The modelling behind the EU Long-Term Strategy

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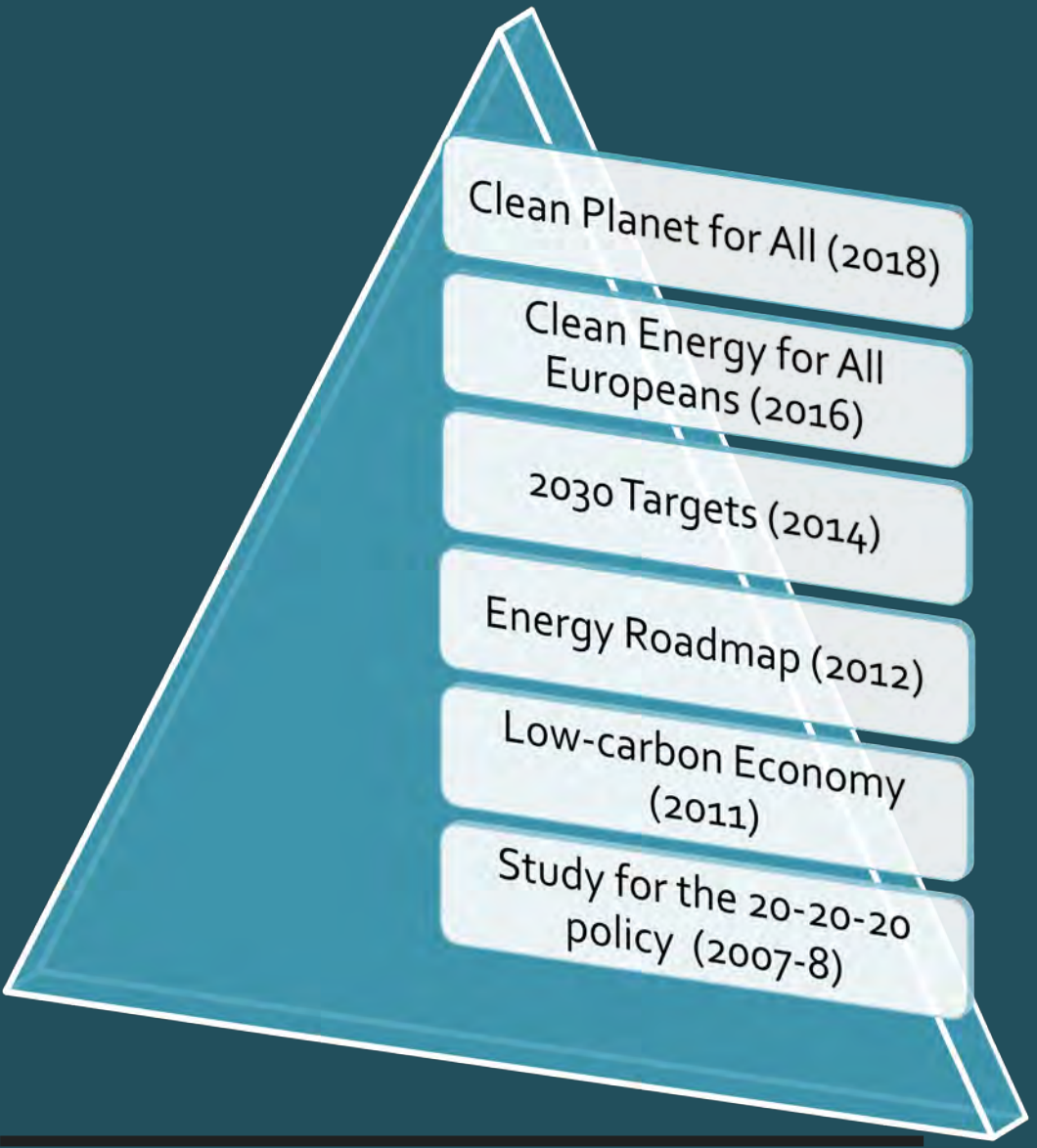
10-years of decarbonisation strategy studies for the EU



Targets

-40% GHG in 2030 (32% RES, 32.5% EE)

-80% in 2050 (2°C) but -95% for climate neutrality (1.5°C)

The basic strategy is similar in all roadmaps

- Strong energy efficiency savings, in particular in buildings
- Renewables as a major pillar
- Nuclear and CCS are valid options, but limited
- Electrification of mobility and heat enables considerable emission reductions
- Power generation decarbonisation crucial for the successful implementation
- Transport: electromobility, advanced biofuels, improved system efficiency

<u>But, not enough to achieve climare neutrality:</u>

Unabated emissions mainly in transportation, industry, and non-energy

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No Regret Options

Energy efficiency for buildings, appliances, vehicles

Electrification of transport and heating where cost-effective

Maximise RES in power generation

Infrastructure, market expansion and integration

Biogas and advanced biofuels

Nuclear and CCS where possible

Disruptive Changes

Energy savings beyond conventional wisdom, e.g. circular economy, sharing of vehicles

New energy carriers, energy distribution and equipment (hydrogen, extreme electrification)

GHG-neutral fuels, instead of fossils, while maintaining current infrastructure

CO_2 as commodity; captured (air, biogenic, combustion, processes) , used (for fuels, materials), and sequestrated (materials, underground)

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PRIMES modelling to explore contrasted strategies

Max Efficiency & Circular Economy	Maximum Electrification	Hydrogen as an end-use carrier	GHG-neutral fuels (gaseous, liquids)
Pros • Non expensive • No pressure in the energy supply potential **Cons** • Depends on investment by individuals • Potential uncertain • Unclear appropriate policy signals • Low demand discourages investment in the supply side	**Pros** • Efficient and convenient • Modest growth of demand for electricity **Cons** • Cannot fully electrify industry and transport • Lack of competition among carriers • High seasonal and daily variability, high balancing costs	**Pros** • H2 can be a universal carrier • Chemical storage of electricity • Less electricity intensive than e-fuels **Cons** • Infrastructure changes • Uncertain future costs of H2 and fuel cells • Public acceptance	**Pros** • Existing infrastructure and way of consuming energy • Chemical storage of electricity • Competition among carriers **Cons** • Carbon neutral CO2 feedstock (DAC, biogenic) • Uncertain future costs of e-fuels • Vast increase of total power generation

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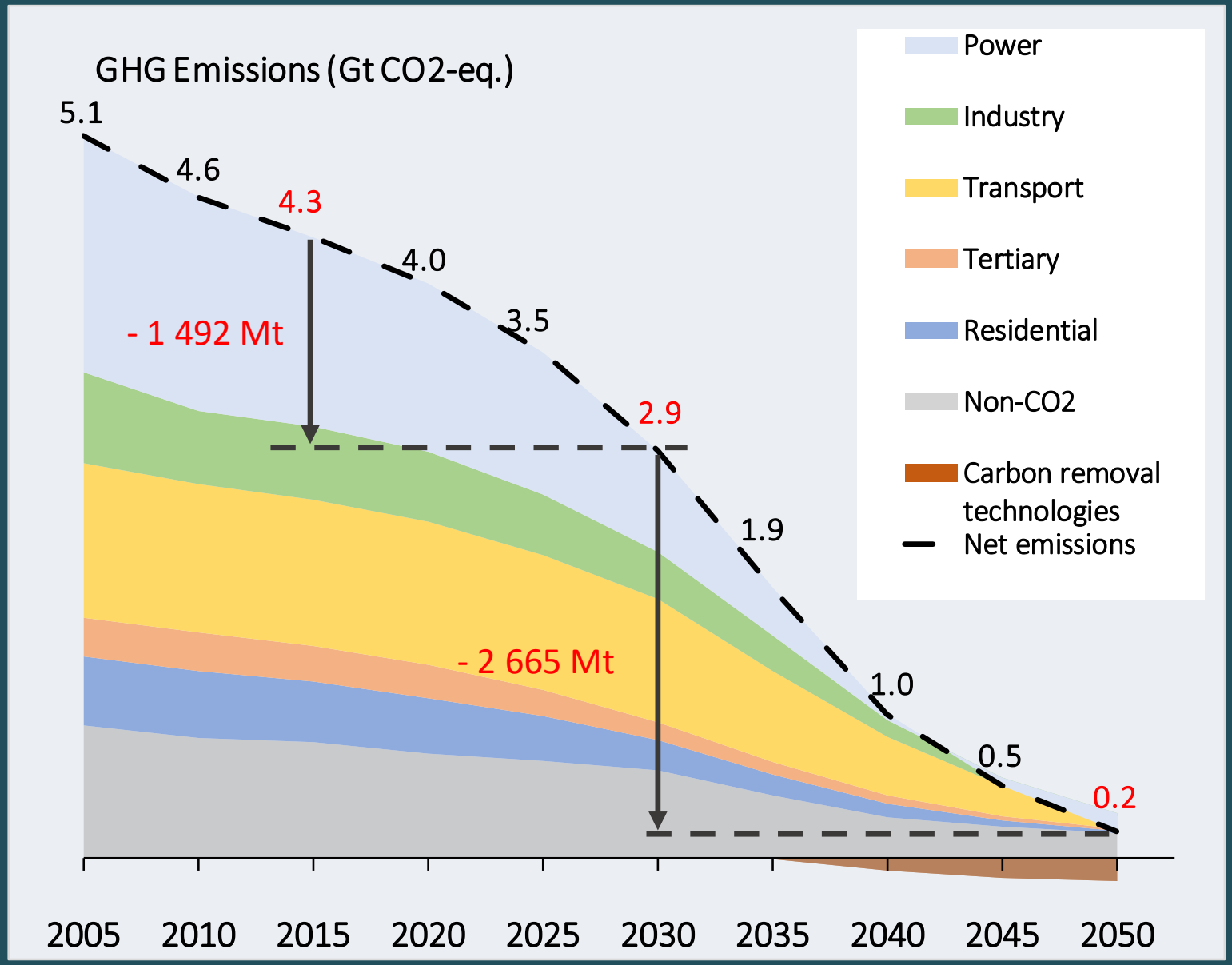
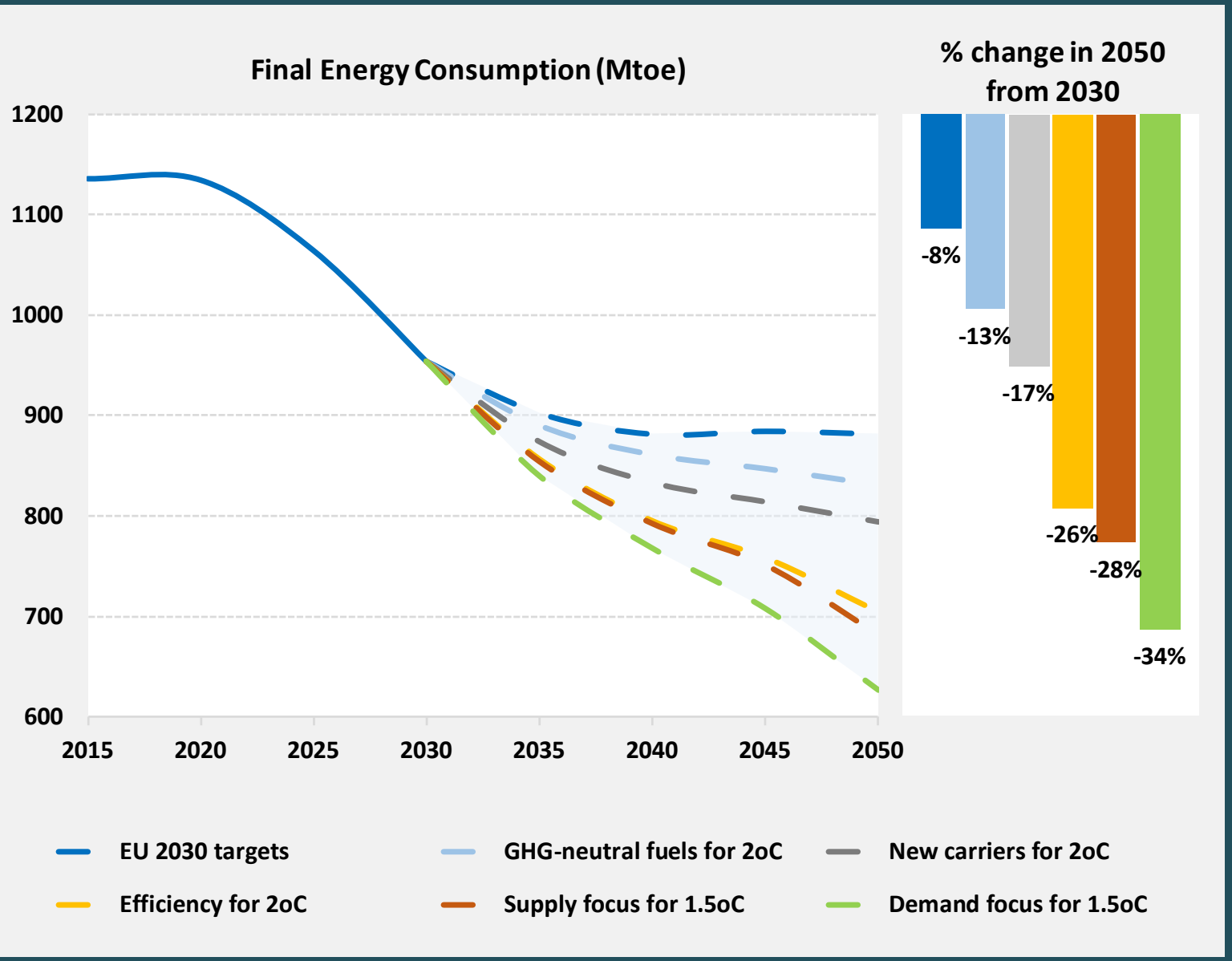
Carbon neutrality by 2050



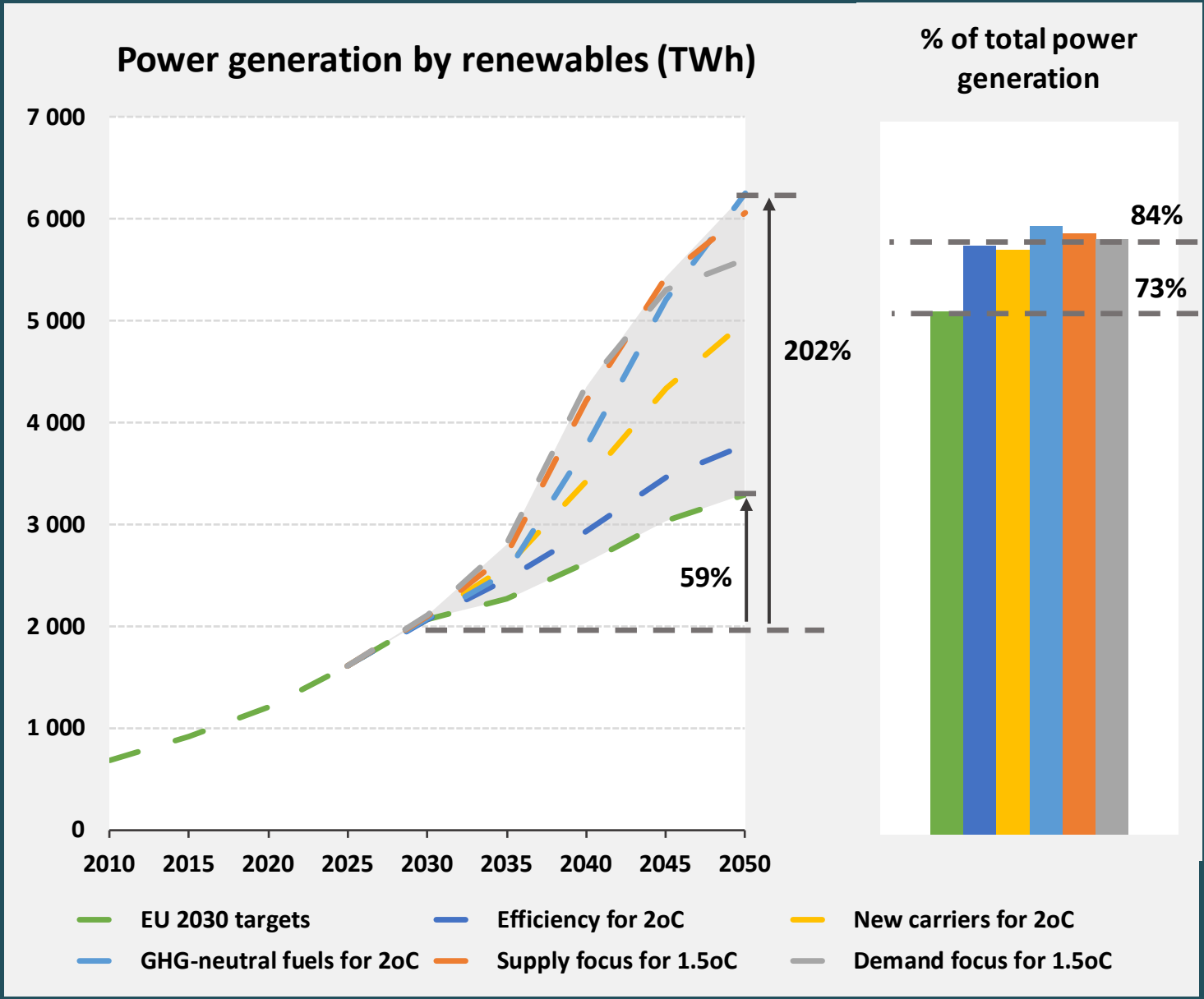
- Including the LULUCF emission sink, a climate-neutral EU economy by 2050 is feasible
- Carbon removal technologies are BECCS and carbon sequestered in materials
- Negative emissions, albeit small in magnitude, compensate for remaining emissions in 2050

Efficiency in Final energy consumption

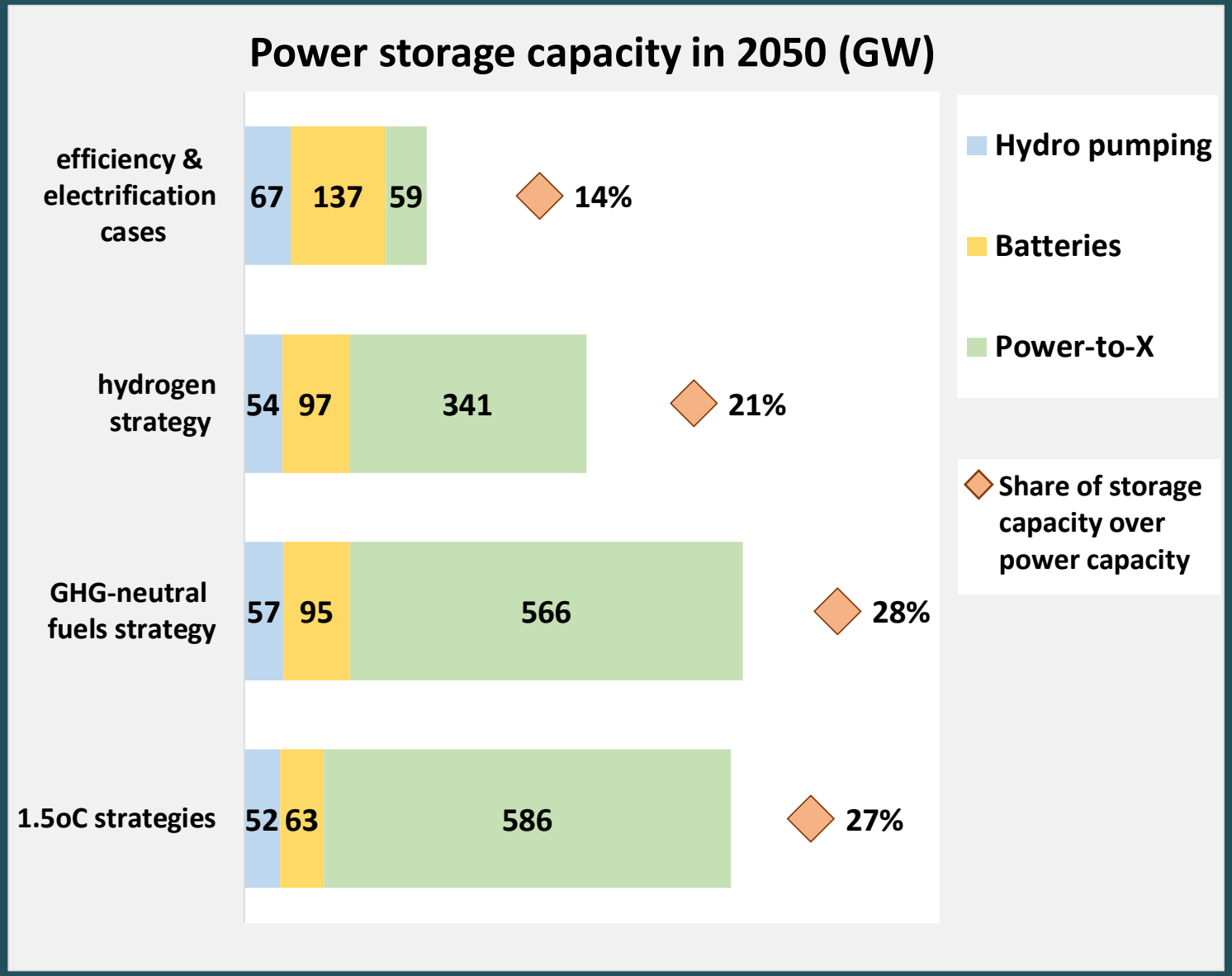


- The demand-focus strategies aim at very ambitious reduction of energy consumption
- The 1.5°C strategies require even higher reduction of energy consumption irrespective of the focus, on demand or supply
- The largest efficiency gains come from direct energy savings e.g. insulation of houses

Renewables in Power Generation

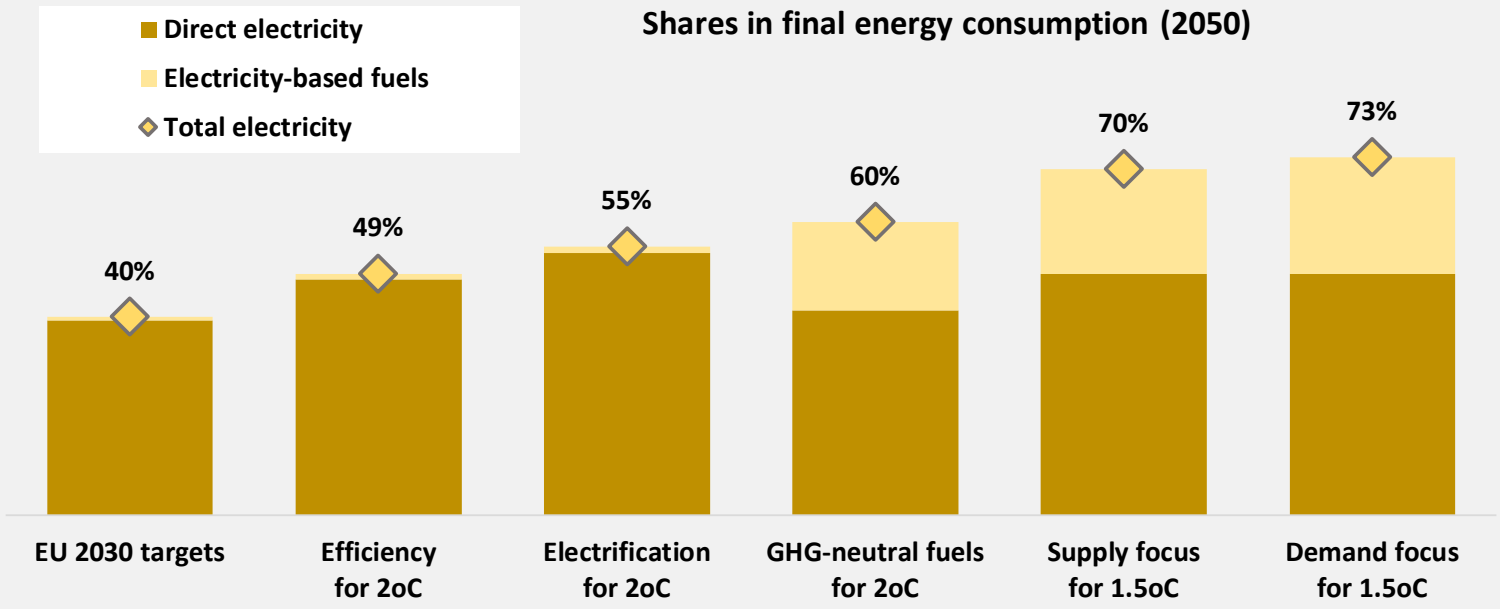


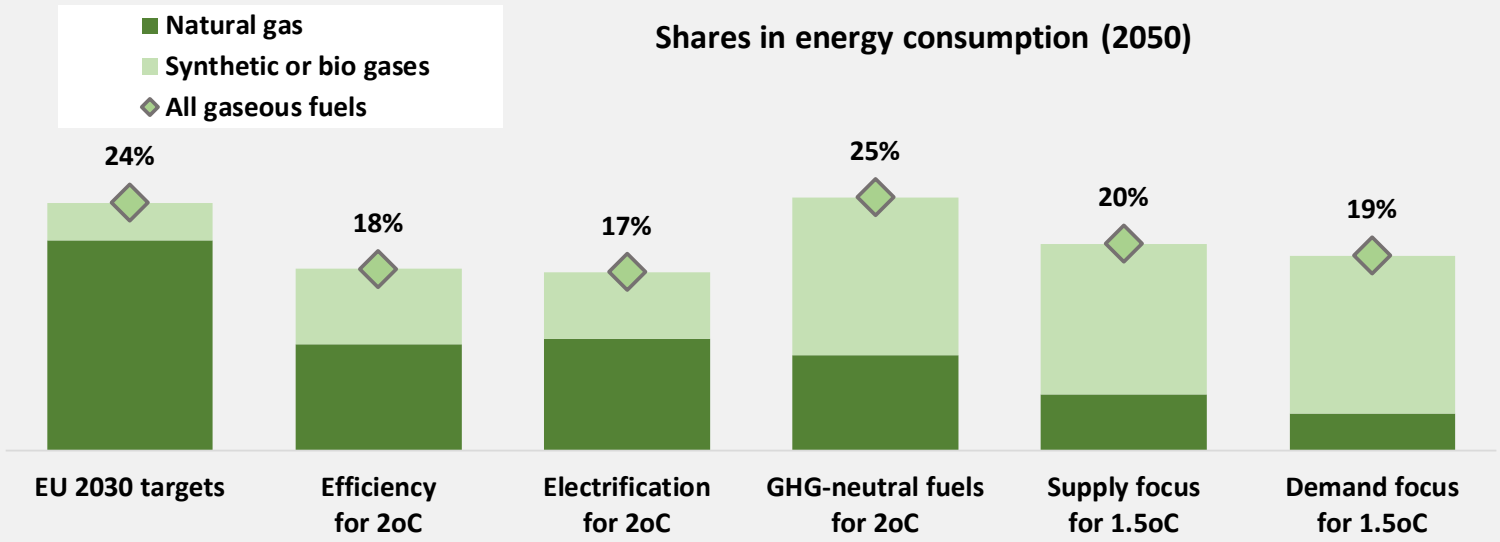
- All scenarios foresee renewables close to 85% by 2050 (70% for variable RES), much above the 30% in 2015 and 55% in 2030.
- RES increase at the same pace as total demand for electricity (including the production of H2 and e-fuels)
- The GHG-neutral fuels strategy almost doubles RES compared to the efficiency strategy. The new carriers strategy increase RES by 50%.
- The 1.5°C scenarios demand very high RES irrespective of the demand or supply focus



Electricity storage outlook

- Storage and interconnections, rather than gas plants, provide the large flexibility and balancing needs due to large RES share
- Mainly batteries (various scales and system levels) provide storage in the efficiency and electrification variants
- Chemical storage (in scenarios with H2 and e-fuels), enable maximum exploitation of renewables despite the significant increase in total electricity generation

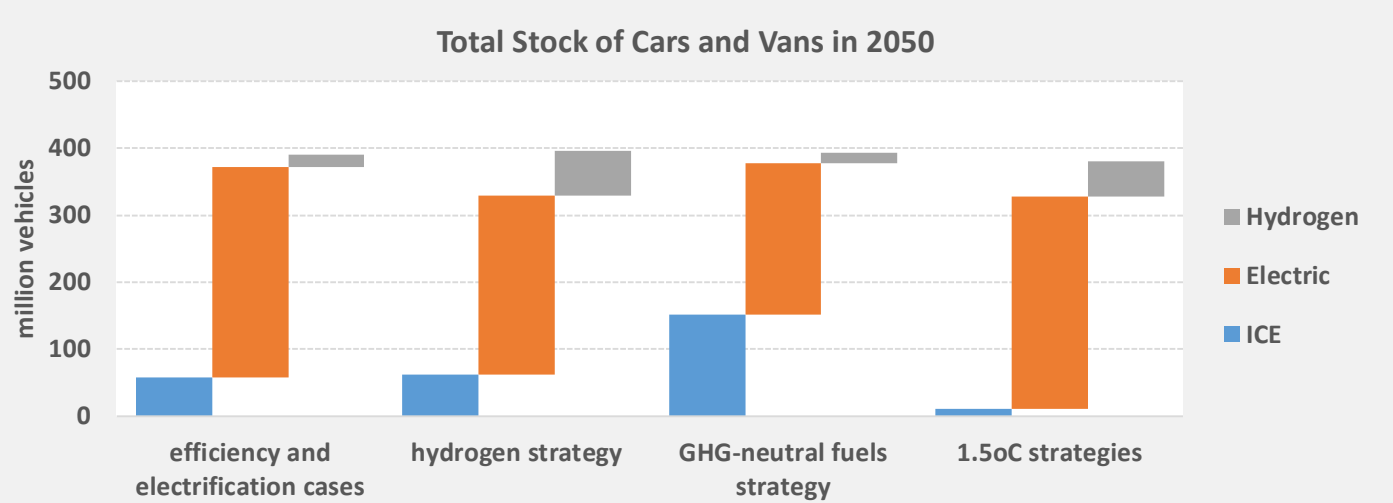


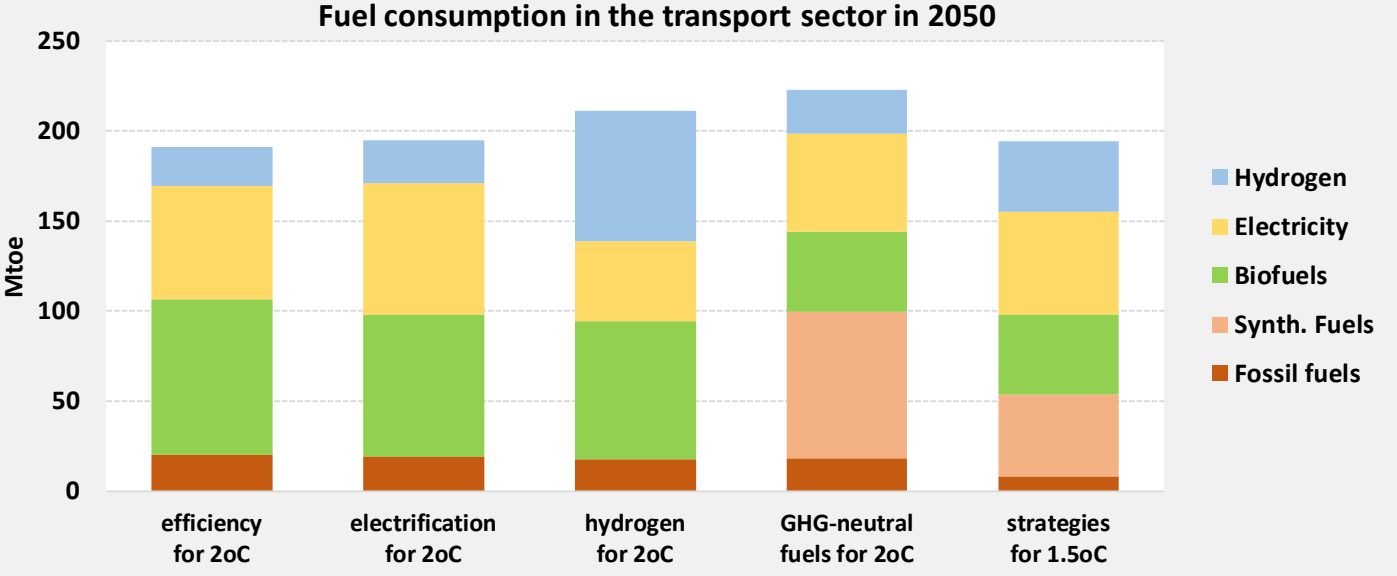


Electricity and Gas shares

- Electricity dominates energy supply both directly in final demand and as feedstock for H2 and e-fuels
- The dominant role of electricity is common feature of all 1.5°C strategies, irrespective of the focus
- The share of gaseous fuels slightly decreases over time, with natural gas dropping dramatically, especially in the 1.5°C strategies
- Independence from natural gas and oil imports is an impressive game changer

Transport fleet and fuel mix





- Electrification of cars and vans is a common feature of all strategies. In maximum cases, EVs reaches 80-85% of the market, but in variants with H2 and e-fuels the shares drops to 60-65%
- Hydrogen enters high mileage market segments (up to 17% in total market of cars and vans)
- ICE vehicles remain at close to 40% if synthetic fuels are available, otherwise they drop to 15% (using biofuels)
- Emissions reduction in the trucks, aviation and maritime is thanks to biofuels and e-fuels if available. In road freight, fuel cell and electric vehicles do not exceed 10-15% of total.

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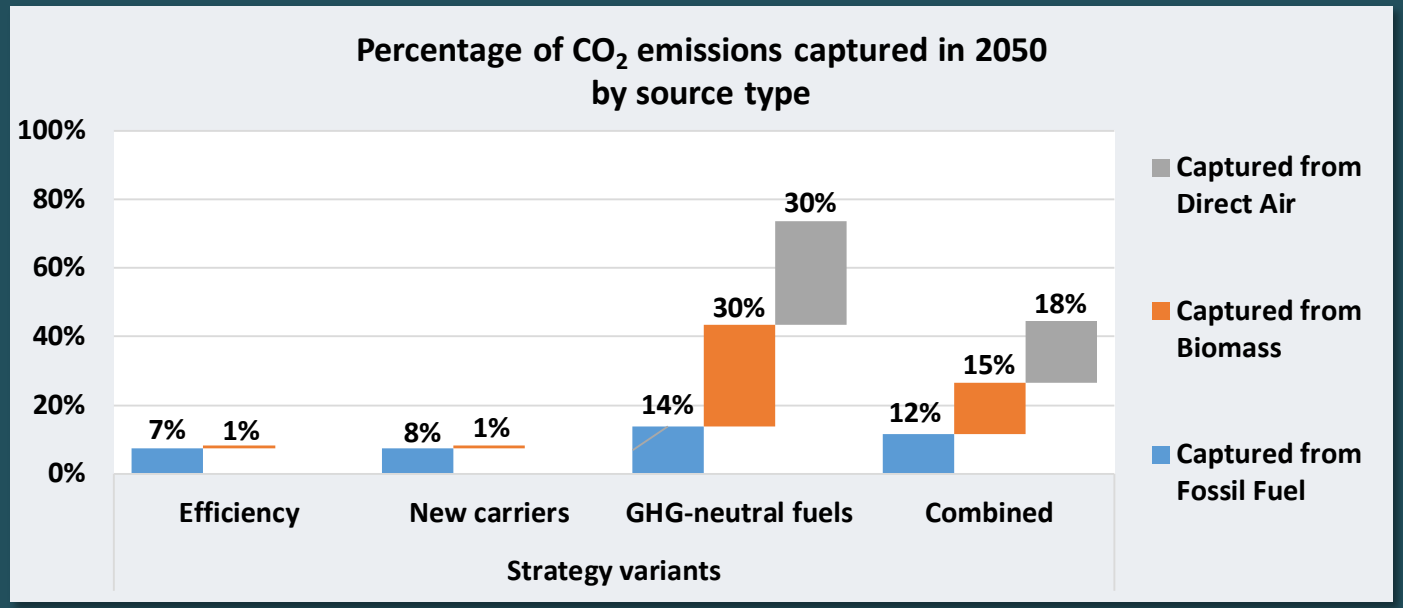
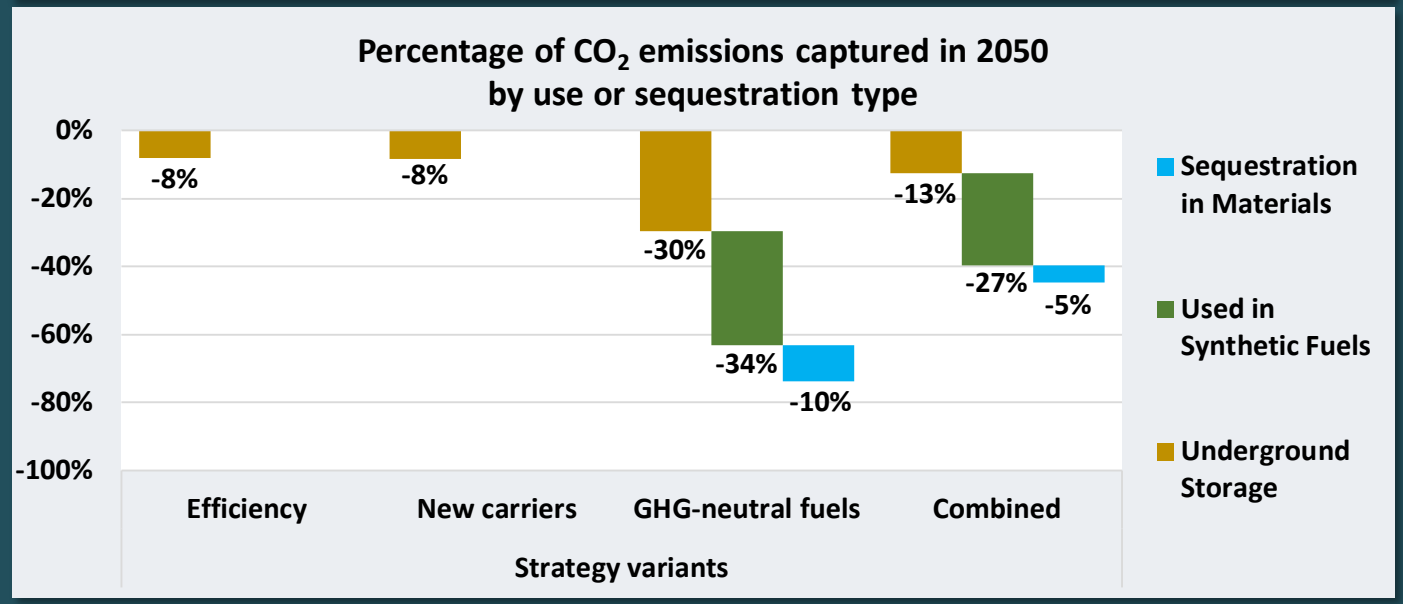
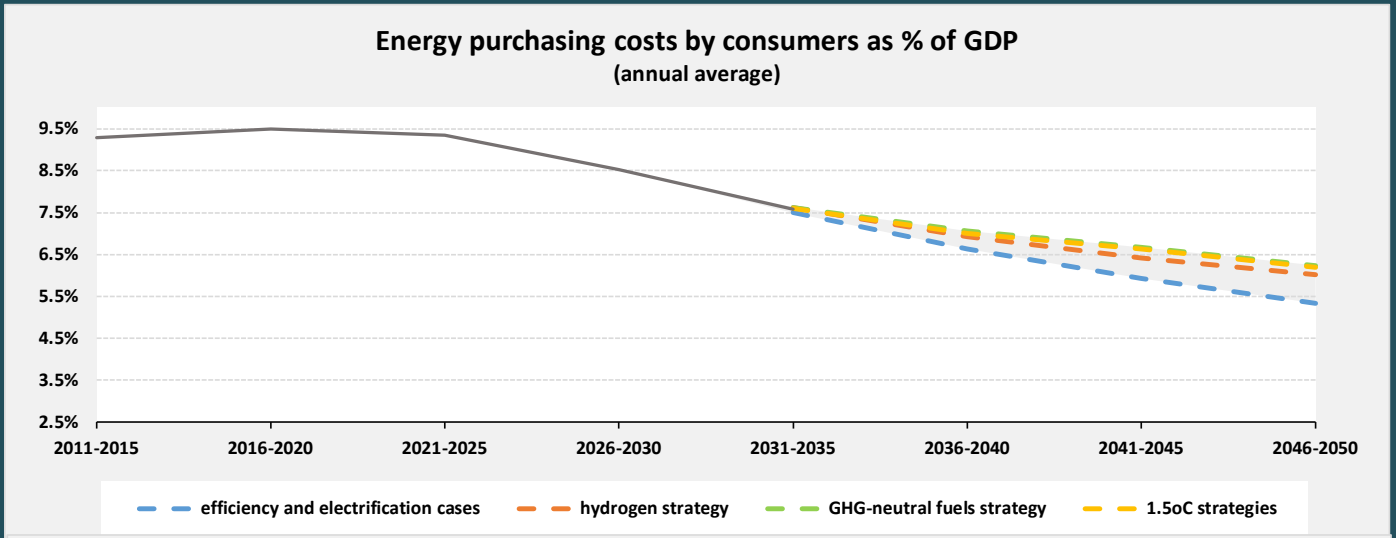
CO_2 capture, use and sequestration

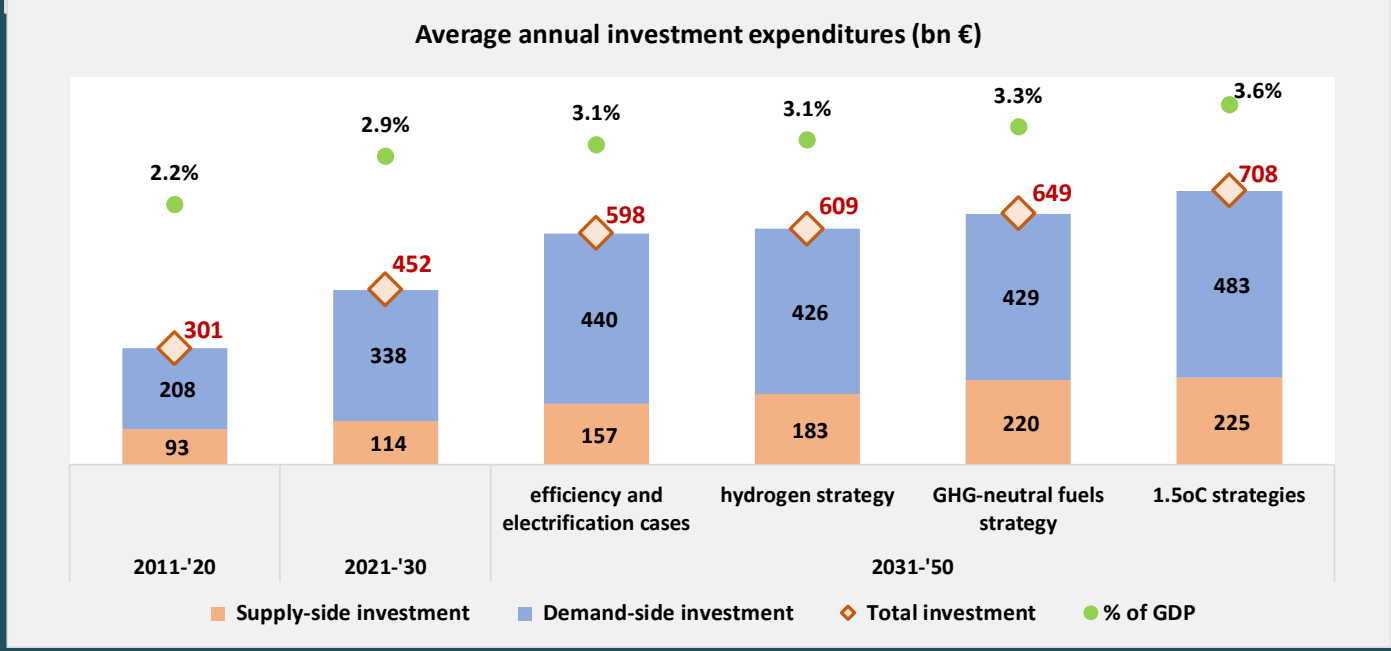




- The efficiency and new-carriers variants do not depend on CC technologies
- Carbon capture from air and biogenic sources is essential for the production of synthetic hydrocarbons
- Use of GHG-neutral H2 and captured carbon in the synthesis of chemical substances constitutes sequestration in materials
- Total sequestration in materials approach 10% of total in a GHG-neutral fuels scenario

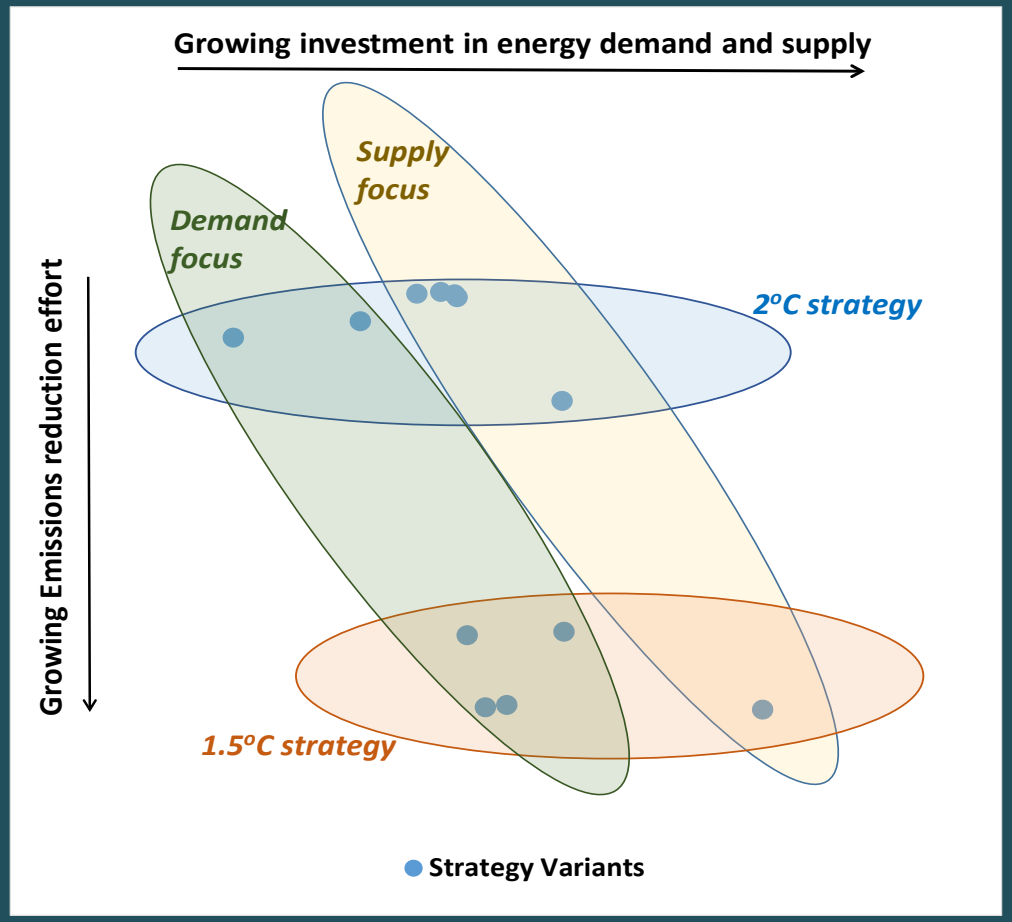
Energy system costs and investment





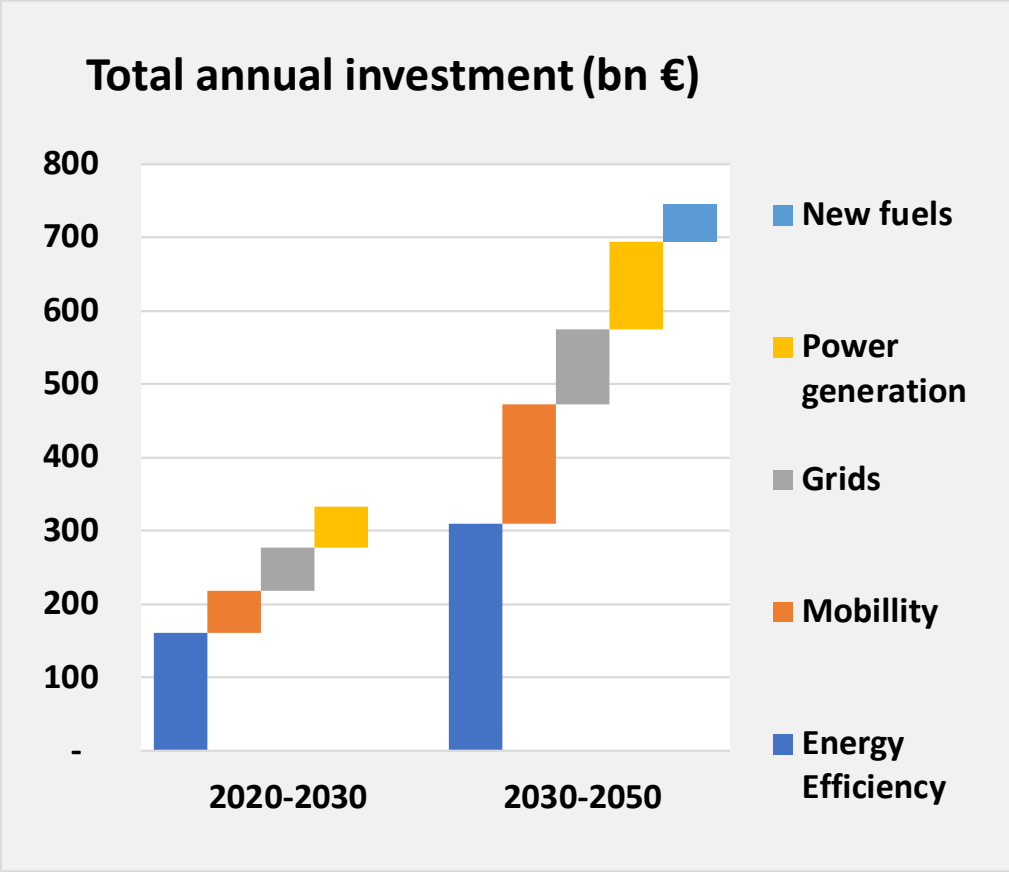
- The long-term strategy needs increasing investment (in both energy demand and supply sectors) but reduces energy purchasing expenditures
- The fastest growing part of investment concerns individuals and firms as end-users of energy.
- Investment in infrastructure is the fastest growing part of investment in energy supply sectors
- The demand focusing variants are less expensive that the supply focusing ones. As expected, the 1.5°C variants are more costly than the 2°C ones, roughly 15% for investment
- The learning-by-doing dynamics of today low TRL technologies are of crucial importance for the costs of the supply focused scenarios.
- Average costs of electricity are similar in all strategy variants, as the decreasing capital costs of RES and chemical storage offset diseconomies of scale.

Concluding remarks



- Carbon neutrality in the EU by 2050 is feasible without excessive cost burden
- However, cost estimations are uncertain as depending on the potential of learning and massive industrial production of new technologies
- There should be no doubt about the no-regret options of the strategy, namely energy efficiency, renewables, electrification and advanced biofuels where cost-effective. The 2030 EU climate and energy is consistent with the LTS
- Disruptive changes are necessary to reach climate neutrality. They may imply changes in the energy production, distribution and consumption paradigm.

Concluding remarks



- The choice of a single strategy for disruptive changes is not yet mature. Actions are necessary to resolve the technology, as investment requires long-term visibility.
- From a today's perspective, a balanced approach seems appropriate: *enhance efficiency, RES and electrification and prepare the ground for production of carbon-neutral hydrogen, gas and liquid fuels, as well as for carbon capture, use and storage.*
- The next decade is of utmost importance for infrastructure, industrial development of immature technologies and the power sector restructuring
- Addressing concerns related to investment by individuals and firms with poor fund raising capabilities constitutes a new policy priority

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ご清聴ありがとうございました。

Thank you for your attention.

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