Study launch

Breaking free from fossil gas

A new path to a climate-neutral Europe

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Climate neutrality means an end to the burning of fossil fuels. A new Agora Energiewende project is modelling a robust fossil gas phase-out pathway for the EU

Scope and basic settings	"Deep dives"
→ Decarbonisation pathways until 2050, with Russian gas phase out as quickly as possible (by 2027). → Focus on long-lasting demand reductions, as opposed to short-term behavioural changes. → Cost-optimised balance between direct electrification and "no-regret" applications of hydrogen. → Modelled sectors in 5-year steps: power, buildings, industry + infrastructure including interconnectors and storage (transport and agriculture sectors covered by existing studies). → Consultants: Artelys (power & energy supply), Wuppertal Institute (industry), TEP Energy (buildings).	The EU-27 modelling work was accompanied by "deep dives" in 9 focus countries with 1 partner per country: • **Bulgaria:** Center for the Study of Democracy (CSD) • **Czechia:** Nano Energies • **Greece:** FACETS S.A. • **Croatia:** University of Zagreb – Faculty of Mechanical Engineering and Navel Architecture) • **Hungary:** Regional Centre for Energy Policy Research (REKK) • **Italy:** ECCO Climate • **Poland:** Forum Energii • **Romania:** Energy Policy Group (EPG) • **Slovenia:** University of Ljubjana – Laboratory of Energy Policy (LEST)

Key messages

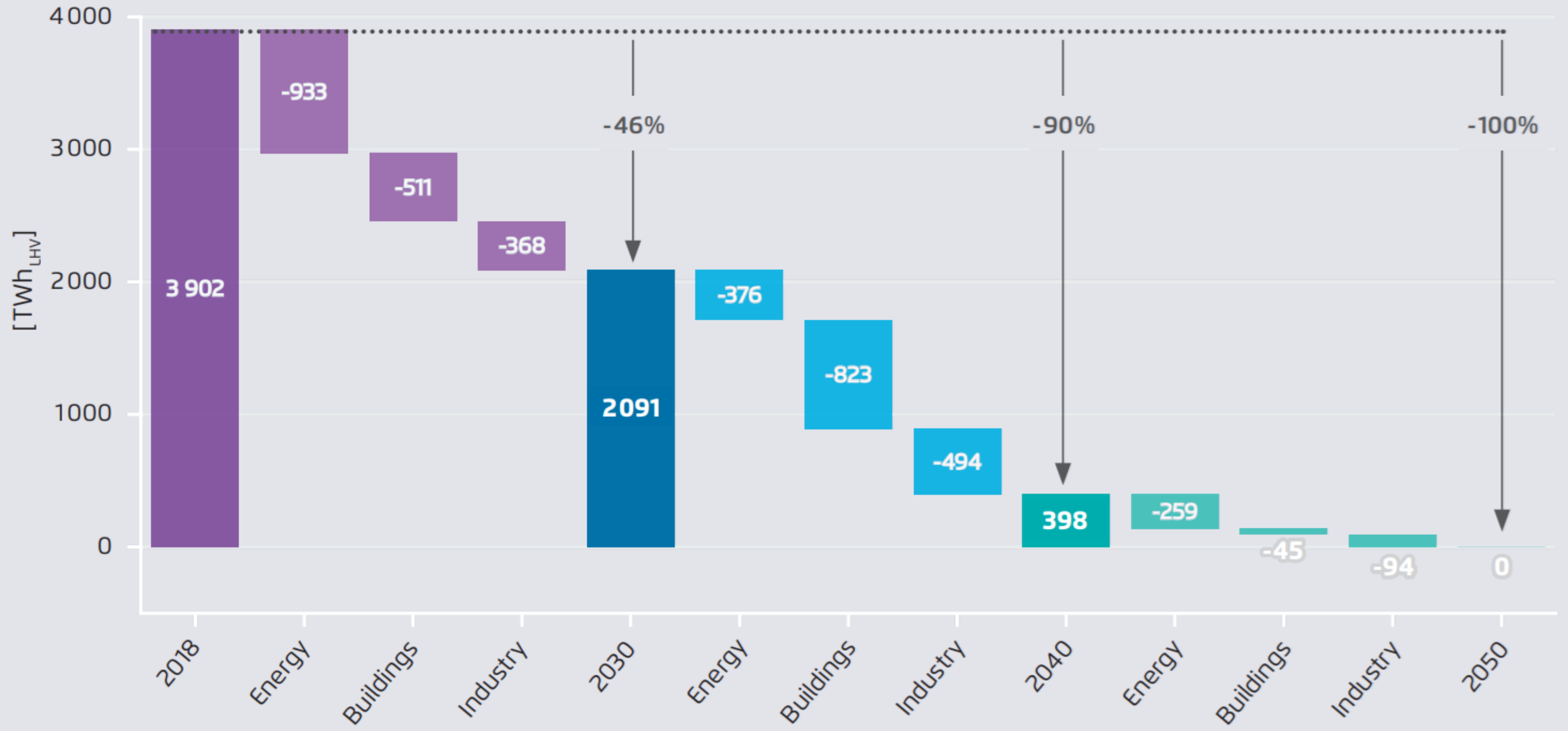
1	Fossil gas use in Europe can be halved by 2030 and completely phased out by 2050. This is possible while maintaining today's level of industrial production and fully ensuring security of supply, without disruptive behavioural changes.
2	By 2040, EU greenhouse gas emissions could decline by 89% relative to 1990 levels, with a projected remaining Union greenhouse gas budget for the 2030-2050 period of 14.3 Gt.
3	Europe will need a significant amount of renewable hydrogen to become climate neutral, but the demand by 2030 could be only a fifth of that foreseen in REPowerEU.
4	EU rules on gas, hydrogen, and infrastructure planning must reflect the projected rapid decline in fossil gas demand.

EU Gas Exit Pathway

Scope
Approach
Main Results

Fossil gas use in Europe can be halved by 2030 and completely phased out of the EU energy system by 2050 without disruptive behavioral changes or short-term demand destruction in industry, while fully ensuring security of supply

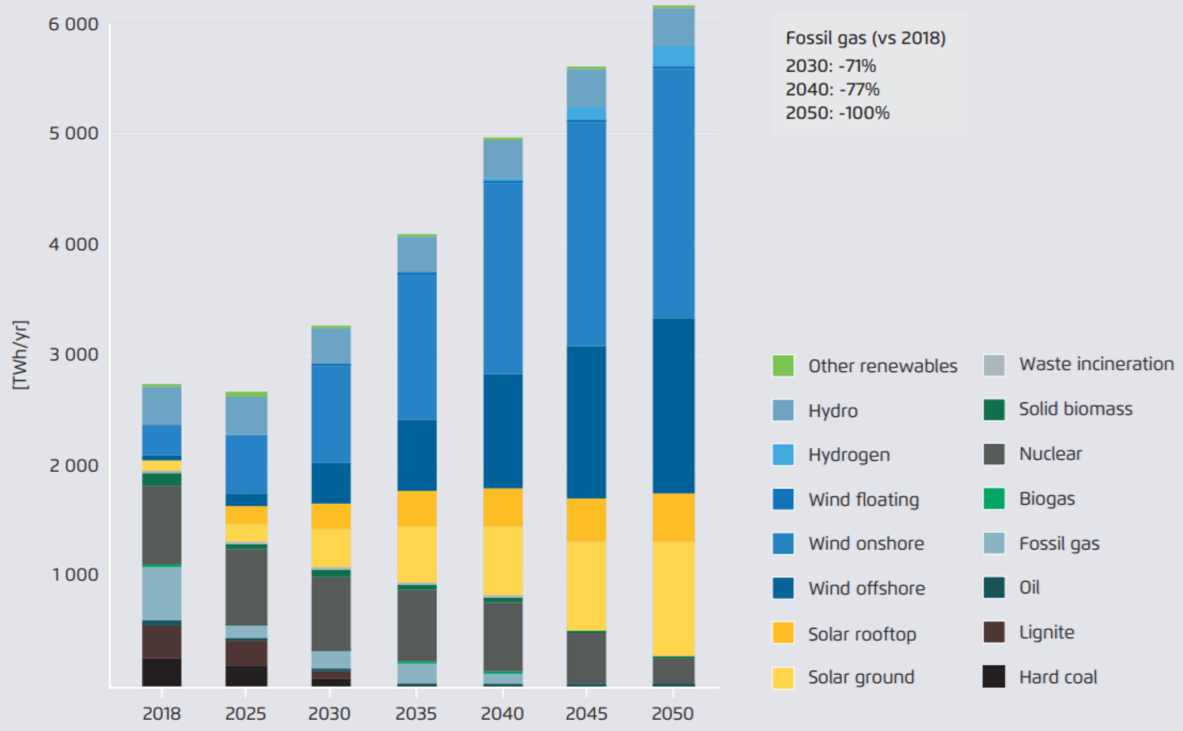
Evolution of total fossil gas consumption in the EU-27, 2018-2050 (in TWh_{LHV})



Artelys, TEP Energy, Wuppertal Institute modelling (2023)

The energy sector, in particular the power sector, is quickest to reduce its consumption of fossil gas, which is largely displaced by wind and solar

Net electricity generation in the EU Gas Exit Pathway

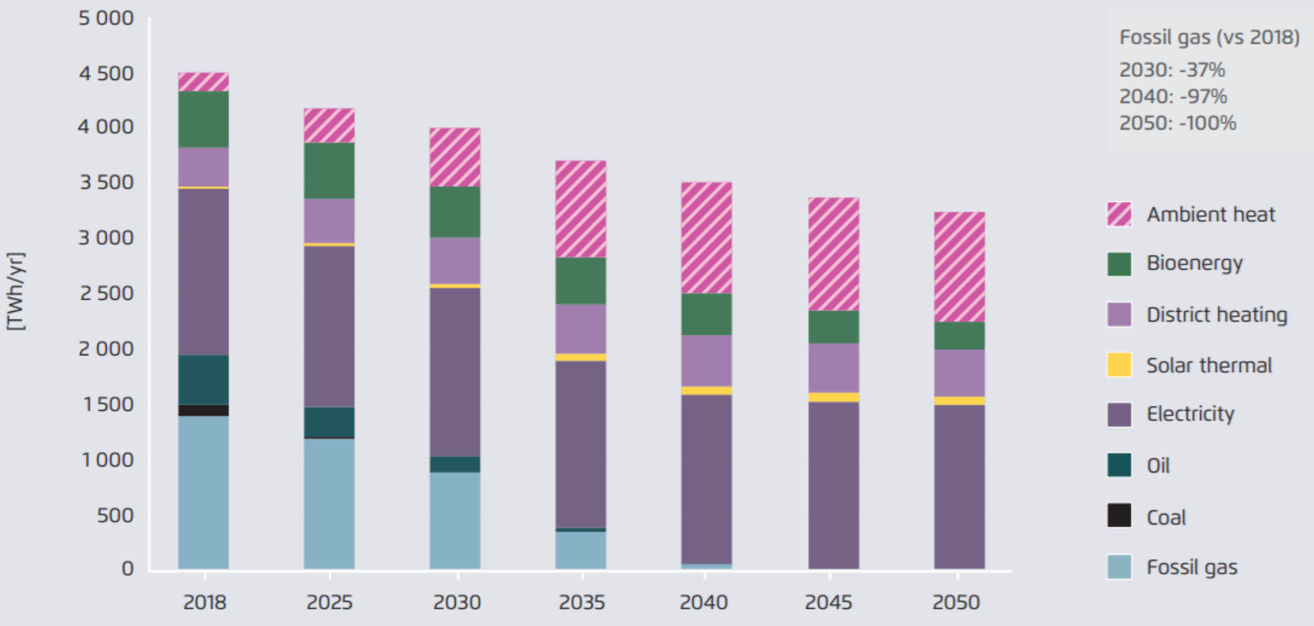


Artelys, TEP Energy, Wuppertal Institute modelling (2023)

- -60% demand by 2030, -83% by 2040 in the energy sector. -71% and -77% in the power sector respectively.
- Wind and solar installed capacity is multiplied by 4 between 2018 and 2030, consistent with REPowerEU. Renewable power makes up 70% of the mix in 2030 and 85% in 2040.
- Oil, coal and lignite power generation steadily decline to be phased out by 2035.
- Phase-in of domestic renewable hydrogen production in 2030, replacing hydrogen from SMR. Hydrogen plays a role in the power sector starting 2035.
- Power demand increases by 22% to 3 240 TWh in 2030 and by a further 48% to 4 800 TWh by 2040, largely due to electrification of transport, buildings and industry + growing renewable-hydrogen production after 2030.
- Refineries close-down by 2040 due to the electrification of transport.

Buildings are nearly fossil gas-free by 2040. Efficiency, heat pumps & decarbonised district heating are the key levers for achieving a fossil free building stock.

Final energy consumption in the buildings sector

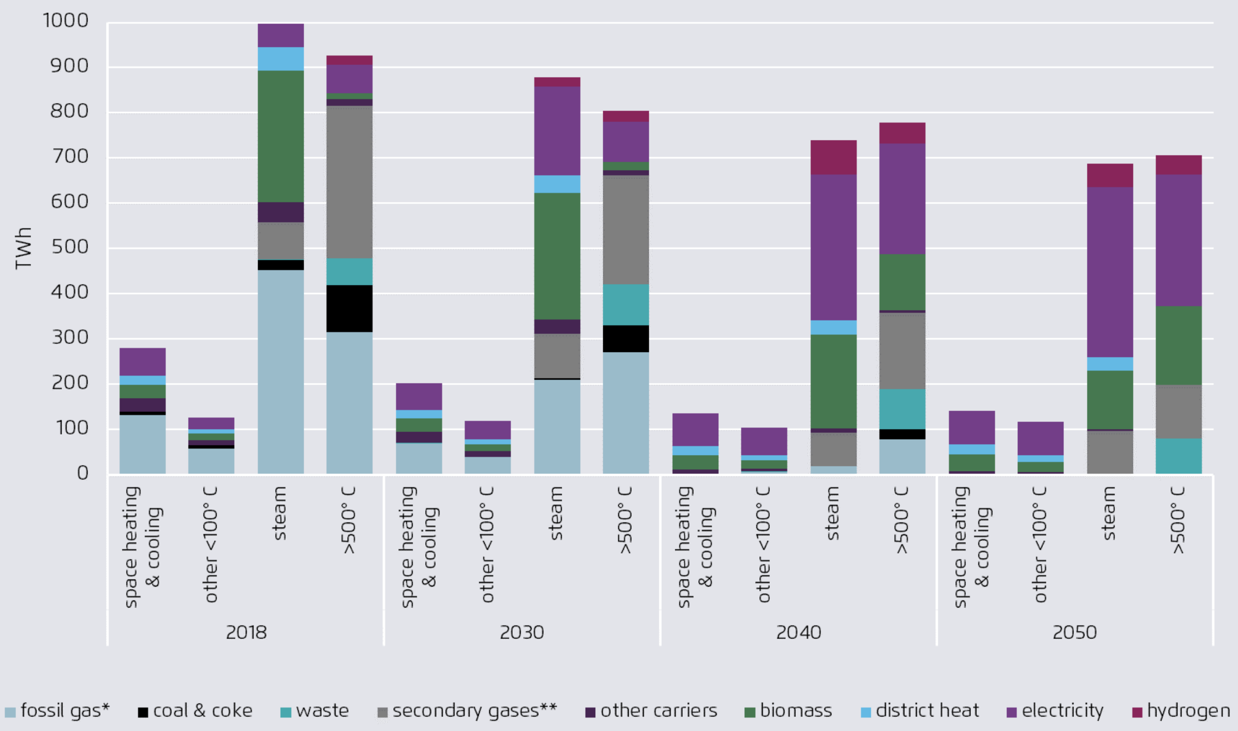


Artelys, TEP Energy, Wuppertal Institute modelling (2023)

- → -37% demand by 2030, -97% by 2040.
- → Efficiency: Final energy demand substantially reduced from 2018 to 2040 due to efficiency improvements (appliances & buildings) & replacement of older appliances through more efficient technologies.
- → Air-source and ground-source heat pumps are key technological lever.
- → District heating: floor area served rises by more than 2/3 between 2020 and 2030 (+68% vs 2020 levels) and more than doubles by 2040 (+107%) but energy consumption only increases by 17% until 2030 and 33% by 2040 thanks to efficiency improvements.
- → Other direct renewable heat sources, notably solar thermal and the continued use of bioenergy (though slightly lower) allow for additional gas displacement.

Fossil gas demand reductions in industry are mostly driven by direct electrification and efficiency increases, complemented by renewable H2 and BECCS later on

Final energy demand by temperature level (in TWH)

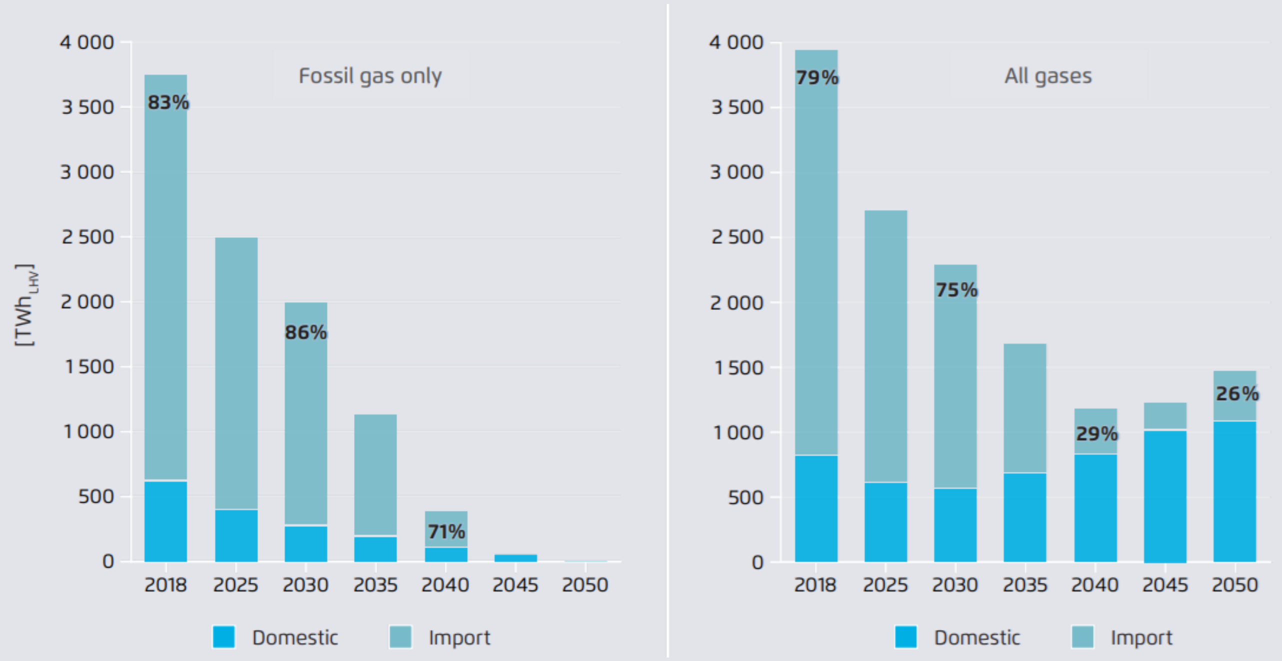


Artelys et al. modelling (2023) *fossil gas includes natural gas, refinery gas and LPG **secondary gases include coke oven gas, blast furnace gas, basic oxygen furnace gas and steam cracker by-products

- → -38% demand by 2030, -90% by 2040.
- → Many industrial processes are electrified: heat pumps and electric boilers, sometimes combined with the use of waste heat, especially in the low- to medium-temperature segments until 2030.
- → CHPs partly phased down already by 2030; Industrial buildings are better isolated.
- → In Southeast Europe, concentrated solar power (CSP) will produce steam for the chemical sector, increasing significantly from 2030 to 2040.
- → Biomass+CCS in some high-temperature processes (e.g. minerals and steel), as well as renewable hydrogen for some applications and feedstock use.
- → Material circularity including higher shares of secondary raw materials

Europe significantly reduces its currently high dependency on fossil gas imports, relying more on domestic resources by 2050

EU gas supply by source and import dependency in the EU Gas Exit Pathway

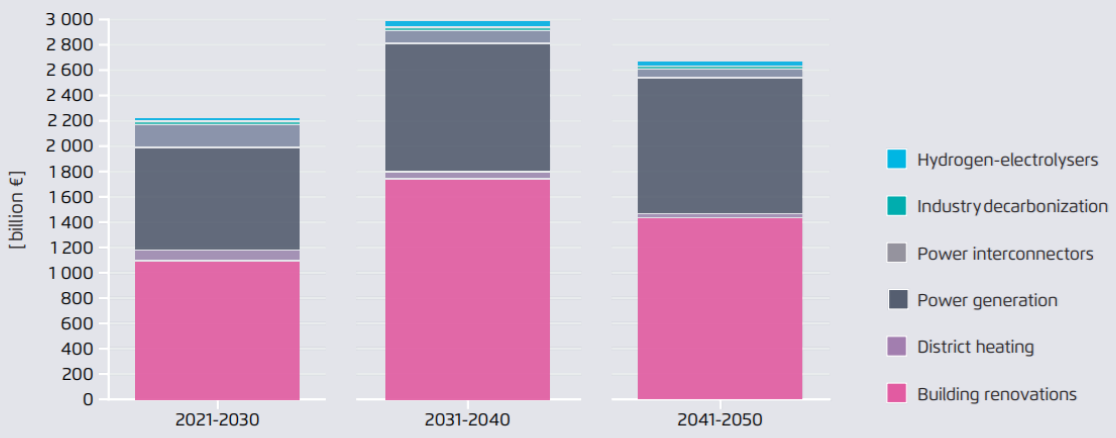


Agora Energiewende based on Artelys, TEP Energy, Wuppertal Institute modelling (2023)

- → Energy import dependency declines quickly from 79% today to 29% in 2040 (all gases) due to a combination of lower fossil-gas imports and mainly domestic hydrogen production.
- → Energy import dependency declines further to 22% in 2045, before increasing again to 32% in 2050 as imports of hydrogen and hydrogen-derivatives increase.
- → These outcomes are despite the assumption that biogas & biomethane production remains constant until 2045 before even declining in 2050.

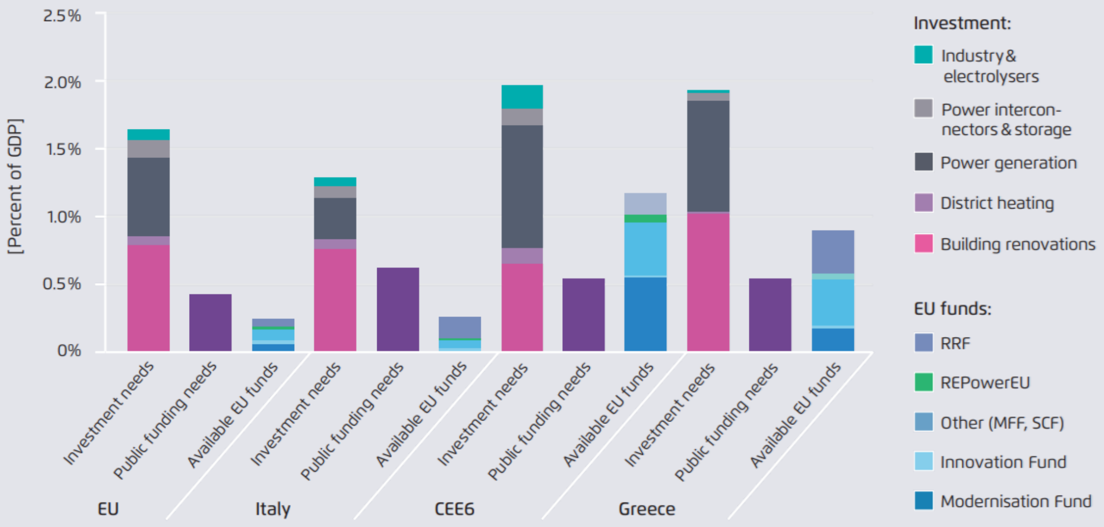
Investment needs for the sector transitions are large and grow after 2040. EU funds available before 2030 offer a solid starting point to close existing investment gaps if well prioritized.

Cumulative investment per 10-year period



Artelys, TEP Energy, Wuppertal Institute modelling (2023)

Annual average investment needs and EU funding in 2021-2030 in different regions

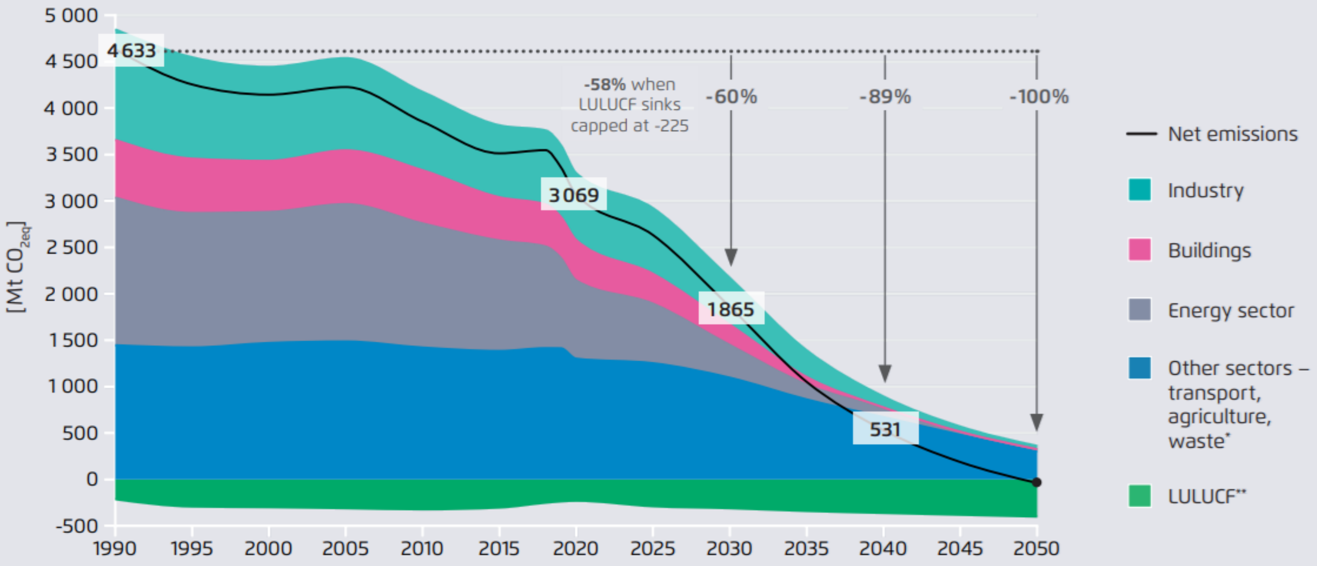


Agora Energiewende based on Artelys et al. modelling (2023), EU Commission EU funding programmes and REPowerEU plan

Implications for EU climate and energy policy

The EU's ambition for the 2040 greenhouse gas reduction target should be set at around -90%, based on 1990 levels.

GHG emissions by sector – EU27 in Mt CO2eq



Eurostat; Artelys et al. modelling (2023)
* Based on scenarios by Transport & Environment (Transport) and the European Commission (Agriculture & Waste)
** Based on the LULUCF+ scenario from the EC Climate Target Plan impact assessment (assumes a 5-year delay)

→ The Commission must propose an EU 2040 GHG-target latest 6 months after the first Global Stocktake under the Paris Agreement at COP28 in Dubai (30.11 - 12.12.2023).

→ Accelerated GHG reductions can be achieved with the right investments starting today: net-GHG emissions reductions of -60% by 2030, -89% by 2040 and -100% by 2050.

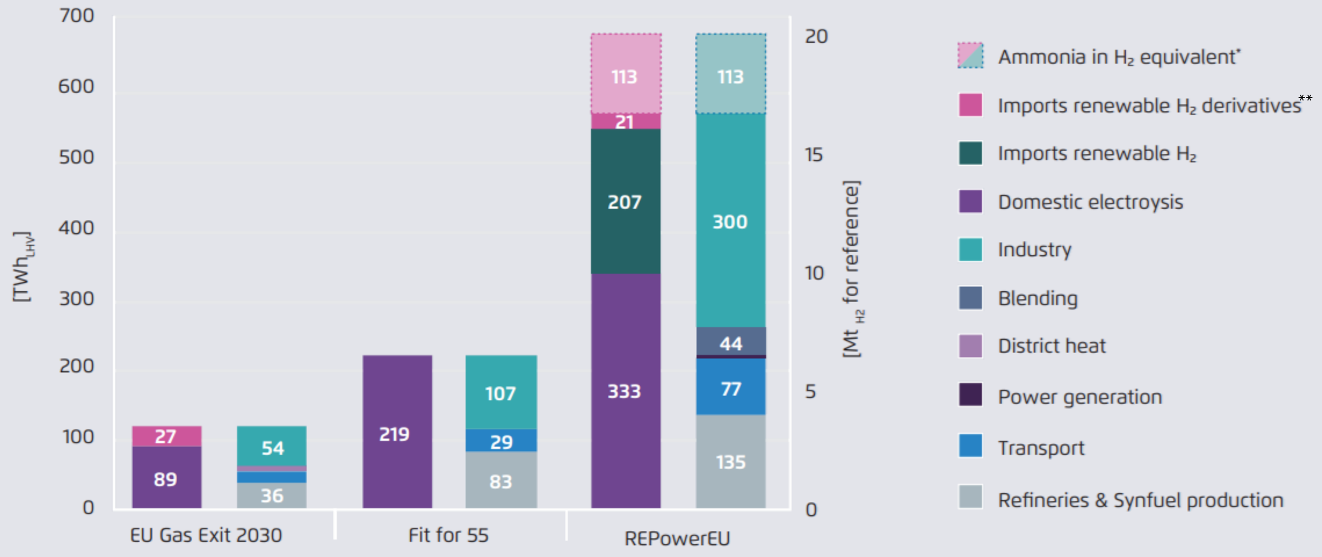
→ A target of -90% by 2040 would avoid 3.3 Gt more GHG emissions than projected in the EU's 2020 Climate Target Plan.

→ Transport, agriculture, waste and LULUCF covered by existing studies by Transport & Environment and the European Commision: Additional efforts in these sectors could achieve further reductions by 2040.

→ Broadly speaking the last 10% of residual emissions will be the hardest to mitigate.

Demand for renewable hydrogen and derivatives in the EU Gas Exit pathway is a fifth of the foreseen demand in REPowerEU in 2030.

Supply by source and sectoral demand for renewable hydrogen and derivatives



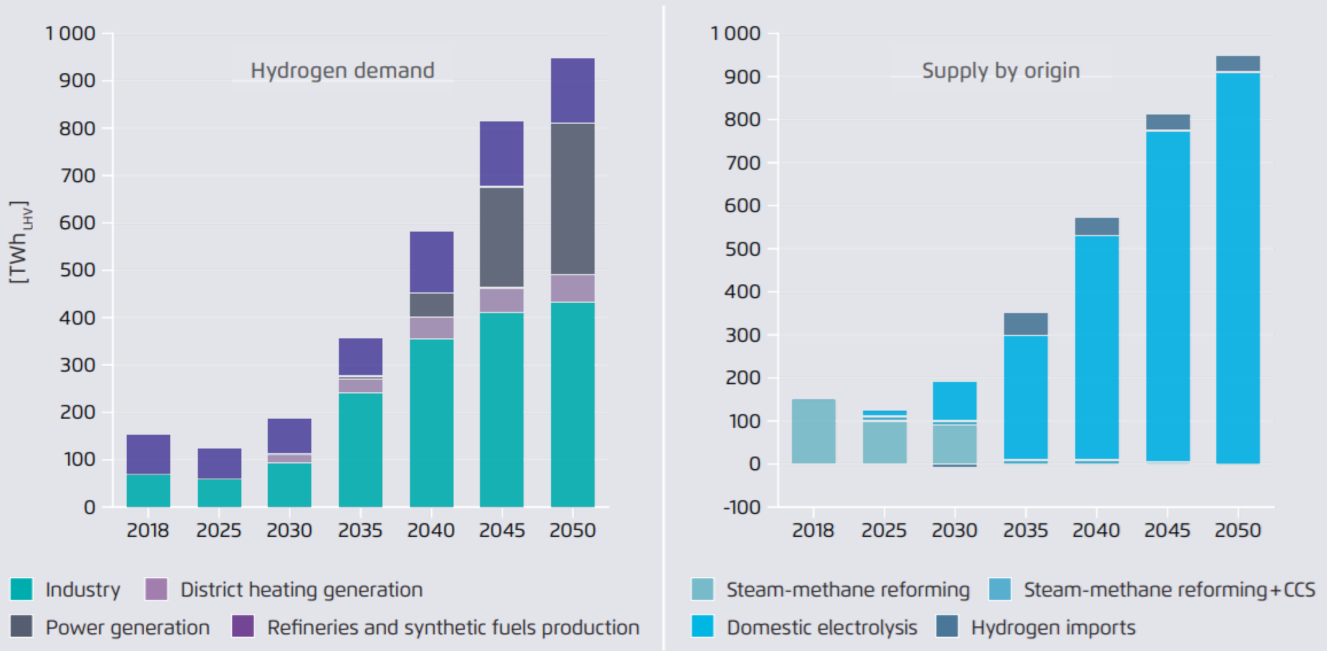
Artelys et al. modelling (2023). Commission staff working document accompanying the REPowerEU plan (2022). Assuming the 20 Mt hydrogen and derivatives in the REPowerEU plan are all renewable.

- → When cost-optimised, hydrogen and its derivatives are first used in the historical sectors, i.e. industry and refineries to displace their fossil equivalent as it can be observed in the EU Gas Exit Pathway. Some synthetic fuels are also imported for the transport sector.
- → The REPowerEU plan foresees a significant scale up of demand in industry, but also roughly half of the final hydrogen demand is consumed in lower-priority applications, including road or rail transport (77 TWh, 32%) and blending for consumption in the building sector (44 TWh, 18%), leading to a strong reliance on imports.
- → In the short to medium term, the use of limited renewables generation for indirect electrification stands in direct competition with its more efficient use for direct electrification.

* Ammonia has a lower calorific value than H2. The REPowerEU plan seems to have used the same conversion rate for ammonia as for H2 for its calculations in Mt.
** Derivatives include ammonia and synthetic fuels.

Though the volume will increase, hydrogen demand will remain concentrated in industry for cost and efficiency reasons and can largely be supplied domestically.

Hydrogen demand by sector and supply by origin

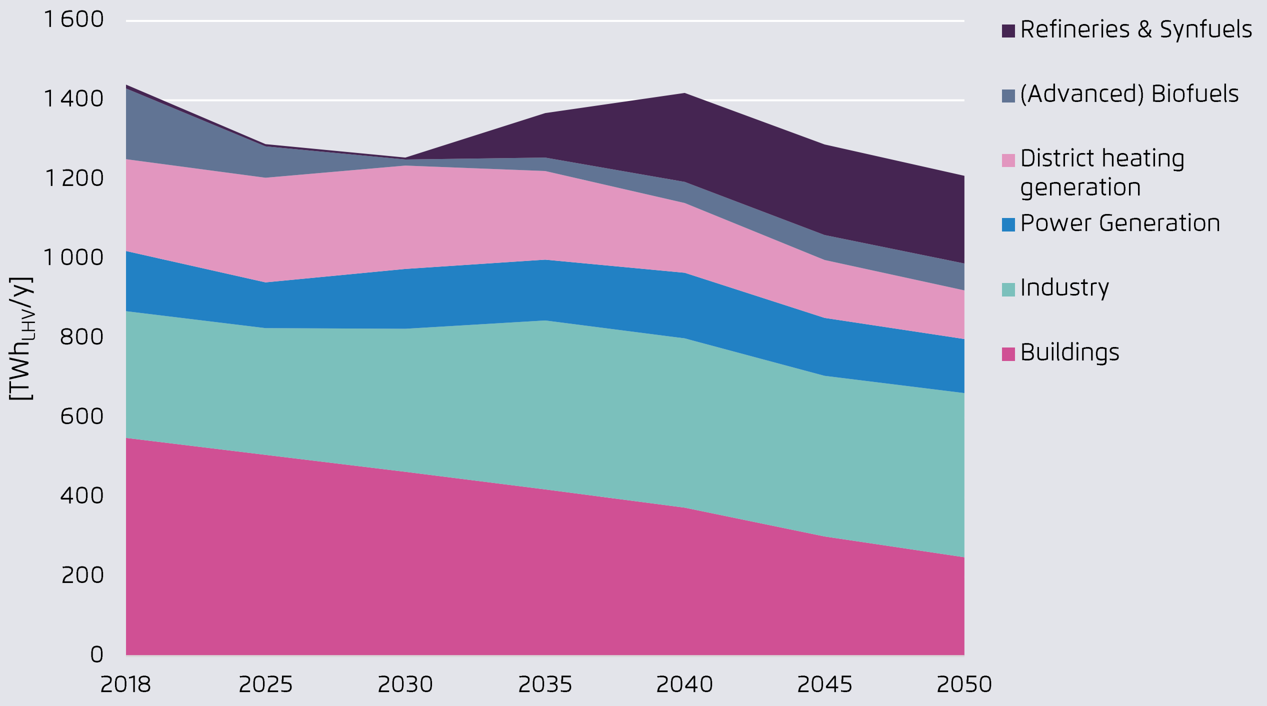


Artelys, TEP Energy, Wuppertal Institute modelling (2023)

- Until 2030, current fossil hydrogen is replaced by domestic renewable hydrogen in the industry and refineries, displacing fossil gas demand. New applications are started to be phased in in the industry, the scale up really taking place after 2030.
- The amount of imported renewable hydrogen could be further reduced by importing intermediate goods produced with renewable hydrogen instead of the renewable hydrogen itself, for example through the direct importation of green iron for steel production.
- This ‘embodied hydrogen’ has the benefit of being much easier and cost-efficient to transport to and within Europe with existing infrastructure, as well as reduced risks in terms of security or hydrogen leakages over the supply chain.

Important debates on the sustainable potential of biomethane remain unresolved. The EU Gas Exit Pathway therefore takes a conservative approach to biogas & biomethane deployment and is not aligned with the EU‘s 35 bcm biomethane target.

Bioenergy consumption by sector in the Gas Exit Pathway



Artelys, TEP Energy and Wuppertal Institute modelling (2023)
Note: Including non-energy consumption of biomass feedstocks in chemicals and refineries, but excluding material uses

- In the Gas Exit Pathway, the use of biomass for bioenergy and non-energy feedstock purposes remains below todays levels as biomass consumption declines in the buildings and energy, and is prioritised for higher value applications over time.
- Sustainable production potentials for biomethane are hotly debated, with estimates ranging from 17.5 (171 TWh) – 41 bcm (400 TWh) in 2030 and 29 bcm (283 TWh) – 151 bcm (1 475 TWh) in 2050.
- Key concerns:
  - Expected reliance on energy and food crops leading to higher direct and indirect emissions
  - Competition for limited sustainable feedstocks with food, but also other bioenergy applications (e.g. biofuels)
  - Impact on economic and environmental cost
  - Methane emissions possibly underestimated

Key policy implications for the EU's gas related policy initiatives

(1) The EU should set its 2040 climate target in the order of 90% GHG reductions compared to 1990 levels.

(2) The EU should fundamentally revisit the EU gas and methane package as well the REPowerEU targets on hydrogen and biomethane.

(3) Governments and regulators should prepare for an accelerated decline in gas demand and thoroughly evaluate its impact on gas supply and distribution infrastructure.

(4) The sale of new fossil gas-burning equipment in buildings should end quickly.

(5) Member States should reflect the rapid phasing down of fossil gas demand when updating their National Energy and Climate Plans in 2023-24.

Key messages

1	Fossil gas use in Europe can be halved by 2030 and completely phased out by 2050. This is possible while maintaining today's level of industrial production and fully ensuring security of supply, without disruptive behavioural changes. The phase-out requires a fast ramping up of energy efficiency and renewable energy, as well as the electrification of applications in the buildings and industry sectors.
2	By 2040, EU greenhouse gas emissions could decline by 89% relative to 1990 levels, with a projected remaining Union greenhouse gas budget for the 2030-2050 period of 14.3 Gt. The sectoral transition pathways developed in this report show that based on latest technological progress, an EU greenhouse gas reduction target of -90% by 2040 is realistic. It would avoid 3.3 Gt more greenhouse gas emissions than projected in the EU's 2020 Climate Target Plan.
3	Europe will need a significant amount of renewable hydrogen to become climate neutral, but the demand by 2030 could be only a fifth of that foreseen in REPowerEU. By prioritising direct electrification and reserving its use for no-regret applications, the EU would need only 116 TWh of renewable hydrogen by 2030, compared to 666 TWh in REPowerEU. This is more cost-effective, more realistic from a security of supply perspective and consistent with the hydrogen sub-targets in the new Renewable Energy Directive. The REPowerEU target should thus be revised.
4	EU rules on gas, hydrogen, and infrastructure planning must reflect the projected rapid decline in fossil gas demand. (1) A new impact assessment is needed for the EU gas and methane package. (2) Governments should evaluate the impact of the decline in gas demand on gas supply and distribution infrastructure, and when updating their National Energy and Climate Plans. (3) The sale of new fossil gas-burning equipment in buildings should end quickly.

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