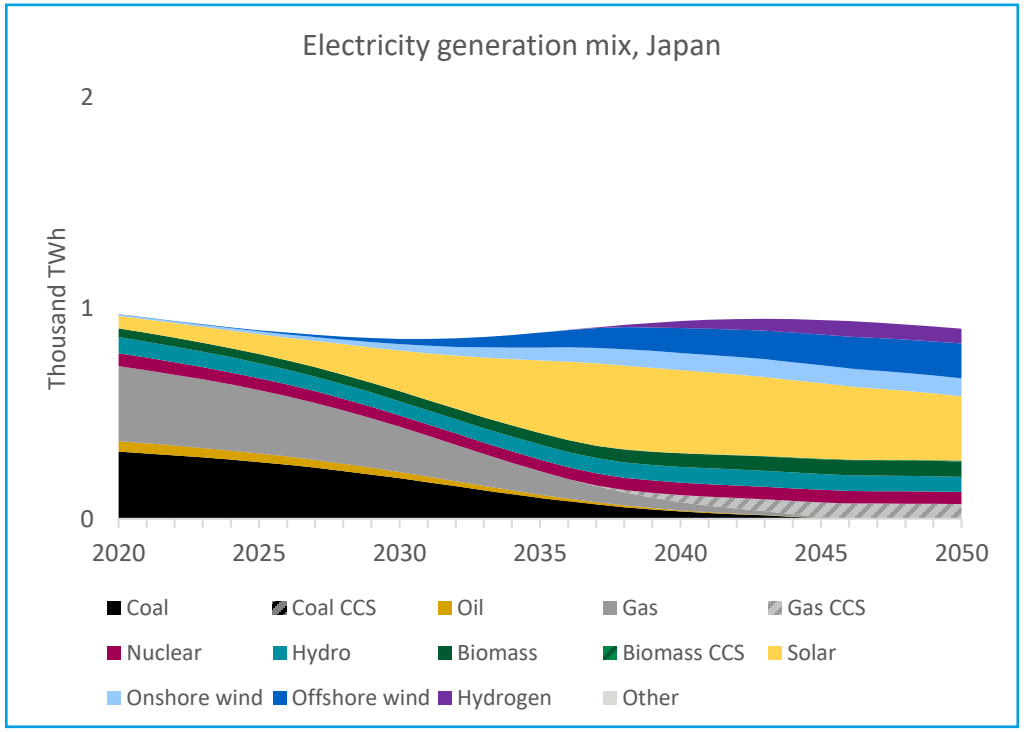
Generation mix, India and Japan





- India's power mix decarbonises substantially, though unabated fossil generation remains well past 2050
- Wind and solar grow from around 5% of the mix in 2020 to over 35% in 2030 and around 65% in 2050

- Japan phases out unabated coal generation and achieves 100% clean power by 2045
- Wind and solar grow from under 10% of the mix in 2020 to around 30% in 2030 and over 60% in 2050; offshore wind plays an important role due to land constraints

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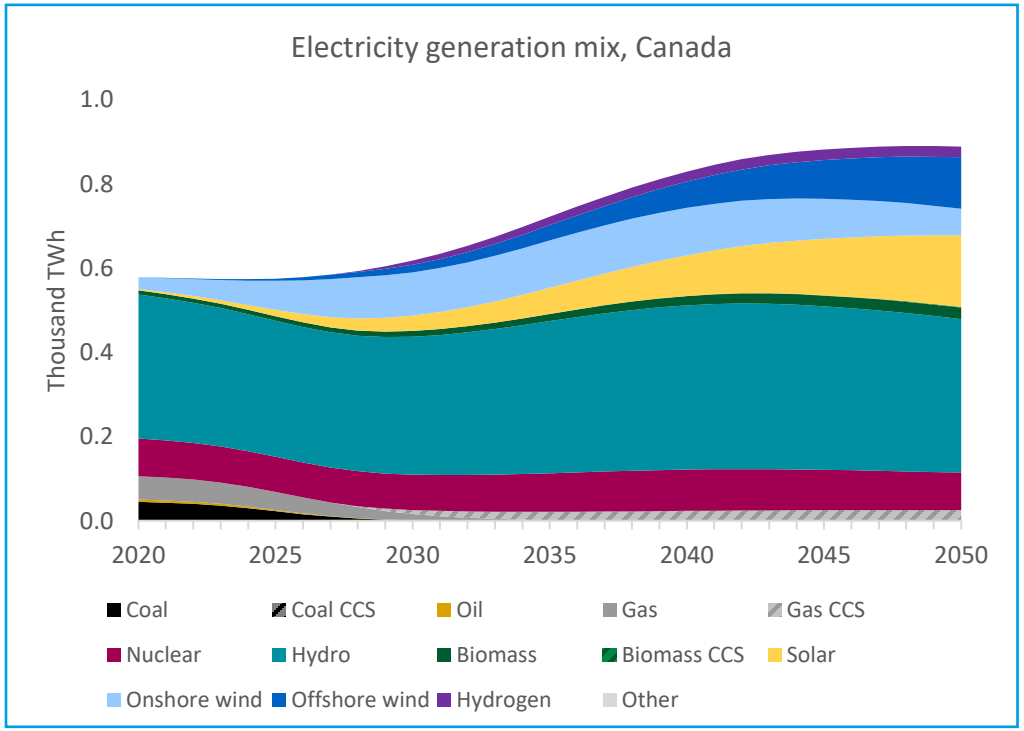
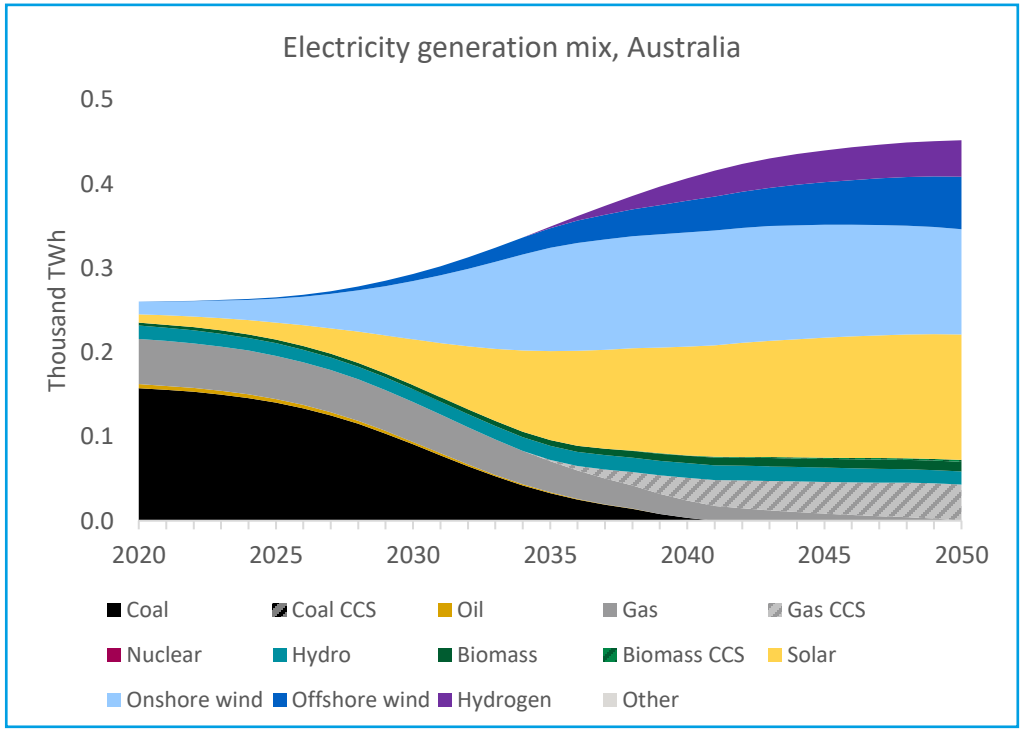
Generation mix, Canada and Australia





- Canada phases out unabated coal generation by 2030 and achieves 100% clean power by 2035
- Hydro continues to play a major role in the mix, though its share falls from around 60% in 2020 to 35% in 2050
- Wind and solar provide the majority of demand growth, and account for 40% of the mix in 2050

- Australia phases out unabated coal generation by 2040 and achieves 100% clean power by 2050
- Wind and solar grow from around 10% of the mix in 2020 to 45% in 2030 and almost 75% in 2050

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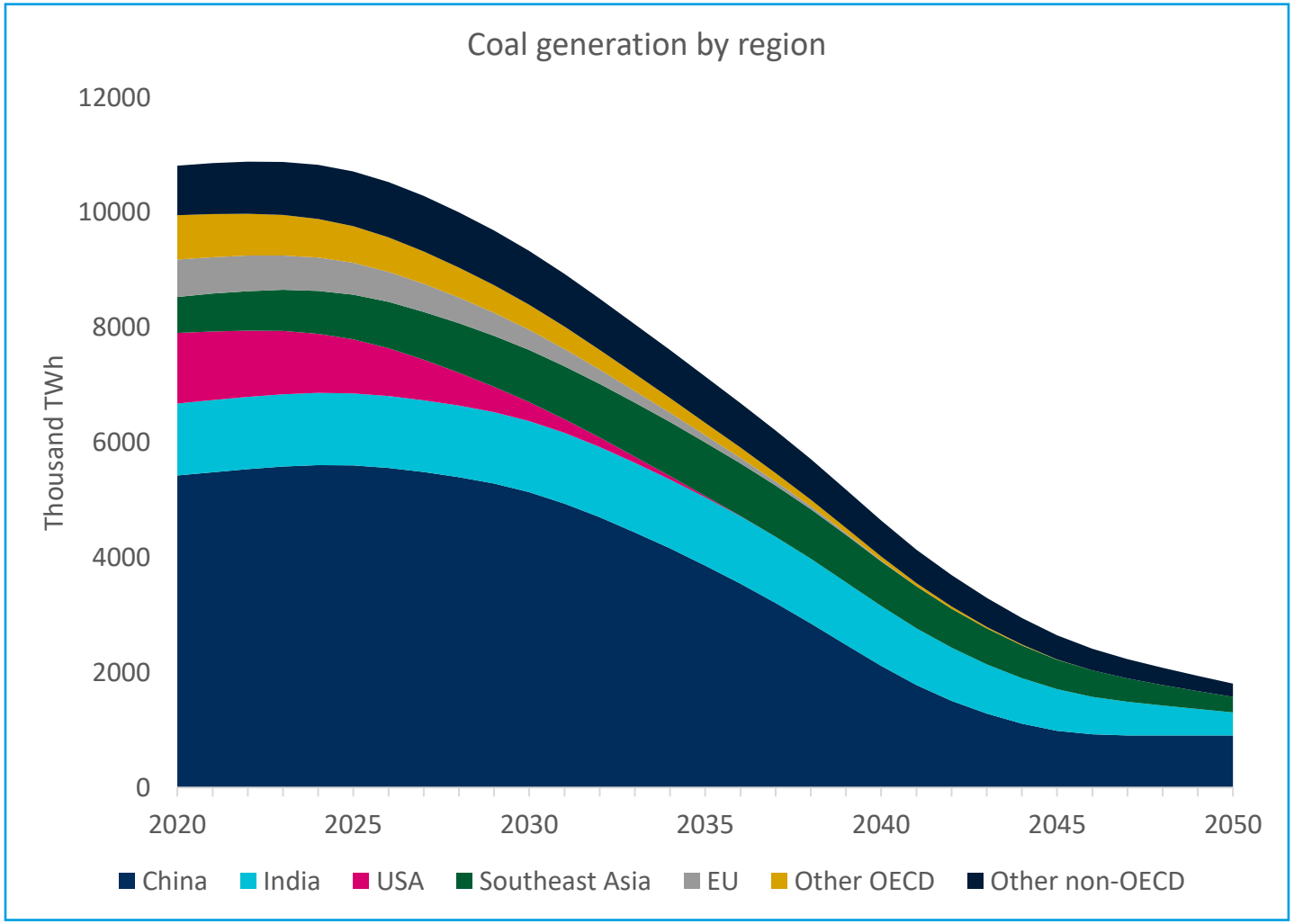
Coal-fired power generation declines around 80% to 2050, with non-OECD countries accounting for all coal generation post-2040



- Coal-fired power generation declines around 80% between 2020 and 2050
- Coal generation in the USA, EU and other OECD countries falls to zero by 2040-5 as they phase out unabated coal and rely on gas CCS and hydrogen for dispatchable low-carbon power. From 2045, all coal generation is located in non-OECD countries.
- Coal generation in China falls over 80% between 2020 and 2050, driven by the phase out of unabated coal. From 2045, residual coal generation in China is retrofitted with CCS to reduce emissions.

Note: chart shows total coal, both with and without CCS

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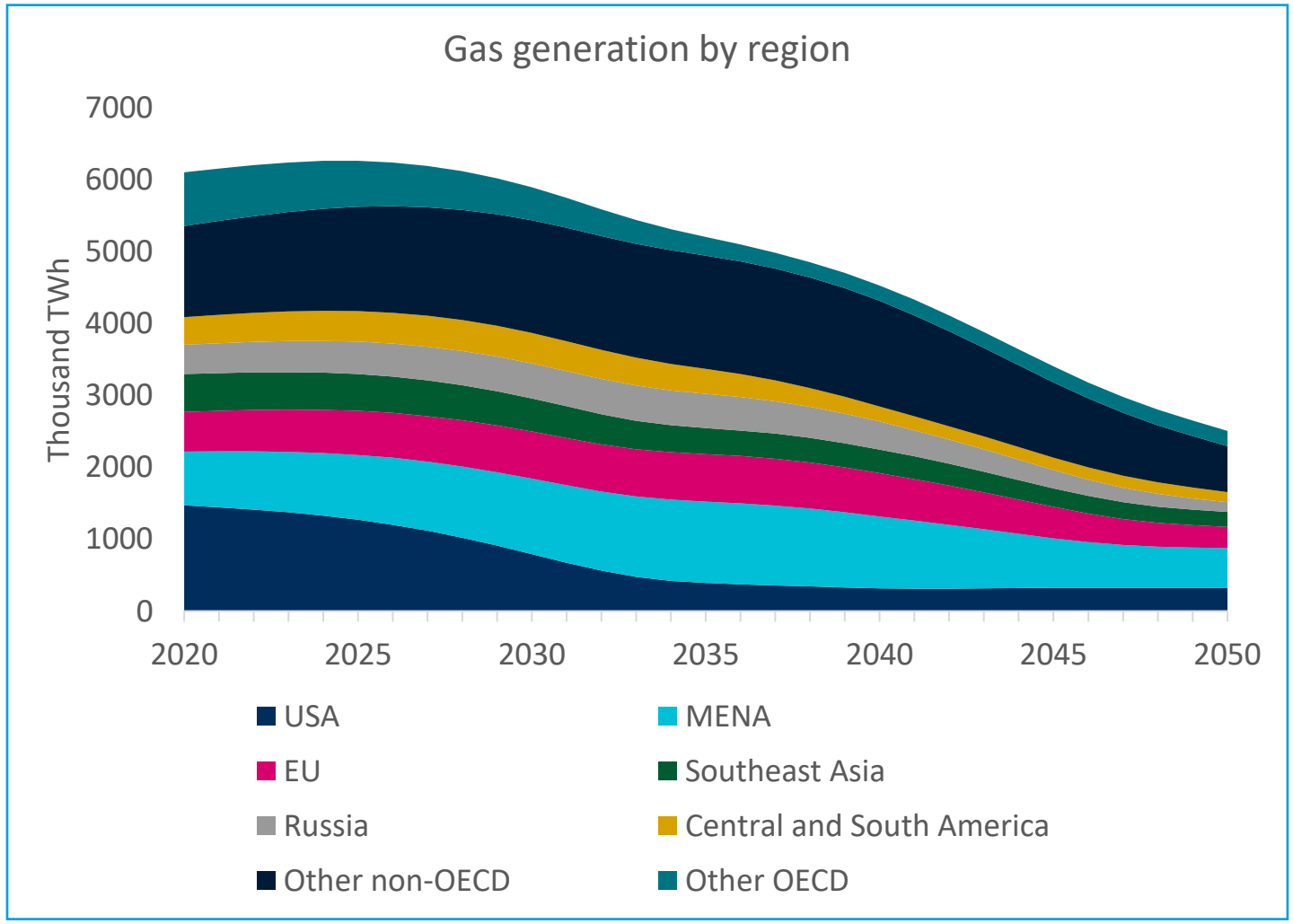
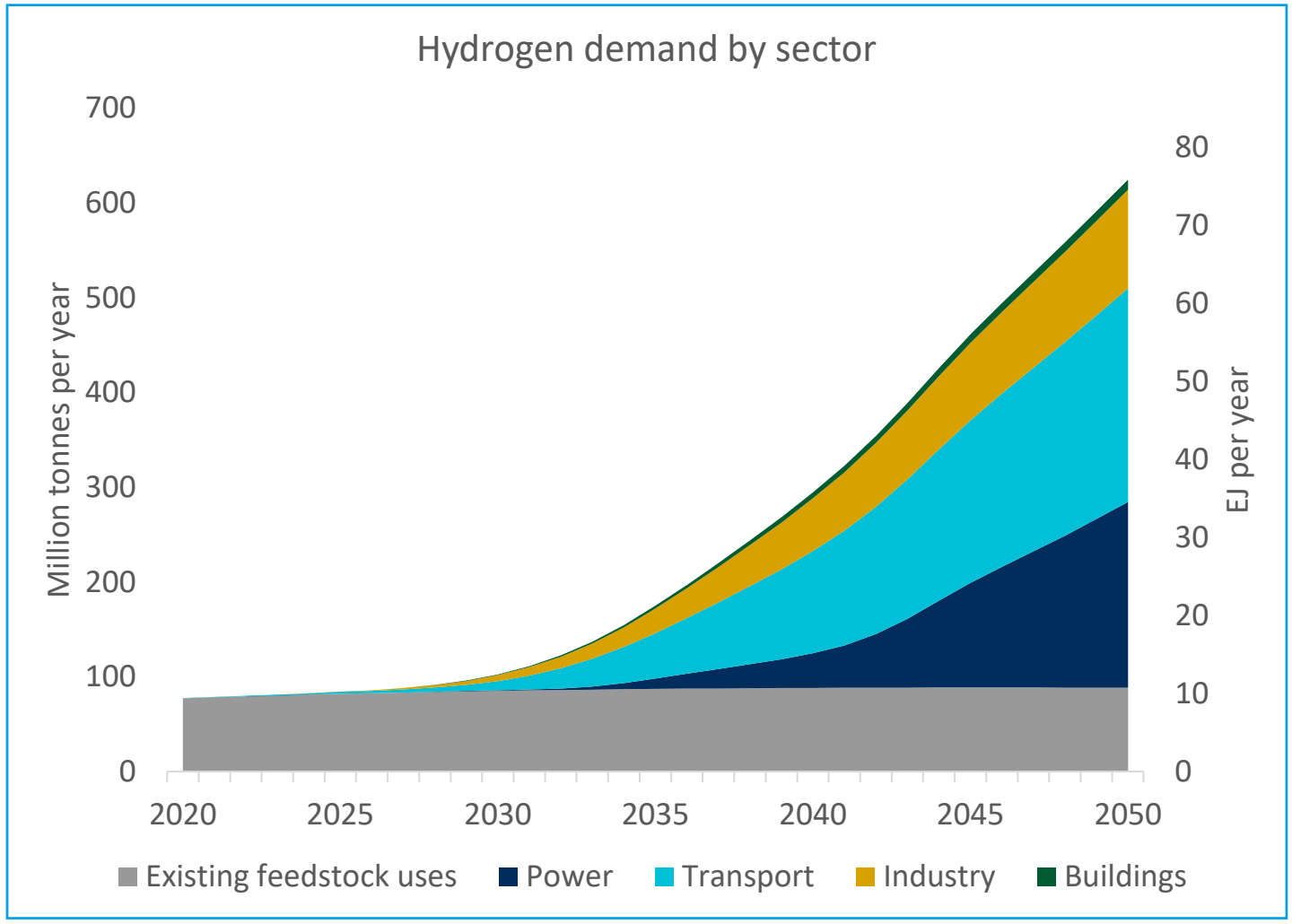
Gas-fired power generation declines around 50% to 2050, with non-OECD countries accounting for a growing majority of overall gas generation



- Gas-fired power generation declines around 50% between 2020 and 2050
- Gas generation in the USA, EU and other OECD countries falls around 70% between 2020 and 2050 as they decarbonise their electricity systems
- Gas generation in MENA, Southeast Asia and other non-OECD regions falls only 30% over the same period, due to rising electricity demand and less rapid power sector decarbonisation
- As a result, the share of total gas-fired power generation represented by OECD countries falls from 45% in 2020 to around 30% in 2050

INEVITABLE POLICY RESPONSE

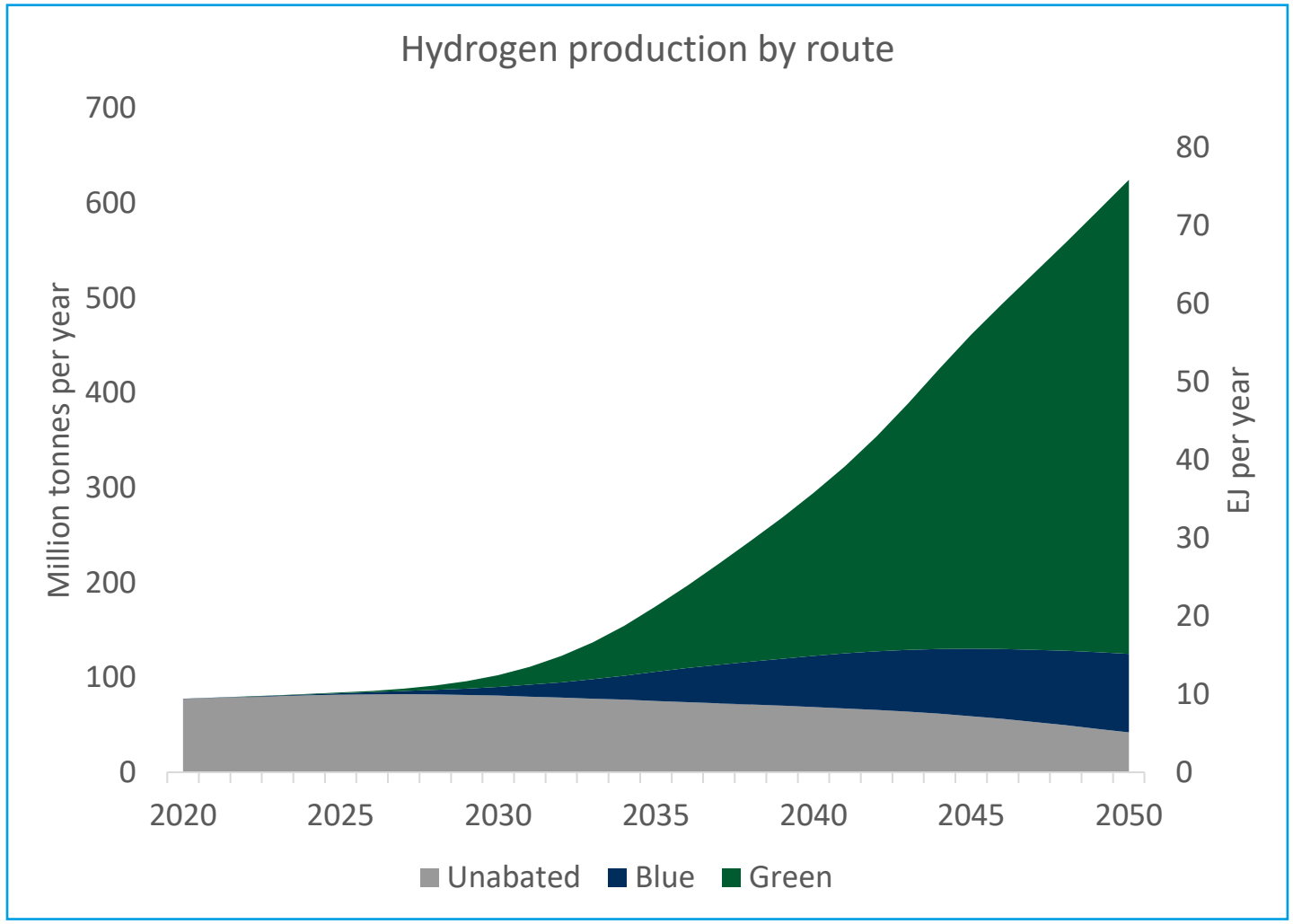
Hydrogen emerges as an important fuel in power, transport and industry, with around 15% of primary energy used for hydrogen production by 2050



- Hydrogen emerges as an important fuel across multiple sectors
- Power accounts for the largest share of demand, as hydrogen plays an important role in balancing supply and demand
- In transport, hydrogen is used as a fuel in the road freight, aviation and shipping sectors
- In industry, hydrogen is used as a reducing agent in iron and steel production, and as an alternative to fossil fuels in generating high temperature heat in a range of industries
- In buildings, hydrogen plays a small role as a low-carbon heating fuel
- Overall, around 15% of primary energy demand is used to produce hydrogen

INEVITABLE POLICY RESPONSE

Green hydrogen dominates the hydrogen mix, though blue hydrogen plays an important early role in meeting overall low-carbon hydrogen demand



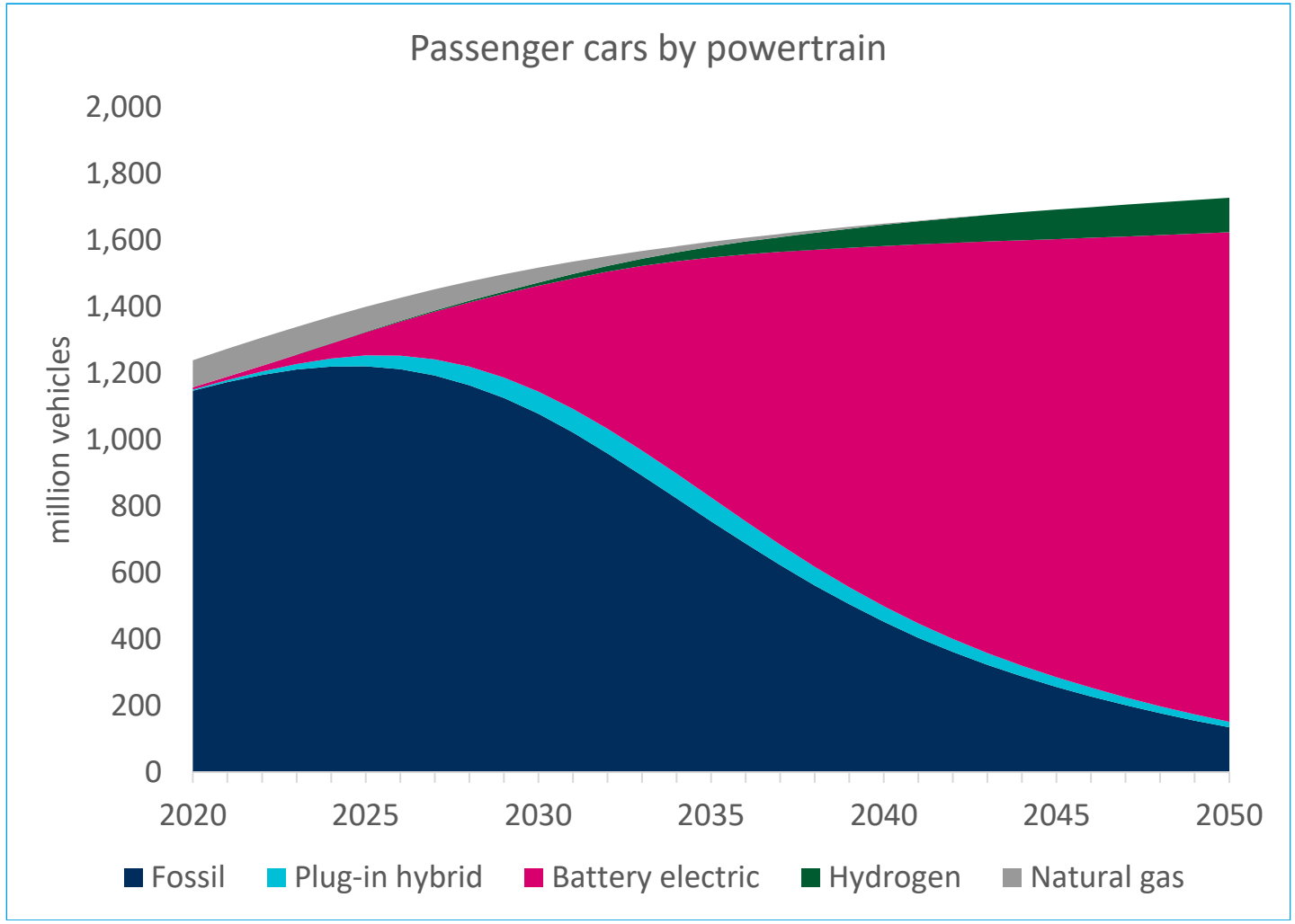
- As hydrogen demand grows to meet climate targets, the composition of hydrogen production shifts substantially
- Unabated hydrogen, the dominant form of hydrogen production today, is replaced by low-carbon (blue and green) hydrogen
- Low-carbon hydrogen accounts for around 25% of total in 2030, and 95% by 2050
- Blue hydrogen plays a small but important role in meeting demand for low-carbon hydrogen as green hydrogen scales up
- Green hydrogen meets almost 60% of low-carbon hydrogen demand by 2030 and 85% by 2050

INEVITABLE POLICY RESPONSE

Transport, industry and buildings

INEVITABLE POLICY RESPONSE

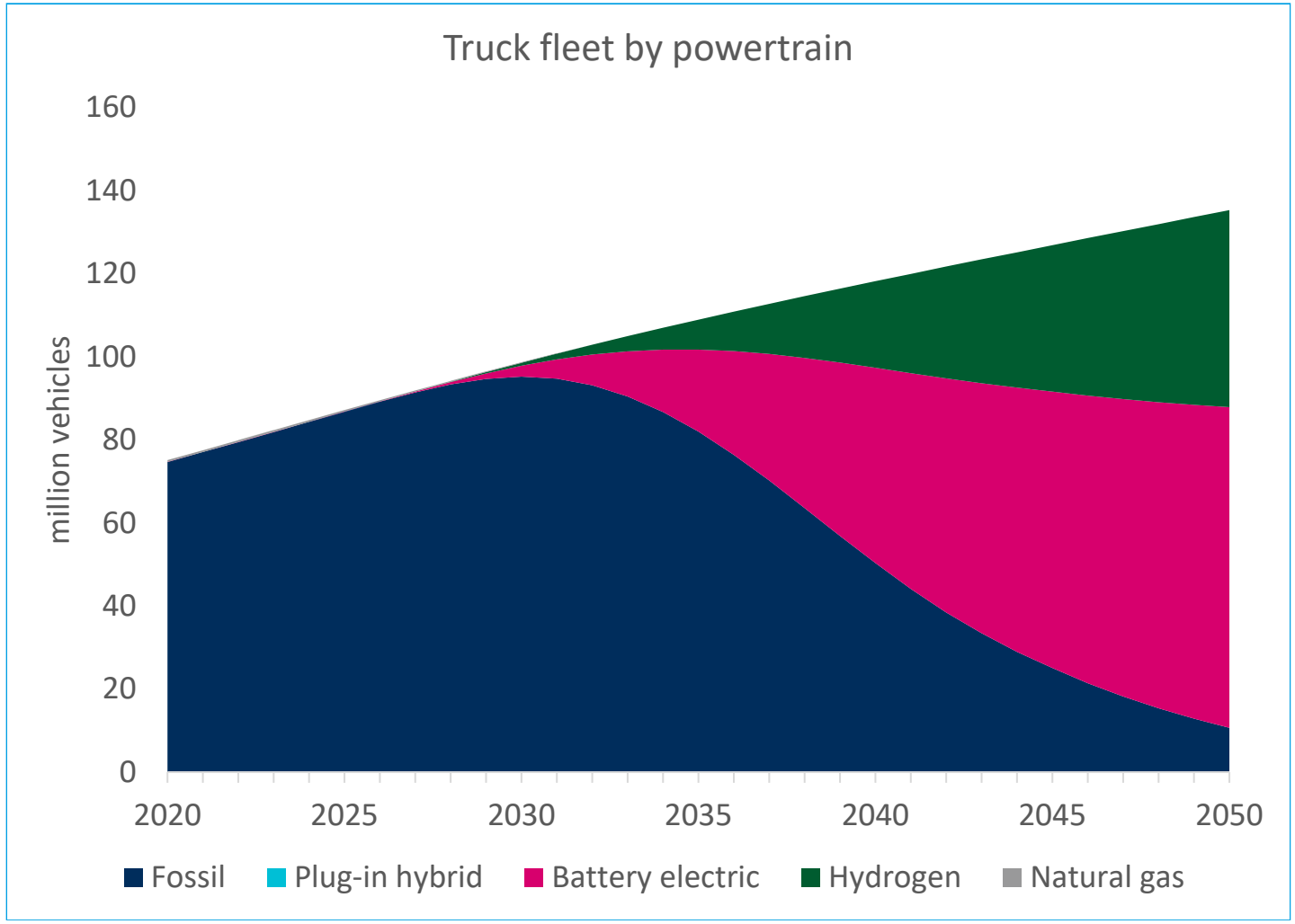
Electric vehicles quickly dominate in light duty vehicles, making up the majority of the vehicle fleet by 2035



- The share of fossil cars and vans in the fleet falls from almost 100% today to under 75% in 2030, and near-zero by 2050
- In contrast, electrified cars and vans grow rapidly, to over 25% of the fleet by 2030 and almost 100% by 2050
- The majority of electrified vehicles are pure battery electric; however plug-in hybrid vehicles and later, hydrogen fuel cell vehicles gain some market share for market segments with large travel distances

INEVITABLE POLICY RESPONSE

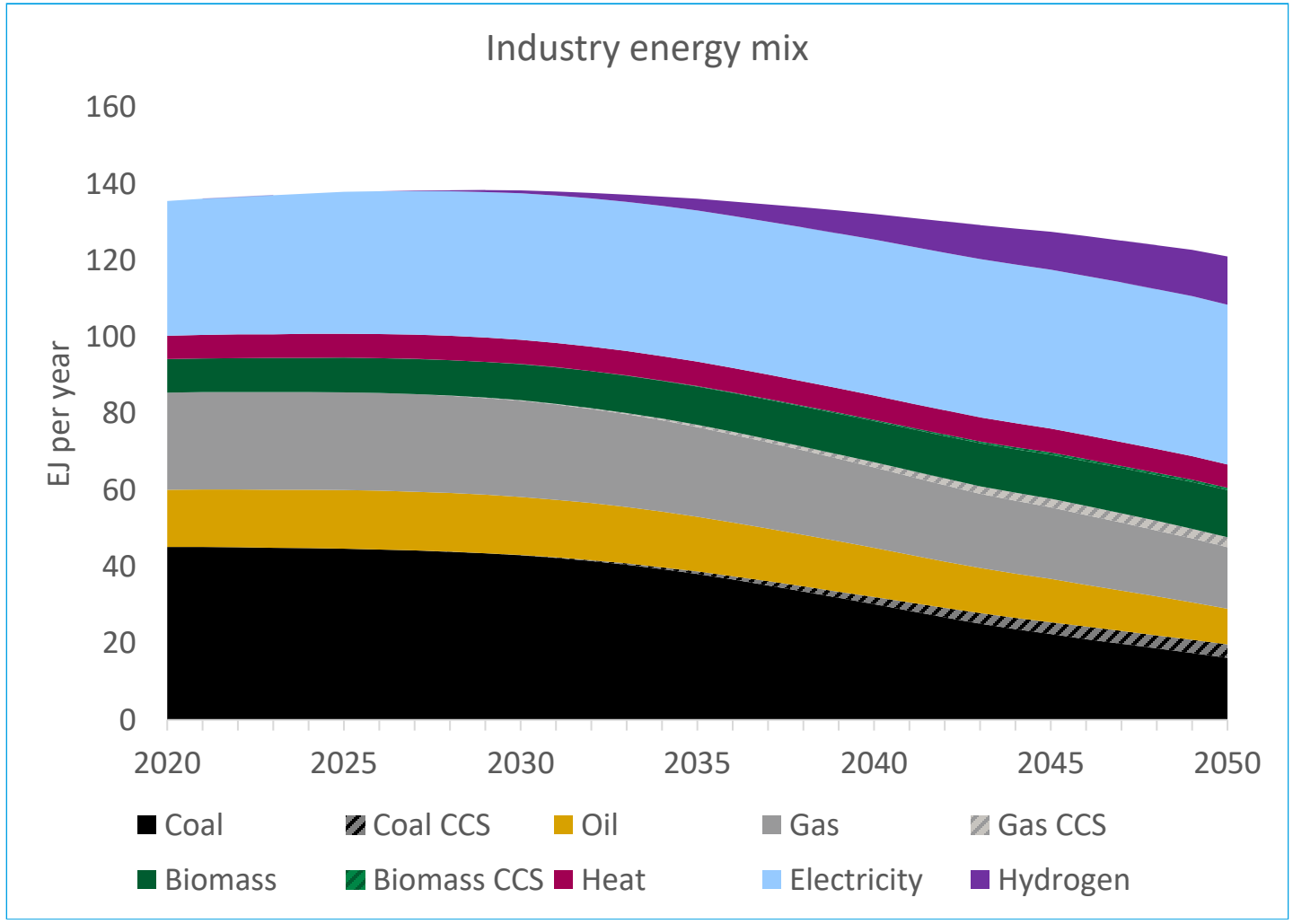
Zero emissions trucks emerge slightly later than light duty vehicles, though grow to dominate the fleet by 2040



- Development of low-carbon trucks and associated policies slightly lag passenger vehicles
- As a result, zero emissions trucks account for only 3% of the fleet by 2030, compared to 30% for light duty vehicles
- However, due to rapid fleet turnover, the share of zero emission trucks grows substantially beyond 2030; these vehicles account for over 55% of the fleet by 2040 and over 90% by 2050
- Hydrogen fuel cell vehicles play an important role, offering long distances required for the long-distance freight

INEVITABLE POLICY RESPONSE

In industry, fossil fuel use falls by 40% and a quarter of fossil fuels are with CCS

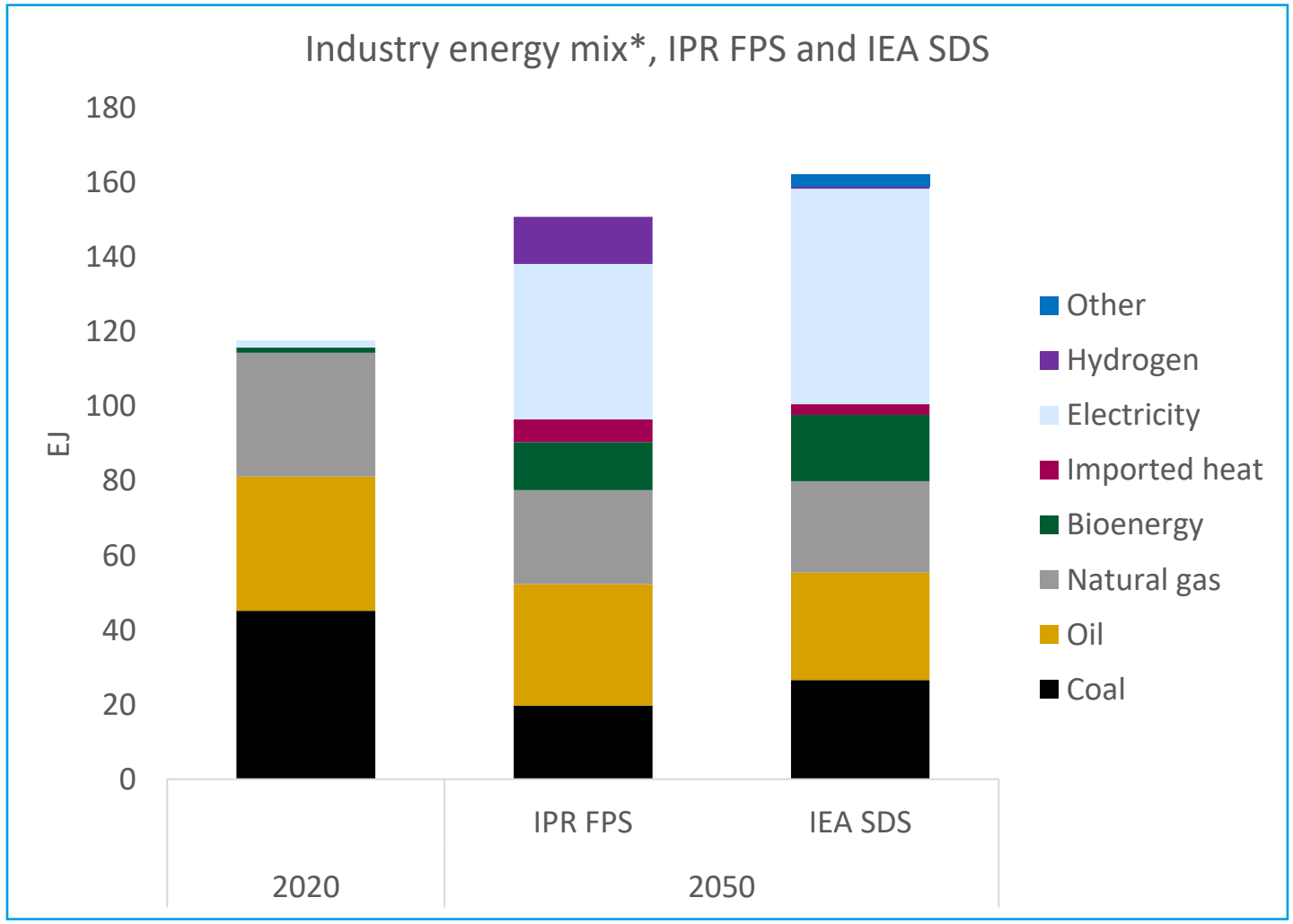


- In industry, total fossil fuel use declines relatively slowly, due to long asset lifetimes and the higher cost of low-carbon technologies
- Coal demand falls 50% by 2050. In 2050, it remains in iron and steel, and in new plant built in the 2020s, particularly in emerging economies. By 2050, around 20% of remaining coal is used with CCS, contributing to the decarbonisation of steel and cement production
- Oil use declines around 35%, though remains in the chemicals sector in regions with more limited climate ambition
- Gas demand falls around 25% over the same period, with around 15% of remaining gas used with CCS
- Electricity demand increases substantially as light industry electrifies
- Hydrogen emerges as the dominant steel production technology, and provides high temperature heat in the chemicals and other sectors

INEVITABLE POLICY RESPONSE

* Energy mix does not include coal, oil and gas used as chemicals feedstocks

The industry energy mix is broadly similar in scale and composition between IEA FPS and IEA SDS

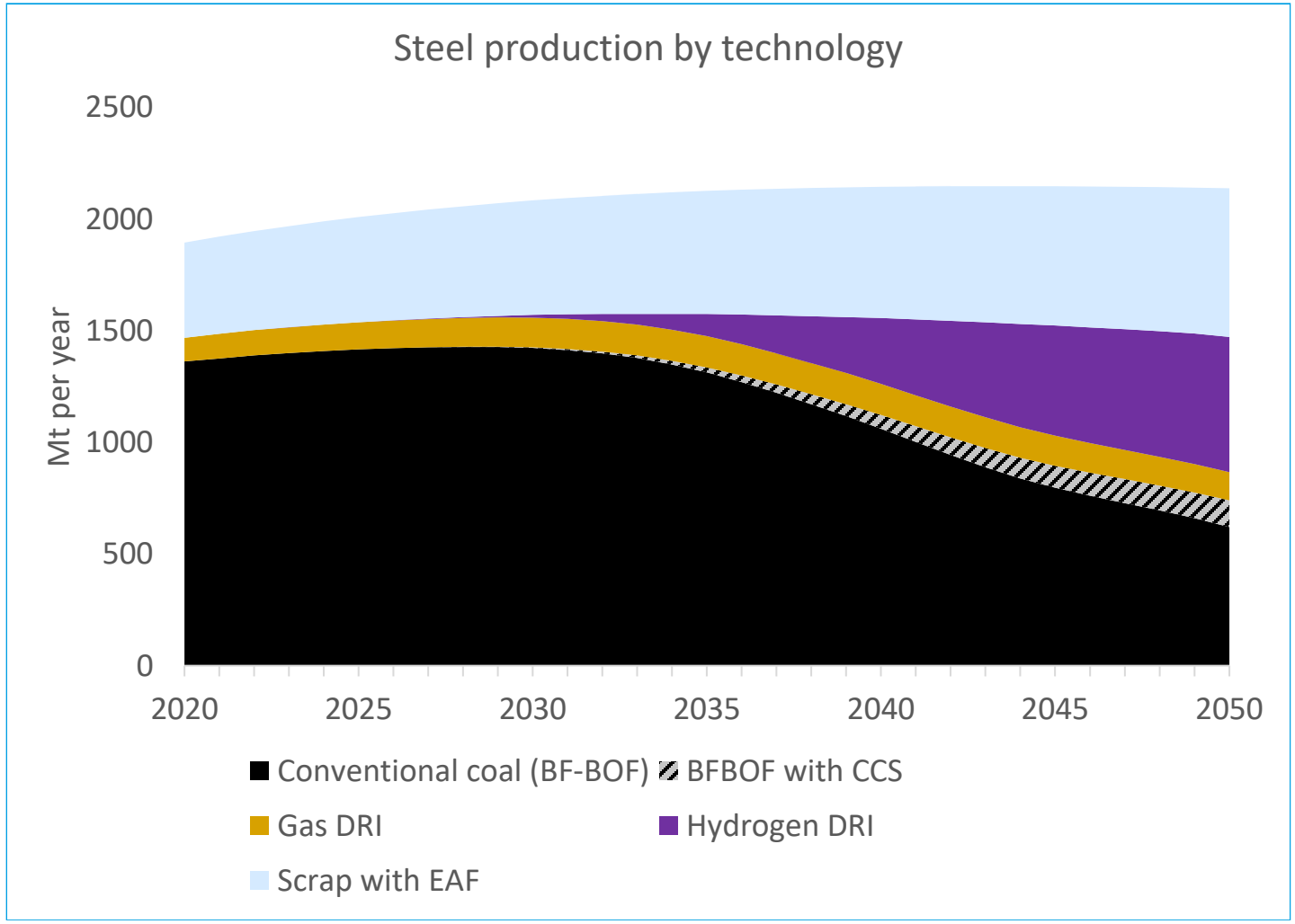


- Energy demand in industry grows by around 30% between 2020 and 2030, a slightly slower pace of growth than in IEA SDS (35%)
- Demand for coal is around 25% lower than in IEA SDS, due to more rapid displacement by hydrogen and electrification
- Demand for oil is around 10% lower, though remains substantial in both scenarios due to its use as a petrochemical feedstock
- Gas demand is broadly similar in both scenarios
- Hydrogen demand is likely to be higher in IPR FPS, IEA SDS reports some hydrogen use as the energy used to generate it (electricity or fossil fuels)

INEVITABLE POLICY RESPONSE

* for comparability with IEA SDS, energy mix includes coal, oil and gas used as chemicals feedstocks

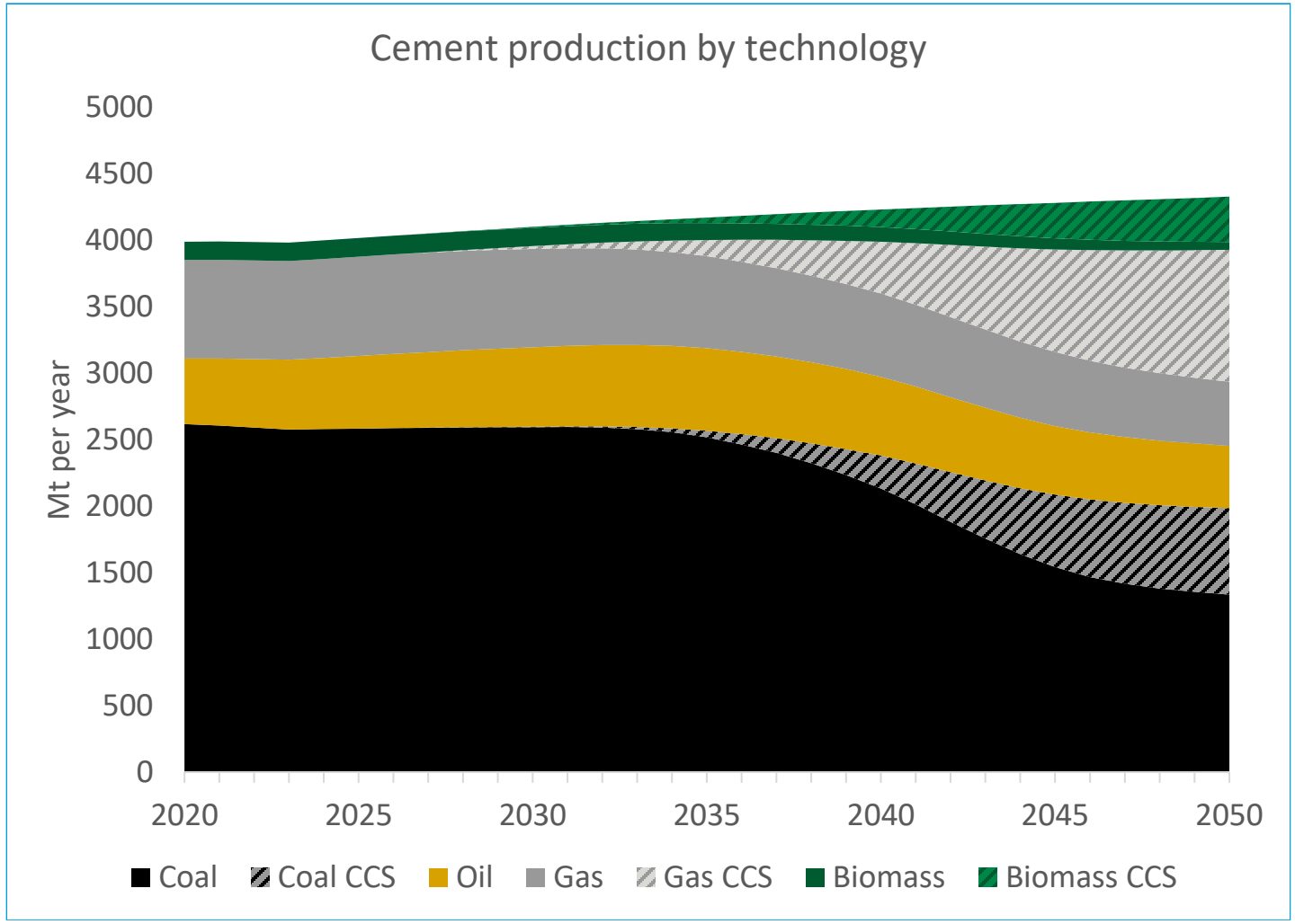
Hydrogen direct reduced iron (DRI) emerges as the dominant clean steel production technology, accounting for half of virgin steel production by 2050



- Conventional coal-based steel production falls by more than half between 2020 and 2050
- Clean steel production, using hydrogen direct reduced iron (DRI) or CCS, rises rapidly after 2030, accounting for around 10% of virgin steel production by 2035 and 50% by 2050
- Hydrogen DRI emerges as the dominant clean steel production technology, accounting for 85% of low-carbon virgin steel production, due to the relatively low capture rates of CCS in the steel sector

INEVITABLE POLICY RESPONSE

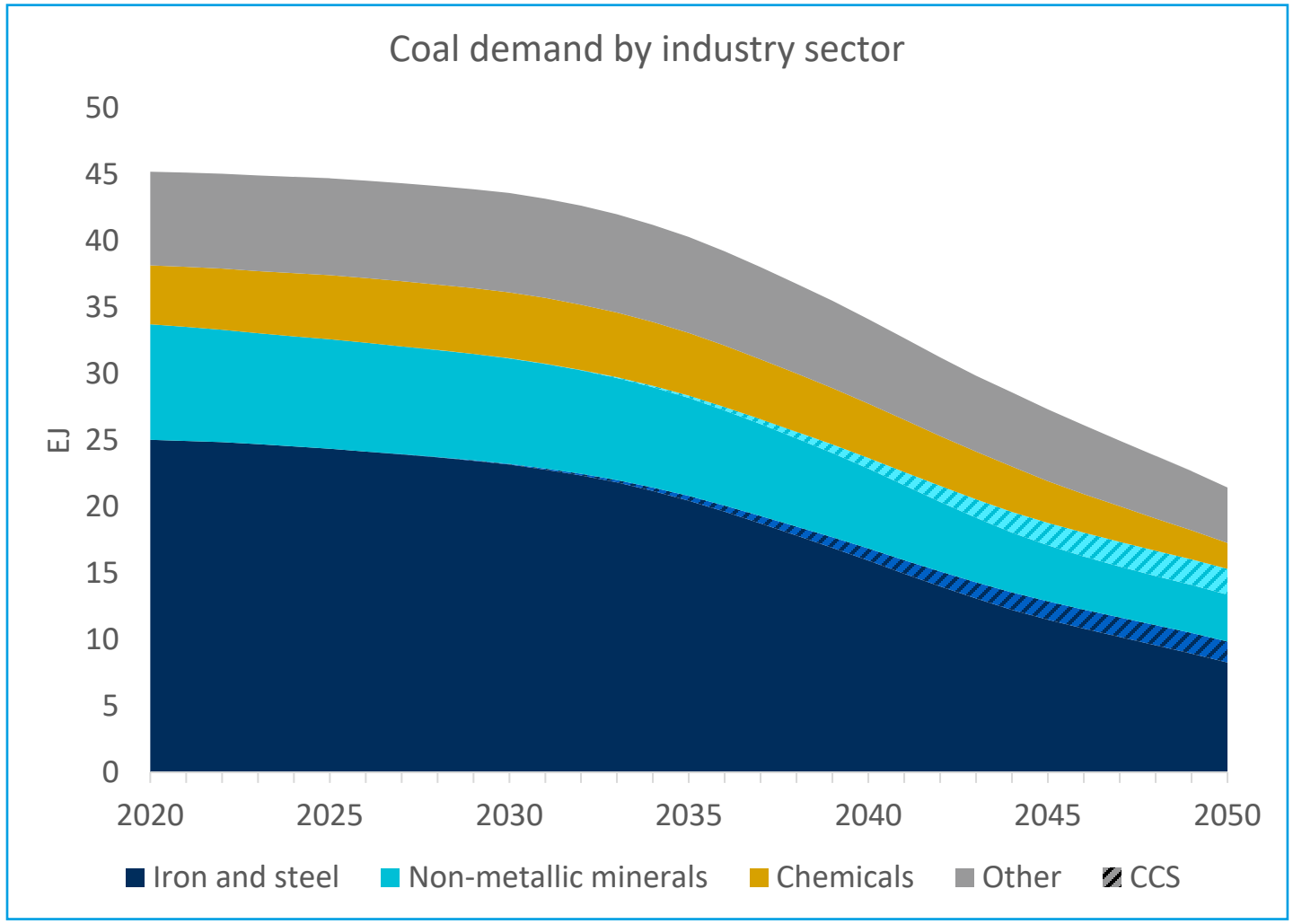
Carbon capture and storage is the primary solution to decarbonize the cement sector, capturing both combustion and process emissions



- Unabated fossil fuel based cement production falls by around 40% between 2020 and 2050; by 2050, unabated fossil fuels accounts for only half of the production mix
- A further 35% of the mix is accounted for by fossil fuels with CCS. As industrial processes account for more than half of total emissions from cement, CCS is a vital technological solution in production of low-carbon cement
- Biomass with CCS accounts for a small share of cement production, delivering negative emissions in addition to capturing process emissions

INEVITABLE POLICY RESPONSE

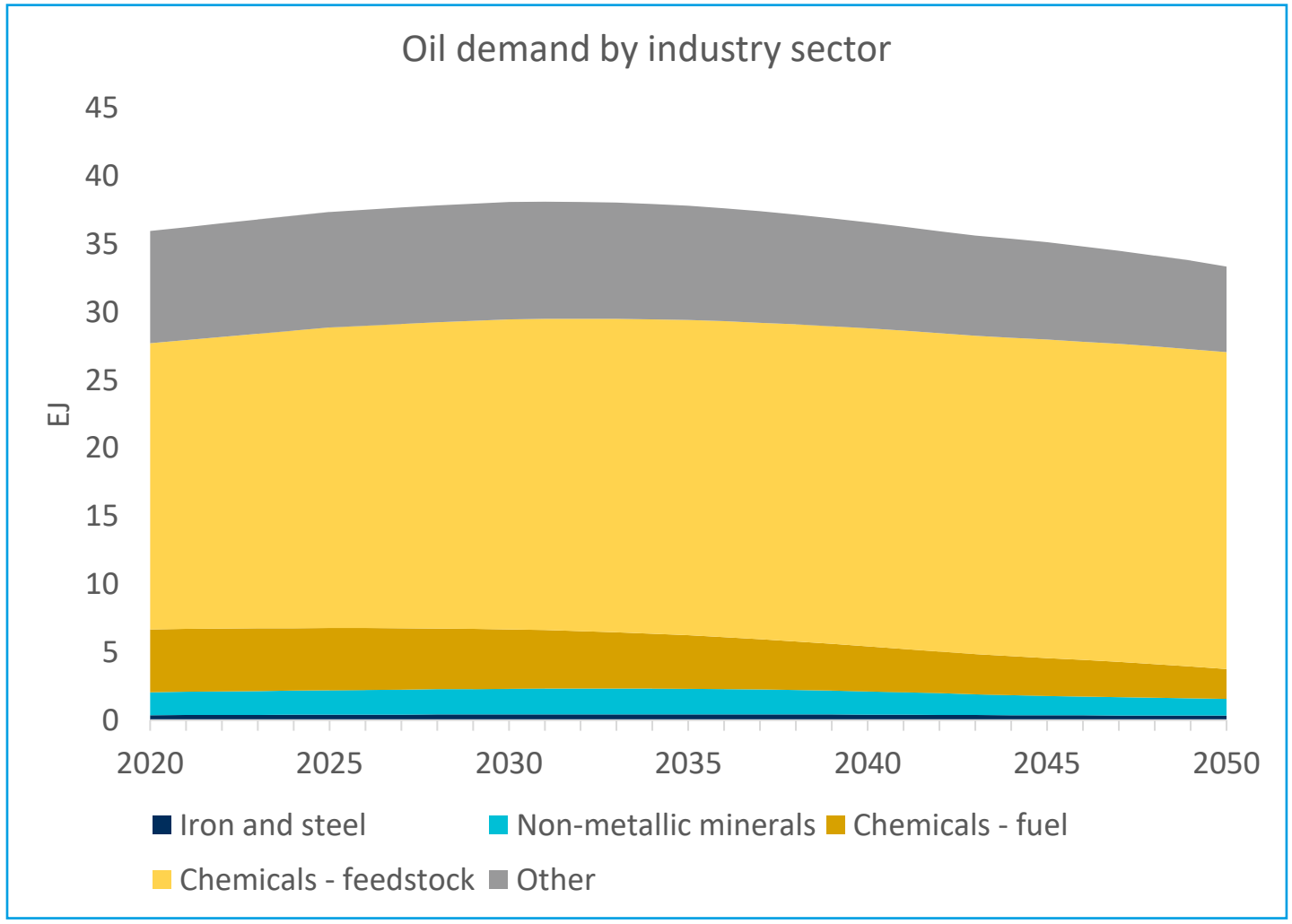
Coal demand falls in all industry sectors, with decarbonization of iron and steel driving the majority of the reduction



- Overall, coal demand falls 50% 2020-50 as low-carbon production technologies displace it in most industry sectors
- Coal demand falls most rapidly in iron and steel, decreasing around 60% between 2020 and 2050 as production shifts to hydrogen over the period
- Demand falls more slowly in the non-metallic minerals sector, dominated by cement. Coal remains an important fuel in cement production, and coal CCS provides a solution to decarbonise both fuel and process emissions
- In chemicals and light industry, coal use declines by around 50% as electrification and hydrogen reduce the need for coal in these sectors
- Remaining unabated coal is located primarily in countries with more limited climate commitments

INEVITABLE POLICY RESPONSE

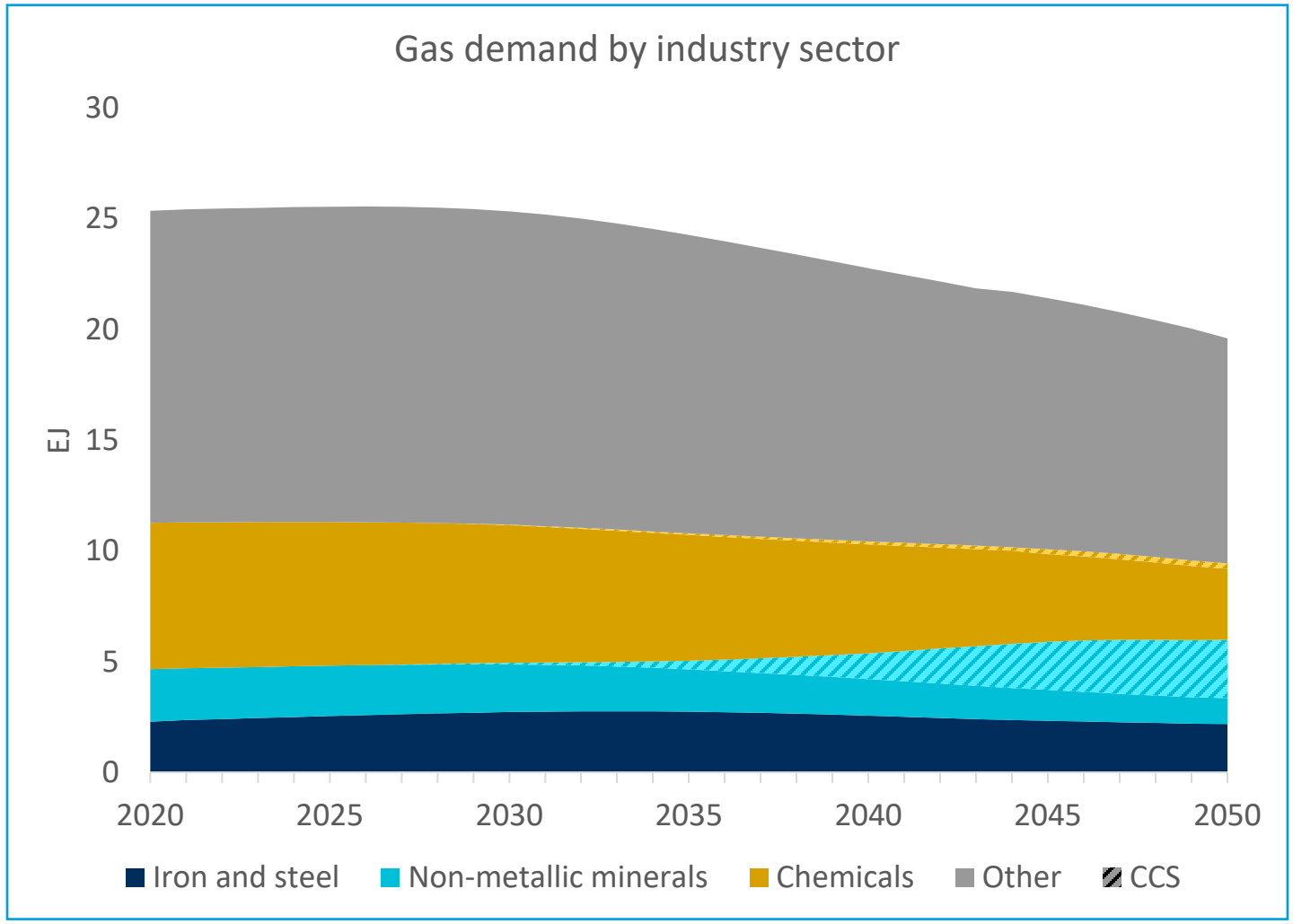
Oil demand in industry remains broadly flat, though it is used primarily as feedstock for chemicals where carbon is embedded



- Oil in industry is used primarily as a feedstock for chemicals, and as a fuel in light industry
- Use of oil as a fuel declines slightly to 2050 as electric and hydrogen heating replace it in many regions; but oil remains in use in countries without net zero targets
- Oil continues to be used as a feedstock for plastics and other high value chemicals, where the carbon is embedded
- Policy moderates but does not eliminate the growth in demand for plastics and other high value chemicals

INEVITABLE POLICY RESPONSE

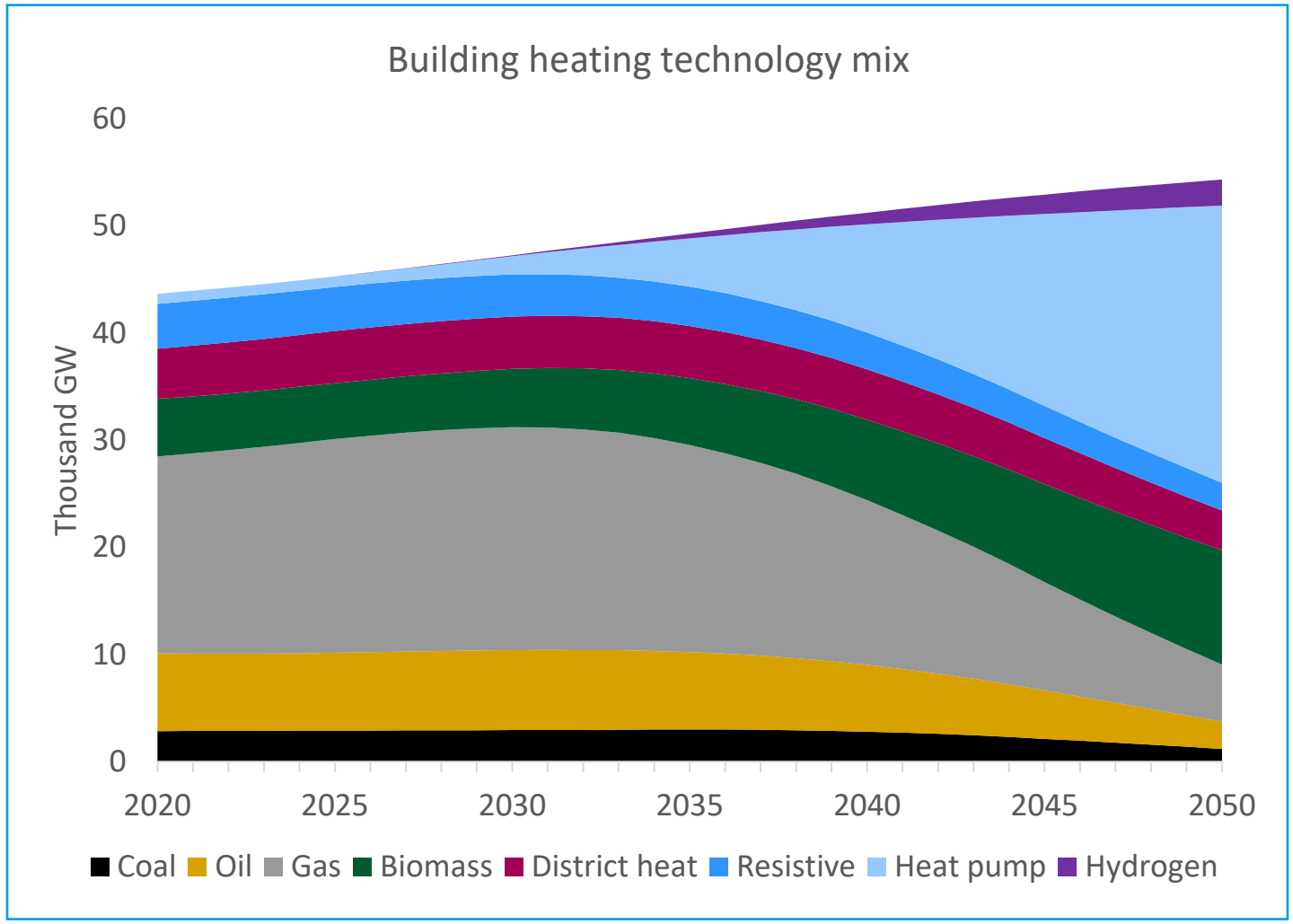
Sustained use of gas in light industry, chemicals and non-metallic minerals results in gas demand falling relatively slowly in industry



- Gas demand falls around 25% 2020-50. The fall in gas demand is less marked than for coal, due to its lower CO2 emissions and growth of industrial production in regions with more limited climate commitments
- Gas is primarily used as a fuel in light industry and chemicals. Between 2020 and 2050 demand falls around 30% in light industry and 35% in chemicals as production shifts to electrification and hydrogen in regions with net zero targets
- Gas demand grows slightly in non-metallic minerals as some production shifts from coal to gas, and gas CCS and coal CCS provides a solution to decarbonise both fuel and process emissions

INEVITABLE POLICY RESPONSE

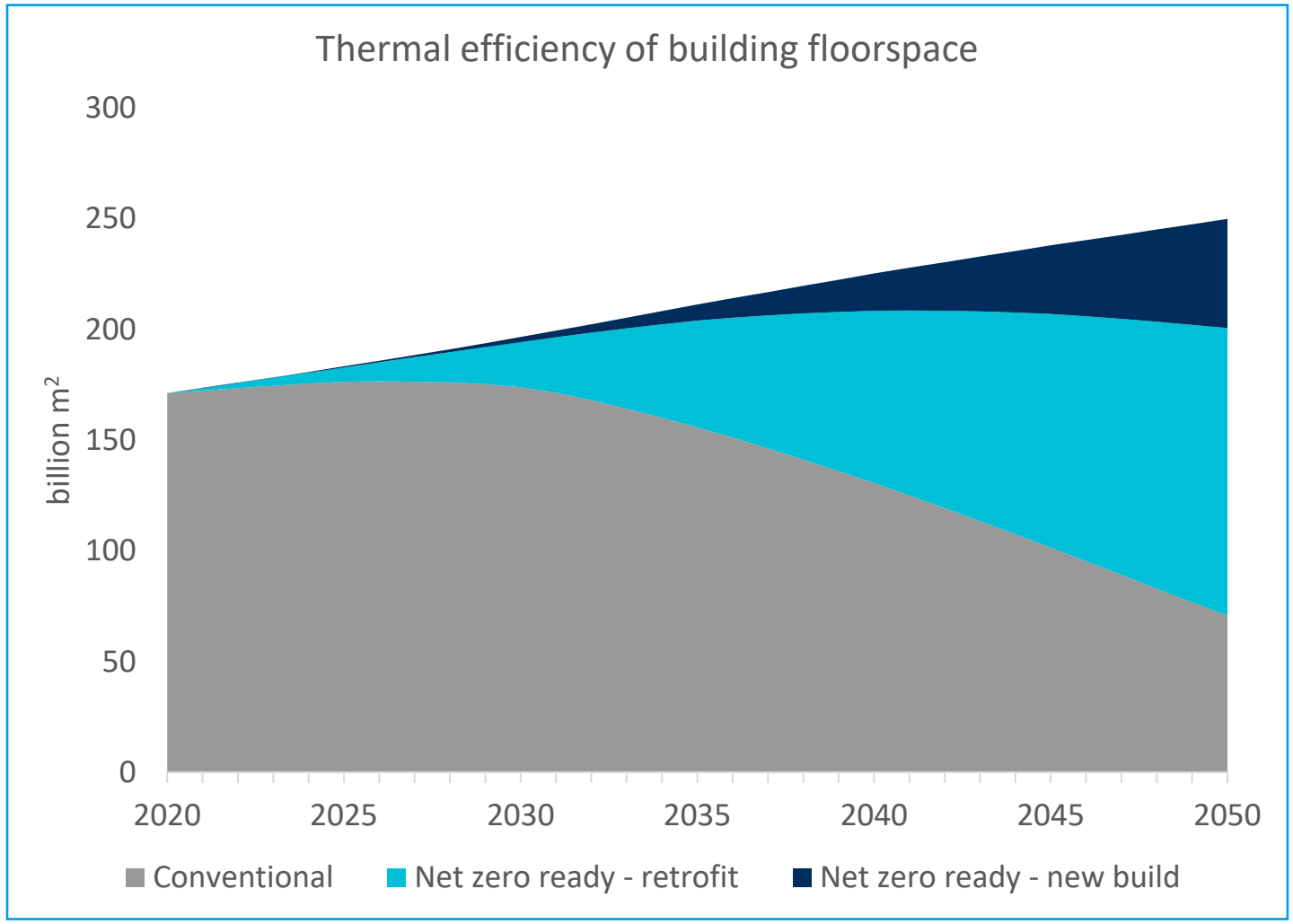
In buildings, electric heat pumps displace fossil heating systems to become the dominant heating technology by 2050



- Policy phases out new fossil heating systems between 2035 and 2050
- Driven by policy, heat pumps begin to dominate heating mix by 2050
- Remaining coal, oil and gas demand is in countries with later phase outs; coal and oil continue to be used in areas not connected to the gas grid
- Hydrogen meets a share of heating demand in regions with an existing gas grid, and a less efficient building stock

INEVITABLE POLICY RESPONSE

Thermal efficiency of the building stock improves substantially between 2020 and 2050



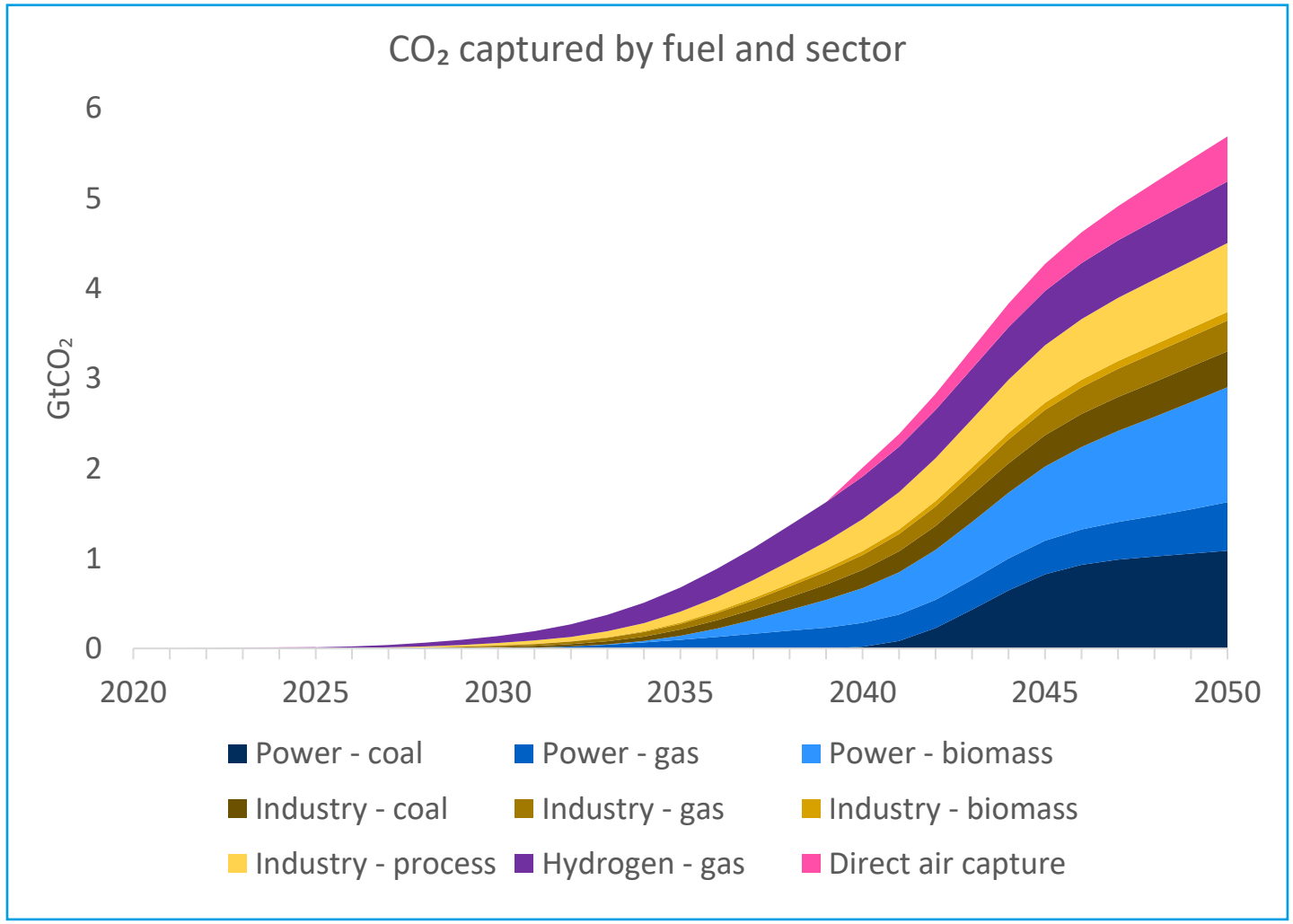
- Total building floorspace grows around 35% between 2020 and 2050
- A growing share of buildings are 'net zero ready', with high levels of thermal efficiency
- By 2050 around 15% of floorspace is in new buildings that are built net zero ready, while a further 60% is in buildings that are retrofit under energy efficiency policies
- By 2050, only around 30% of buildings have poor levels of thermal efficiency, primarily located in regions without net zero targets

INEVITABLE POLICY RESPONSE

Carbon Capture and Storage (CCS)

INEVITABLE POLICY RESPONSE

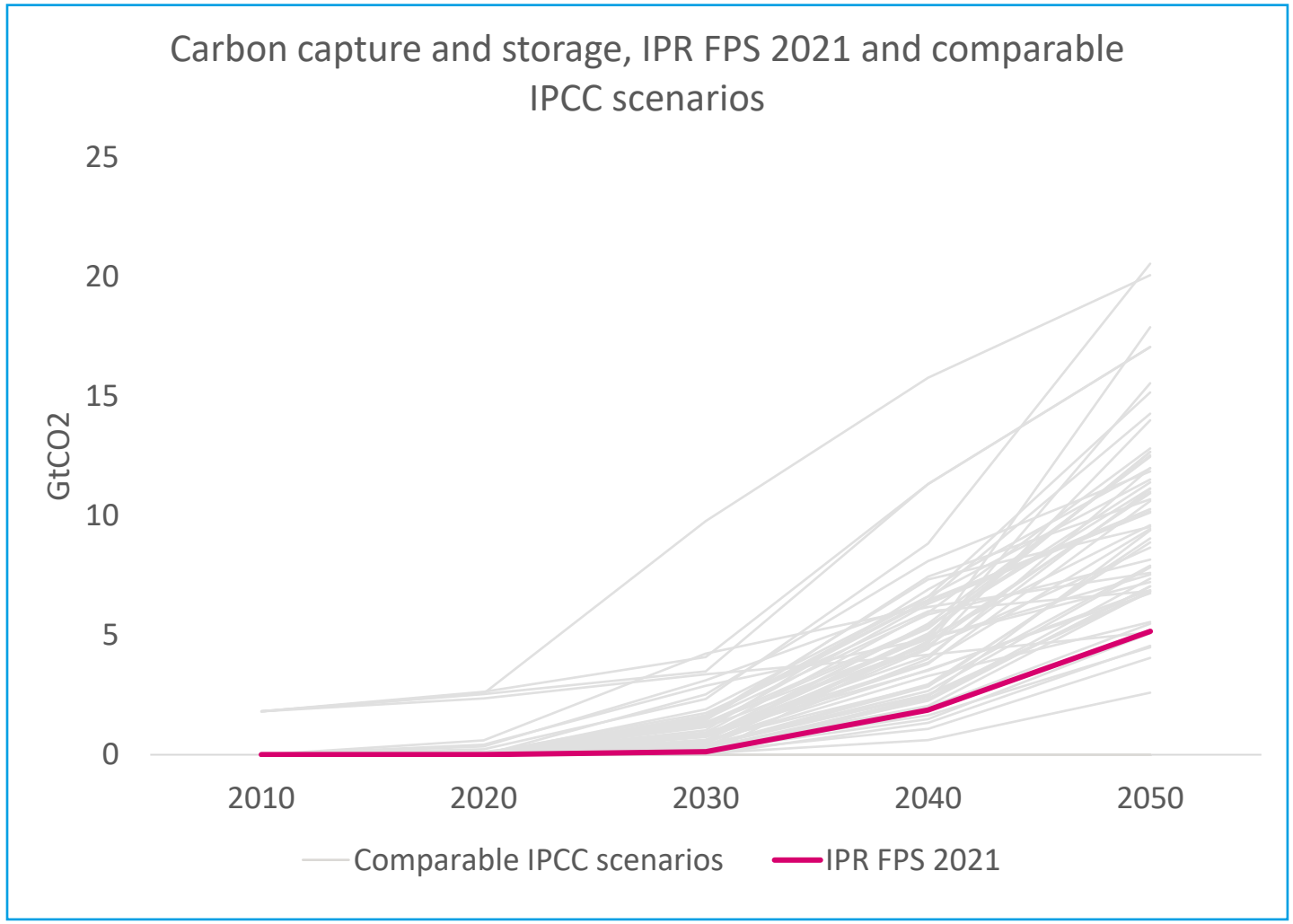
Carbon capture and storage (CCS) reduces emissions by 5 $GtCO_2$ across energy sectors



- Overall around 5 $GtCO_2$ are captured and stored in 2050
- Of this, around 2.5 Gt is captured in the power sector, and 1.5 Gt in the industry sector, where process emissions are otherwise hard to reduce
- A further 0.7 Gt is captured in the production of blue hydrogen
- Finally, 0.5 Gt is captured through Direct Air Capture
- Of the total 5 Gt CCS, around 3.5 Gt of CO_2 is from fossil fuels or industrial processes, while around 1.5 Gt is from biomass or DAC, generating negative emissions

INEVITABLE POLICY RESPONSE

CCS Comparisons



- Almost all scenarios that achieve below 2 degree climate outcome require CCS
- Across a range of 57 comparable IPCC scenarios (with temperature outcomes between 1.7 and 1.9 degrees), CCS captures between 2.5 and 20.5 $GtCO_2$ by 2050
- In IPR FPS, around 5 $GtCO_2$ are captured and stored in 2050, lower than levels in over 90% of comparable IPCC scenarios

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Thank you!

Please see PRI website for further details:

https://www.unpri.org/climate-change/what-is-the-inevitable-policy-response/4787.article

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INEVITABLE POLICY RESPONSE

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Appendix 1: Vivid Energy System Modelling (VESM) toolkit

The Vivid Energy Systems Model (VESM) toolkit covers the entire energy system allowing complex scenario analysis and development

Inputs

Energy demand

Housing/services:
- Lighting and appliances, heating, cooling

Commodity demand
- Iron/steel, cement, chemicals, light industry

Transport
- Passenger
- Freight

Technology

Energy production and transformation
- By sector
- By region
- By fuel
- Emissions profiles

Storage
- Batteries or hydrogen storage

Constraints

Physical constraints
- E.g. coal supply

Policy constraints
- E.g. ICE phase out

Technical constraints
- E.g. funding limits

Techno-economic analysis

Model type
- Global whole energy system model
- Calibrated to latest energy balances

Granularity
- 21 regions
- ~ 2,700 technologies

Time resolution
- 2015 to 2100 with annual resolution

Outputs

- Energy mix
- Discounted cost analysis
- Emissions accounting
- Investment portfolio

VESM is developed in OSeMOSYS - the Open Source Energy Modelling System (http://www.osemosys.org/)

INEVITABLE POLICY RESPONSE

Annex

Annex: IEA Announced Pledges Scenario

Scenario emissions ($GtCO_2$)

Scenario	2020	2030	2040	2050
Announced Pledges Case (APC) May 2021	33.9	30.5	24.8	22.0
Announced Pledges Scenario (APS) October 2021	34.1	33.6	26.7	20.7

- This report has compared emissions in IPR FPS to the IEA Announced Pledges Case (APC) scenario from the May 2021 Net Zero Emissions report
- In WEO 2021, IEA APC is renamed Announced Pledges Scenario (APS), with a slightly modified emissions pathway

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