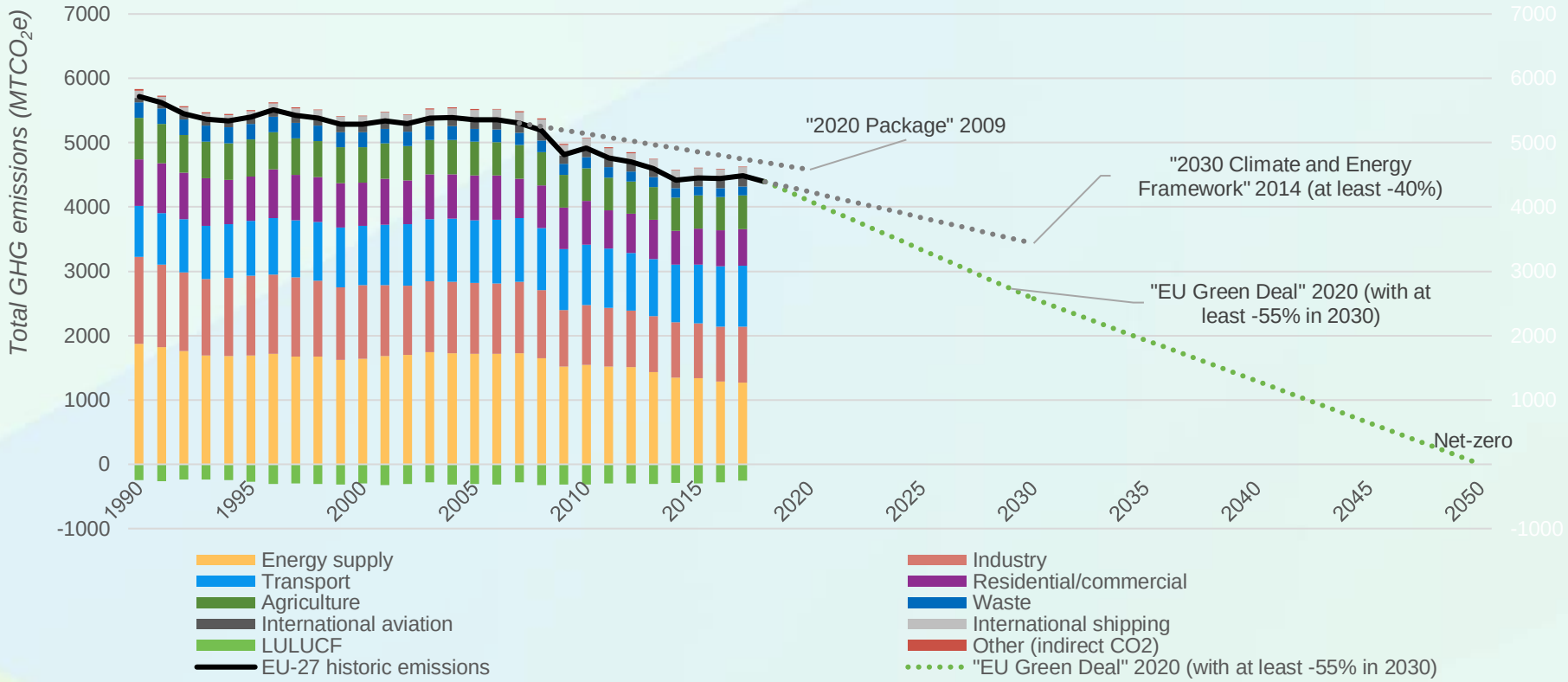
Hydrogen4EU

CHARTING PATHWAYS TO ENABLE NET ZERO

Hydrogen4EU study

Key graphs

European energy transition and the new policy challenges

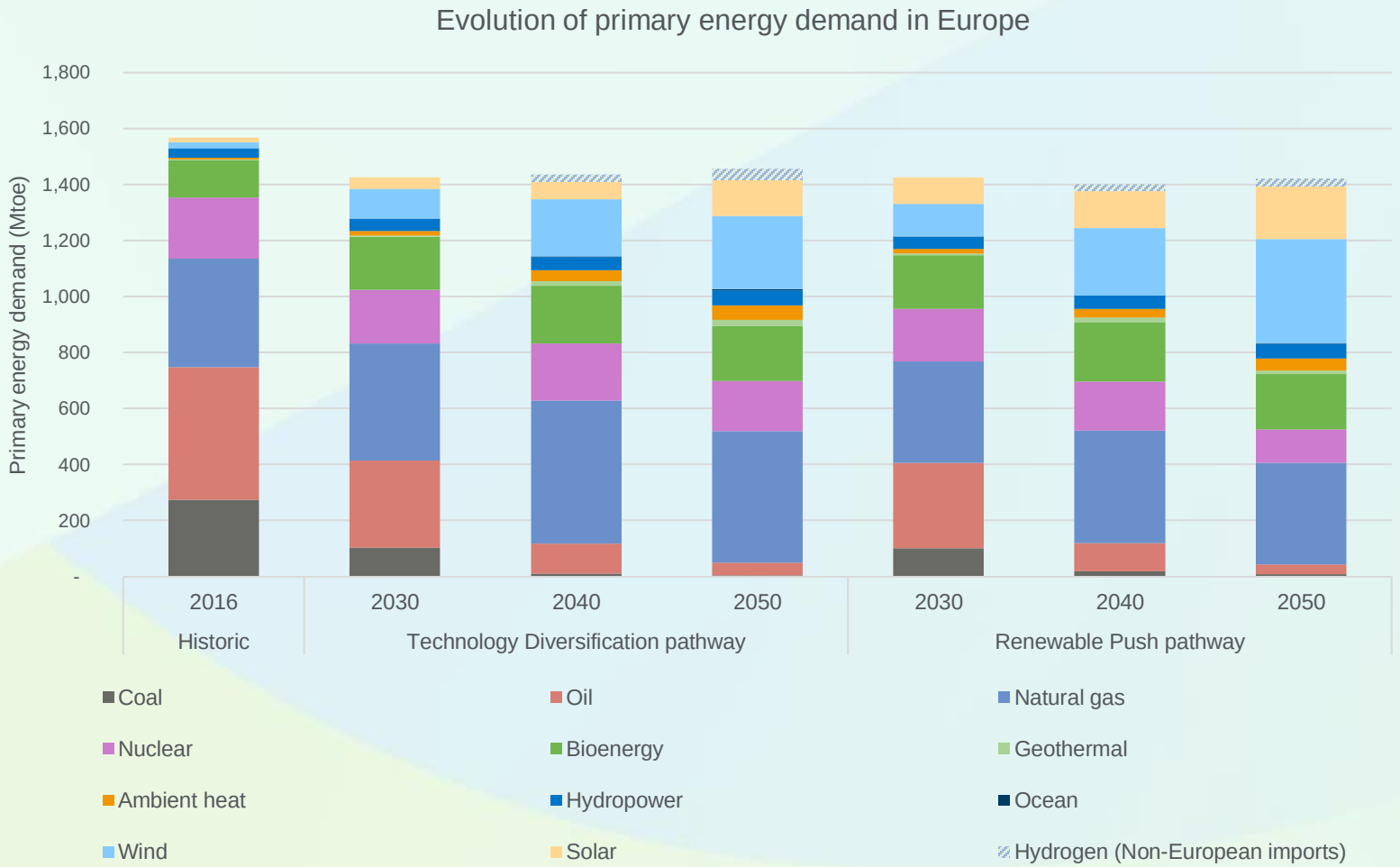


Own elaboration based in European Environmental Agency (EEA) data.

Note: The figure includes emissions from international aviation, and net removals from land use, land use change and forestry sector (LULUCF). Completed with linear trajectories to comply with enacted legislations.

The transformation of energy supply

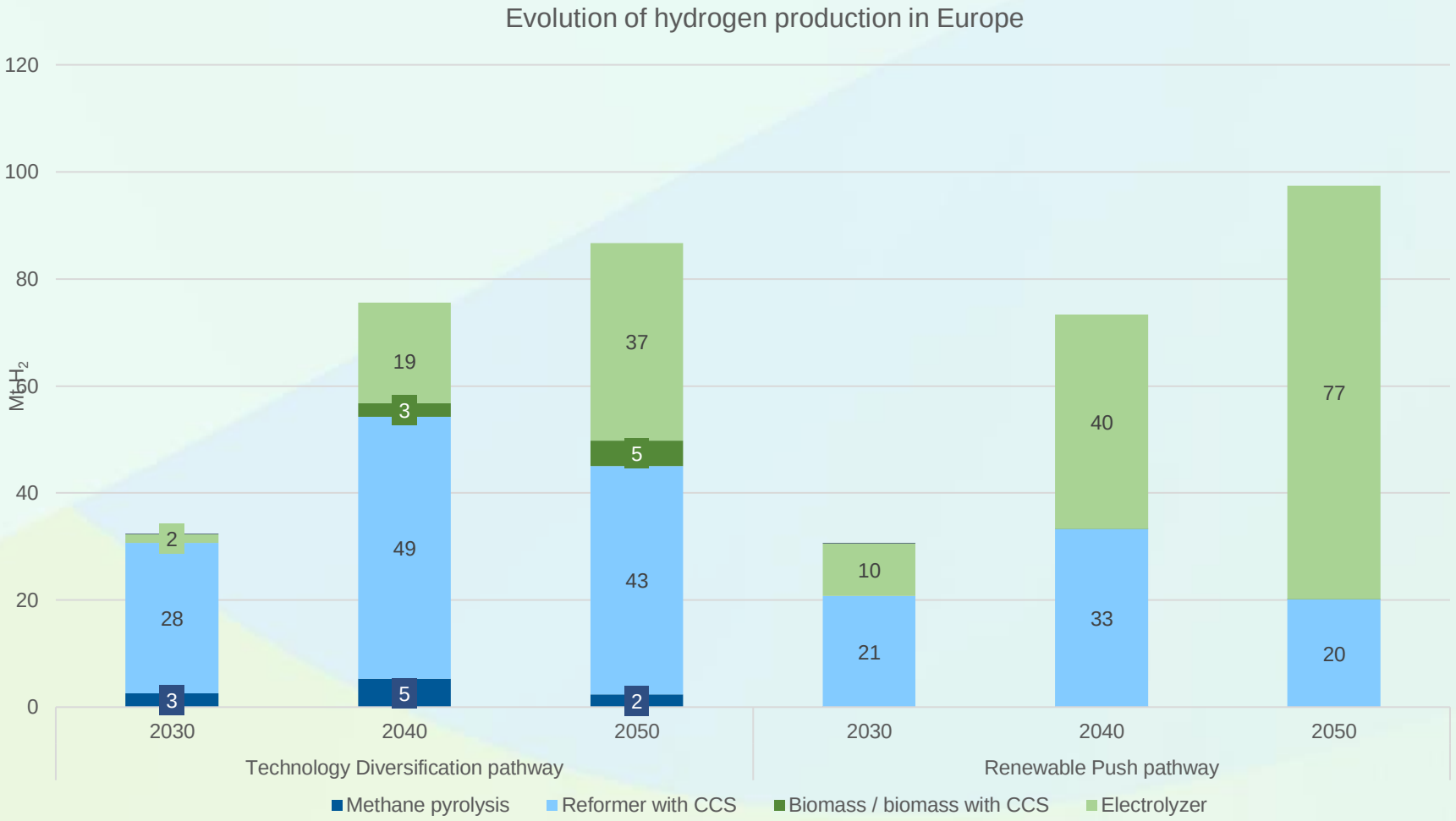
Primary energy demand decreases around 0.2%-0.3% on average between 2016 and 2050



Primary energy demand decreases by 0.2% on average every year from 2016 to 2050 in the Technology Diversification scenario and by 0.3% on average in the Renewable Push scenario, spurred by energy efficiency efforts. Significant substitutions between energy supply sources are observed.

The rise of a European hydrogen industry

Renewable and low-carbon hydrogen are complementing each other



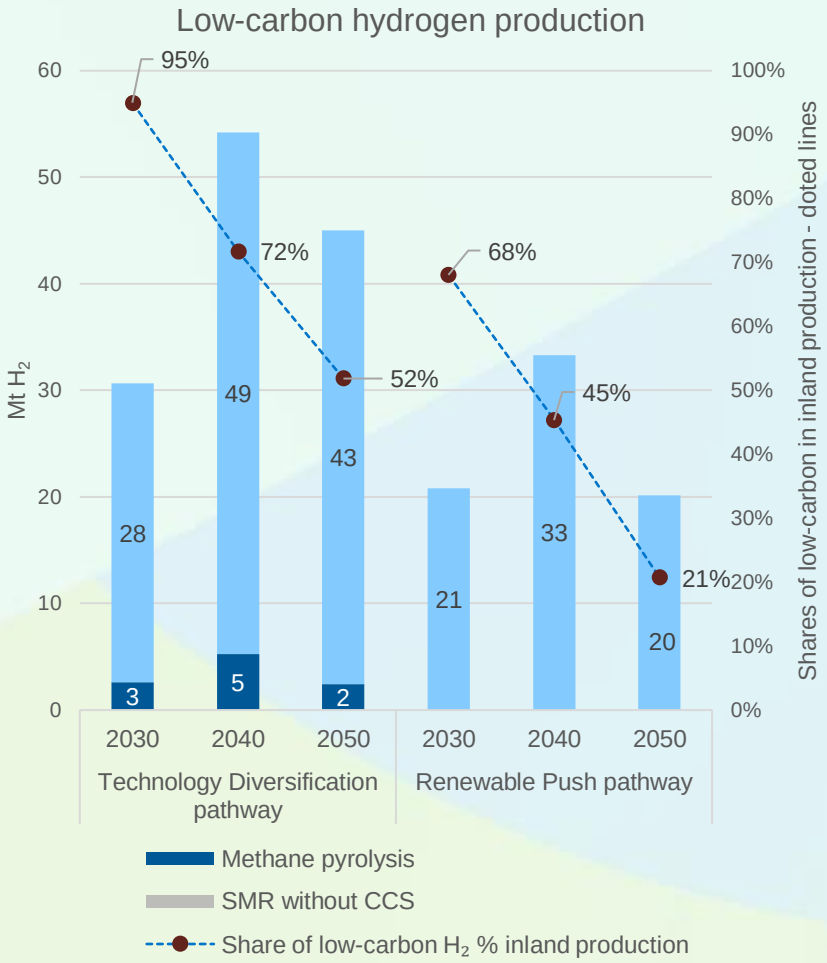
Diversity in hydrogen is essential to the transition to net zero. Low carbon hydrogen is an enabler for renewable hydrogen as the industry is building up.

- Early renewable deployment has a direct positive impact on renewable (electrolysis) hydrogen prospects, as soon as 2030 (10 Mt in Renewable Push)
- Low-carbon hydrogen from reformers with CCS plays a critical role in establishing a hydrogen economy in the first half of the outlook period and is particularly resilient in the Renewable Push pathway
- Pyrolysis is a viable alternative where renewables are scarce and CCS faces political headwinds

European hydrogen production

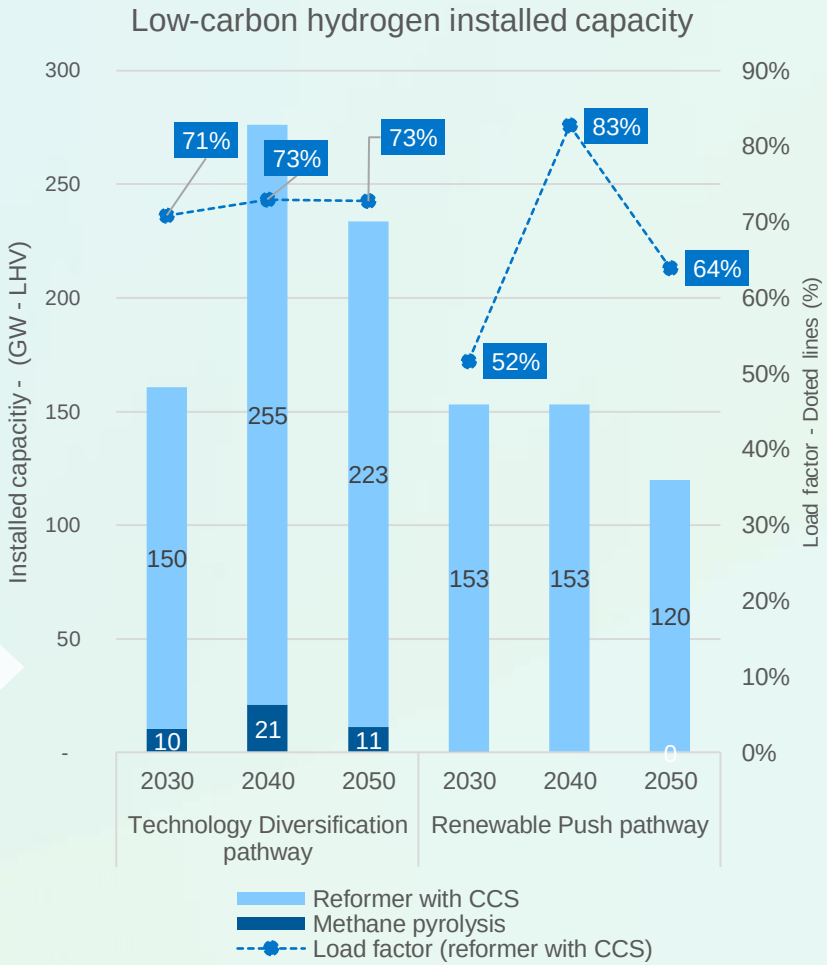
Low-carbon* hydrogen plays an essential role in the transition

**Not including hydrogen from ongrid electrolysis, that is considered "renewable" (up to 5 MtH_2 – 5% of total in 2050)*



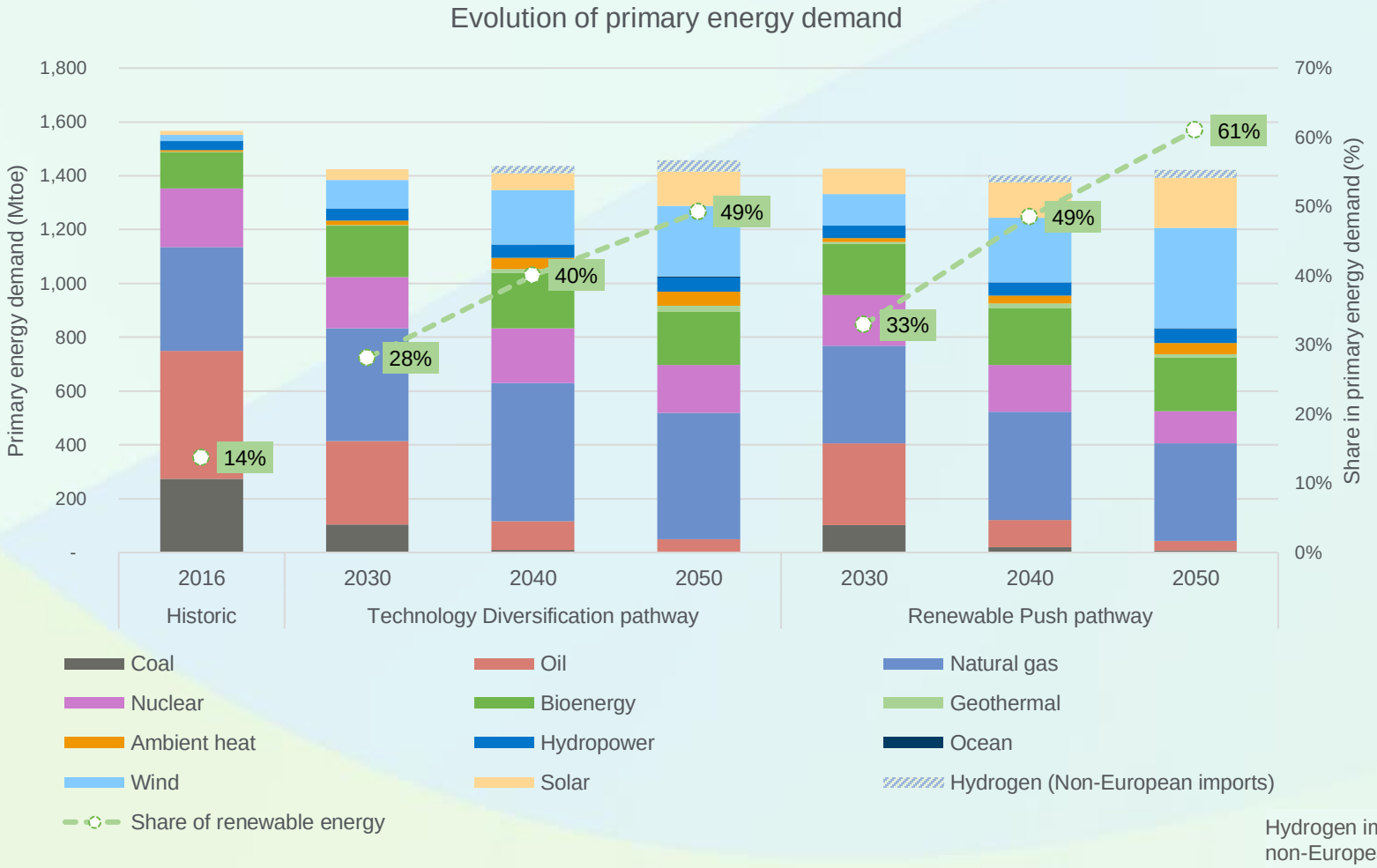
Low-carbon hydrogen production decreases after a peak in 2040 : late assets could face the risk of becoming stranded depending on other economic drivers (see later slides)

Early investments are required in low-carbon hydrogen as it allows to establish the hydrogen economy during the 2020s and 2030s.



The transformation of energy supply

The share of renewable energy sources in primary supply more than triples

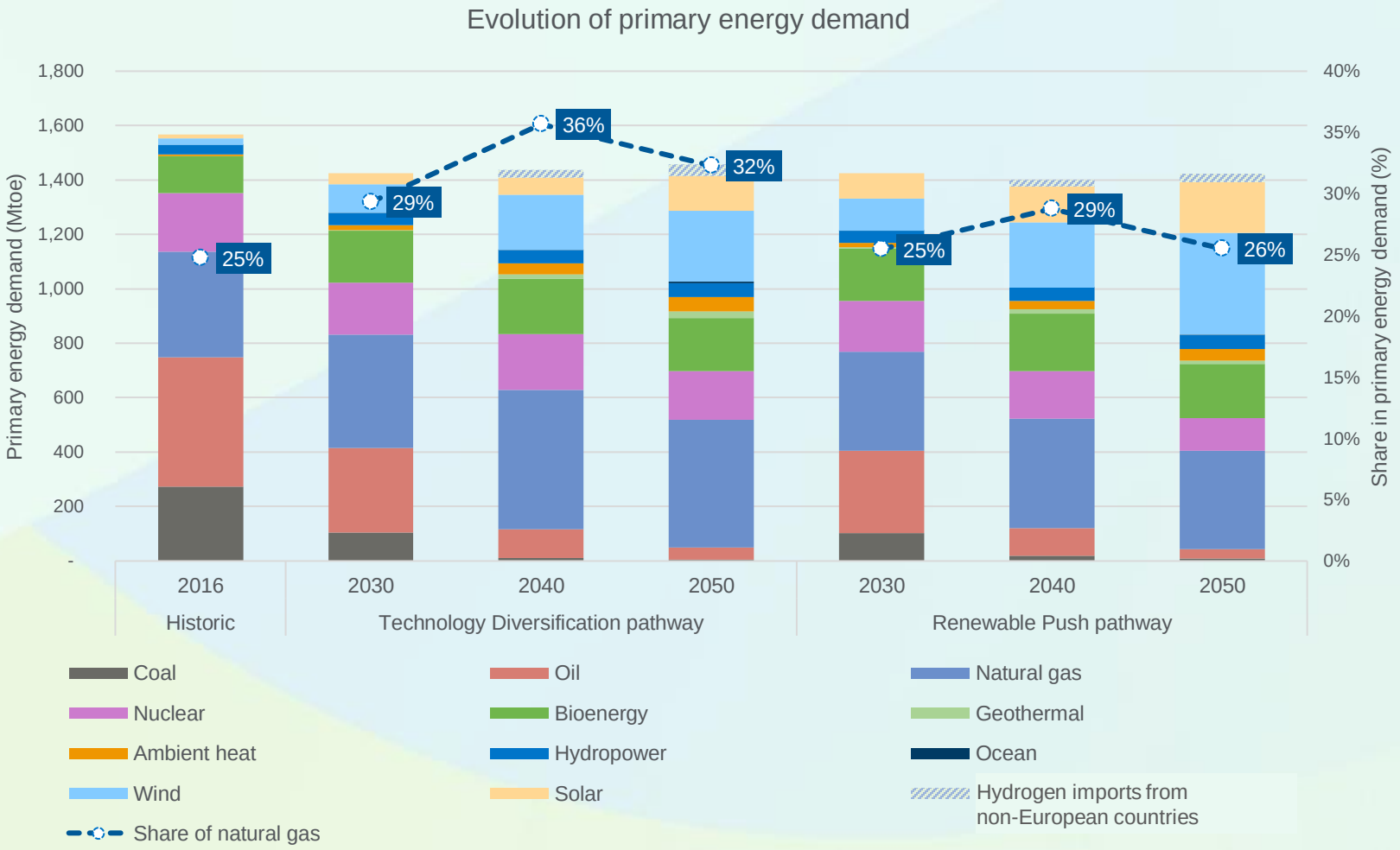


The share of renewable energy supply more than triples to reach 49% in the Technology Diversification scenario and as high as 61% in the Renewable Push, sustained by very ambitious increases in wind and solar (tenfold increase between 2016 and 2050).

Hydrogen imports from non-European countries

The transformation of energy supply

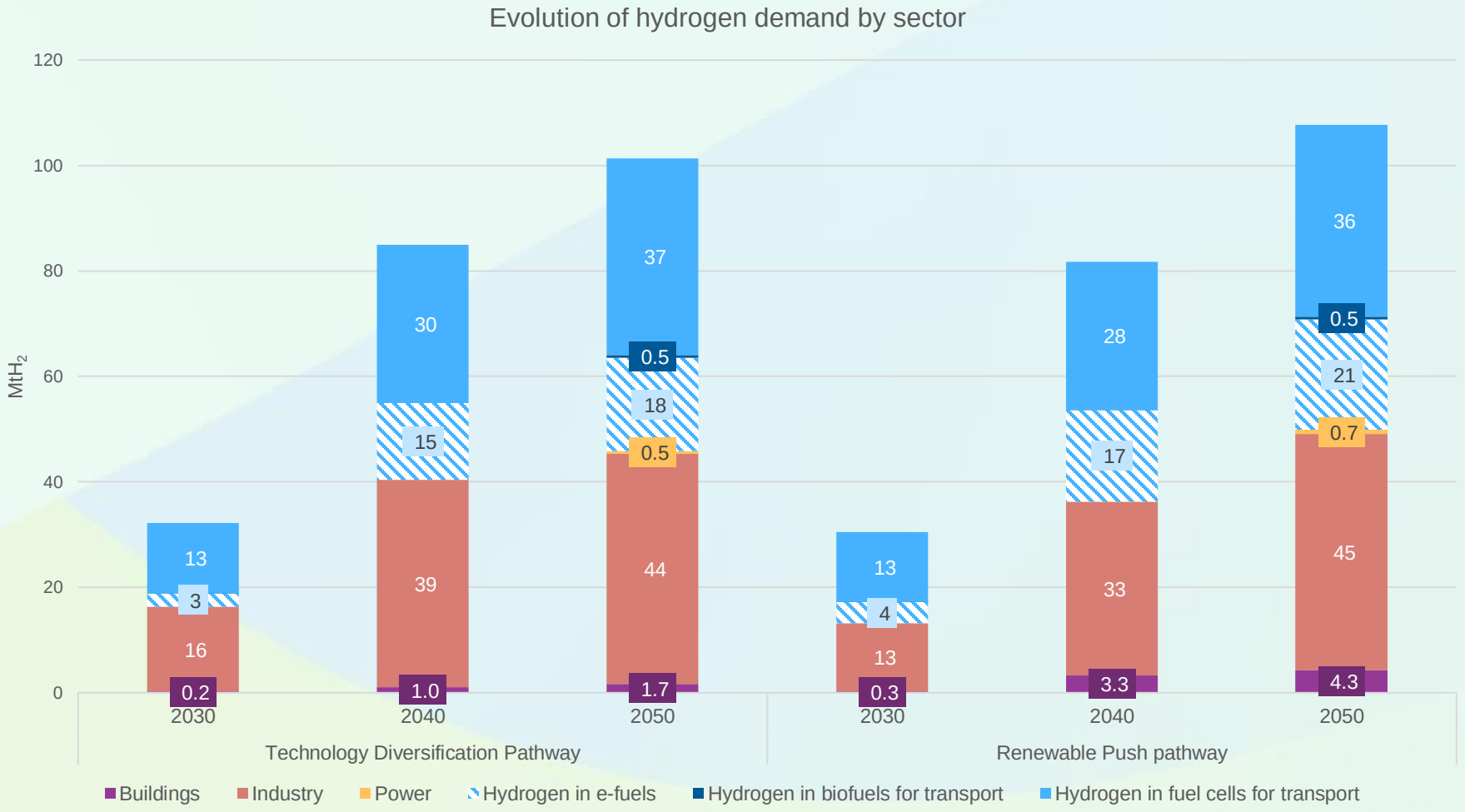
Natural gas plays a central role in the transition to net-zero emissions



Natural gas is an element of continuity in the energy mix and remains resilient even in the Renewable Push pathway, where it provides important flexibility as a complement to renewables. Natural gas offers greatest benefits when coupled with CCUS.

Hydrogen demand

Hydrogen plays a similar role in the two scenarios as it proves a robust solution for hard-to-abate sectors

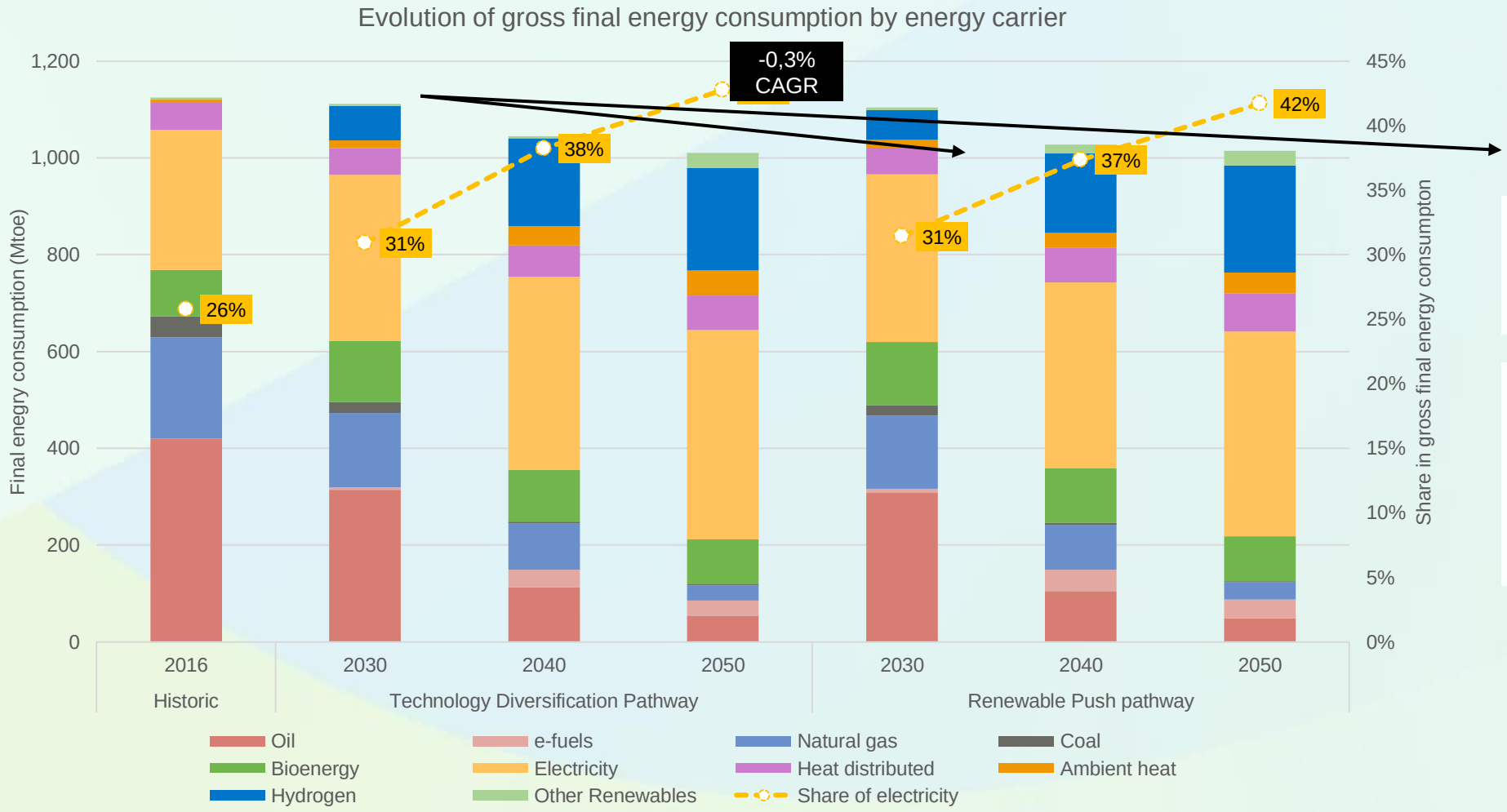


- Hydrogen demand already exceeds 30 million tons in 2030
- The biggest ramp-up phase happens between 2030 and 2040 as the demand is multiplied by more than x2.5.

- Transport and industry make up the vast majority of hydrogen demand in both scenarios, confirming the role of hydrogen in hard to abate sectors.
- Hydrogen also contributes to decarbonization in buildings and power generation<

Energy transition and final uses

Electrification and energy efficiency play their expected role in the transition…

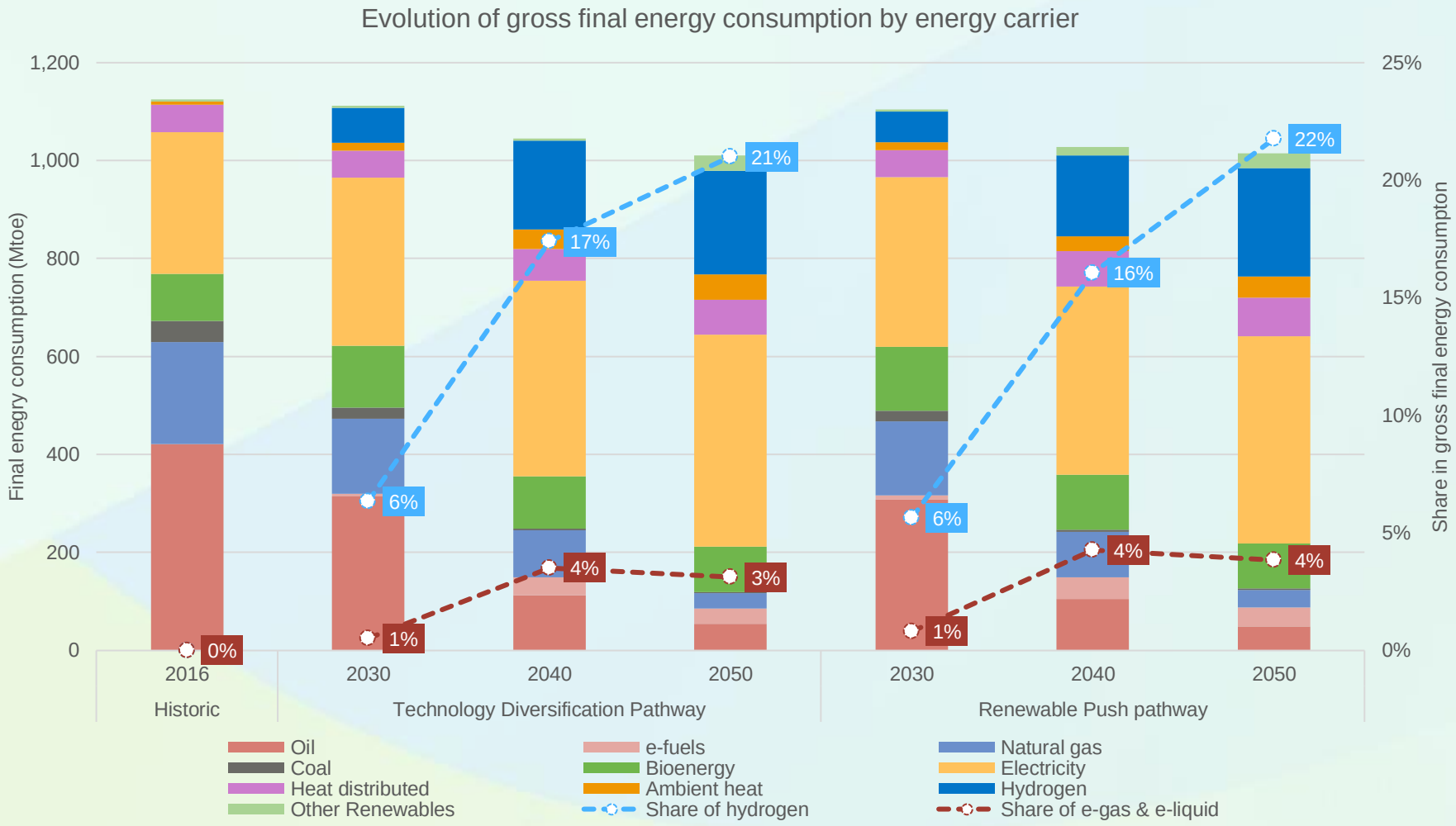


Near doubling of the share of electrification between 2016 and 2050

Energy efficiency contributes to reduce final energy consumption by almost a quarter in 2050 when compared to 2005 (-0.3% every year) in both pathways

Energy transition and final uses

… but hydrogen and other synthetic/biofuels hold the keys to net zero



- Hydrogen plays a dual role: as a gas for final energy consumption, and as an energy carrier for the production of e-fuels and other molecules.
- Combined with e-fuels, hydrogen reaches a share of around 25% in 2050 in both scenarios.

Note: hydrogen also includes related hydrogen used for ammonia production for energy-use in the maritime sector

European hydrogen production

Renewable hydrogen uptake relies on electrolysis powered by wind and solar

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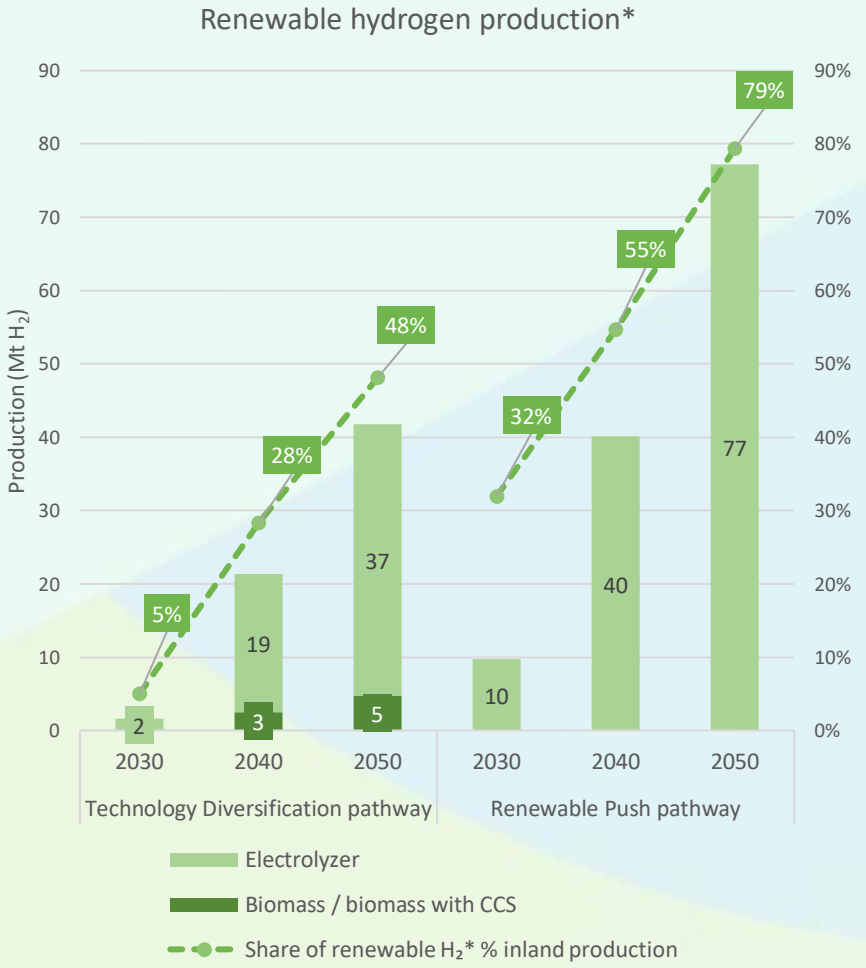
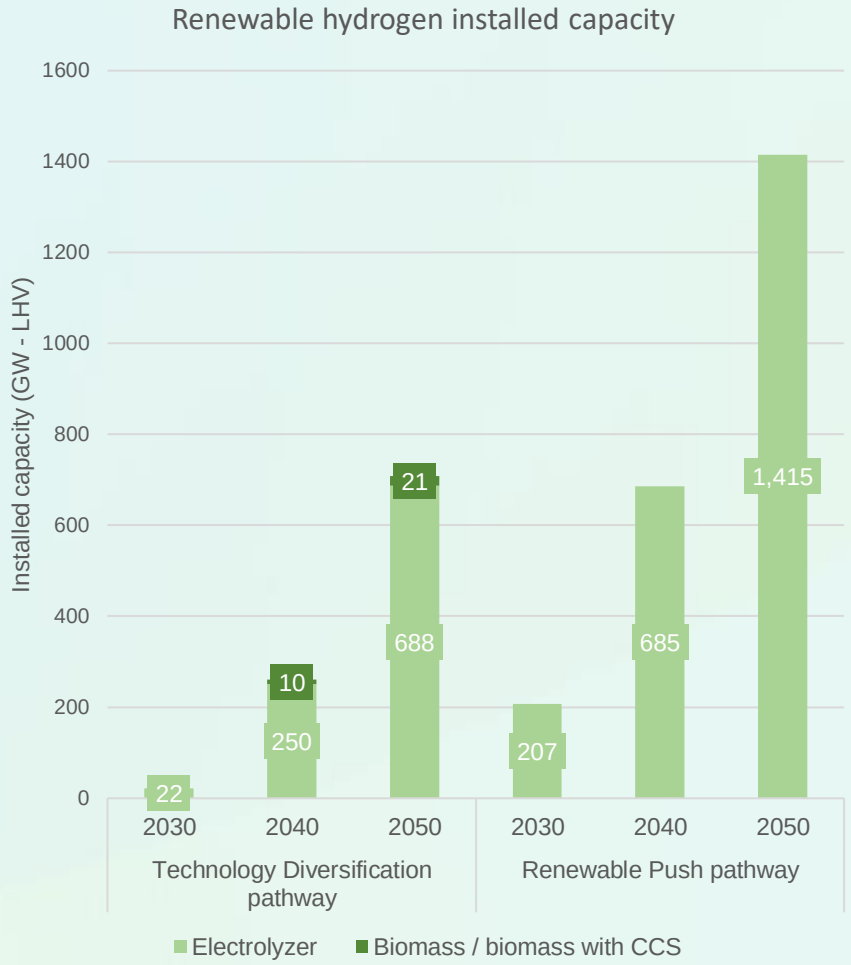


Production of hydrogen by electrolysis reaches more than 1.5 Mt in 2030 in the Technology Diversification pathway and 10 Mt in the Renewable Push pathway.

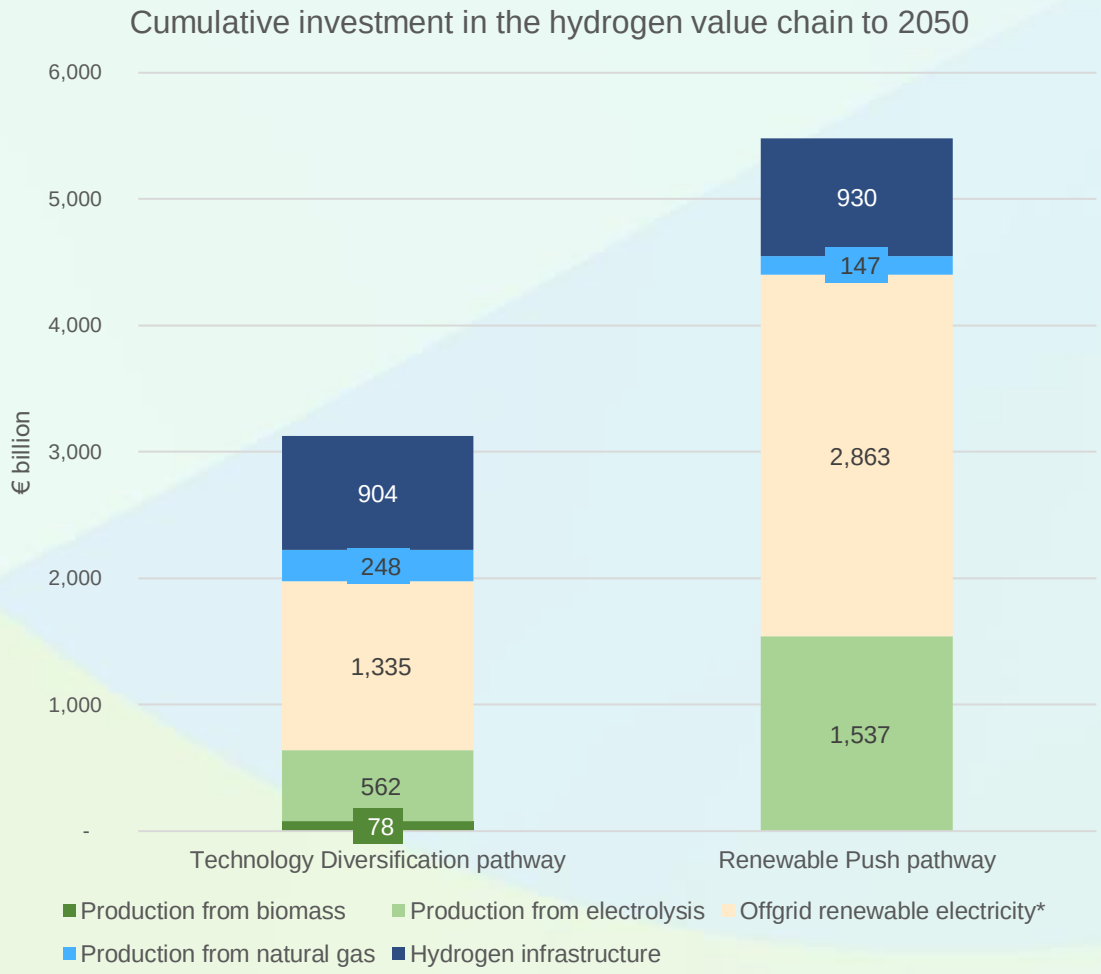
Hydrogen by electrolysis faces a major ramp-up in the last decade. It relies on the expansion of renewable capacities.



**Including hydrogen from ongrid electrolysis, that is considered "renewable" (up to 5 MtH_2 – 5% of total in 2050)*

Investment pathways

Three to five trillion euros of dedicated investments in the hydrogen value chain



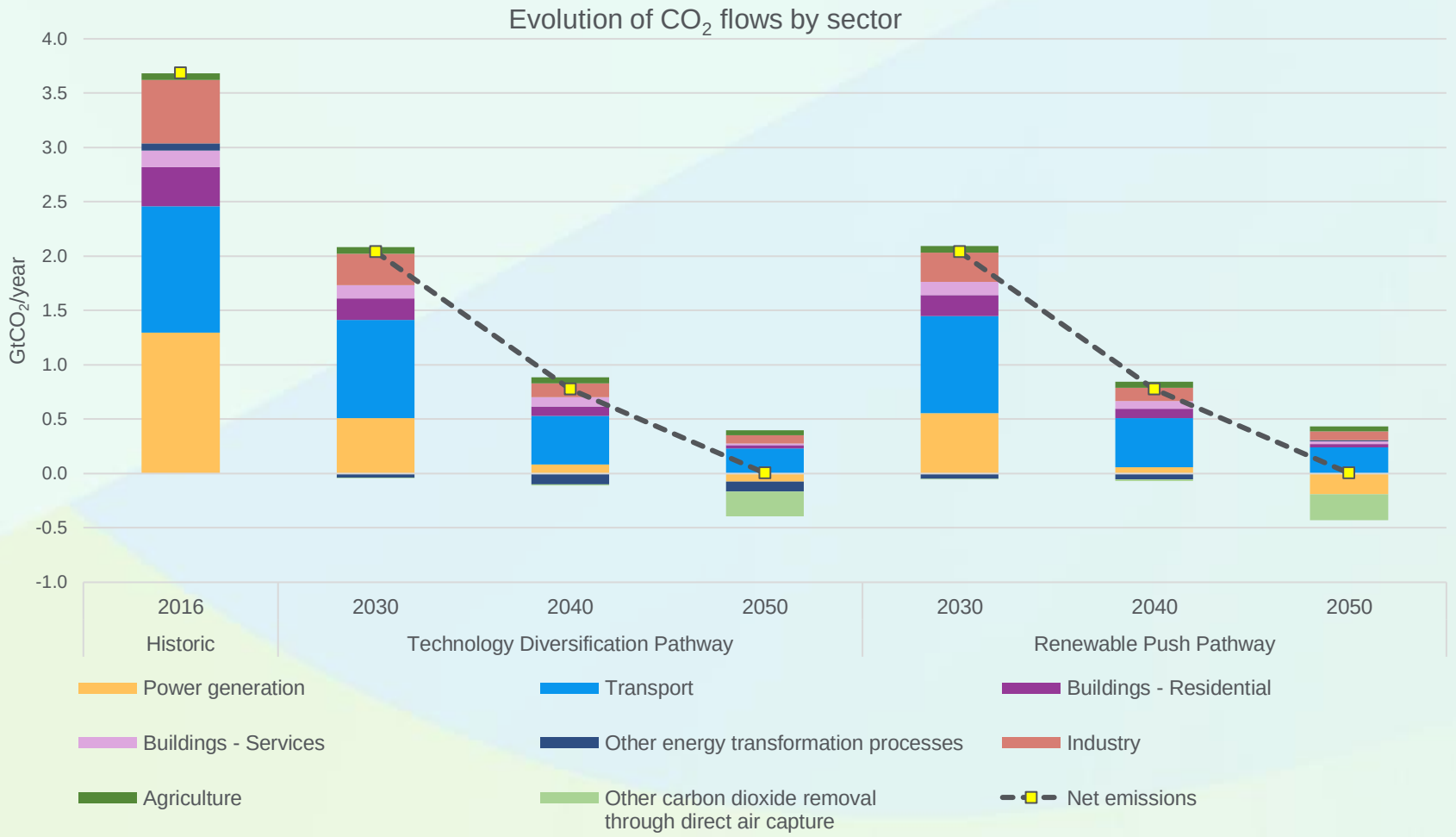
Cumulative investments in the hydrogen value chain, including investments in renewables for offgrid electrolysis, amount to several trillion euros over the outlook period.

The difference of more than two trillion in capital spending between the two scenarios demonstrates the higher capital intensity of a pathway focusing primarily on renewable assets and electrolyzers. As such, one of the main challenges of the Renewable Push pathway is the ability to mobilize almost twice as much capital over the next thirty years to accomplish the hydrogen uptake.

**Fixed investment costs for the hydrogen value chain (CAPEX + O&M fixed costs)*
Post treatment of results was carried out to retrieve CAPEX from offgrid renewables

A pathway to carbon neutrality

CO_2 removal solutions are key to achieve net-zero



- Energy-related CO_2 emissions reach the target constraint (-55% in 2030, -100% in 2050 with interpolation between those dates).
- Between 394 and 418 $MtCO_2$ of negative emissions in 2050 to ensure net zero

A pathway to carbon neutrality

CO_2 storage and re-use as an enabler of low-carbon technologies' full potential

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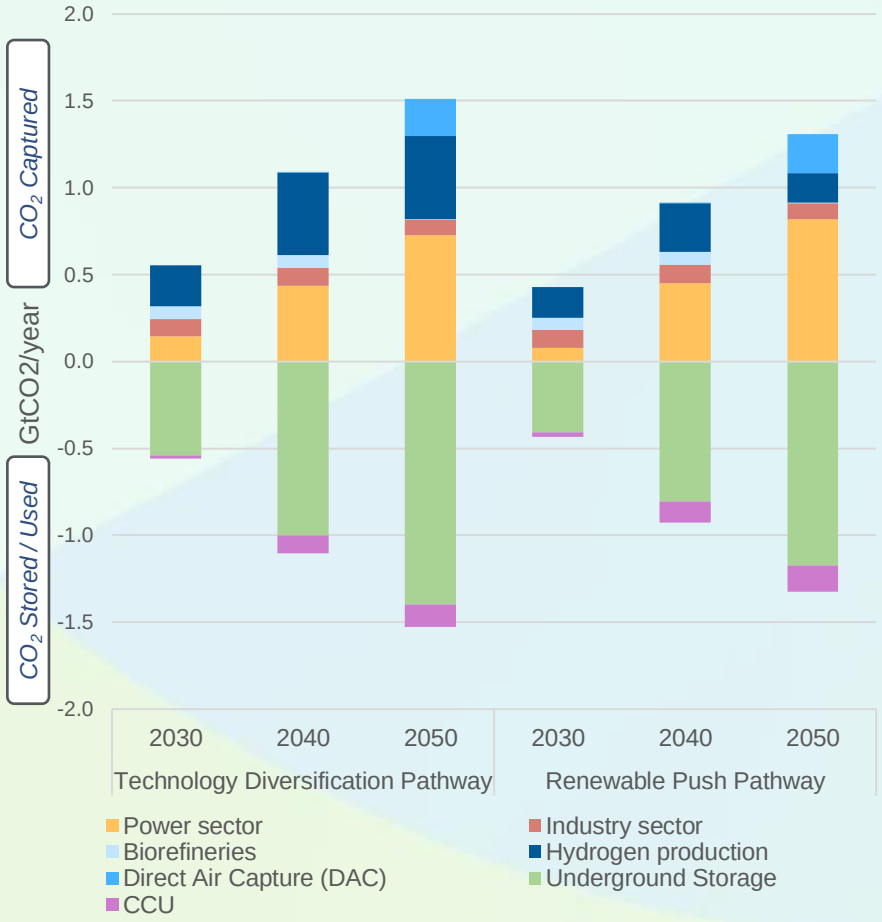
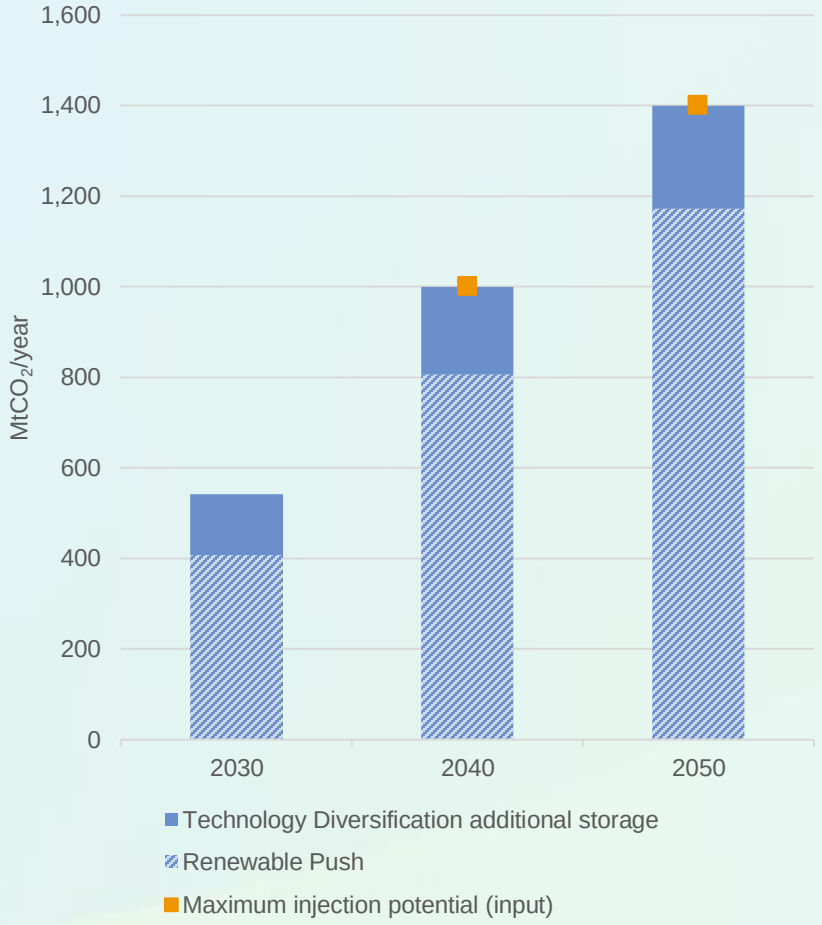
Evolution of CO_2 flows in the CCUS value chain



Evolution of CO_2 storage injection rate



Energy transition and final uses

The share of natural gas in final energy falls as hydrogen replaces natural gas where CO2 capture is difficult.