Evaluating a Low Emission Pathway for Pakistan

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LUMS

Introduction

- Pakistan’s current emission projections are based on overestimated economic growth and do not reflect realistic decarbonization potential.

- This project analyzes one carefully designed low-emission pathway for Pakistan, built using assumptions on energy demand, technology costs, and investment capacity.

- Using the MESSAGEix Pakistan model, we simulate how Pakistan’s energy system evolves under a strict emission constraint aligned with a low-carbon trajectory.
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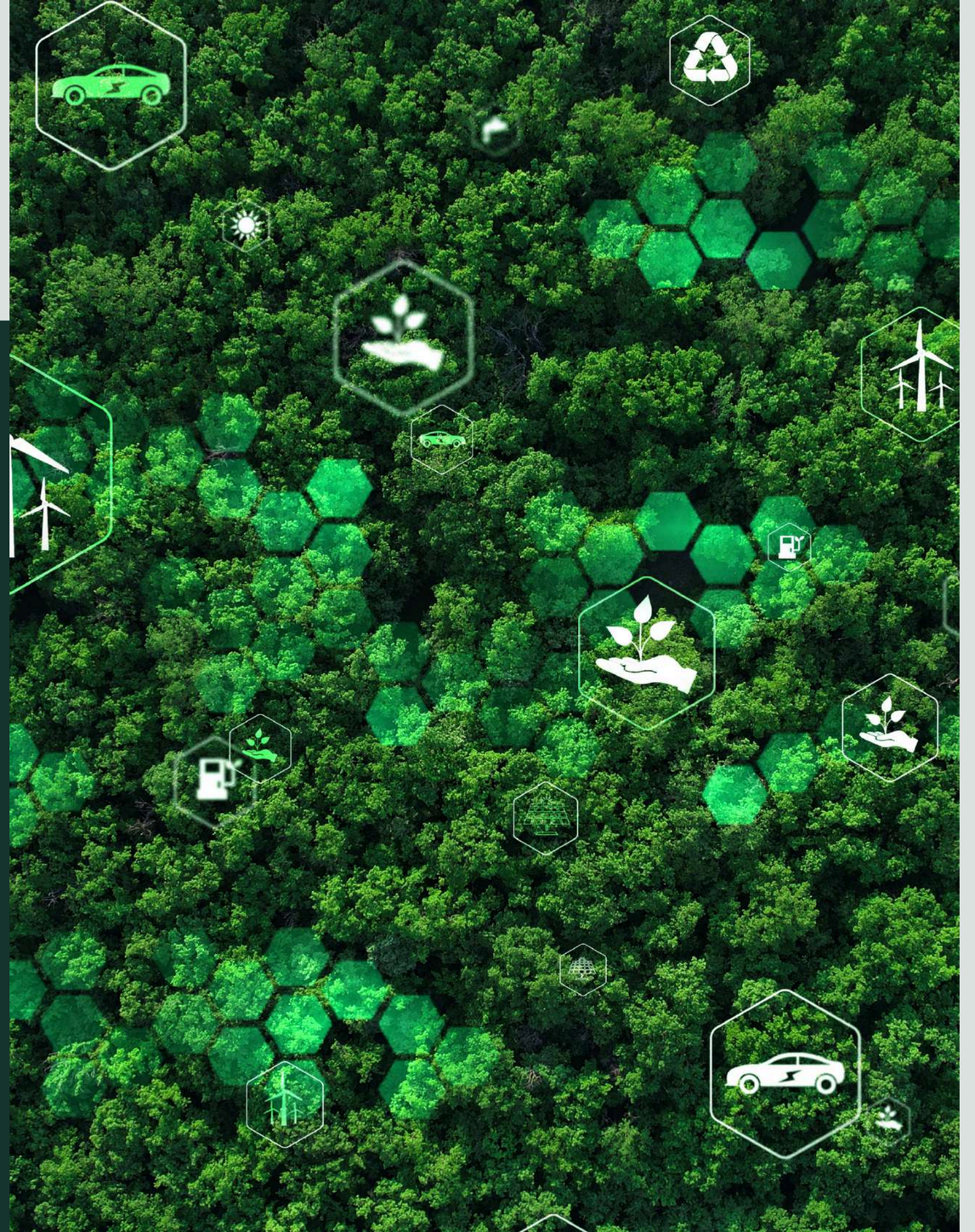
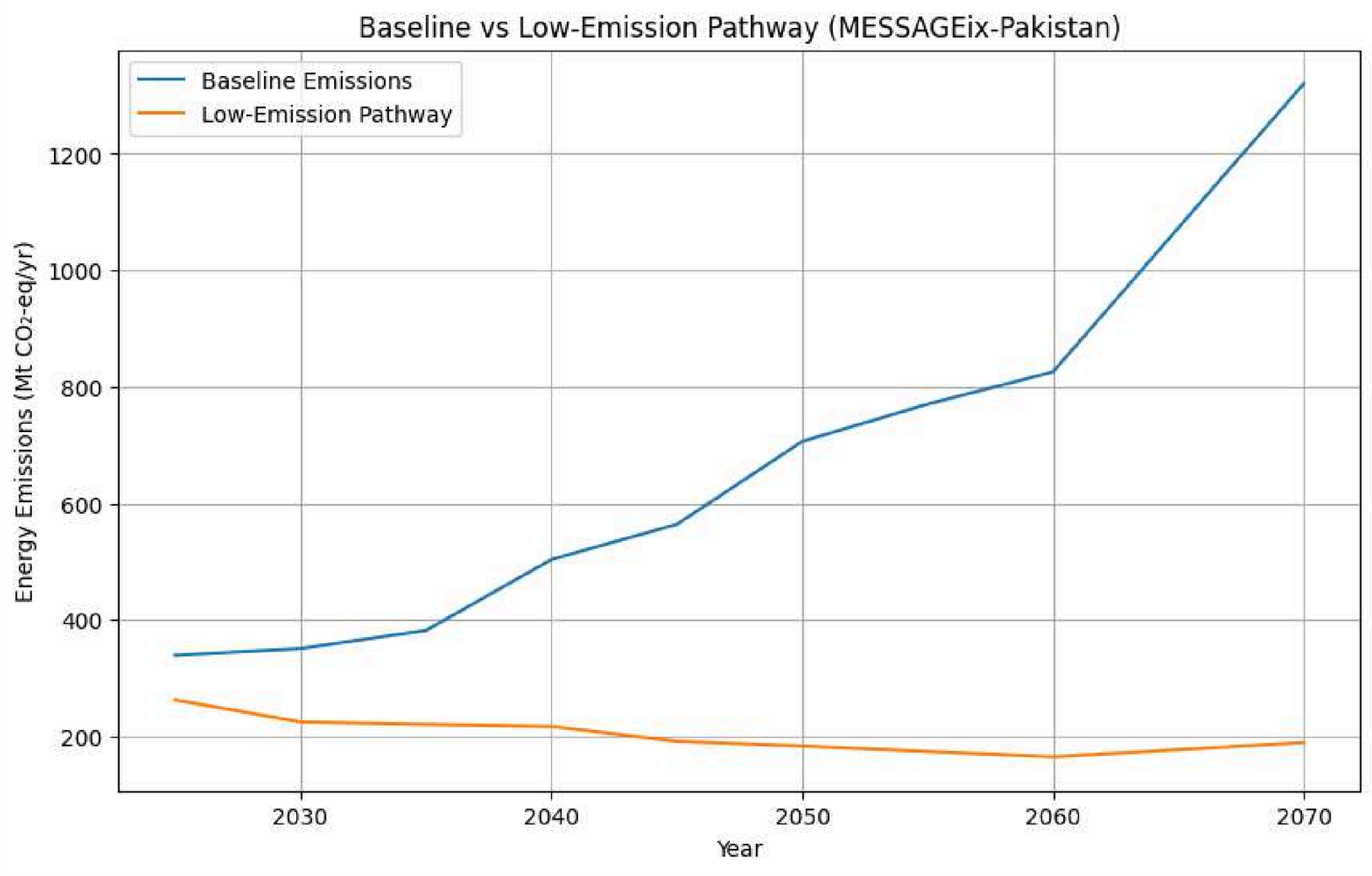
- The study aims to identify the feasibility, system costs, and optimal generation mix for this low-emission pathway, offering insights for future climate and energy planning.

How the Low-Emission Scenario Was Constructed

- Define an emission target for 2025-2070: Average emissions is 55 Mt C (201 Mt CO2)
- Apply this emission constraint to the baseline (business as usual) Pakistan scenario
- Solve the scenario with Message-ix through GAMS
- Obtain the Low emission pathway results



Energy Emission Pathway

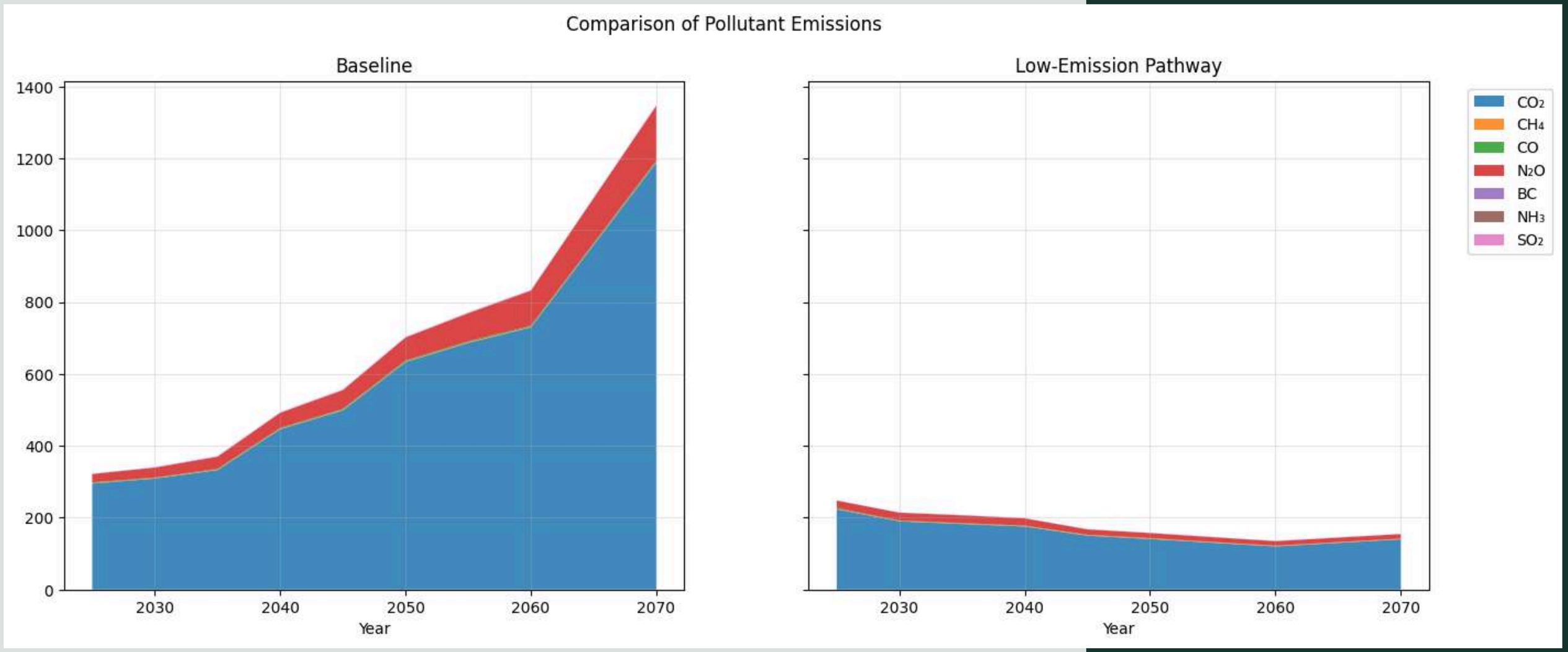


Baseline trajectory, emissions rise continuously and exceed 1300 $MtCO_2$ by 2070

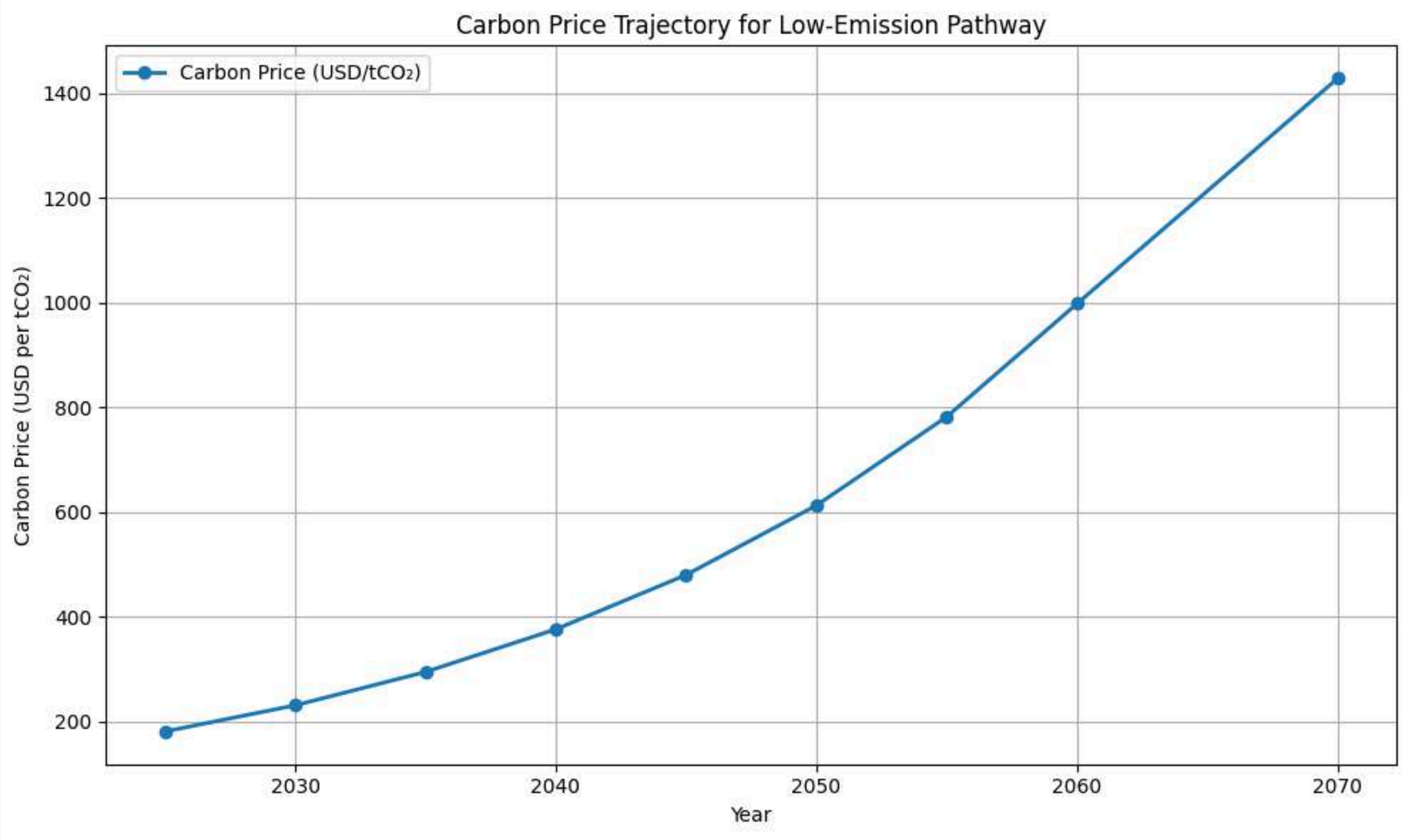
Low-emission pathway where emissions fall and stabilize around 170–220 $MtCO_2$

The slight difference in starting points is due the average constraint we applied

Composition of Emissions



Carbon Price (Shadow Price) - Low Emission Pathway



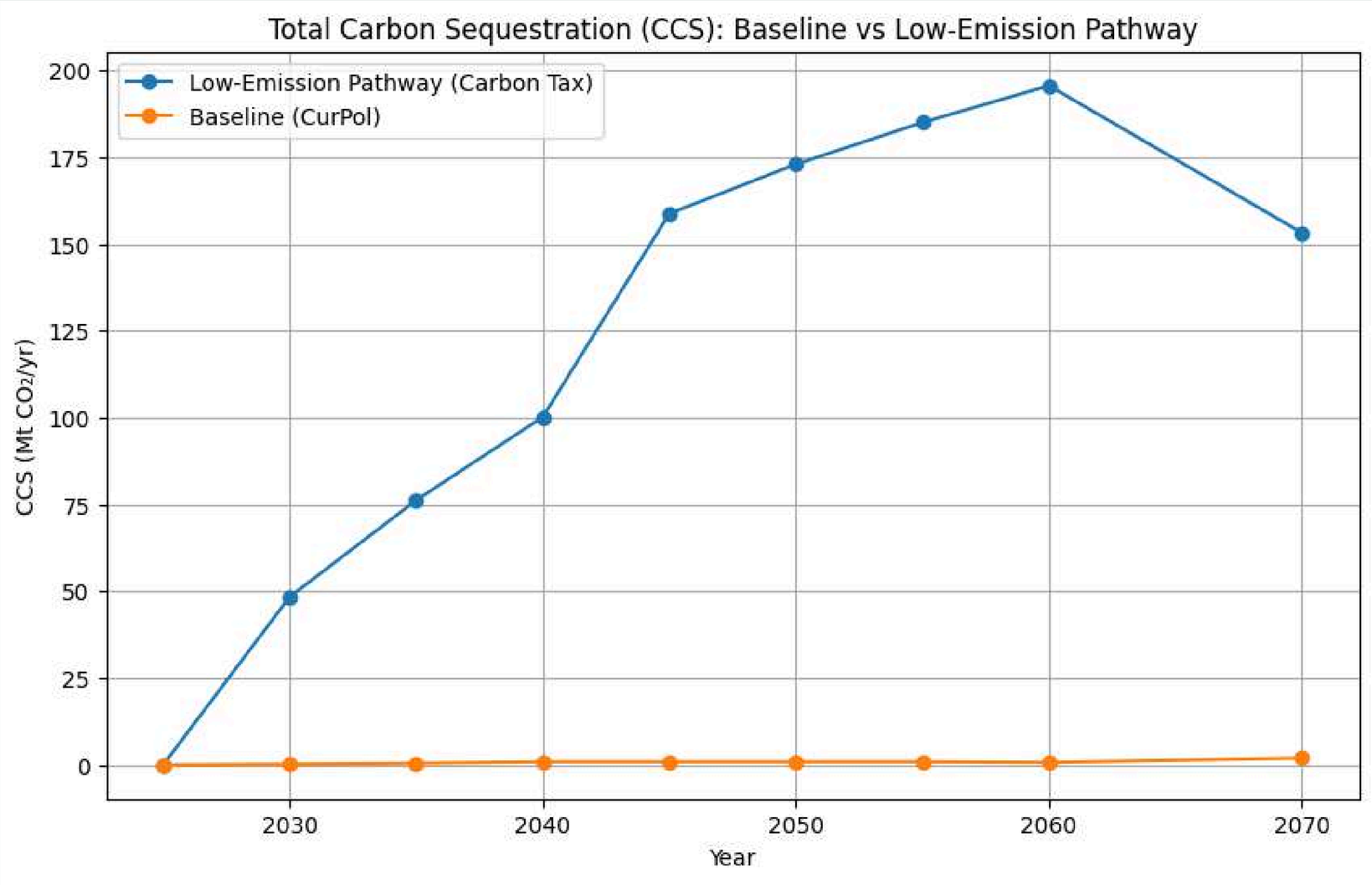
A carbon price is the economic cost assigned to emitting one ton of CO_2 into the atmosphere.

It represents: How expensive it becomes for the energy system to pollute.

Beginning around **$181** USD/$tCO_2$, increasing to **$1428** USD/tCO_2 by 2070

it becomes harder and more expensive to remove each additional ton of CO_2

Carbon Capture and Storage - CCS

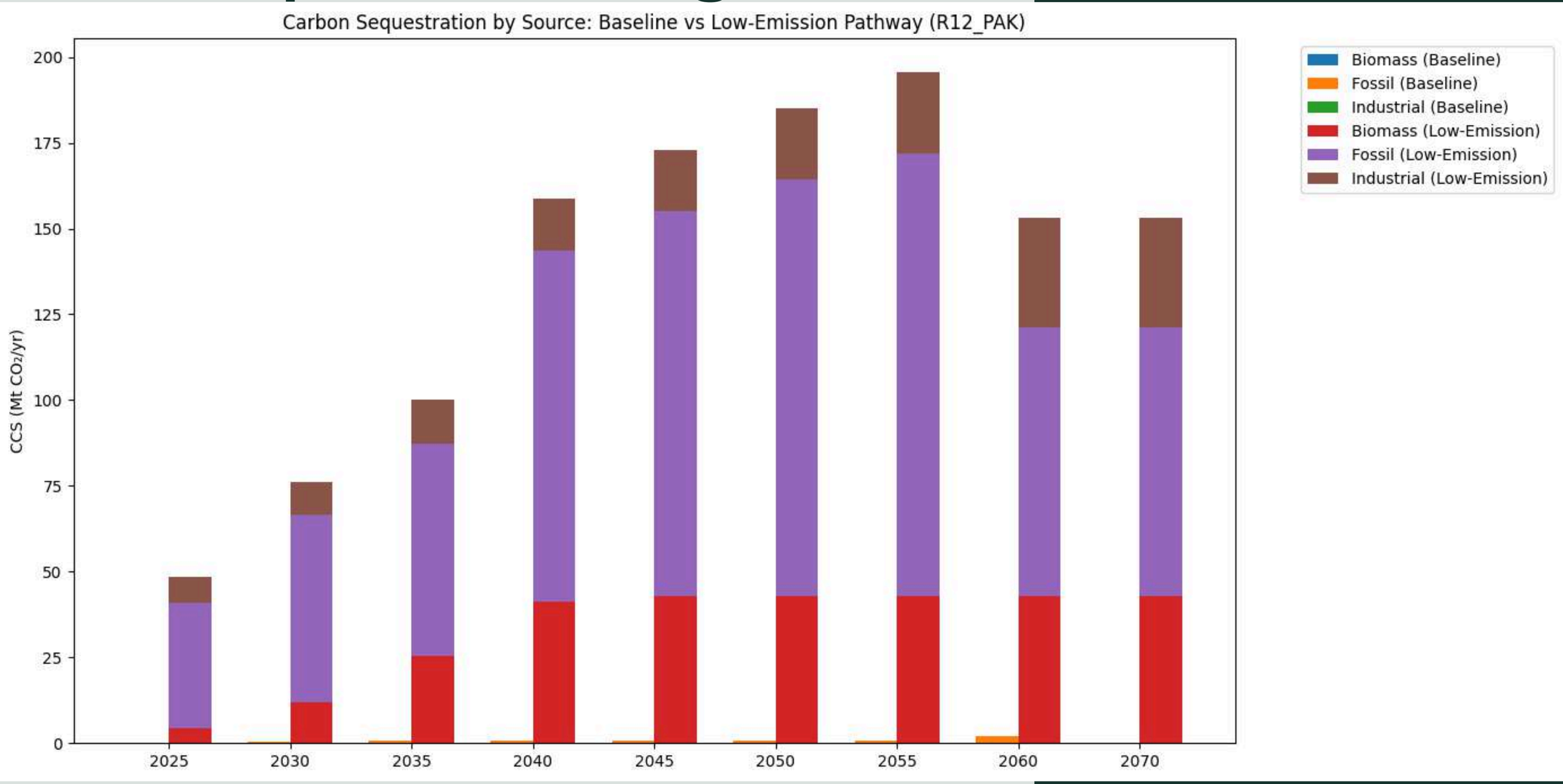


Baseline CCS is almost zero in all years while Low-Emission pathway introduces large-scale CCS

After 2060 CCS decreases for the low emission pathway.

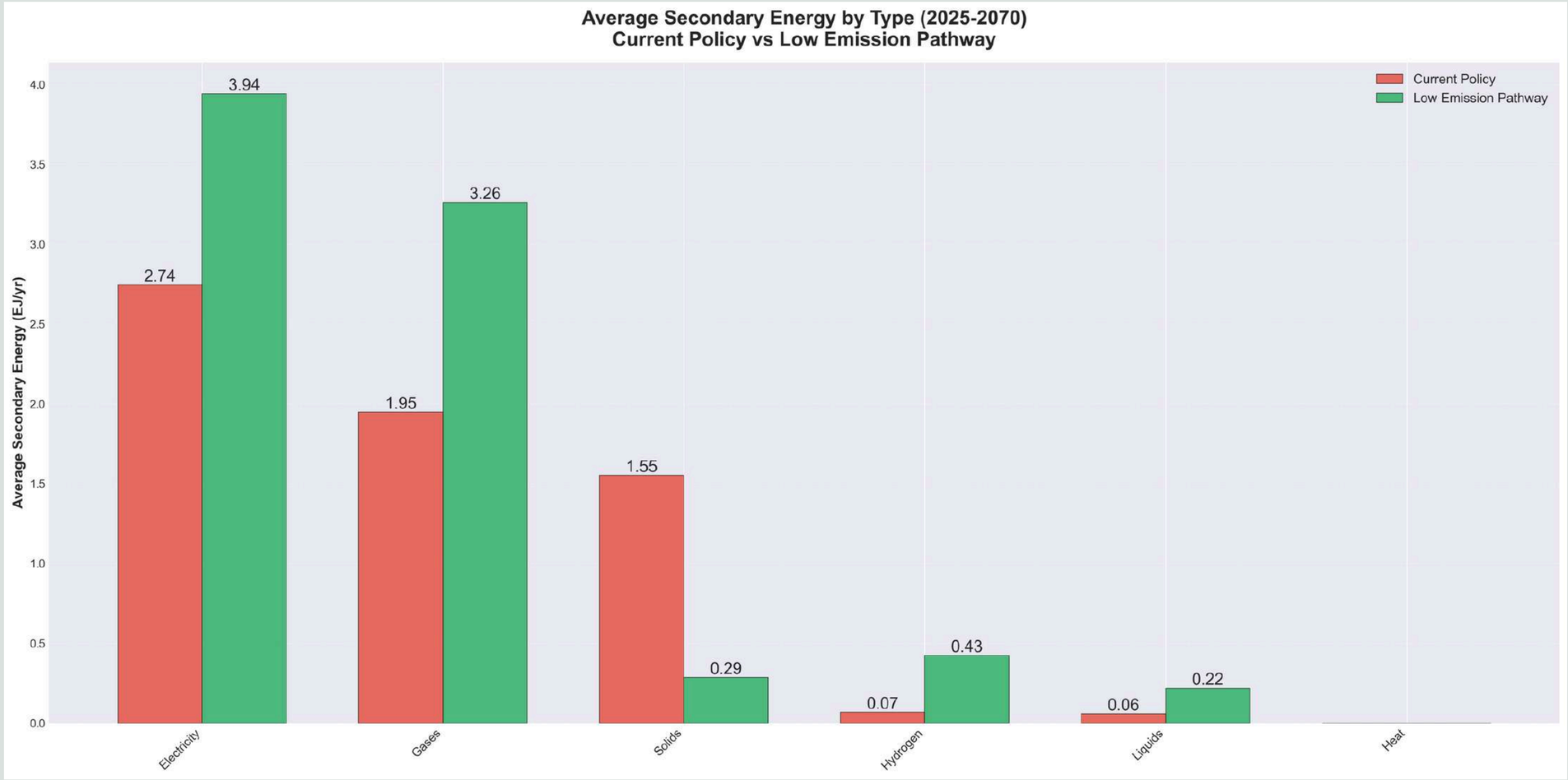
The energy system becomes cleaner over time as a large share of fossil fuels has already been replaced and CCS becomes less cost-effective compared to renewables.

Carbon Capture and Storage - CCS



Secondary Energy

Average Secondary Energy by Type

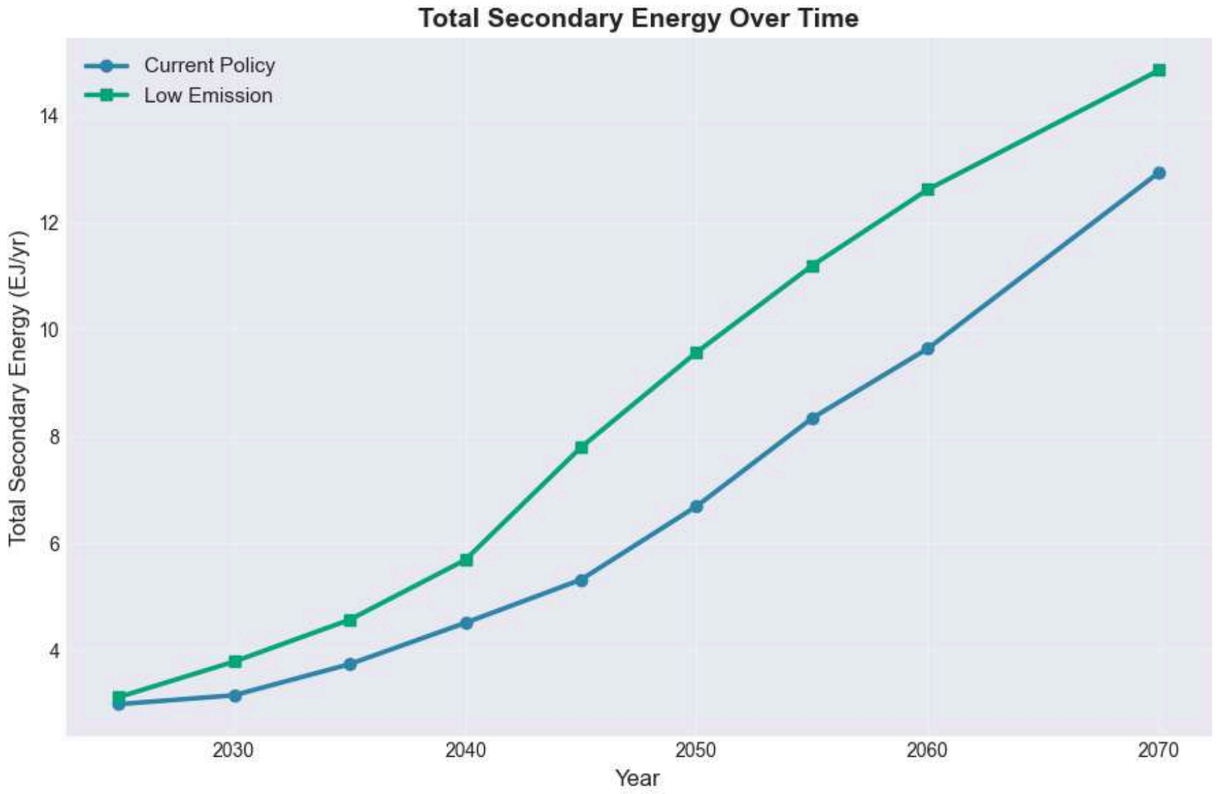


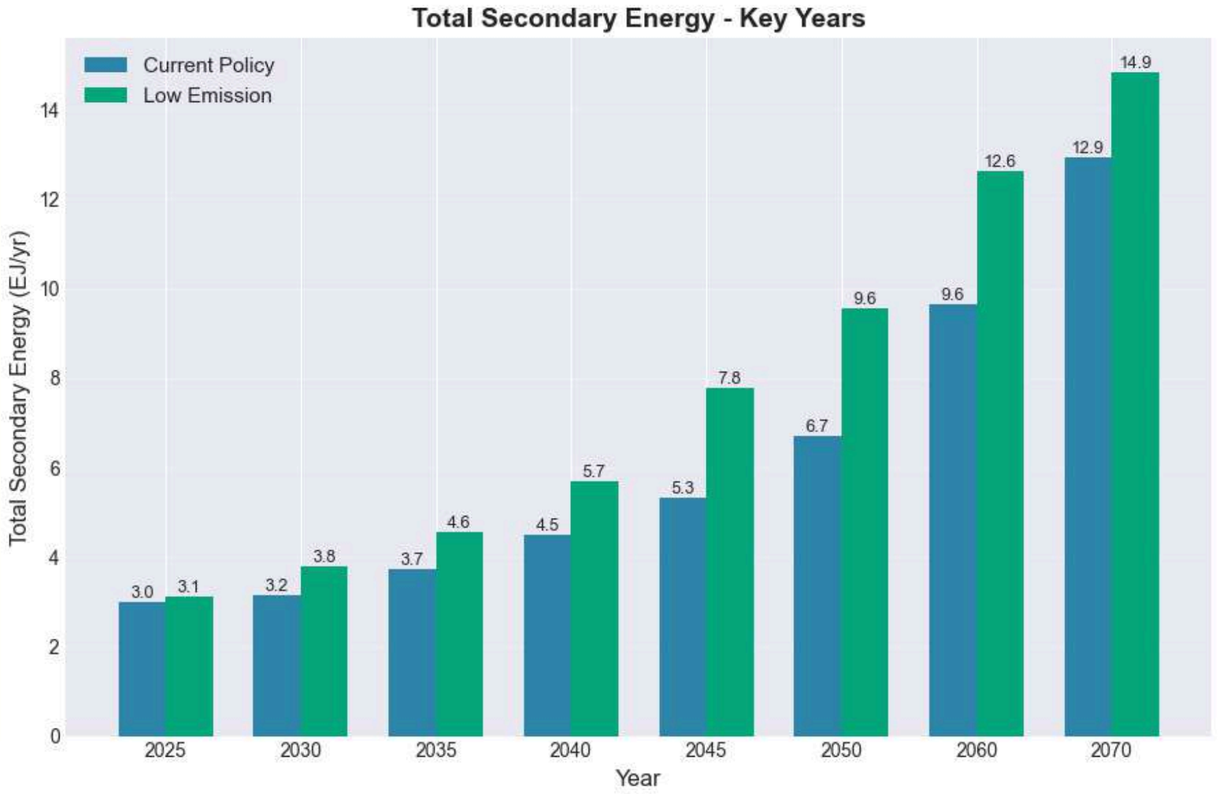
More electrification in our end-user sectors i.e. transport, buildings

Rapid increase of Gases : essential low-carbon alternatives, necessary for sectors that are difficult to electrify

Solids (Coal/Coke products) are nearly eliminated. signifying the removal of carbon-intensive coal-based energy from the system

Total Secondary Energy over Time



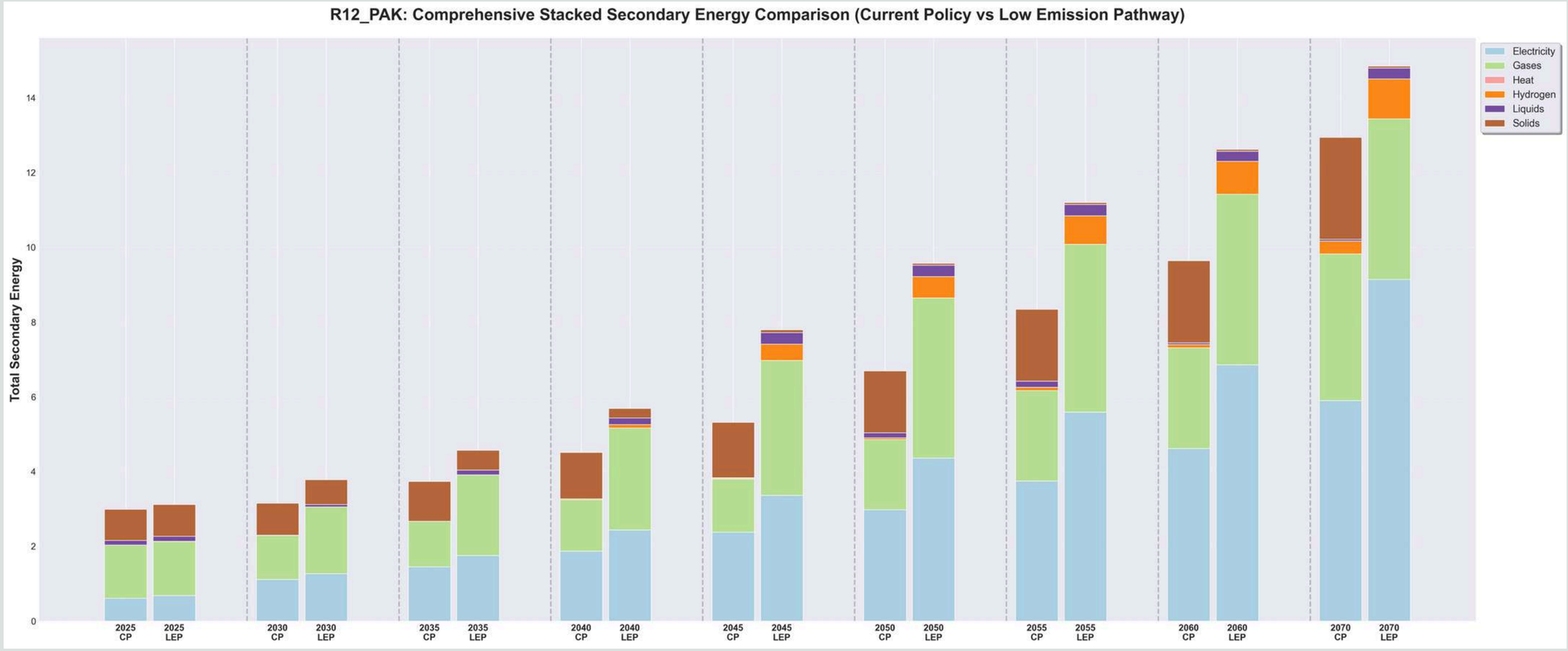


Both the CP and the LEP show a strong, consistent increase in total secondary energy

LEP requires a higher total volume of secondary energy compared to CP

Energy loss incurred when converting primary sources into clean carriers i.e. Electricity

Secondary Energy over Time by Type



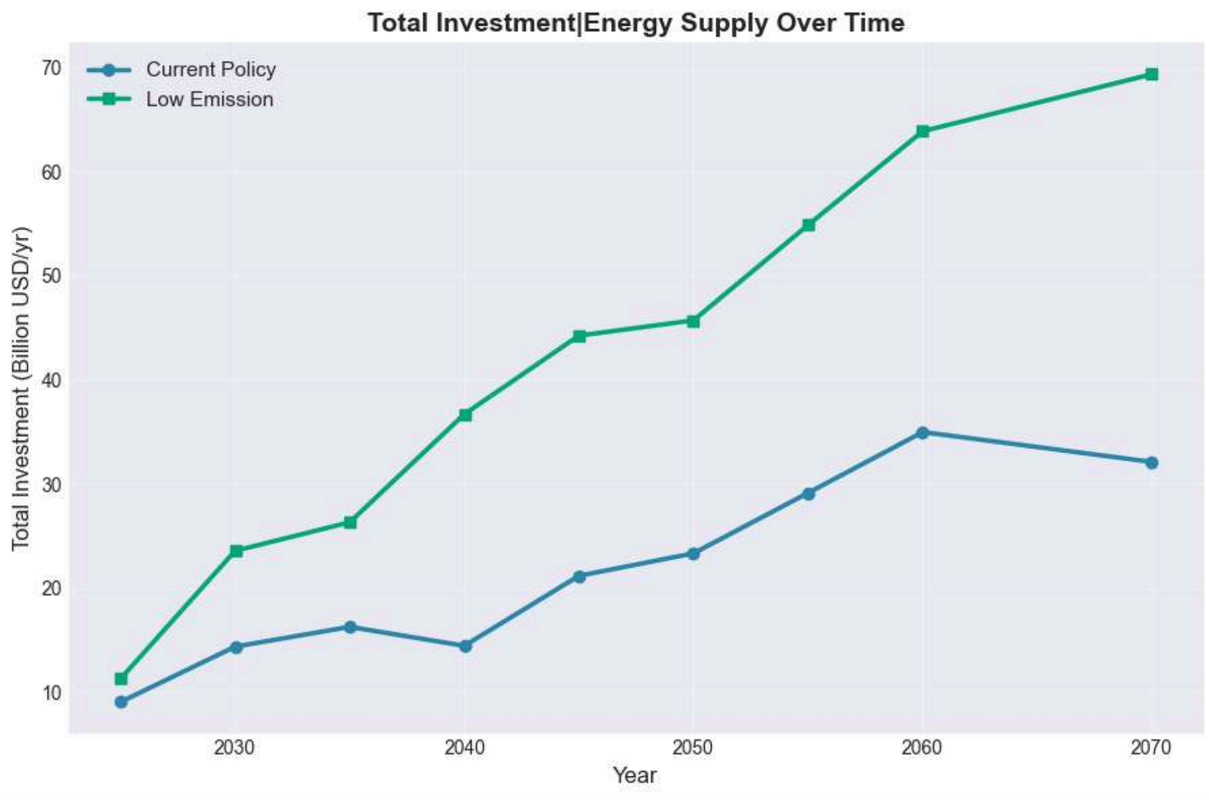
Electricity (light blue) becomes the single most dominant energy carrier

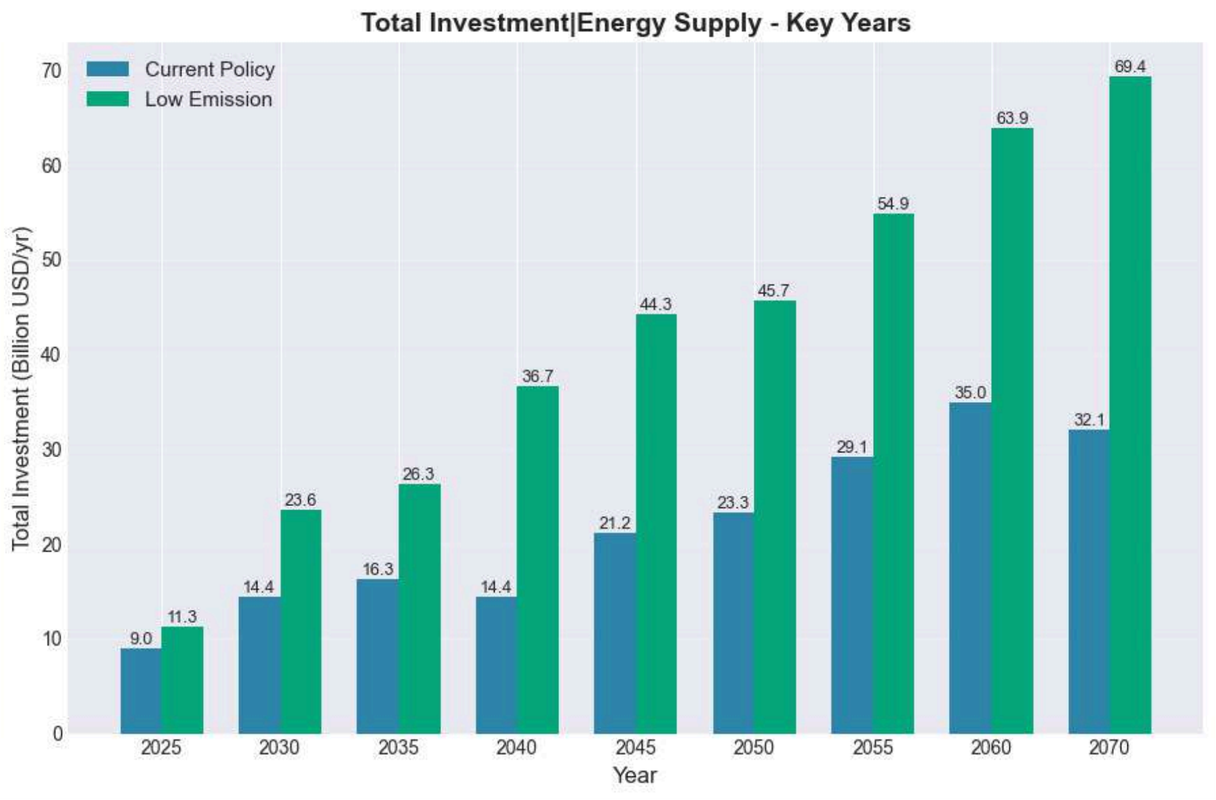
Increase in Gases (light green), not all things can be electrified. low carbon alternatives.

Elimination of Solids. end of coal-based secondary energy

Investment

Total Investment over time





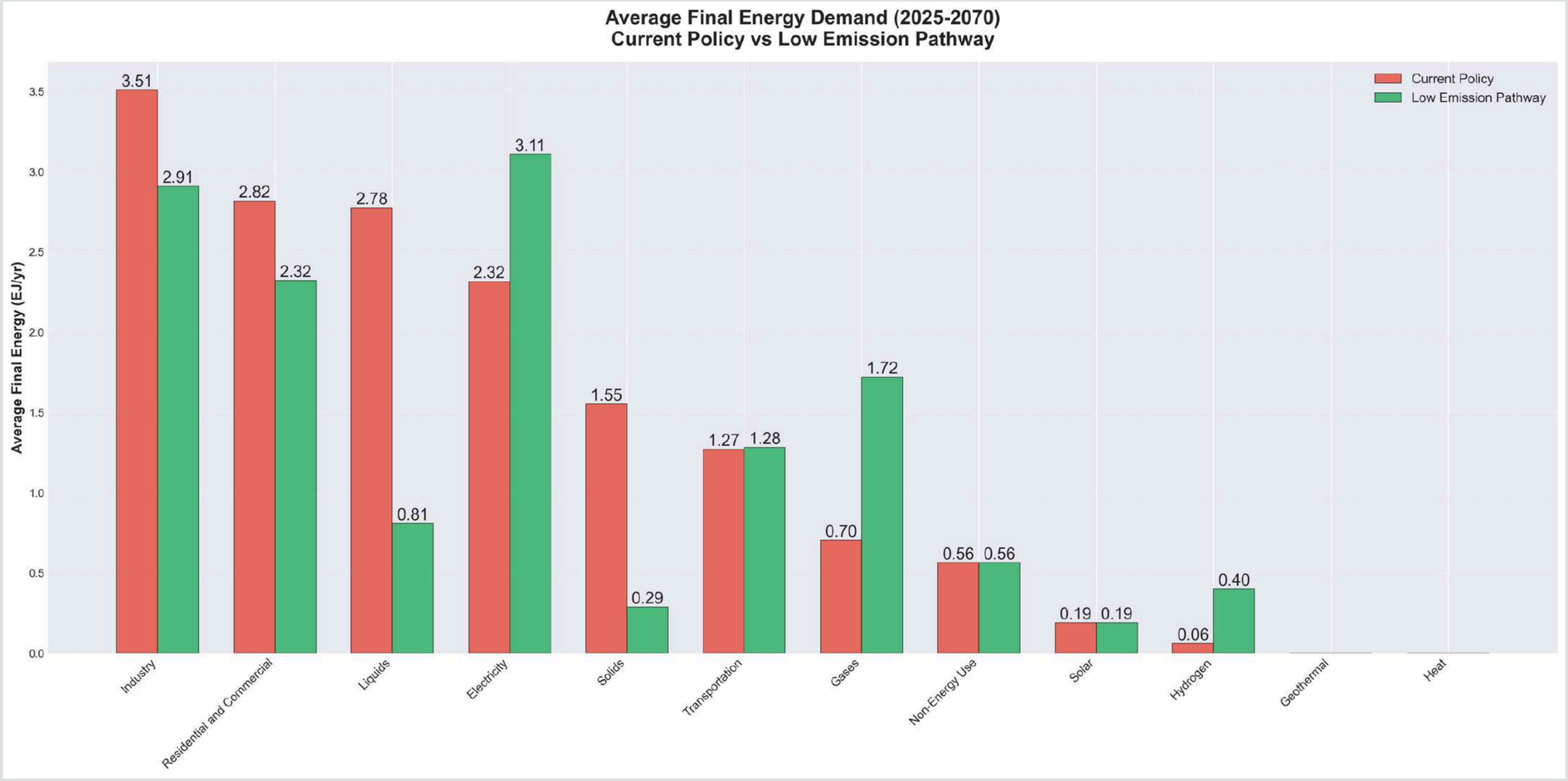
Requires a significantly higher and accelerating annual investment in energy supply

Necessary to fund the massive scale-up of clean secondary carriers

Transition to a low-emission system is not cheap. requires substantial front-loaded capital expenditure

Final Energy

Average Final Energy Demand by Categories

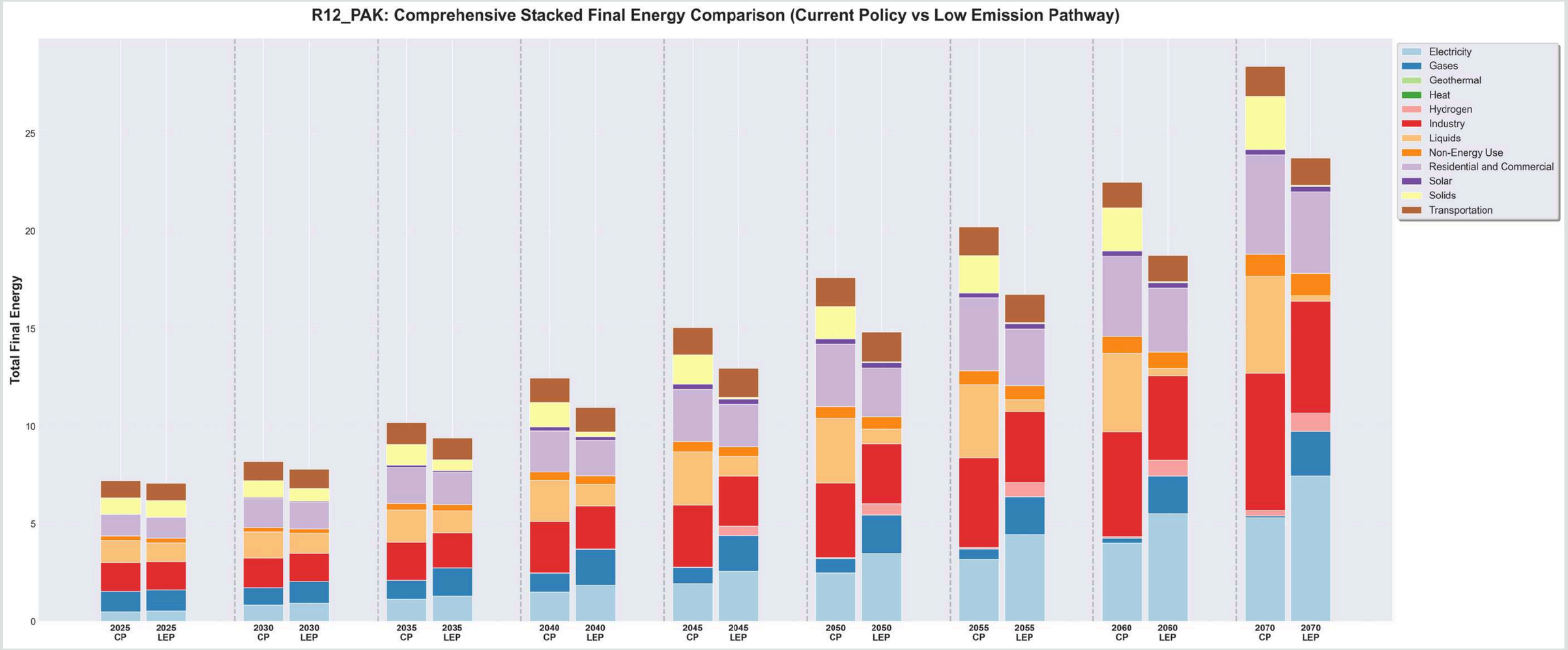


Liquids demand drops steeply. Electrification of vehicle fleet replacing gasoline and diesel

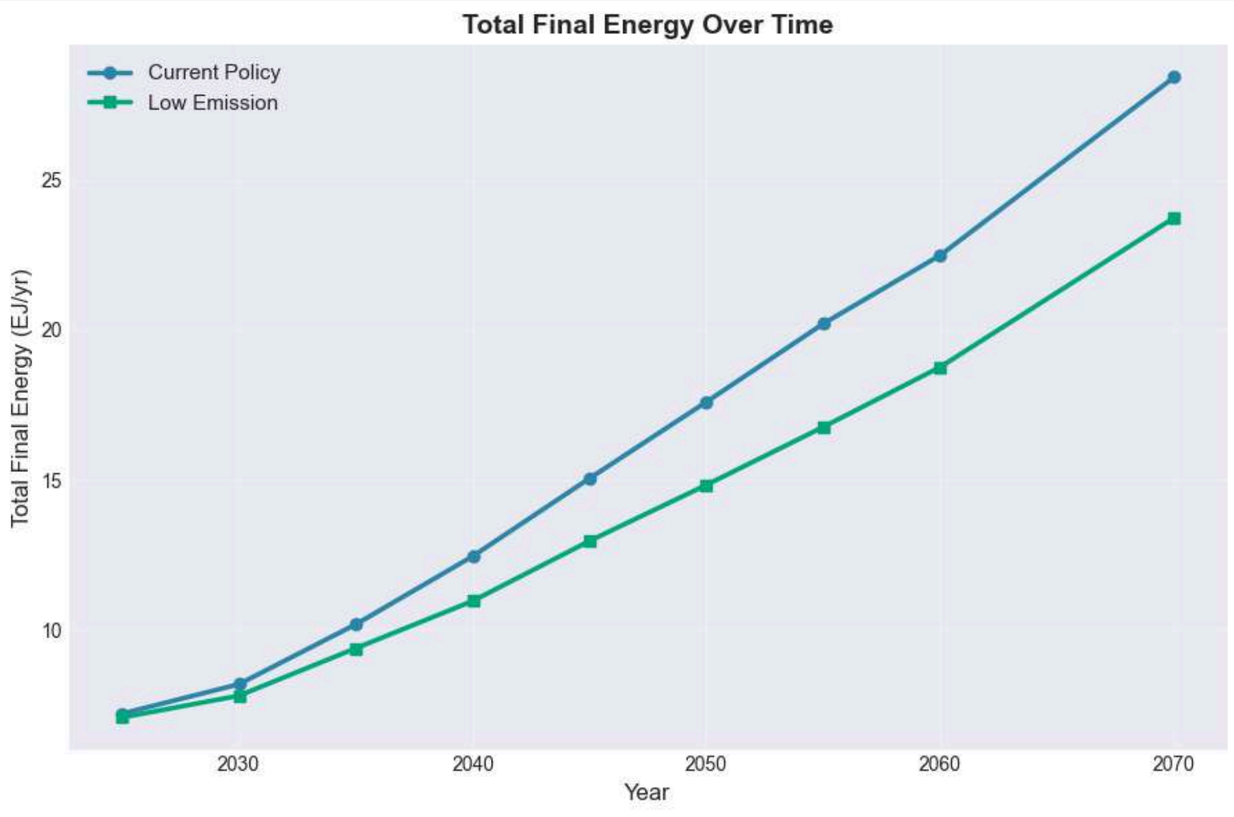
Solid demand drops steeply. Phase-out of coal and its products

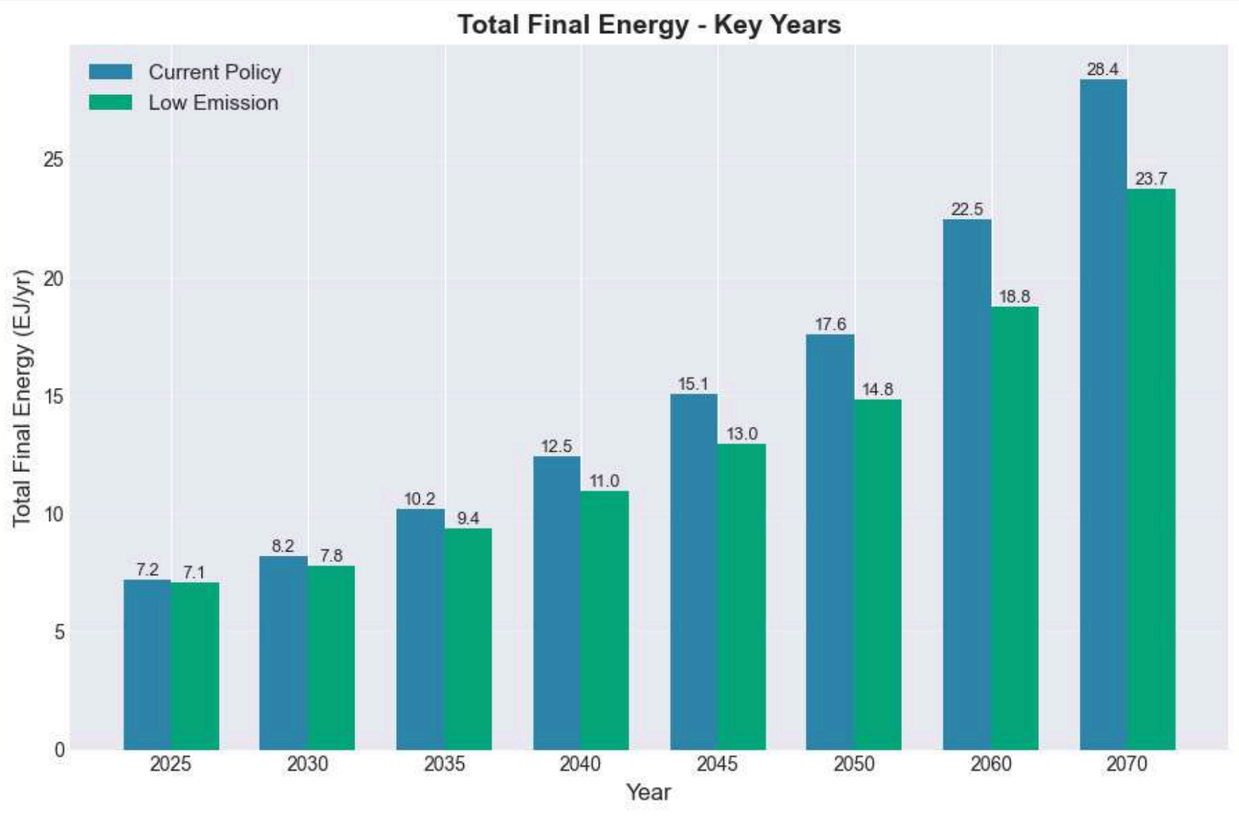
Electricity demand increases, electrification. Gas demad increases, must be met by clean sources (biogas, synthetic methane)

Final Energy Demand over time by categories



Final Energy Demand over time by categories





Conclusion

- The low-emission pathway is not practically achievable, as it relies on an imposed 55 MtC annual cap (vs. baseline emissions of 339 $MtCO_2$ in 2025 rising to 1320 $MtCO_2$ by 2070).
- Required technology shifts—especially large, rapid CCS deployment—are unrealistic: CCS rises from 0 Mt in 2025 to 196 $MtCO_2$/yr by 2055, far beyond Pakistan's current capacity (which is 0 $MtCO_2$/yr in reality).
- The scenario produces extremely high carbon prices, increasing from 180$/$tCO_2$ in 2025 to 1400$/$tCO_2$ in 2070) → These values indicate major economic infeasibility.
- The required annual investment in energy supply for the LEP reaches $69.4 billion USD/yr by 2070, more than double the Current Policy.

Thank You!