

Supplementary Information

A multi-model analysis of hydrogen uptake in a climate-neutral Europe

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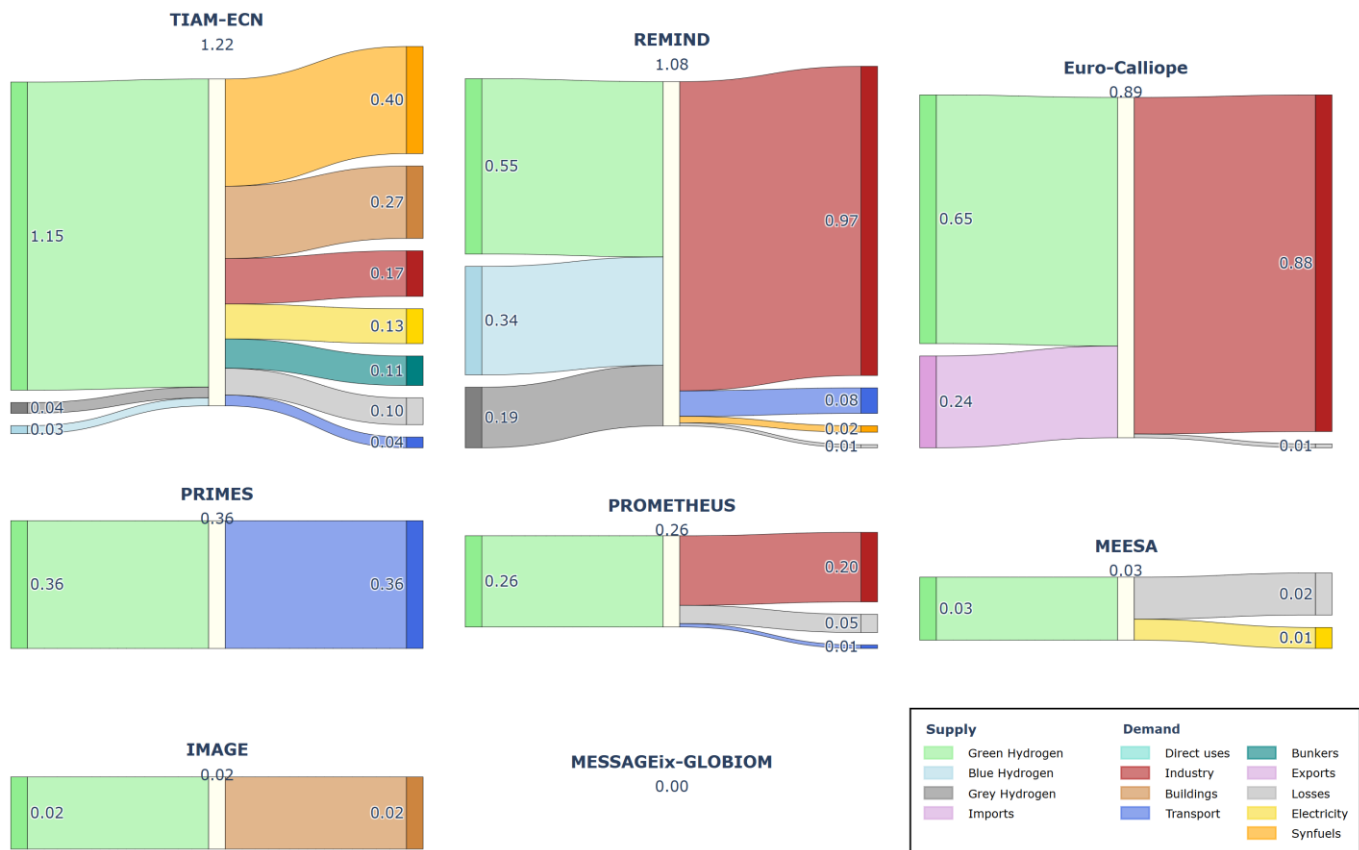
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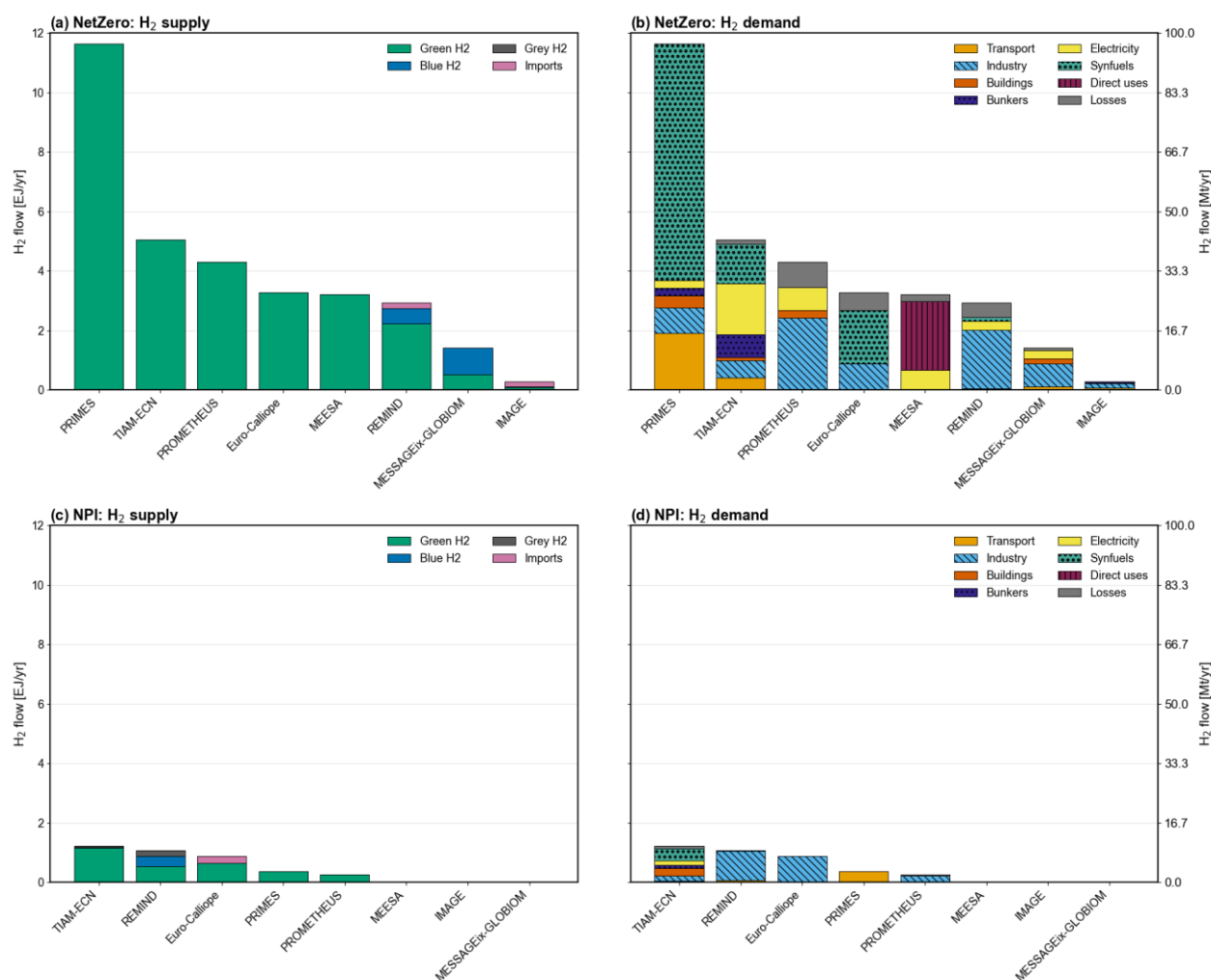
Supplementary Note 1 The hydrogen conversion chain under NPI



Supplementary Figure 1. Modelled hydrogen conversion pathways under the NPI scenario Sankey diagrams illustrating the hydrogen transformation chain across all models in 2050 under the NPI scenario. Diagrams are scaled across models. Indirect uses are divided into Electricity and Synfuels. Green hydrogen: renewable-electrolysis; Blue hydrogen: fossil-reforming with CCS or biomass gasification (with or without CCS); Grey hydrogen: fossil-reforming without CCS. NPI, National Policies Implemented; CCS, carbon capture and storage; synfuels, synthetic fuels.

Supplementary Note 2 Hydrogen conversion chain demonstrated through bar chart

In the main text, hydrogen conversion pathways are presented using Sankey diagrams (Fig 1). For a more compact cross-model comparison, this supplementary figure shows the same underlying data as stacked bar-chart visualizations, with NetZero in the top row and NPI in the bottom row (supply on the left, demand on the right).

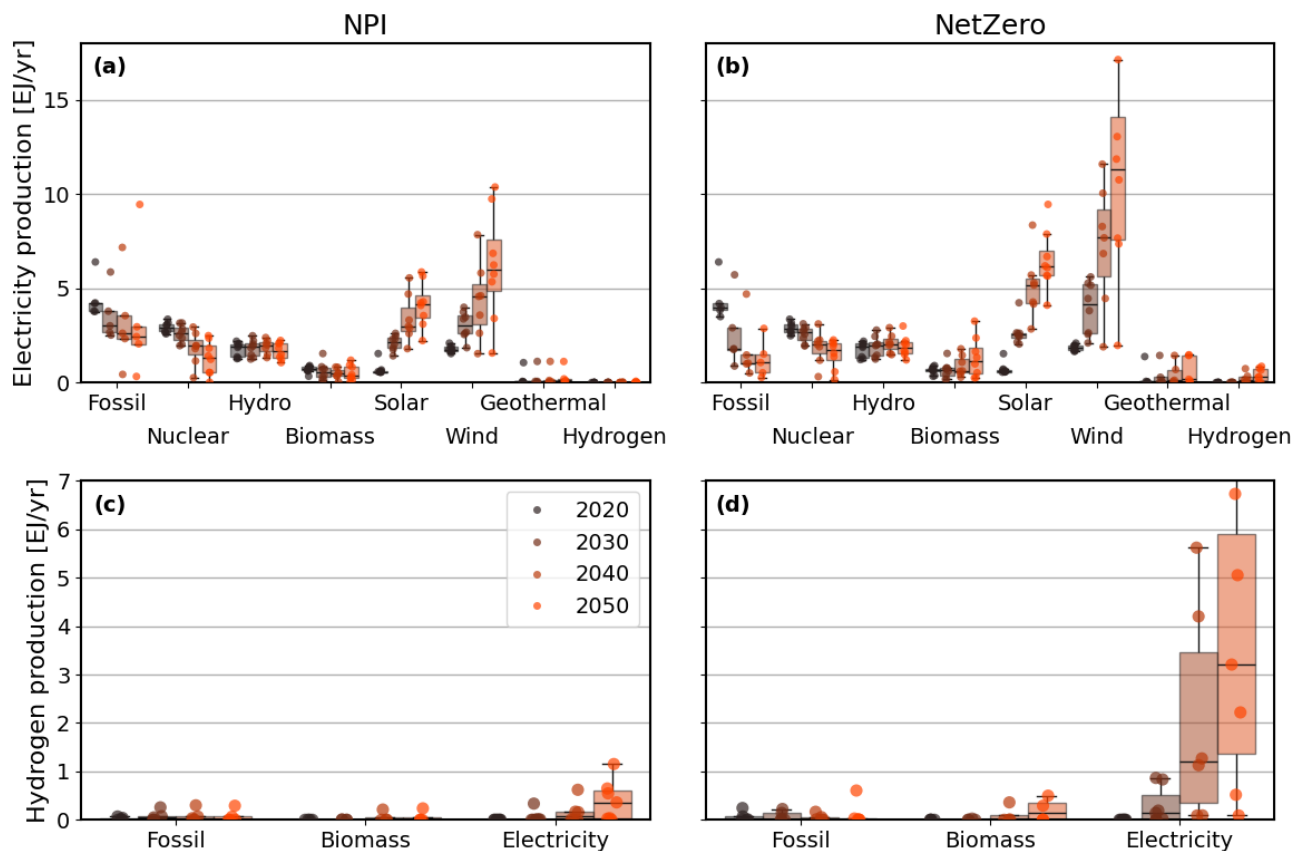


Supplementary Figure 2. Modelled hydrogen supply and demand composition across models in 2050 under NetZero (a,b) and NPI (c,d) Stacked bar charts show hydrogen supply (a,c) and demand (b,d) by model, with models ordered by total hydrogen supply. Supply is disaggregated into Green, Blue, Grey, and Imports; demand is disaggregated into Transport, Industry, Buildings, Bunkers, Electricity, Synfuels, Direct uses, and Losses. Bars are in EJ yr⁻¹ (left axis), and the right axis shows equivalent Mth₂ yr⁻¹ (LHV conversion). NPI, National Policies Implemented; NetZero, net-zero greenhouse gas emissions in Europe by 2050; CCS, carbon capture and storage.

Supplementary Note 3 Supply side

Supplementary Figure 3 highlights the centrality of electrified pathways in future hydrogen supply and electricity generation. Across all models and scenarios, hydrogen derives overwhelmingly from electrolysis, with wind and solar energy forming the twin pillars of power generation. The NetZero trajectory unleashes a rapid doubling of electrolytic hydrogen each decade (Supplementary Figure 3d), which drives median electricity-based hydrogen production from near zero in 2020 to some 4 EJ yr⁻¹ by 2050, with model upper

bounds exceeding 7 EJ yr^{-1} . This uptake rate translates into an annual increase of roughly 8% in green hydrogen production. This expansion underscores the imperative for accelerated domestic build-out of electrolyzers, synchronous growth in renewable capacity, or substantial hydrogen imports to Europe^{1,2}. Yet, the widening interquartile ranges reflect divergent model assumptions regarding technology learning, resource availability and system integration.



Supplementary Figure 3. Evolution of electricity and hydrogen supply by source across models and scenarios. Dots show model outputs at decadal intervals from 2020 to 2050, coloured by year (see legend). Boxplots indicate the interquartile range (IQR); whiskers extend to $1.5 \times \text{IQR}$, with outliers shown individually. Panels: (a) electricity production under NPI; (b) electricity production under NetZero; (c) hydrogen production under the NPI scenario; (d) hydrogen production under the NetZero scenario. NPI, National Policies Implemented; IQR, interquartile range.

In contrast, under the NPI scenario, total hydrogen output remains negligible (Supplementary Figure 3-c): fossil- and biomass-based routes together remain below 0.1 EJ yr^{-1} to 2050, while low-carbon, electricity-based hydrogen barely reaches 0.4 EJ yr^{-1} (median).

Biomass-derived hydrogen appears in several models at low volumes (Supplementary Figure 3d), though its categorisation as ‘green’ or ‘blue’, when coupled with CCS, remains unclear. The European Commission instead employs the term ‘renewable hydrogen’, which

encompasses hydrogen produced via water electrolysis powered by renewable electricity, as well as from biogas reforming or the biochemical conversion of biomass³.

Electricity generation is mostly decarbonised through the expansion of wind and solar energy (Supplementary Figure 3). Under NetZero (Supplementary Figure 3-b), solar energy surges to 6 EJ yr⁻¹ (median) and wind energy to 12 EJ yr⁻¹, compressing fossil generation to ~1 EJ yr⁻¹ and stabilising nuclear around 2 EJ yr⁻¹. Electricity generation under NPI shows less decarbonisation: fossil-fired output falls from ~4 to ~2 EJ yr⁻¹ by 2050, while solar and wind energy incrementally expand to medians of ~4 and ~6 EJ yr⁻¹, respectively; nuclear and hydro stay flat and biomass-to-power remains subordinate. The broad spread of solar and wind boxplots reflects significant uncertainty arising from modelling assumptions such as investment costs, capacity factors, spatial potentials, and member-state policies.

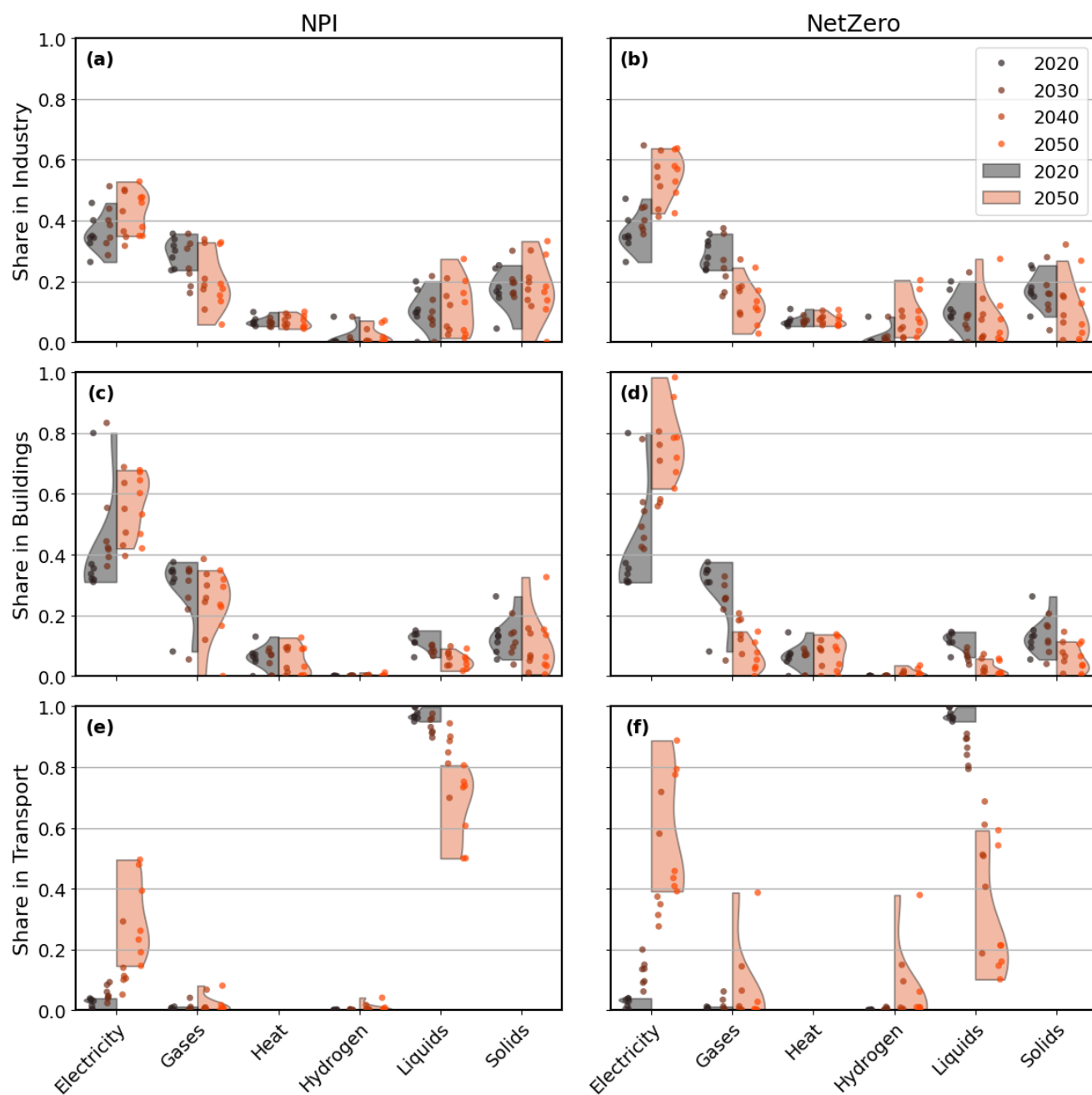
Supplementary Note 4 Demand side

Supplementary Figure 4 provides a detailed view of both the distribution and trajectory of energy mix in final demand sectors. The overarching story echoes the supply-side shifts of Supplementary Figure 3: electricity's role in final demand swells in every sector, yet the magnitude and pace of change vary markedly.

In industry (Supplementary Figure 4a,b) electricity's share expands noticeably by 2050, yet the breadth of model outcomes underscores persistent uncertainty in electrification investment costs, electricity price, and storage and flexible industry potential. Under NetZero, green hydrogen climbs from virtually zero to 5-20% of FEC by 2050, mirroring the roll-out of electrolyzers and renewables surge that we observed in Supplementary Figure 3. Under NPI, hydrogen remains below a few percent.

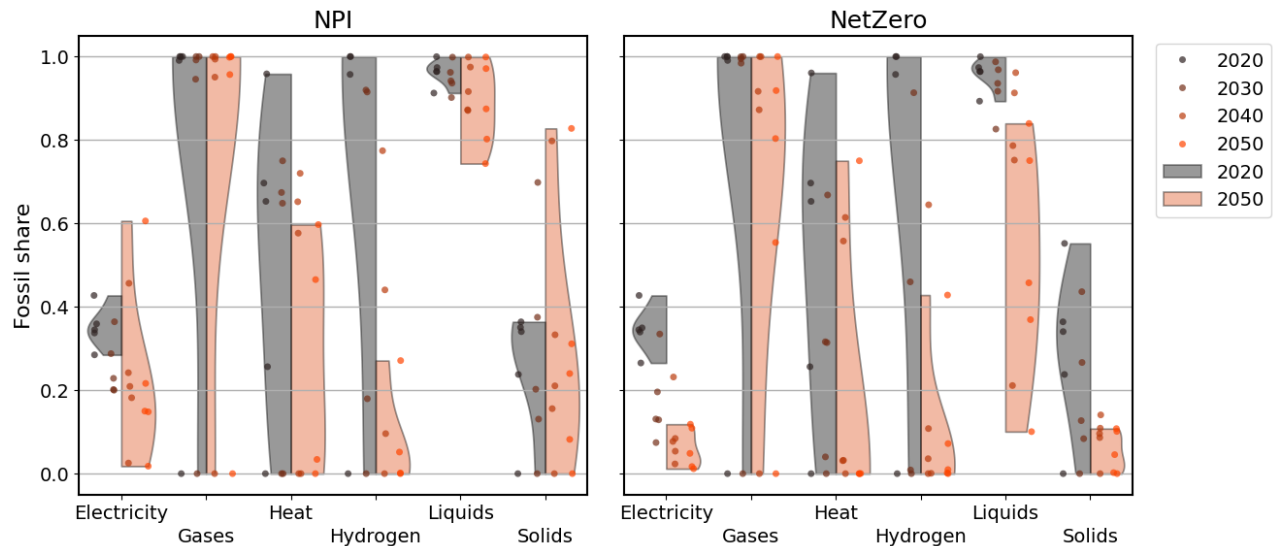
Buildings exhibit tighter consensus (Supplementary Figure 4c,d). Models agree that electricity will grow from around one-third of final demand in 2020 to approximately 60% by 2050 under NPI, and further to near 80% under NetZero. The steeper rise in the NetZero case drives a commensurate drop in gaseous fuels, whereas solids and hydrogen remain negligible.

Transport (Supplementary Figure 4e,f) exhibits the most significant variability. Liquid fuels shrink from nearly 95% today to under 50% by mid-century in the NetZero pathway, reflecting both fossil phase-out and substitution with advanced biofuels and power-to-liquids (Supplementary Figure 5). Electrification accelerates nonlinearly, most sharply between 2030 and 2040, before tapering, while hydrogen remains a niche option, barely reaching 5% in a few models.



Supplementary Figure 4. Evolution of final energy carrier shares across sectors and scenarios. Shares of energy carriers in major FEC sectors are displayed by scenario and year. Violin plots (augmented by decadal scatter points for 2020, 2030, 2040 and 2050) illuminate both the central tendencies and the spread of model projections under the NPI and NetZero scenarios. Panels show: (a, b) energy carrier shares in industry for the NPI and NetZero scenarios, respectively; (c, d) energy carrier shares in buildings for NPI and NetZero; and (e, f) energy carrier shares in transport for NPI and NetZero. FEC, final energy consumption; NPI, National Policies Implemented; NetZero, net-zero greenhouse gas emissions in Europe by 2050.

Supplementary Note 5 Fossil share in secondary energy carriers



Supplementary Figure 5. Evolution of fossil shares across carriers and scenarios. Shares of fossil fuels in energy carriers are displayed by scenario and year. Violin plots (augmented by decadal scatter points for 2020, 2030, 2040 and 2050) illuminate both the central tendencies and the spread of model projections under the NPI and NetZero scenarios. NPI, National Policies Implemented; NetZero, net-zero greenhouse gas emissions in Europe by 2050.

Supplementary Note 6 CO₂ emission envelope by final-energy sector (quadratic fit)

Across the three sectoral panels of Supplementary Figure 6, the uncertainty envelopes reflect the distinct decarbonisation dynamics of Buildings, Industry, and Transport, driven by differences in electrification potential and the role of hydrogen across sectors. Together they decompose the aggregate transition documented in Fig 5, where the NetZero electricity share spans 45-65% and hydrogen remains below 9% in 2050 at the total final energy level.

In Buildings (Supplementary Figure 6, top row), electrification is the dominant and early decarbonisation lever, consistent with the aggregate finding in Fig 5 that electricity carries the initial decarbonisation burden. The electricity share under NetZero rises from a median of 46% in 2030 to 64% in 2040 (+18 percentage points), with hydrogen remaining negligible (0-2% in 2040, 0-3% in 2050). TIAM-ECN consistently occupies the high-electrification extreme, reaching 80-93% by 2040-2050. Hydrogen adoption in buildings is minimal across

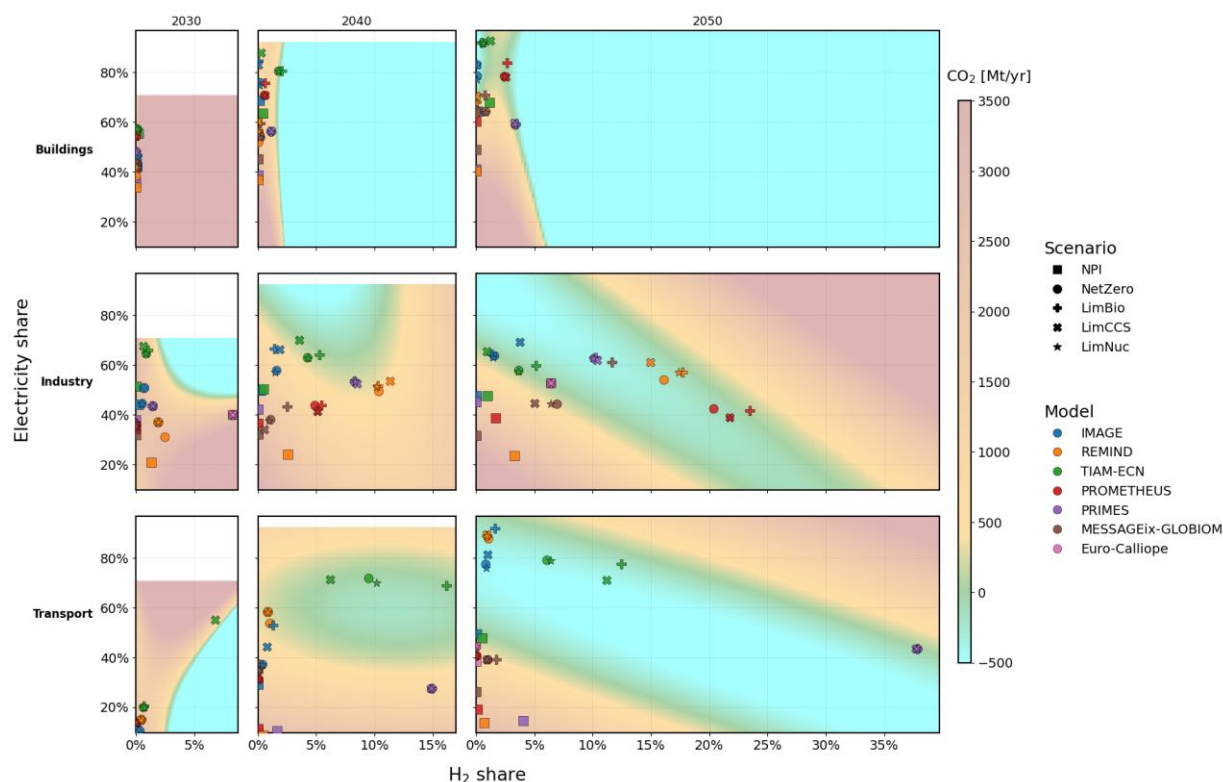
all models and scenarios, confirming that direct electrification (e.g., heat pumps) is the primary pathway for this sector.

In Industry (Supplementary Figure 6, middle row), hydrogen plays a structurally larger role than in Buildings, and its contribution grows over time. This sector is the primary driver of the post-2040 hydrogen acceleration observed at the aggregate level in Fig 5. Under NetZero, the hydrogen share spans 1-8% in 2030, widening to 1-10% by 2040 and 2-20% by 2050, with a median of 7% in 2050. Electrification is more constrained here, plateauing at a median of approximately 54% in 2050, reflecting hard-to-electrify industrial processes. The highest hydrogen shares (up to 24%) appear in PROMETHEUS under LimBio in 2050, flagging hydrogen as a biomass substitute for industrial and transport uses in this model. Industry thus displays the clearest evidence of the two-step transition described for Fig 5: electrification carries the initial burden, followed by increasing hydrogen penetration as first-mover electrification opportunities are exhausted.

In Transport (Supplementary Figure 6, bottom row), the transition is the most heterogeneous across models. Electricity shares are low in 2030 (NetZero median 14%, range 6–20%) but surge between 2030 and 2040 (median +23 percentage points, the largest sectoral increase in Supplementary Figure 6), reaching 36% by 2040, which contributes substantially to the sharp aggregate electricity rise seen in Fig 5 over the same period. Hydrogen in transport is generally modest (median 1% in 2050 under NetZero), but PRIMES projects an extreme value of 38% hydrogen share in 2050 under NetZero, driven by hydrogen uptake in heavy-duty and shipping segments. This single model substantially widens the upper bound of the sector's hydrogen uncertainty envelope in Supplementary Figure 6 and partly underlies the PRIMES outlier behaviour noted in Fig 5.

By 2040 (Supplementary Figure 6, middle column), the NPI-NetZero separation in electricity share is sharpest in Transport, where the NPI range (5-29%) and NetZero range (28-72%) barely overlap (1.7 percentage points), compared to Industry (12 pp overlap) and Buildings (17 pp overlap). This confirms Transport electrification as the strongest early sectoral discriminator between mitigation and reference pathways, underpinning the aggregate 45% electrification threshold identified in Fig 5. Across all sectors of Supplementary Figure 6, hydrogen adoption remains largely a post-2040 phenomenon under NetZero, consistent with its role in decarbonising residual hard-to-abate processes rather than leading the

transition.

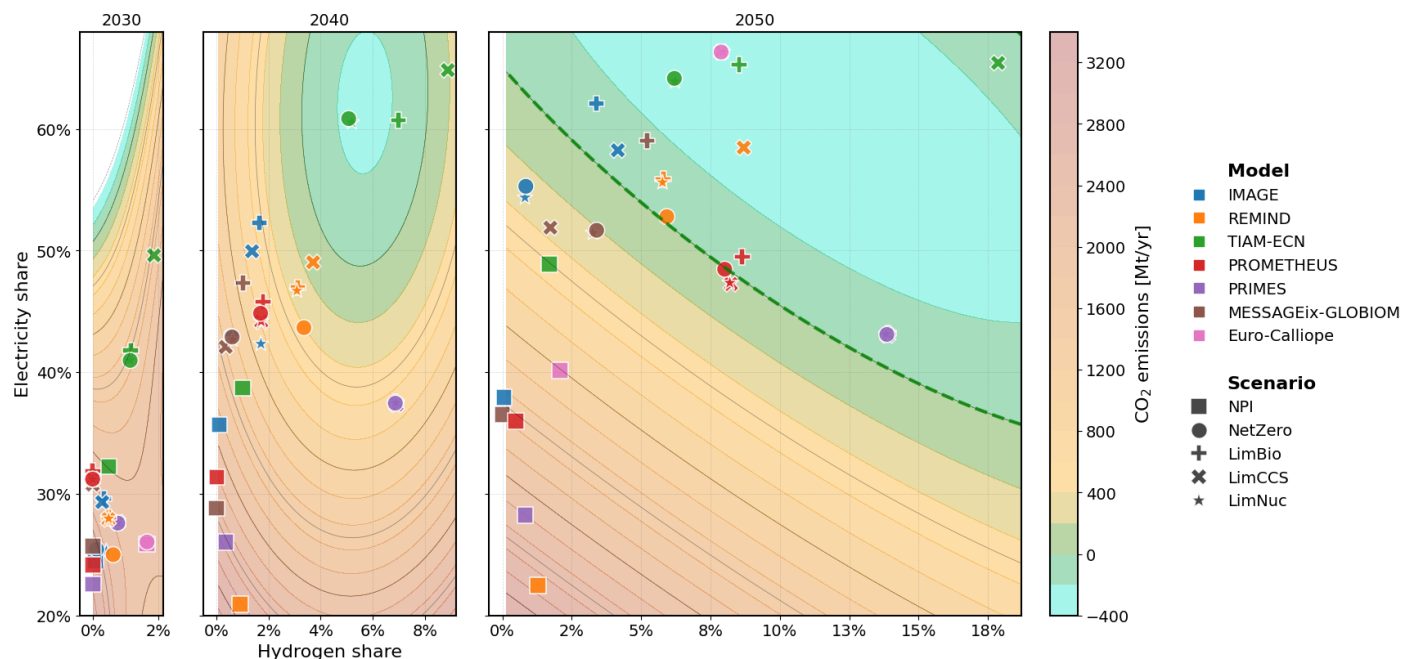


Supplementary Figure 6. Envelope of CO₂ emissions and electricity/hydrogen shares in sectoral FEC. Scatter plots show the association between CO₂ emission levels and the shares of electricity and hydrogen in sectoral FEC for Buildings (top row), Industry (middle row), and Transport (bottom row), in 2030 (left column), 2040 (middle column), and 2050 (right column). Each point represents an individual scenario, with colours indicating models and marker shapes indicating scenarios (see legend). The background shading shows a smooth quadratic fitted emission surface (regression-based), used to highlight the underlying pattern in the data. Colours range from net-negative emissions (cyan), to near-zero emissions (green), to higher emissions (dark orange/brown), as indicated by the colour bar. CO₂, carbon dioxide; FEC, final energy consumption.

Supplementary Note 7 The net-zero frontier of the CO₂ emission envelope

The net-zero emissions frontier (dashed green line, Supplementary Figure 7, 2050) demarcates the boundary between combinations of electricity and hydrogen shares that are sufficient to achieve carbon neutrality and those that are not. Combinations lying above or to the right of this frontier correspond to net-negative or near-zero CO₂ emissions, while those below and to the left remain above zero. This frontier illustrates that net-zero is not uniquely determined by a single decarbonisation pathway: multiple combinations of electrification and hydrogen penetration can, in principle, achieve the same emissions outcome. The frontier is crossed by a substantial number of model–scenario combinations in 2050, confirming that net-zero is technically achievable across a diverse range of pathways. However, most NetZero-variant data points cluster near or just above the frontier, with median electricity shares around 55% and median hydrogen shares around

8% across the NetZero scenario variants. Only two model-scenario combinations exceed a 9% hydrogen share in 2050: PRIMES under NetZero and TIAM-ECN under LimCCS, suggesting that high hydrogen penetration, while feasible, represents a less common decarbonisation pathway among the models assessed.



Supplementary Figure 7. Envelope of CO₂ emissions and electricity/hydrogen shares in FEC with quadratic fit. Scatter plots show the association between CO₂ emission levels and the shares of electricity and hydrogen in FEC for the years 2030 (left), 2040 (middle), and 2050 (right). Each point represents an individual scenario, colour-coded by model (see legend). The background shading shows a smooth quadratic fitted emission surface (regression-based), used to highlight the underlying pattern in the data. Colours range from net-negative emissions (cyan), to near-zero emissions (green), to higher emissions (dark orange/brown), as indicated by the colour bar. The dashed green line in the 2050 panel marks the net-zero emissions frontier (fitted CO₂ = 0 Mt yr⁻¹), separating combinations of electricity and hydrogen shares associated with net-negative emissions (above/right) from those with residual positive emissions (below/left). CO₂, carbon dioxide; FEC, final energy consumption.

Supplementary Note 8 Survey of participating models

To support interpretation of cross-model similarities and divergences, we report the full results of the model survey covering key structural characteristics and assumptions of the participating models. The survey documents differences in model scope (e.g., regional versus global), modelling paradigm (e.g., optimisation, simulation, or equilibrium), temporal and sectoral resolution, foresight, and the treatment of hydrogen demand, infrastructure, and trade. This information is provided to improve transparency and to

contextualise divergent outcomes observed in the Results and Discussion, rather than to enable direct quantitative attribution of individual results to specific modelling choices. Given the fundamental differences in model design and system definition, the survey is intended as a qualitative interpretative aid for the ensemble comparison.

Supplementary Table 1. Summary of model characteristics and key assumptions.

The table reports the results of a structured survey completed by the participating modelling teams in 2024, documenting model scope, spatial and temporal resolution, sectoral coverage, modelling paradigm (e.g., optimisation, simulation, or equilibrium), planning foresight, and the representation of hydrogen demand, infrastructure, and trade. The information is provided to support qualitative interpretation of cross-model differences and commonalities in the ensemble results. As models continue to evolve, some characteristics reported here may have changed since the survey was conducted due to ongoing model development.

Model	MEESA 1.1	PROMETHEUS	IMAGE 3.3	MESSAGEix-GLOBIOM 1.1	TIAM-ECN 1.2	Euro-Calliope	REMIND 3.3.2	PRIMES
What option describes your modelling approach best?	Investment and/or operation optimisation (i.e., process based)	Market simulation	Integrated assessment simulation model	Investment and/or operation optimisation (i.e., process based)	Investment and/or operation optimisation (i.e., process based)	Investment and/or operation optimisation (i.e., process based)	hybrid: energy supply system is investment with perfect foresight, coupled to a mix of investment/market simulation model with recursive dynamic formulation	Investment and/or operation optimisation (i.e., process based)
What is the geographical scope of your model?	Europe (e.g., EU27 & UK & EEA)	Global	Global	Global	Global	Europe (e.g., EU27 & UK & EEA)	Global	Europe (e.g., EU27 & UK & EEA)
What is the spatial resolution of your model concerning the EU region?	Multiple-country (~1-4 EU countries in each model region)	EU divided in 2-3 subregions	EU divided in 2-3 subregions	EU divided in 2-3 subregions	EU divided in 2-3 subregions	Country level	Multiple-country (~1-4 EU countries in each model region)	Country level
How is planning foresight treated in your model?	Perfect foresight	Myopic foresight (short sighted)	Myopic foresight (short sighted)	Perfect foresight	Perfect foresight	Snapshot analysis (e.g., one year at a time)	Perfect foresight	Perfect foresight
What time intervals are considered in the model horizon? (Please tick all that apply)	2- to 5-yearly;	Yearly;	Yearly;	2- to 5-yearly; 10-yearly and/or longer;	2- to 5-yearly;	No intervals (one-year and/or snapshot analysis);	2- to 5-yearly;	2- to 5-yearly
What planning/modelling horizon is used in your analysis?	~2050 (mid century)	~2050 (mid century)	~2100 (full century)	~2100 (full century)	~2100 (full century)	~2050 (mid century)	~2100 (full century)	~2050 (mid century)

How is the sub-annual temporal resolution represented in your model?	Seasonal and intra-day time slices	Yearly (No sub-annual time slices)	for power sector modelling: 12 months, each with 13 time slices	Yearly (No sub-annual time slices)	Seasonal and intra-day time slices	Chronological multi-hourly	Yearly (No sub-annual time slices)	Seasonal and intra-day time slices
Does your model represent different temporal resolutions for electricity and hydrogen?	No	No	Yes	No	No	No	No	Yes
How is the sub-annual temporal resolution of electricity balance represented in your model?			for power sector modelling: 12 months, each with 13 time slices					Seasonal and intra-day time slices
How is the sub-annual temporal resolution of hydrogen balance represented in your model?			Yearly (No sub-annual time slices)					Seasonal and intra-day time slices
If you answered "Representative time slices" or "Other" in questions 11, 13, and 14, please explain further for each question. For example, the method of sampling/clustering and/or the length of t...			for power sector modelling: 12 months, each with 13 time slices					
Is the weather uncertainty in multiple years included in your model parameters?	No	No	No	Yes	No	Yes	Not relevant	Yes
Which of the following demand and supply-side sectors are included in your model? Please choose all that apply.	Power (supply sector; Heat supply (including district heating/cooling); Renewable-based fuels and derivatives (e.g., green hydrogen);	Buildings; Fossil fuel supply and conversion; Industry sector; Feedstocks of the industry sector; Renewable-based fuels and derivatives (e.g., green hydrogen); Trans	Buildings; Fossil fuel supply and conversion; Industry sector; Feedstocks of the industry sector; Renewable-based fuels and derivatives (e.g., green hydrogen); Trans	Buildings; Fossil fuel supply and conversion; Industry sector; Feedstocks of the industry sector; Renewable-based fuels and	Buildings; Fossil fuel supply and conversion; Industry sector; Feedstocks of the industry sector; Renewable-based fuels and derivatives (e.g., green hydrogen); Synthetic fuels with renewable	Fossil fuel supply and conversion; Industry sector; Feedstocks of the industry sector; Renewable-based fuels and derivatives	Buildings; Fossil fuel supply and conversion; Industry sector; Feedstocks of the industry sector; Renewable-based fuels and derivatives (e.g., green hydrogen); Synth	Buildings; Fossil fuel supply and conversion; Industry sector; Feedstocks of the industry sector; Renewable-based fuels and derivatives (e.g., green hydrogen); Synth

		port sector;Aviation and navigation sectors;Power (supply) sector;Heat supply (including district heating/cooling) ;	port sector;Aviation and navigation sectors;Power (supply) sector;Heat supply (including district heating/cooling) ;	derivatives (e.g., green hydrogen);Tra nsport sector;Aviatio n and navigation sectors;Power (supply) sector;Heat supply (including district heating/cooling);	origin;Transport sector;Aviation and navigation sectors;Power (supply) sector;Heat supply (including district heating/cooling);	(e.g., green hydrogen);Syn thetic fuels with renewable origin;Transpo rt sector;Aviatio n and navigation sectors;Heat supply (including district heating/cooling);Power (supply) sector;Buildin gs;	etic fuels with renewable origin;Transport sector;Aviation and navigation sectors;Power (supply) sector;Heat supply (including district heating/cooling) ;	etic fuels with renewable origin;Transport sector;Aviation and navigation sectors;Power (supply) sector;Heat supply (including district heating/cooling)
How is hydrogen demand represented in your model?	Exogenous: Static demand (no response to supply cost)	Endogenous demand	Endogenous demand	Endogenous demand	Endogenous demand	Exogenous: Static demand (no response to supply cost)	Endogenous demand	Endogenous demand
Which hydrogen supply sources for Europe are represented in your model? Please choose all that apply.	Electrolysis;	Biomass gasification;Natu ral gas reforming (steam methane reforming);Elect rolysis;Import/su pply with an exogenous price/cost;	Natural gas reforming (steam methane reforming);Biom ass gasification;Elect rolysis;Import with endogenous price;coal, oil;	Natural gas reforming (steam methane reforming);Bio mass gasification;El ectrolysis;Imp ort with endogenous price;Hydroge n from coal gasification with and without CCS;	Natural gas reforming (steam methane reforming);Biomass gasification;Electrolysis;Ammonia cracking;	Natural gas reforming (steam methane reforming);Bio mass gasification;El ectrolysis;Imp ort with endogenous price;Import/s upply with an exogenous price/cost;	Natural gas reforming (steam methane reforming);Biom ass gasification;Elect rolysis;Import/su pply with an exogenous price/cost;	Ammonia cracking;Electrolysis;Import/supply with an exogenous price/cost
In case you selected "Other" in the last question, please list other hydrogen supply sources in your model.			coal, oil	Hydrogen from coal gasification with and without CCS				
Do you use hydrogen demand proxies? Please briefly explain your method.		No		No.				

Is your model able to report hydrogen price?	Yes, endogenous	Yes, endogenous	Yes, endogenous	Yes, endogenous	Yes, endogenous	Yes, endogenous	Yes, endogenous	Yes, endogenous
Do you include any assumption on hydrogen supply for Europe in your model?	No	No	Yes	No	Yes	Yes	Yes	Yes
Please briefly explain/list these assumptions.			We have a hydrogen demand threshold in place for moving from small scale on-site hydrogen production to large scale hydrogen production		minimum 150 PJ domestic green hydrogen production from 2030 onwards	Self-sufficient Europe. No trades outside Europe unless otherwise specified.	We assume all new hydrogen demand to be for low-carbon hydrogen, thus we forbid any investment into coal/gas-based H2 without CCS. criteria for we constrain - minimum 2GW, maximum 20GW electrolyzer capacity globally in 2020 - maximum of 0.1 EJ global hydrogen production from biomass w/o CCS - maximum of 0.1 EJ global hydrogen production from biomass w/ CCS	We apply the additionality principle according to the EU legislation for ensuring that green hydrogen meets the criteria for RFNBO
Which hydrogen demand options for Europe are represented in your model? Please choose all that apply.	Electricity generation (e.g., SOFC, CCGT);	Fuel for Transport (e.g., cars, trucks);Basic metal production (e.g., steel production with direct reduction);Mix with the natural gas;Chemical production (e.g., hydrogen fueled steam crackers);Electricity generation (e.g., SOFC, CCGT);Conversion to Gases (e.g., syngas);Conversion to heat (e.g.,	Mix with the natural gas;Fuel for Transport (e.g., cars, trucks);Conversion to heat (e.g., hydrogen boilers);Basic metal production (e.g., steel production with direct reduction);Electricity generation (e.g., SOFC, CCGT);Export with endogenous price;For feedstock/chemicals we do	Mix with the natural gas;Fuel for Transport (e.g., cars, trucks);Conversion to heat (e.g., hydrogen boilers);Electricity generation (e.g., SOFC, CCGT);Export with endogenous price;	Mix with the natural gas;Fuel for Transport (e.g., cars, trucks);Conversion to Liquids (e.g., methanol, biofuels);Conversion to Gases (e.g., syngas);Ammonia/fertilizer production;Electricity generation (e.g., SOFC, CCGT);	Fuel for Transport (e.g., cars, trucks);Conversion to Liquids (e.g., methanol, biofuels);Conversion to heat (e.g., syngas);Conversion to heat (e.g., hydrogen boilers);Industrial feedstock;Electricity generation (e.g., SOFC, CCGT);Export/demand with	Fuel for Transport (e.g., cars, trucks);Conversion to Liquids (e.g., methanol, biofuels);Conversion to Gases (e.g., syngas);Conversion to heat (e.g., hydrogen boilers);Basic metal production (e.g., steel production with direct reduction);Industrial feedstock;Electricity generation	Mix with the natural gas;Fuel for Transport (e.g., cars, trucks);Conversion to Liquids (e.g., methanol, biofuels);Conversion to heat (e.g., hydrogen boilers);Ammonia/fertilizer production;Basic metal production (e.g., steel production with direct reduction);Chemical production (e.g., hydrogen fueled steam

	hydrogen boilers);	include hydrogen as an option, but this hydrogen is produced on site within this specific sector;			an exogenous price/cost;	(e.g., SOFC, CCGT);Chemical production (e.g., hydrogen fueled steam (e.g., SOFC, crackers);Ammo nia/fertilizer production;	crackers);Industri al feedstock;Electri city generation (e.g., SOFC, CCGT);Export/de mand with an exogenous price/cost;Conve rsion to Gases (e.g., syngas)	
In case you selected "Other" in the last question, please list other hydrogen demand sources in your model.	Total demand from industry, transport and other sectors. In case of electricity generation the demand is endogenous.	For feedstock/chemi cals we do include hydrogen as an option, but this hydrogen is produced on site within this specific sector				H2 demand from industry other than steel (so Ammonia, chemical production, ...) are represented as one aggregate demand.		
Do you use hydrogen demand proxies? Please briefly explain your method. 2	Typically we use the demand based on CGE model results plus endogenous demand in the power sector.	no	No	No			in Industry (besides steel, which is process- based), all final energies (including hydrogen) are input to a CES function, thus the demand is price- responsive.	
Do you include any assumption on hydrogen demand for Europe in your model?	No	No	No	Yes	No	Yes	No	Yes
Please briefly explain/list these assumptions. 2				In electrification scenarios, we assume a minimum share of electricity, which can be a limit for other energy carriers like hydrogen.		Static demand	Assumptions related to policies that EU- MS has, for example plans of specific steel industries to shift from blast furnaces to DRI.	

Which hydrogen storage options for Europe are represented in your model? Please choose all that apply.	High pressure tank storage;	Underground storage (e.g., salt caverns);Liquefied hydrogen storage (e.g., cryogenic storage);	Underground storage (e.g., salt caverns);	Generic hydrogen storage;	None;	High pressure tank storage;Underground storage (e.g., salt caverns);	none explicitly;	High pressure tank storage
In case you selected "Other" in the last question, please list other hydrogen storage options in your model.				We assume a certain share of investment in T&D for storage. As we don't have sub-annual time slices in the model, we don't explicitly represent hydrogen storage.			Gas storages are not explicitly represented in REMIND, neither for CH4 nor for H2. The costs are included in the general transport & distribution costs for both energy carriers.	
Do you use hydrogen storage proxies? Please briefly explain your method.			We assume that 5% of the hydrogen produced requires storage	Yes, as a % of T&D investment and O&M cost.				
How hydrogen infrastructure of Europe is represented in your model? Please choose all that apply.	Not modeled;	Distribution pipelines;Liquefied hydrogen vessels;Pressurized tanks on trailers;	Cross-border pipelines;Distribution pipelines;We assume distribution costs within a region and transport costs between regions depending on the distance between regions;	Copperplate (single pipeline connecting all supply to all demand);Mixed in the natural gas infrastructure; Distribution pipelines;Cross-border pipelines;Liquefied hydrogen vessels;	Not modeled;	Not modeled;	Not modeled;	Cross-border pipelines;Mixed in the natural gas infrastructure
In case you selected "Other" in the last question, please list other hydrogen infrastructure options in your model.			We assume distribution costs within a region and transport costs between regions depending on the distance between regions. No physical infrastructure					

	modelling is done, just costs						
Do you use hydrogen infrastructure proxies? Please briefly explain your method.				No			REMIND needs to build a generalized transport and distribution network, with costs 3x those of CH4 t&d costs
Textbox				In the model version used in ECEMF, we don't represent hydrogen to gas/liquid routes, hydrogen demand for ammonia, or chemical processes. In more recent versions of the model, these technologies are represented.			

Supplementary References

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2. Shirizadeh, B. et al. Towards a resilient and cost-competitive clean hydrogen economy: the future is green. *Energy Environ. Sci.* 16, 6094–6109 (2023).
3. European Commission. A hydrogen strategy for a climate-neutral Europe. COM(2020) 301 final (2020). https://energy.ec.europa.eu/system/files/2020-07/hydrogen_strategy_0.pdf.