THE OXFORD INSTITUTE FOR ENERGY STUDIES

Modelling Decarbonisation Pathways in Europe: Balancing Ambition and Economic Feasibility

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European Energy Transition and Society: moving towards Implementation
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Key messages

- Under the **90%-by-2040 pathway**, implied marginal abatement costs (a proxy for economy-wide carbon price) rise to ~**€5,000/tCO₂e** by 2040 (€2023); deep, rapid decarbonisation is therefore likely feasible but **extremely costly**.

- **A more gradual net-zero pathway by 2050 offers a cost-effective pathway**, spreading costs more evenly (MAC ~ €400/tCO₂e in 2040)

- **Renewables ramp-up is critical** to meet electrification-driven demand and the 2050 net-zero goal

- **CCS deployment is pivotal:** without it, Europe's gas phase-down is slower, import dependence persists, and total system costs rise.

- **Explicit carbon pricing alone is insufficient;** infrastructure delivery, electrification, and flexibility markets determine the actual speed of decarbonisation.

Policy and Market Context

EU Green Deal sets target for net-zero by 2050

EU proposes Climate Law; Fit-for-55 targets –55% by 2030;
Germany enshrines net-zero by 2045 with interim 88% cut by 2040;

Sweden (2045), Austria (2040), and Finland (2035) also adopt pre-2050 net zero laws

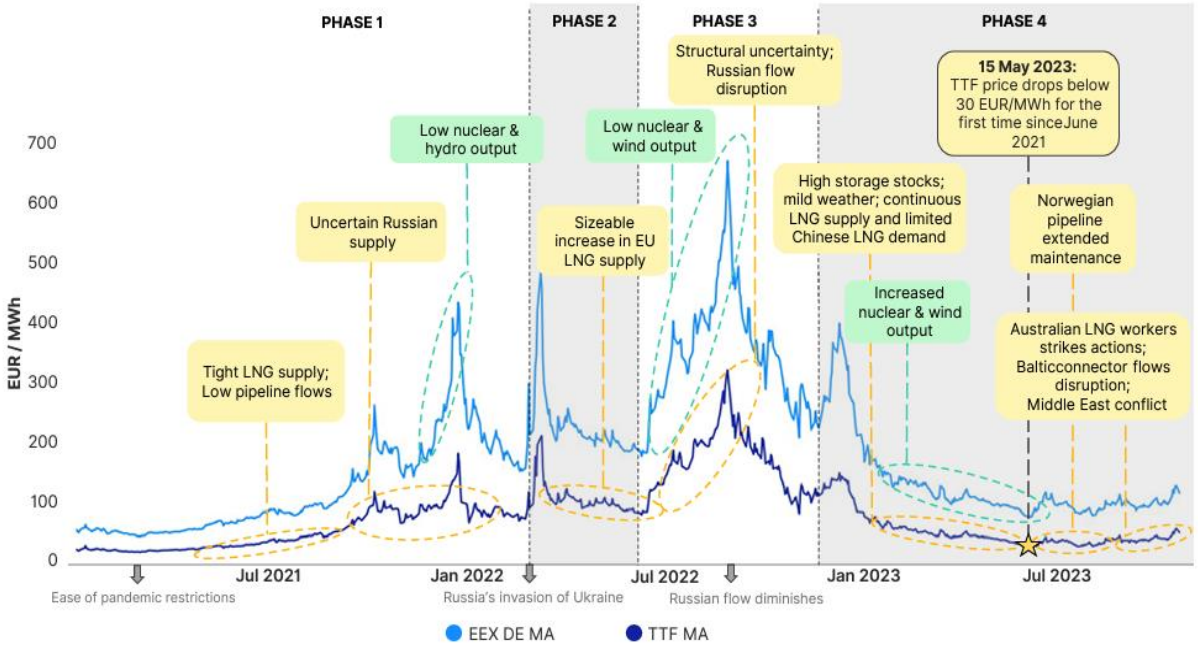
EC proposes 90% GHG cut by 2040

Germany supports 90% target with up to 3% international offsets

EU Scientific Advisory Board warns: offsets risk undermining ambition

EC Proposed amending the European Climate Law: **a 2040 target of a 90% net GHG reduction from 1990 levels**

2019 **2020-21** **Feb 2024** **Apr 2025** **Jun 2025** **Jul 2025**



Modelling Europe's Decarbonisation: Scenario Overview

Scenario	GHG Target	Carbon Price	RES Subsidy	Key Feature
Baseline	None	Moderate	Yes	Reference scenario; gradual policy continuation
High Carbon Price	None	High	Yes	EC net-zero-aligned pricing; no binding targets
Low Carbon Price	None	Low	Yes	Weak incentives; slow decarbonisation
Linear Path to NZ (LPNZ)	55%–**76%**–100% (by 2030–2040–50)	None	No	Cost-efficient glidepath to net zero
Accelerated Path to NZ (APNZ)	55%–**90%**–100% (by 2030–2040–50)	None	No	Front-loaded ambition; high cost pressure

Emissions Reduction vs. Cost Trade-Off

	GHG emissions, $mtCO_{2e}$ (% reduction relative to 1990)			Marginal Abatement (Carbon) Cost, $€/tCO_{2e}$			Average Abatement Cost, $€/tCO_{2e}$		
	2030	**2040**	**2050**	**2030**	**2040**	**2050**	**2030**	**2040**	**2050**
Baseline	2,793 (52%)	1,935 (67%)	908 (84%)	68	193	318	n.a.	69	116
High Carbon Price	2,793 (52%)	1,767 (70%)	833 (86%)	68	257	445	n.a.	125	145
Low Carbon Price	2,793 (52%)	2,285 (61%)	1,878 (68%)	68	91	114	n.a.	n.a.	n.a.
Accelerated Path to Net Zero	2,622 (55%)	583 (90%)	0 (100%)	134	17,246	426	71	2,499	872
Linear Path to Net Zero	2,622 (55%)	1,407 (76%)	0 (100%)	134	420	1,944	71	65	271

Cost Dynamics

- Accelerated Path: MAC €17,246/tCO_2e, AAC €2,499/tCO_2e in 2040
- Linear Path: Lowest AAC at €65 (2040) and €271 (2050)

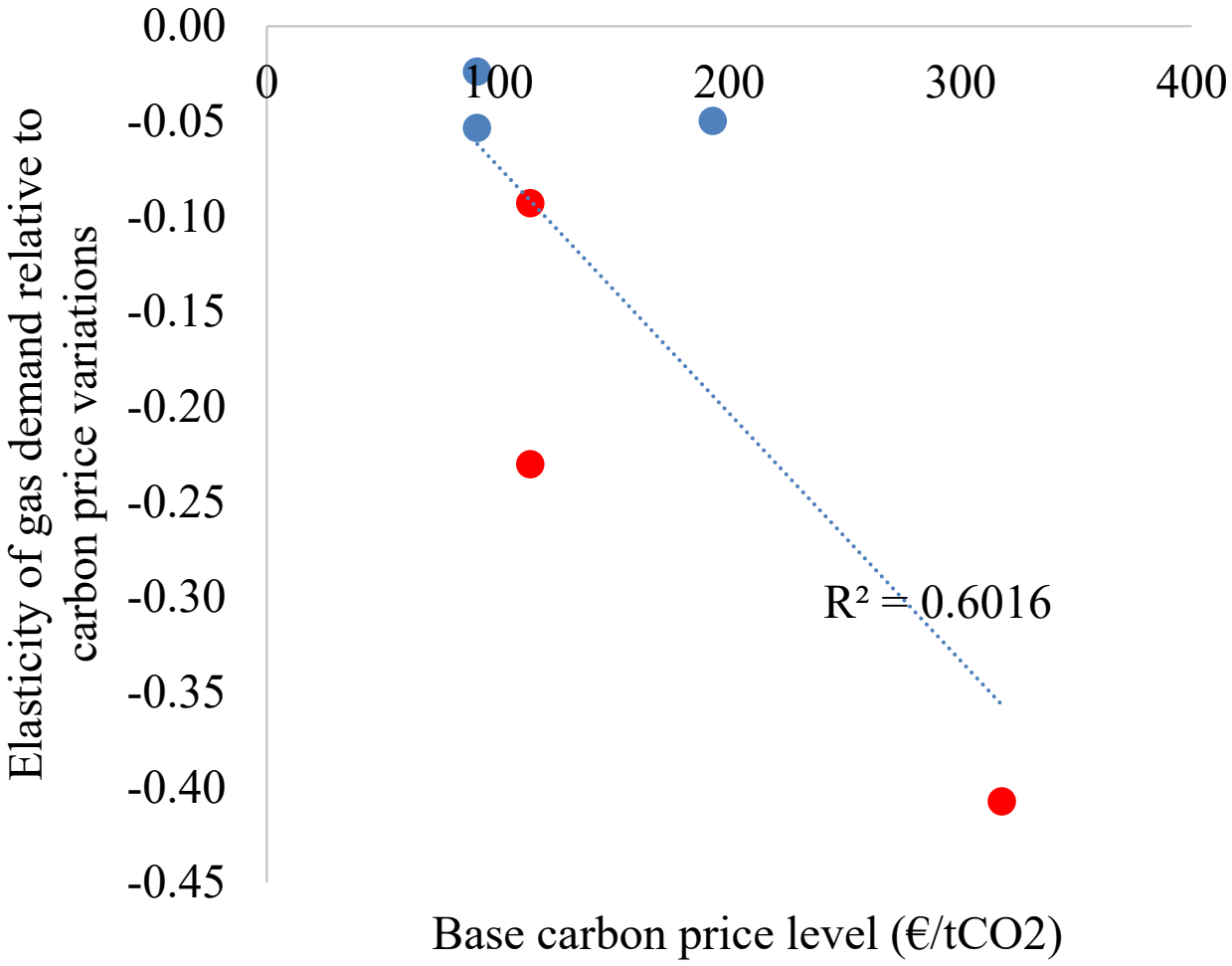
Emissions Outcomes

- Carbon pricing alone leaves up to 1,878 $MtCO_2e$ by 2050, depending on price levels
- GHG reductions achieved: 68-86% by 2050

Economic Justification

- 2040 MAC (Accelerated) exceeds SCC range (€236–€3,938/tCO_2e)
- Linear Path aligns better with SCC under most assumptions

Carbon Pricing: Limited Effectiveness Alone



Notes: red dots represent 2050 elasticities, and blue dots represent 2040 elasticities

Elasticity is Low

- In 2040, gas demand reacts weakly to price: a 10% carbon price increase cuts demand by just **0.2–0.5%**
- By 2050, responsiveness improves slightly, but elasticity stays **below 0.5**

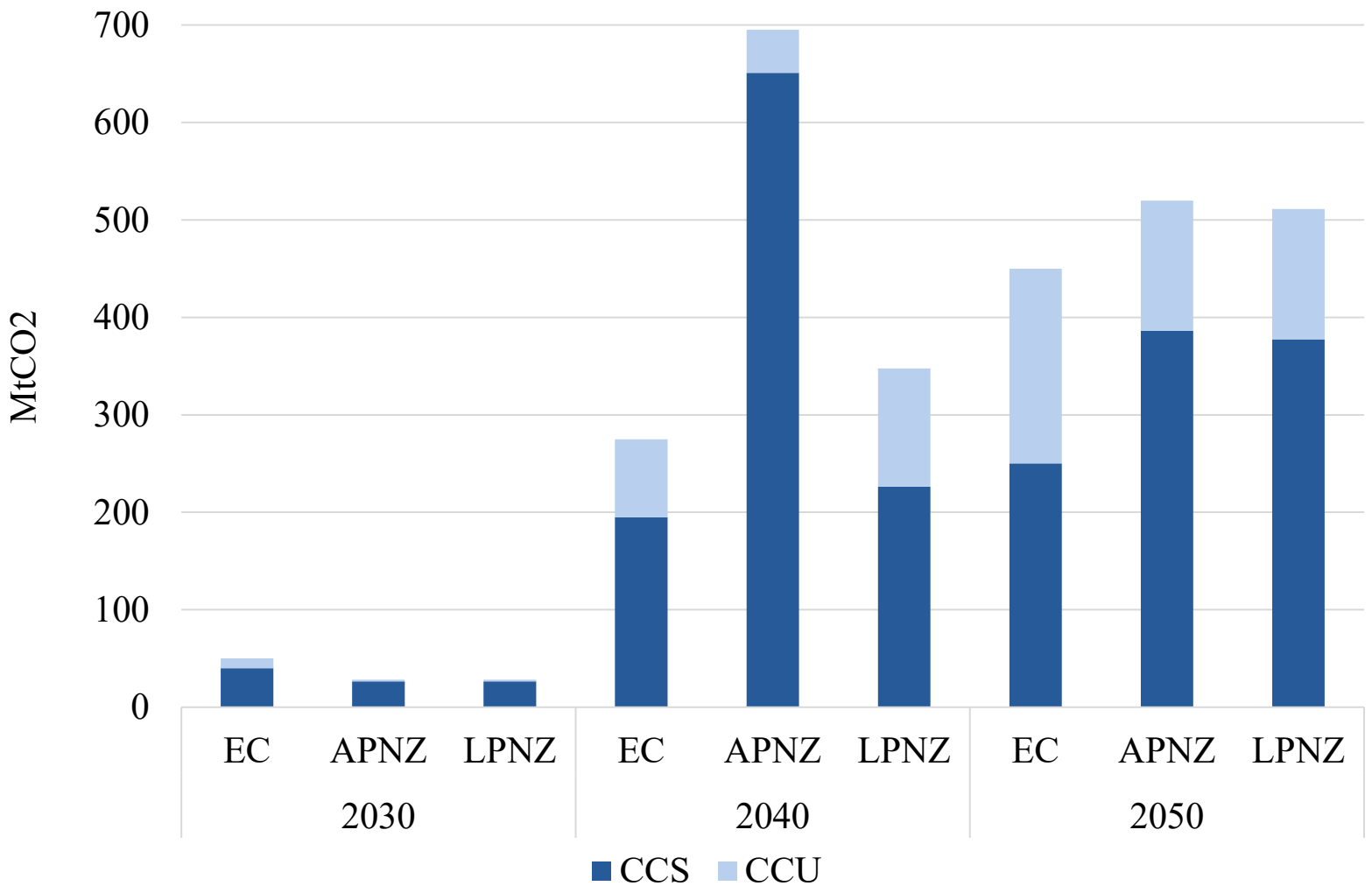
Nonlinear and Time-Dependent

- Elasticity grows more negative over time: stronger response at **higher price levels** in **2050**
- 2040 response limited by infrastructure and tech readiness

Implications

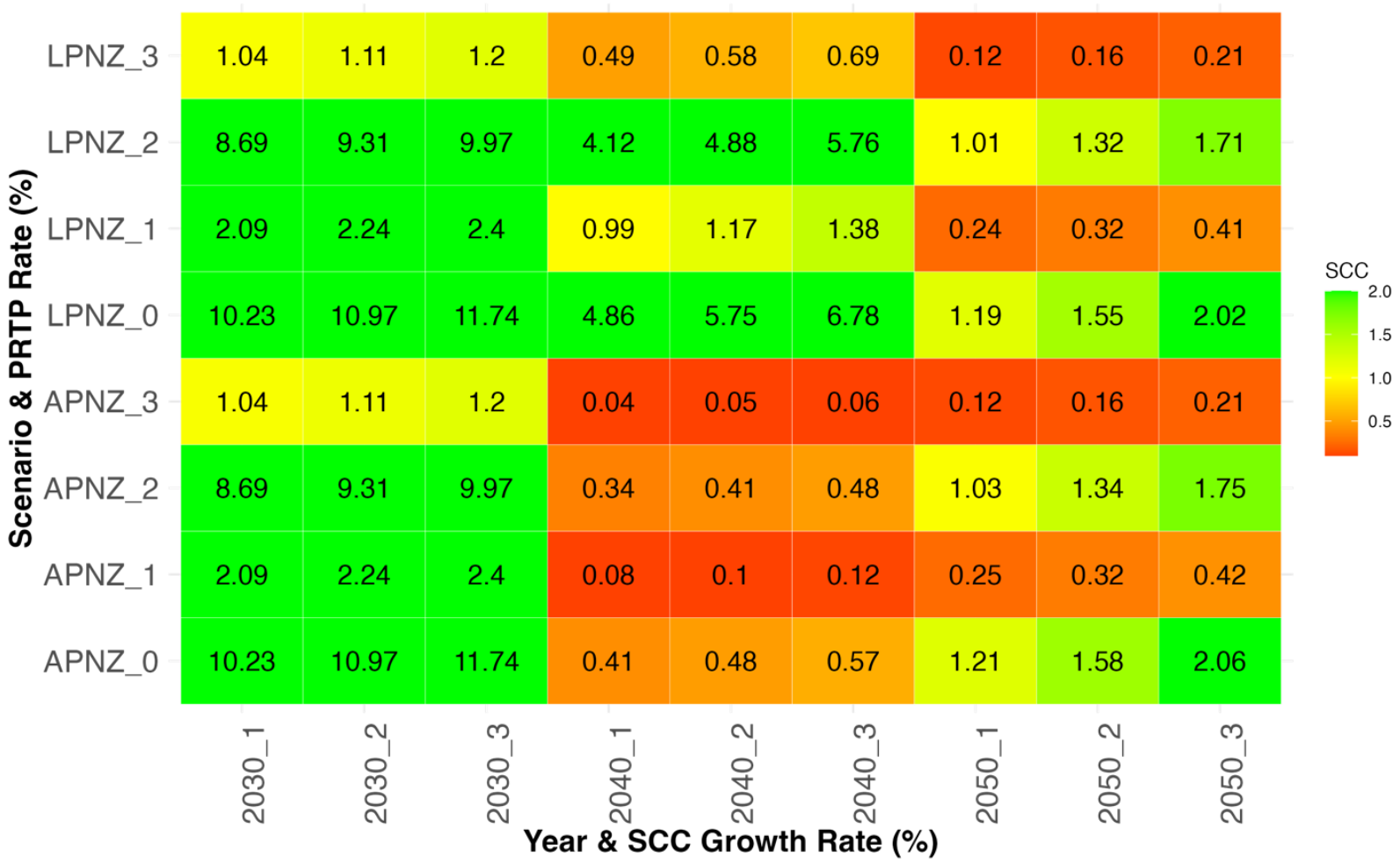
- **Socially accepted carbon pricing is insufficient alone** to drive fuel switching
- **Final consumption sectors** (e.g., buildings) remain price-resistant
- **Complementary policies** (standards, subsidies, electrification) are essential

CCUS: Scale, Timing, and Feasibility



- **APNZ requires >650 $MtCO_2$ storage by 2040**, far exceeding EC strategy (195 $MtCO_2$)
- **LPNZ aligns closely with EC levels**: 226 $MtCO_2$ storage, 121 $MtCO_2$ CCU in 2040
- **Most sequestration in APNZ is negative emissions** (e.g., BECCS, DAC)
- **Modelled CCU use is lower than EC projections**, due to narrower application scope (fuels only)
- **High CCS reliance in APNZ raises feasibility concerns** given a 15-year lead time for infrastructure

Are Climate Costs Justified? Comparing MAC with the Social Cost of Carbon



- **APNZ scenario often exceeds SCC** in 2040: MAC ~ €5,000-17,000/tCO_2e vs SCC max €3,938
- **LPNZ scenario remains mostly within SCC range** by 2050, especially under low discount rate assumptions
- Justifying deep cuts economically **depends on societal valuation of avoided climate damage**

Conclusions

1. **CCS capacity and infrastructure timing** are the main constraints to achieving deep decarbonisation targets.
2. **Balanced policy sequencing** – coordinated RES and CCS expansion, and cross-border CO_2 transport – is essential for cost-effective delivery.
3. **Revise carbon storage planning:** model results indicate ~650 Mt CO_2e capacity needed by 2040, over three times current EC estimates; infrastructure timelines should be updated accordingly.
4. **Establish long-term CO_2 storage incentives** – such as Contracts for Difference (CfDs) or storage credits – and strengthen EU–UK–Norway cooperation on shared offshore infrastructure.
5. **Leverage international carbon markets and low-carbon imports** to reduce decarbonisation costs through offsets and trade in renewable and low-carbon hydrogen and bioenergy.

Thank you!

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