EU LONG-TERM STRATEGY - TOWARDS CARBON NEUTRALITY

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The presentation reflects purely personal opinions of the authors

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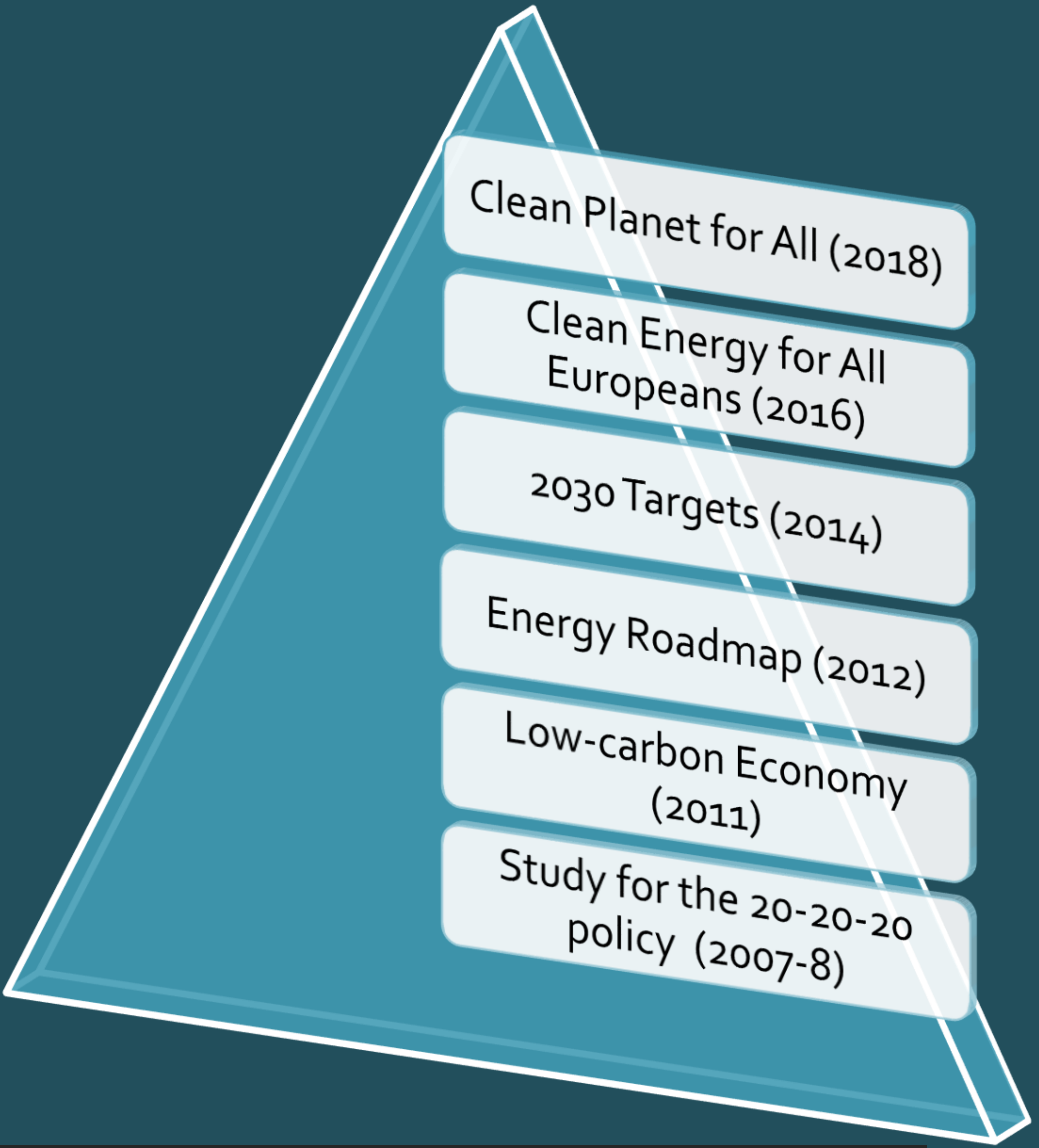
10-years of decarbonisation strategy studies for the EU



Targets

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

-80% in 2050 (2°C) but -95% for carbon 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

But, not enough to achieve carbon neutrality:

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

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No Regret Options

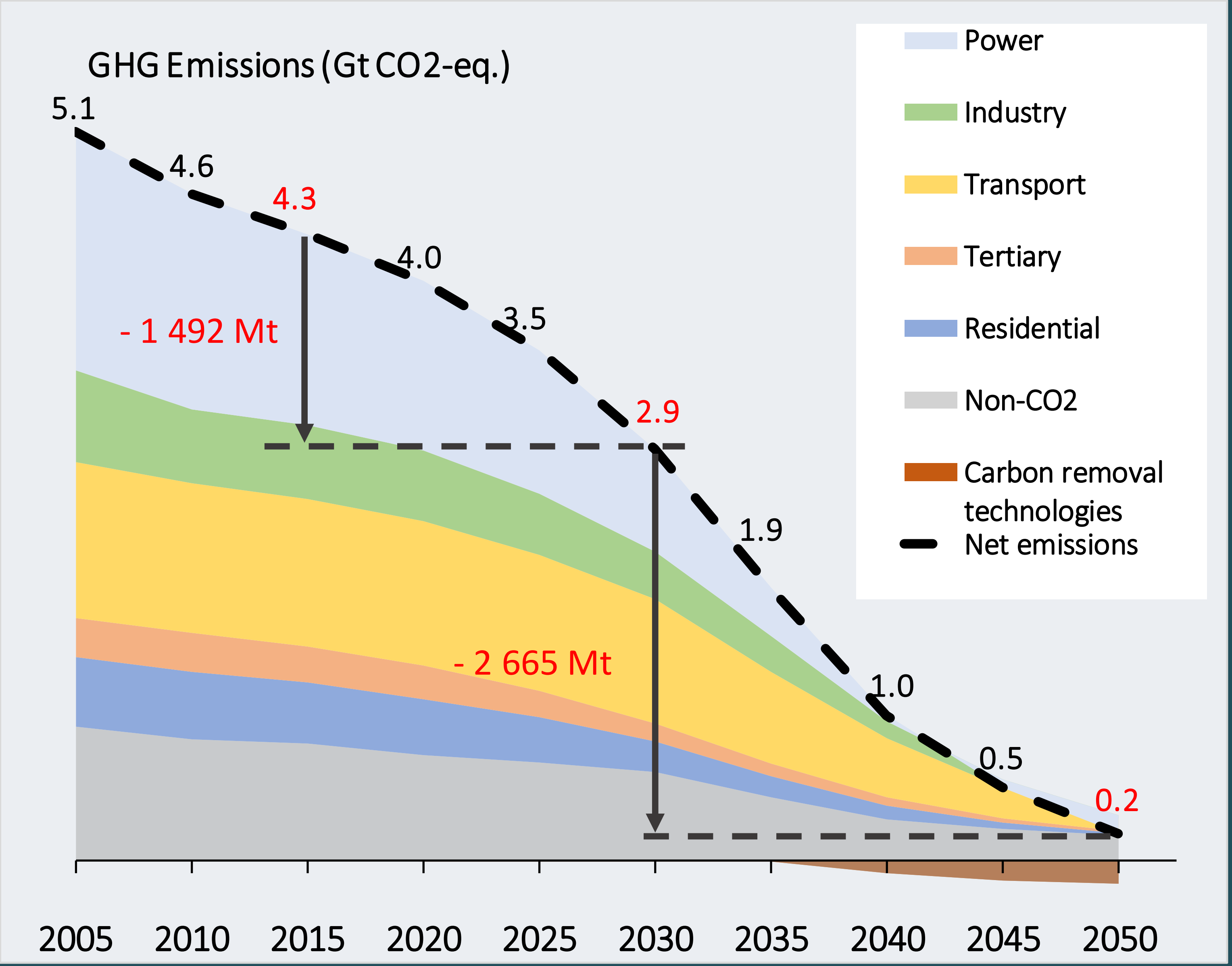
- Energy efficiency for buildings, appliances, vehicles
- Electrification of transport and heating where cost-effective
- Maximise RES in power generation
- Infrastructure, market expansion and integration
- Biogas and advanced biofuels
- Nuclear and CCS where possible

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)

PRIMES modelling to explore contrasted strategies

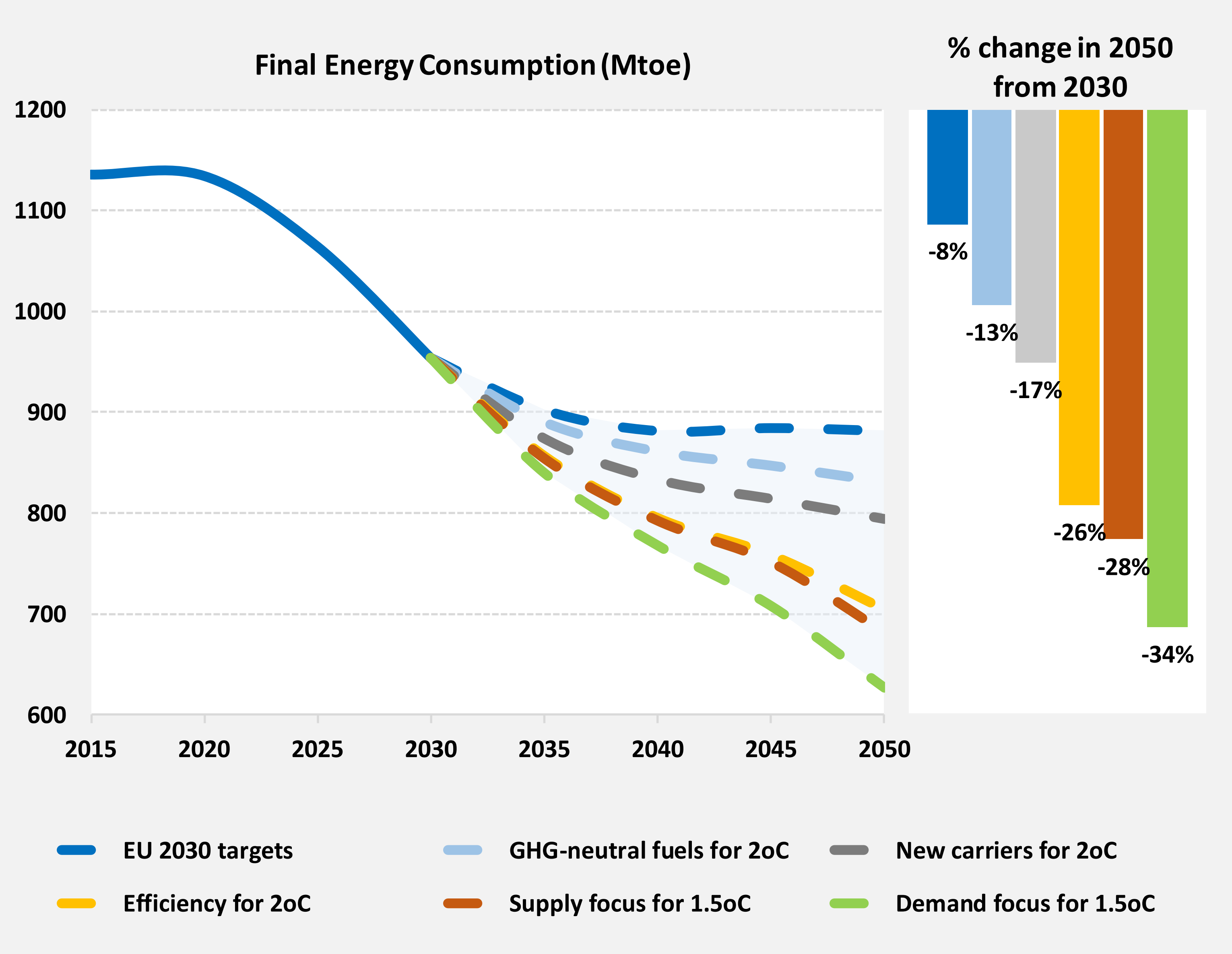
Max Efficiency & Circular Economy	Maximum Electrification	Hydrogen as an end-use carrier	GHG-neutral fuels (gaseous, liquids)
Pros • Non expensive • No pressure in the energy supply potential **Cons** • Depends on investment by individuals • Potential uncertain • Unclear appropriate policy signals • 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** • H_2 can be a universal carrier • Chemical storage of electricity • Less electricity intensive than e-fuels **Cons** • Infrastructure changes • Uncertain future costs of H_2 and fuel cells • Public acceptance	**Pros** • Existing infrastructure and way of consuming energy • Chemical storage of electricity • Competition among carriers **Cons** • Carbon neutral CO_2 feedstock (DAC, biogenic) • Uncertain future costs of e-fuels • Vast increase of total power generation



Carbon neutrality by 2050

- Including the LULUCF emission sink, a carbon-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

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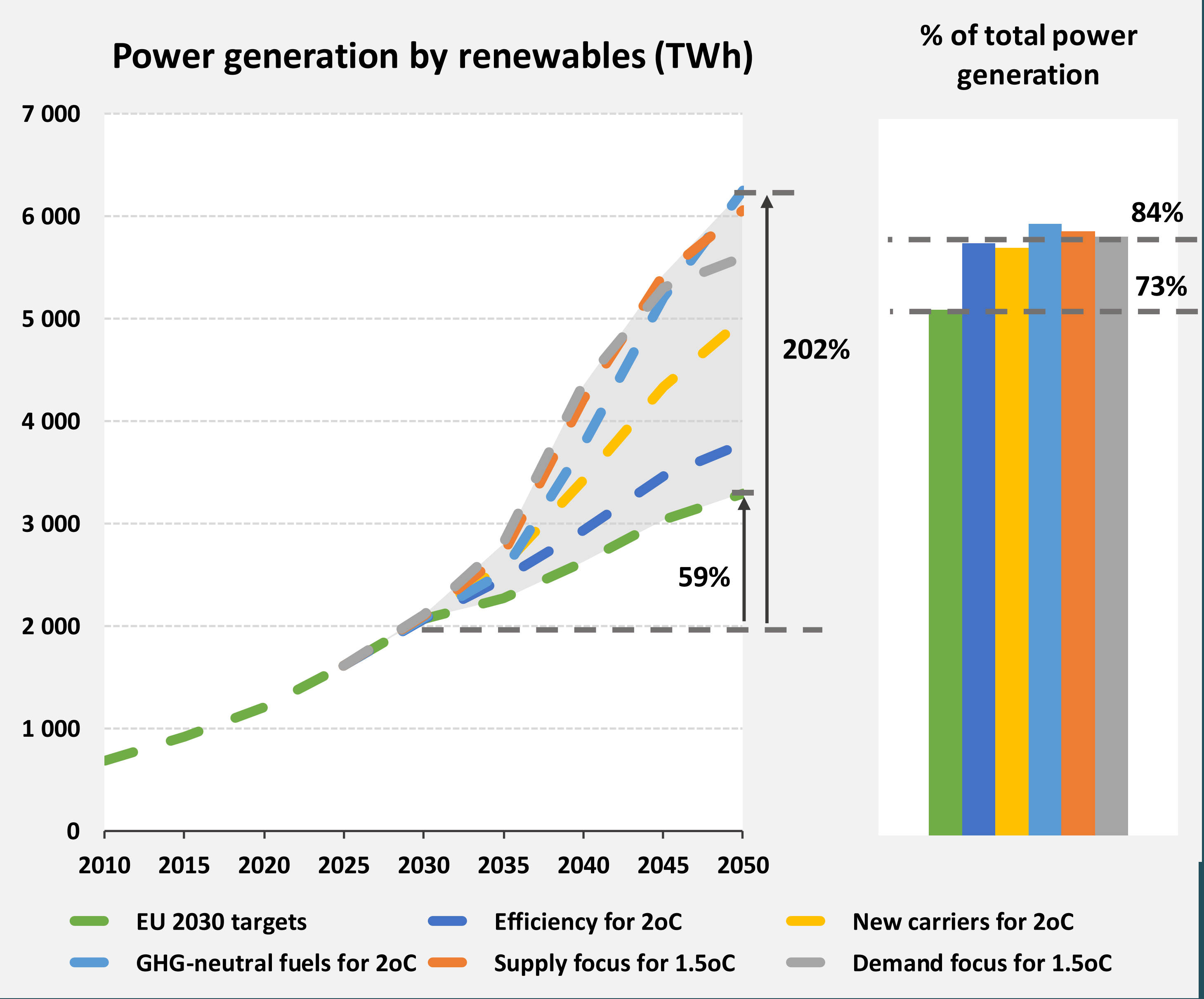

Renewables in Power Generation

- 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

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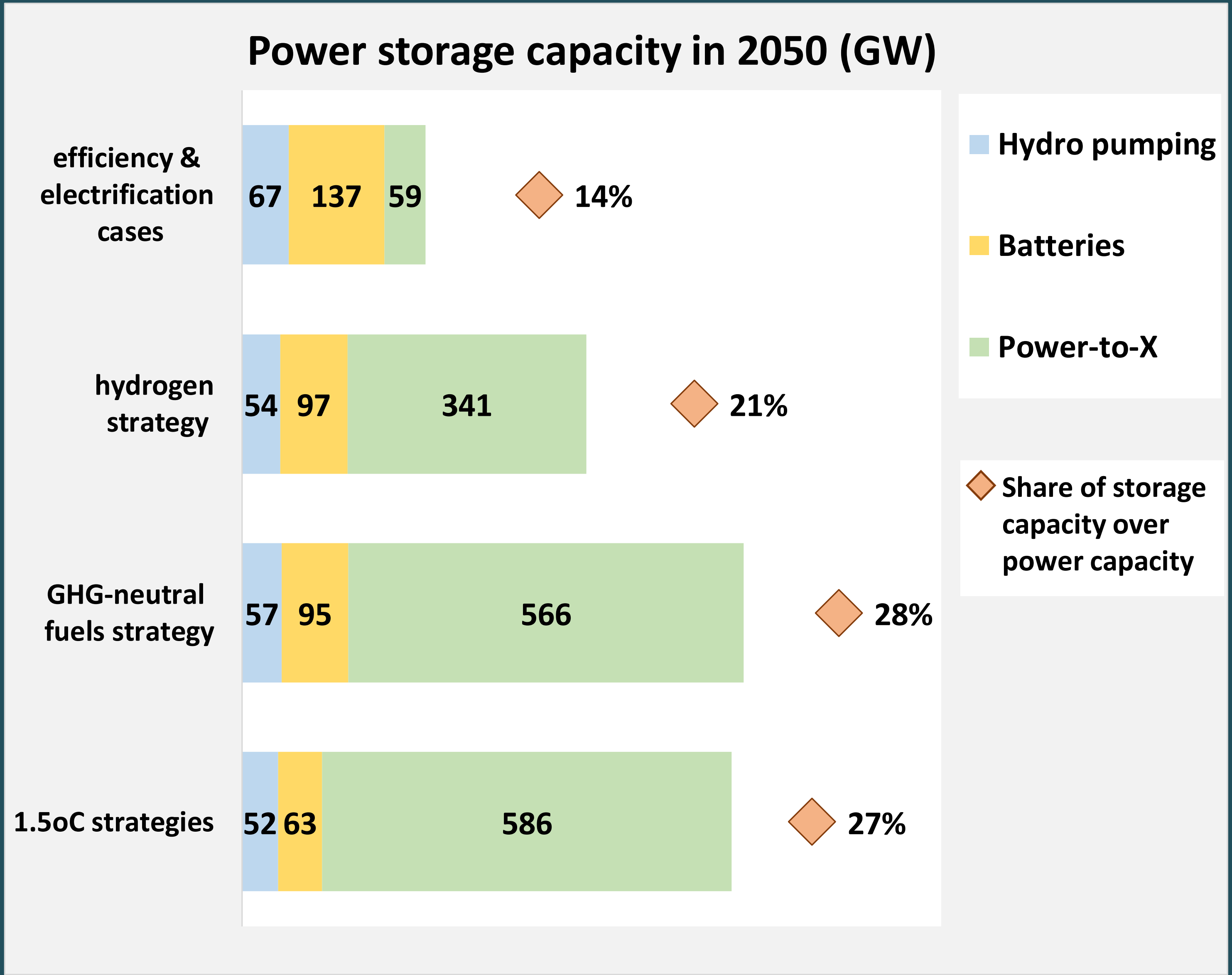

Electricity storage outlook

- 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

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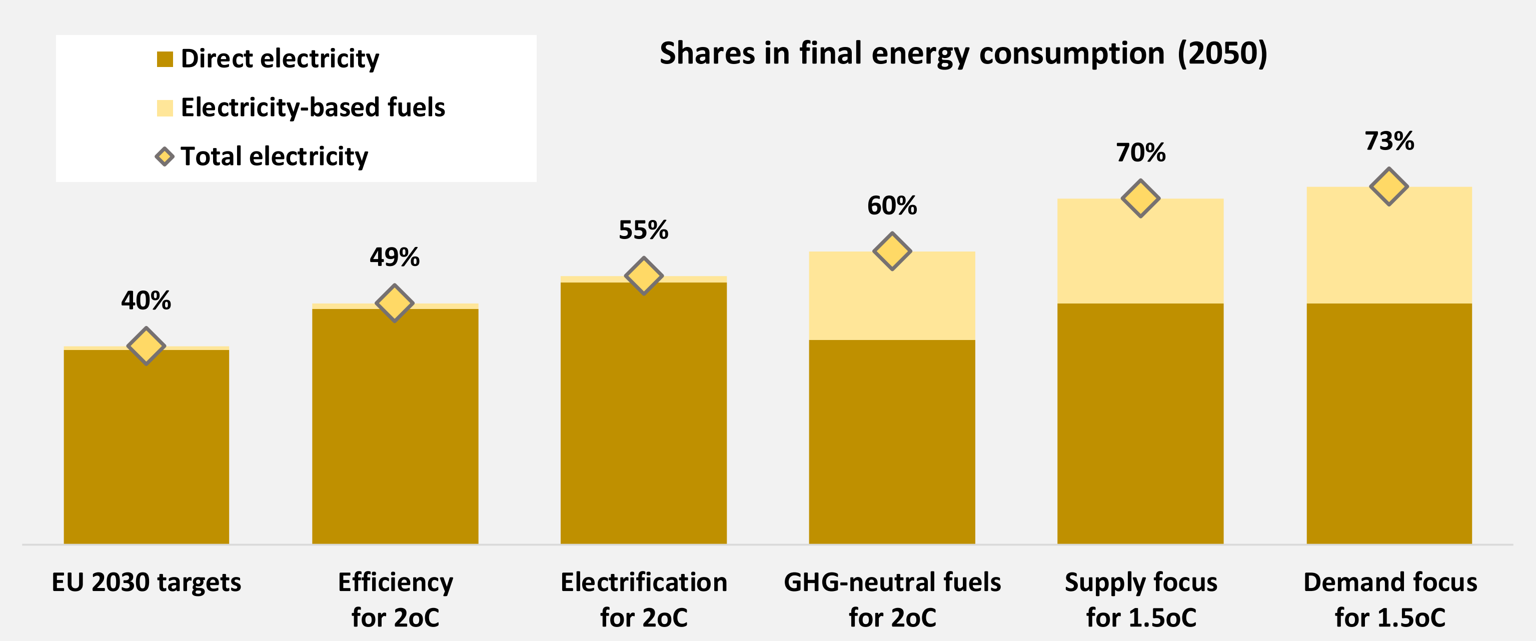

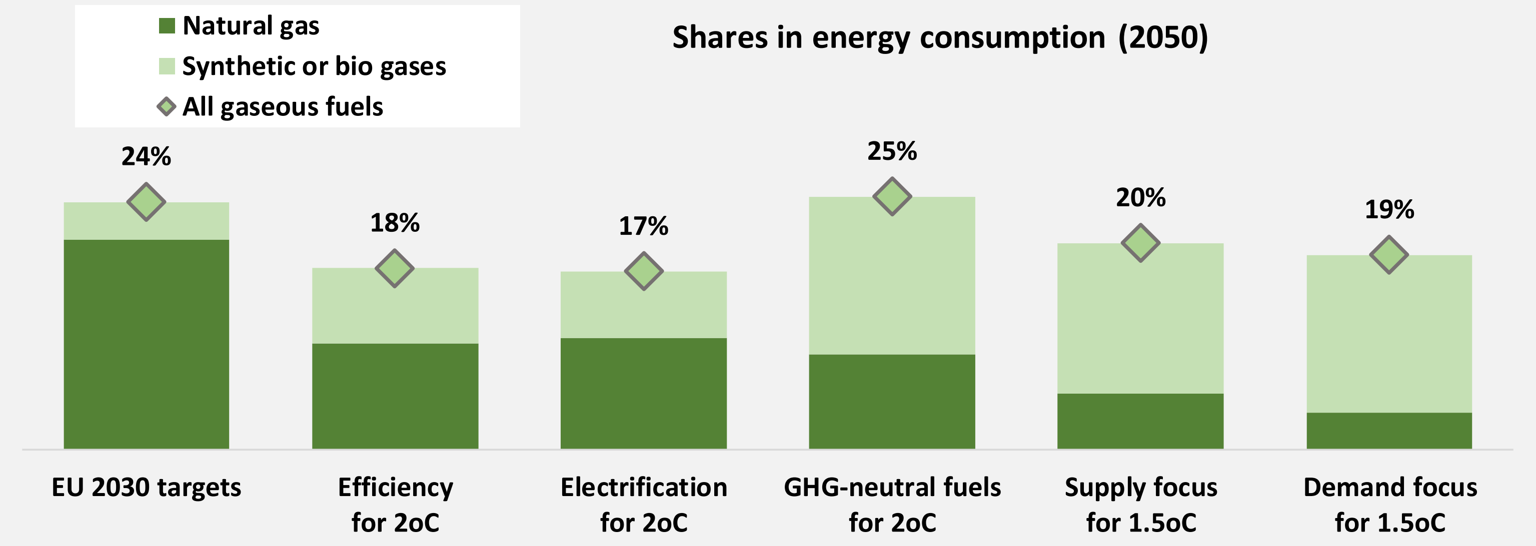

Electricity and Gas shares

- Electricity dominates energy supply both directly in final demand and as feedstock for H_2 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

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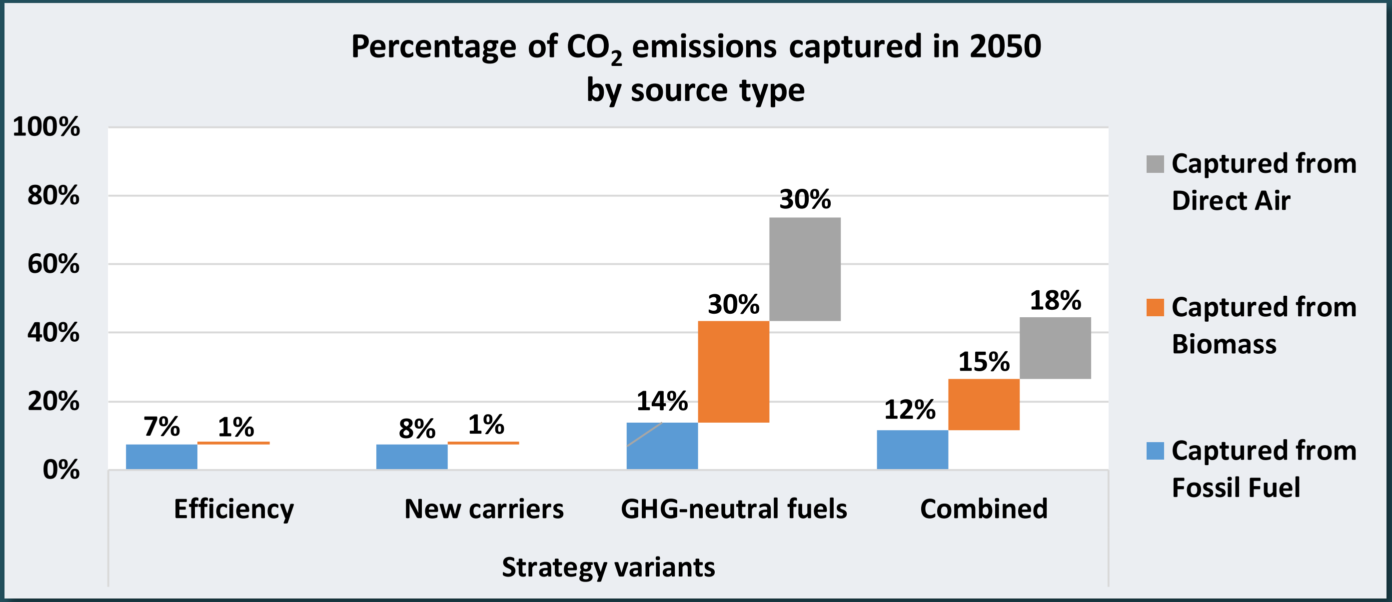

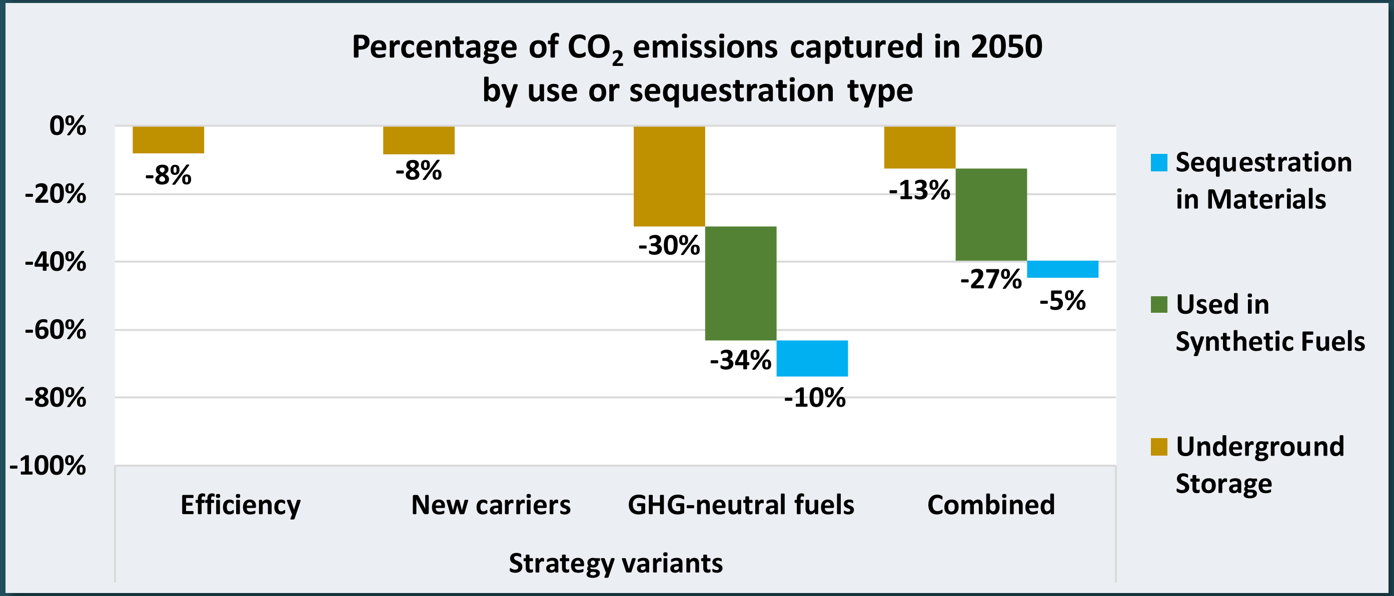

CO_2 capture, use and sequestration

- 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

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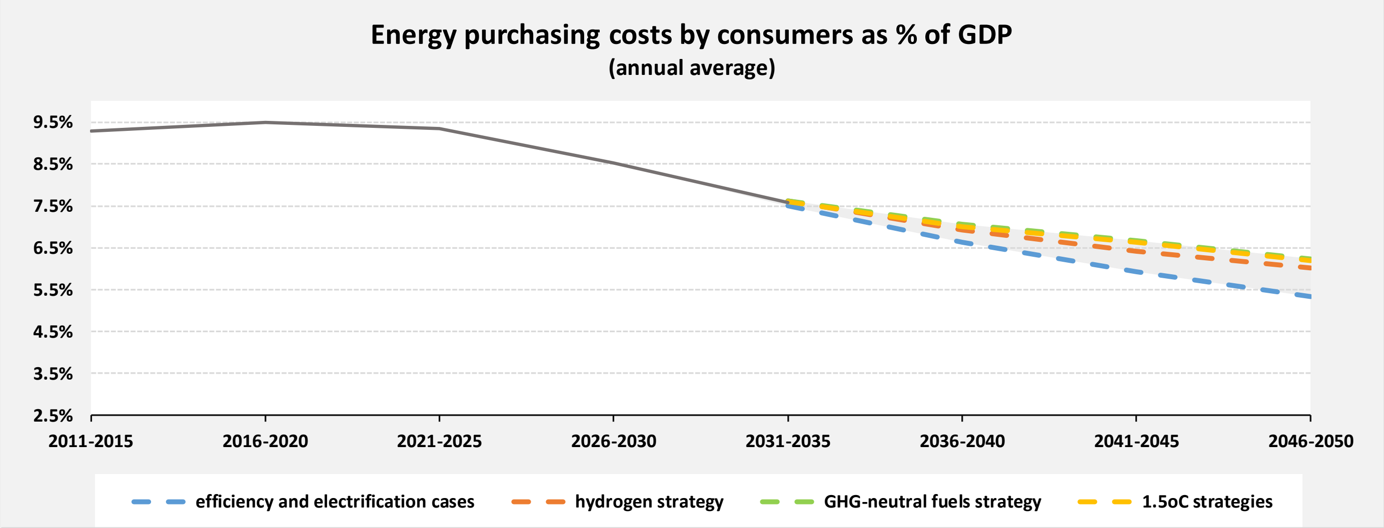
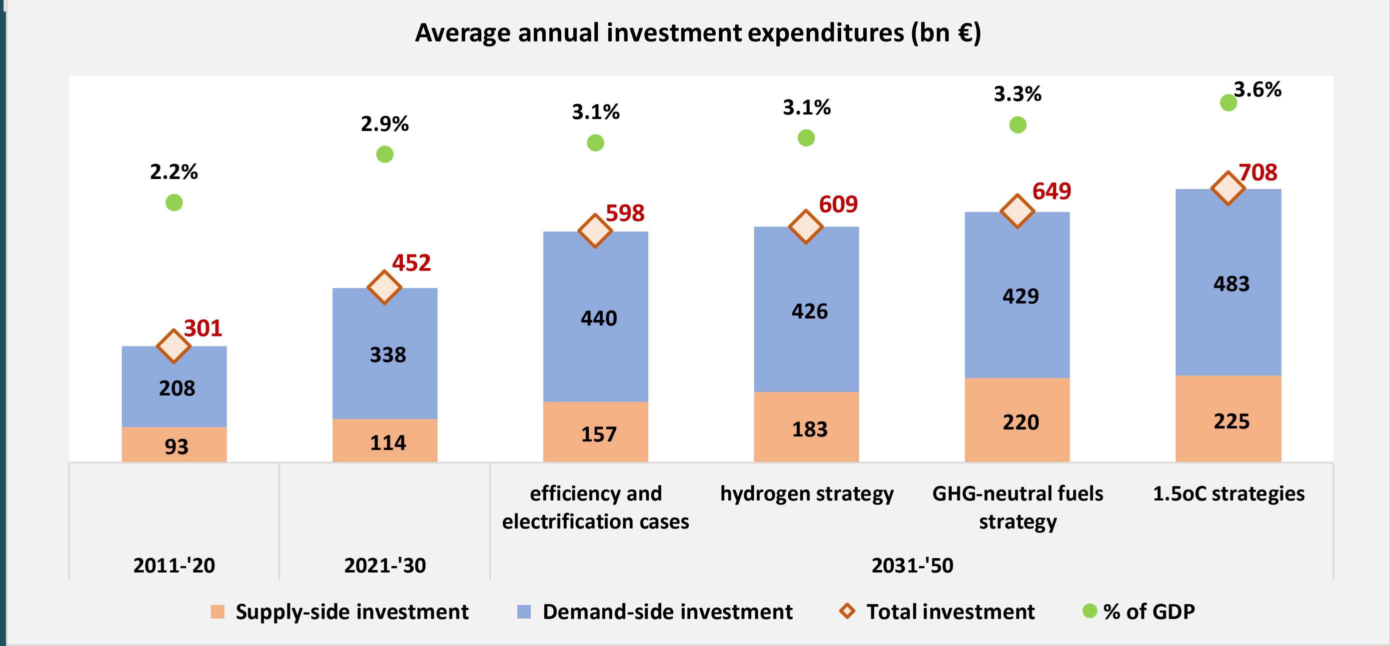
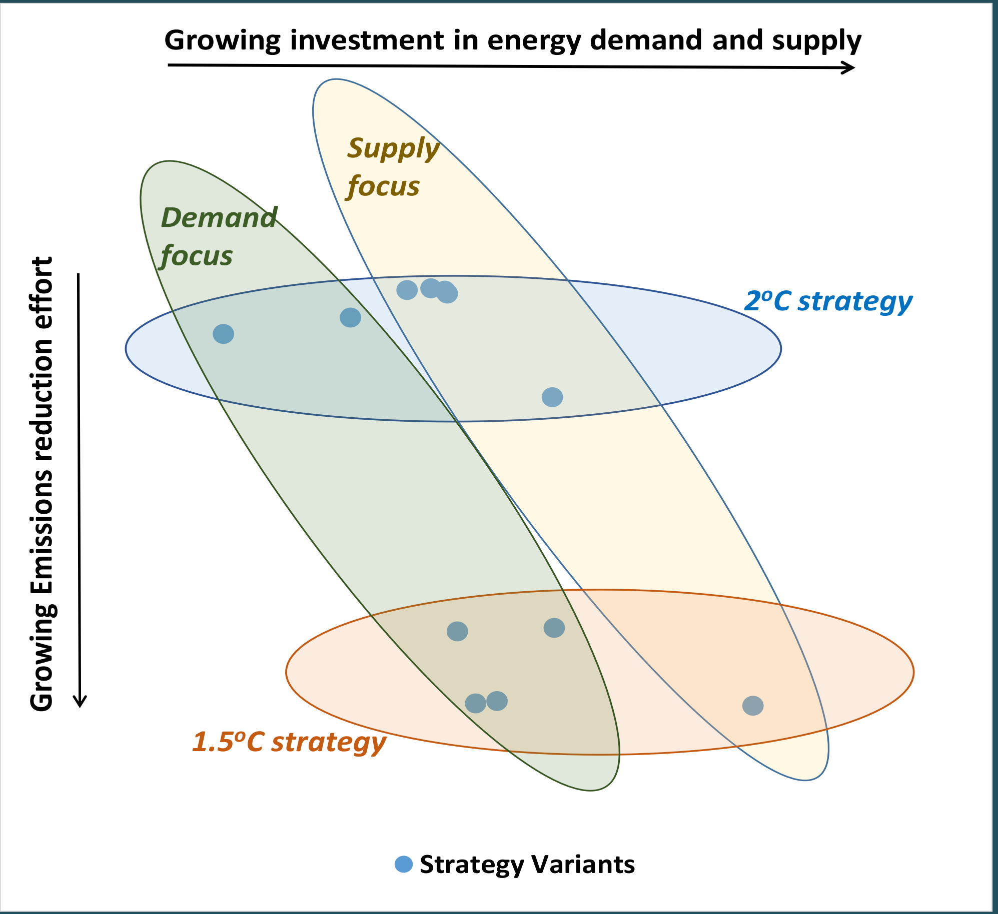
Energy system costs and investment





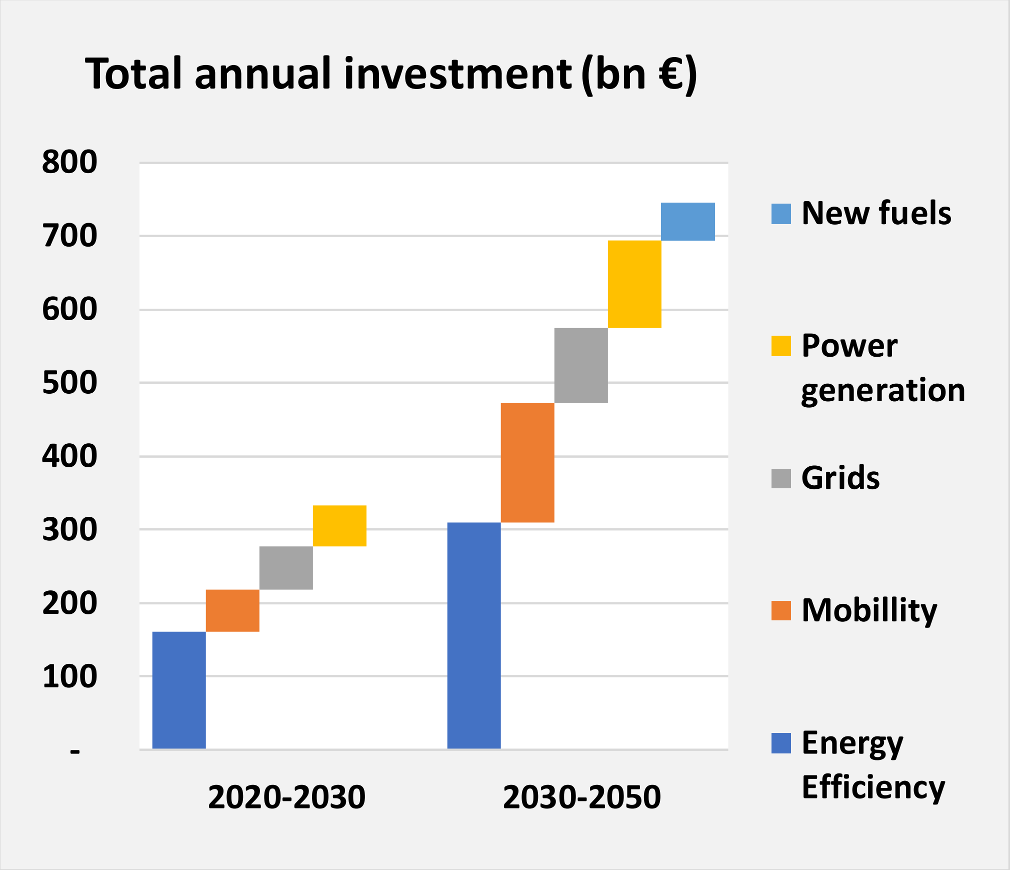
- The long-term strategy needs increasing investment (in both energy demand and supply sectors) but reduces energy purchasing expenditures
- The fastest growing part of investment concerns individuals and firms as end-users of energy.
- Investment in infrastructure is the fastest growing part of investment 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



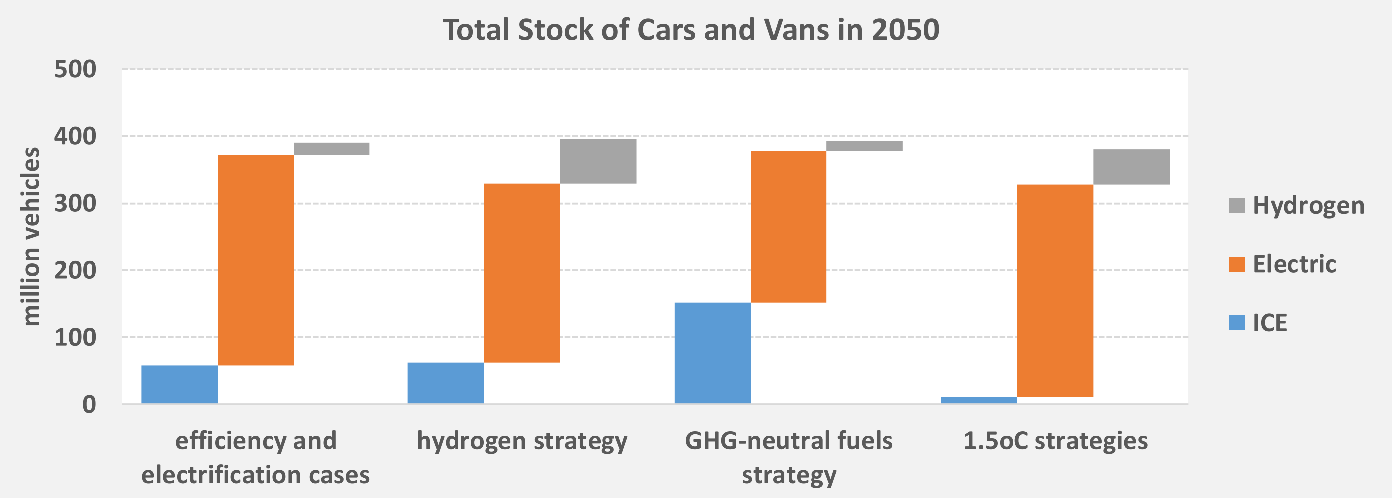
- Carbon neutrality in the EU by 2050 is feasible without excessive cost burden
- However, cost estimations are uncertain as depending on the potential of learning and massive industrial production of new technologies
- There should be no doubt about the no-regret options of the strategy, namely energy 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 carbon-neutrality. They may imply changes in the energy production, distribution and consumption paradigm.

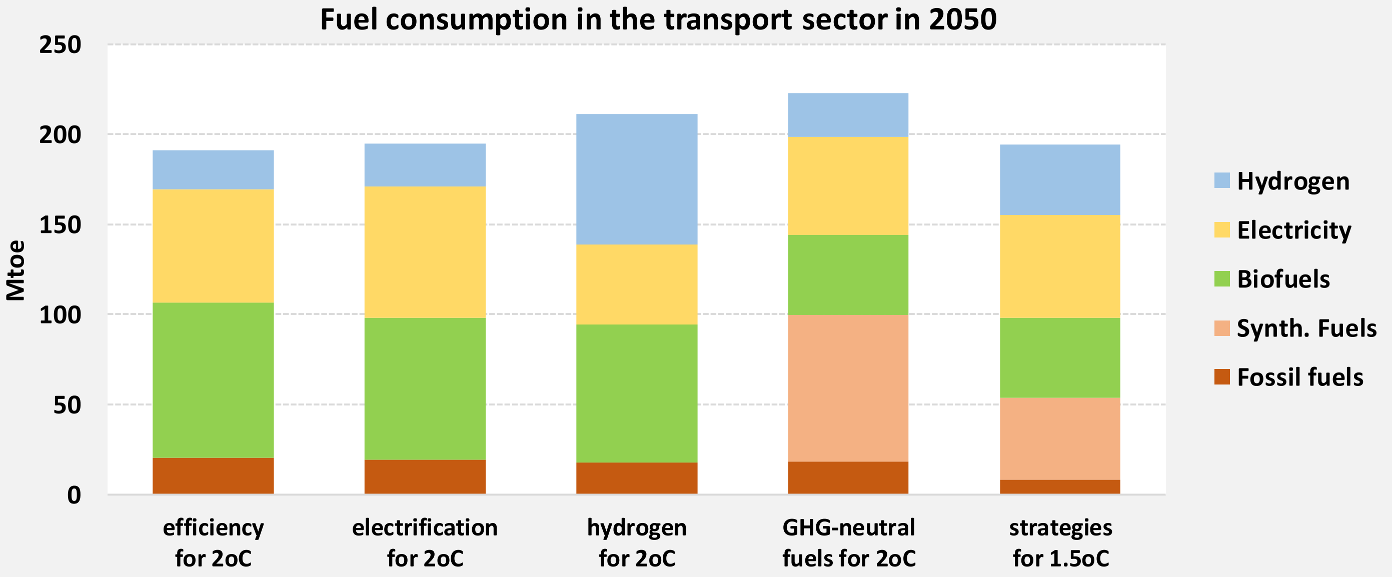
Concluding remarks



- 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

Thank you!





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.