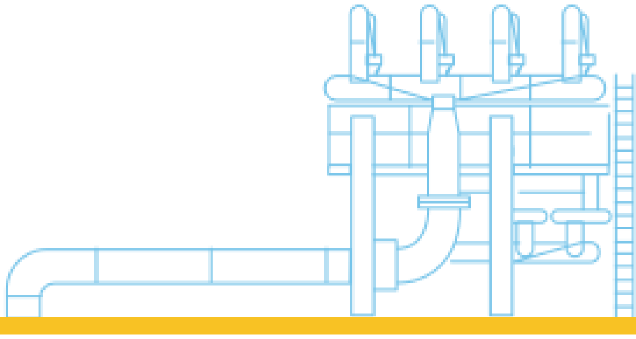
“H_2, CO_2 and CH_4 consultations: Future prospects” process

Presentation of NaTran and Teréga’s H_2, CO_2 and CH_4 scenarios



1. Framework of the consultation process

On 4 April 2025, NaTran and Teréga launched the H_2, CO_2 and CH_4 Consultations for all stakeholders in the hydrogen (H_2), carbon dioxide (CO_2) and methane (CH_4) markets. This document presents the scenarios, with a separate Excel table setting out the underlying figures.

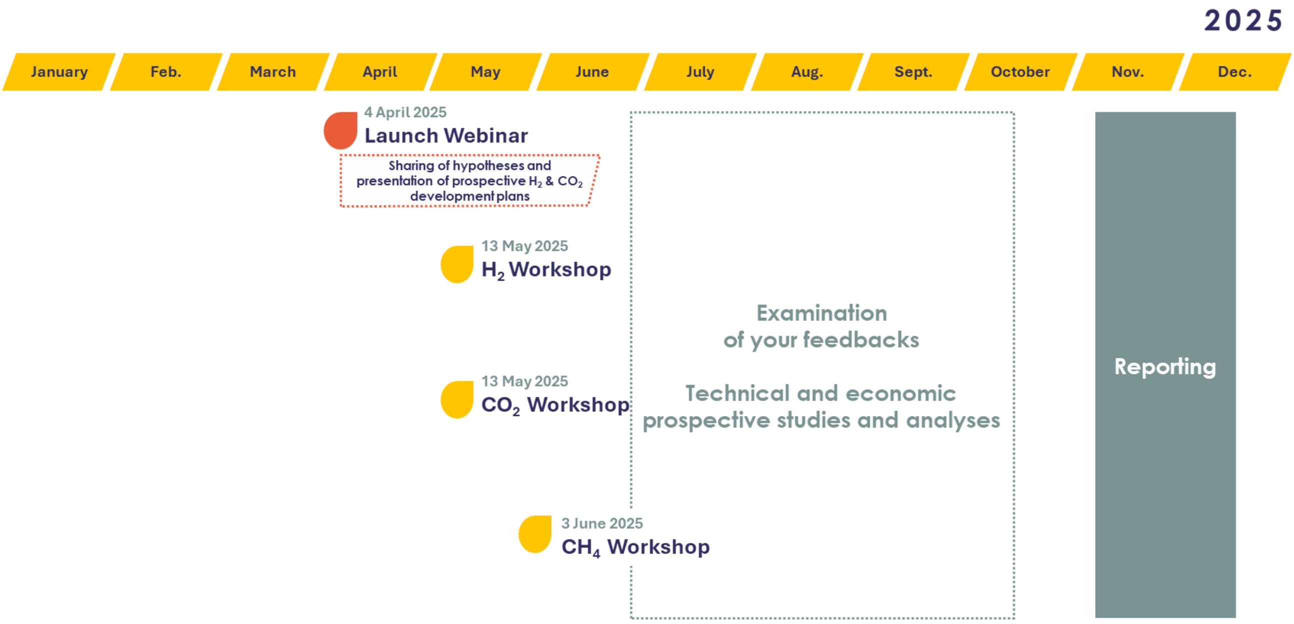
The fourth European Gas Package will make it a legal obligation to jointly construct multi-energy scenarios (hydrogen, electricity and methane) on a national scale, involving a wide-ranging consultation, and NaTran and Teréga are already preparing. The package, consisting of Regulation (EU) 2024/1789 and Directive (EU) 2024/1788, must be transposed into French law by August 2026.

Transmission system operators have an important role to play in ensuring cost-effective investment in hydrogen and methane networks. In order to optimise planning for all energy carriers and supplement the various national and EU approaches to network planning, additional requirements for coherent planning will be introduced. To ensure efficient infrastructure deployment and avoid assets being underused, network planning needs to take into account the increasingly close links between methane, electricity and hydrogen and, where relevant, district heating. Network planning must be transparent and allow for the stakeholders concerned to participate. To achieve this, operators will have to consult widely with the stakeholders concerned. NaTran and Teréga are already contributing to this at European level through the Ten Year Network Development Plan (TYNDP). Under this plan, the two operators are working with RTE to draw up scenarios that will be used to assess hydrogen, electricity and methane infrastructure needs.

NaTran and Teréga have decided to extend this approach by adding carbon dioxide to the mix in order to gain as complete and coherent a picture of transmission needs as possible.

This approach should enable NaTran and Teréga to continue to meet their legal obligations relating to methane, as set out in France’s Energy Code, while preparing for the new responsibilities arising from the fourth European Gas Package, which requires network planning based on broad, open, transparent consultation, involving all the players in the markets concerned, and particularly organisations representing all the stakeholders. This approach also involves working with stakeholders to develop a vision of a target scheme that will give them the visibility they need to agree contracts and decide on their decarbonisation choices over the medium term. All the discussions and work carried out as part of the H_2, CO_2 and CH_4 Consultations are intended to provide input for a number of exercises, including the H_2 and CO_2 development plans, the 2025 multi-year forecast (BPP) and the 2025 ten-year development plan (PDD), as well as analysing the operability of the networks, the commercial offer and the implications for the markets and providing visibility for the energy industry.

Following an initial phase of consultation and joint construction of scenarios for what will be needed up to 2035 throughout the second quarter of 2025, NaTran and Teréga will carry out the analyses required to prepare these various exercises.



2. Scenario presentation

Several scenarios have been developed covering evolutions in needs. The aim of the consultation is to make sure the range of scenarios covers all the uncertainties and developments the various stakeholders have in mind, and then to consolidate them based on contributions from the stakeholders consulted. The consultation will also help to identify the issues that stakeholders consider it important to analyse in order to input the information into these various exercises.

The aim of drawing up these scenarios is not to forecast or predict what might happen, but to shed light on the impact of the various uncertainties and possible developments.

The spectrum of multi-energy scenarios submitted for consultation is centred around national energy planning. In line with the preparations for the transposition of the fourth European Gas

Package, the sensitivity scenarios around the central "government" scenario (PP) are based largely on those put forward by the French gas transmission and distribution system operators in their *Gas Perspectives* documents and the scenarios drawn up by the electricity transmission system operator in its *Generation Adequacy Report*.

« Acceleration of decarbonisation efforts »

Strong ambition for hydrogen and CCU, as well as signification development of green gas

Central scenario

« Partial achievement of ET objectives, taking supply-demand balance uncertainties into account » sensitivity scenarios

More or less significant delays in implementing the energy transition in certain sectors, but also in the production mix, combined with uncertainties that raise questions about te suppy-demand balance

A

Scenario that has several fundamentals in common with the reference scenario in the French gas TSOs' and DSOs' Gas Perspectives documents and the references scenario in RTE's Generation Adequacy Report. Fit for 55 targets achieved

PP

Scenario constructed form the various elements provided by government bodies, including the PPE3 consultation documents

B

A delay of around 5 years compared with scenario A. Scenario based on the contingencies described in the Gas Perspectives and RTE's Generation Adequacy Report.Reduced and delayed ambitions for hydrogen and CCU, less marked drop in methane consumption than in the other scenarios.

A-Aléa prod

Scenario in which the transition of end uses is accelerated (final consumption from scenario A), combined with uncertainties in production that raise questions about the supply-demand balance.

The Central scenario (PP) is made up of the various elements provided by government bodies, including the consultation documents for the PPE-3 multi-year energy programme. As the PPE consultation documents do not contain all the sector-specific consumption targets for 2035, the missing figures were interpolated between the PPE-3 sector-specific figures for 2030 and the SNBC2 low-carbon strategy figures for 2050, calibrated to bring them into line with the PPE-3 targets set for 2035.

To allow for a reasonable range of uncertainty, NaTran and Teréga are submitting additional sensitivity scenarios around this central scenario for consultation.

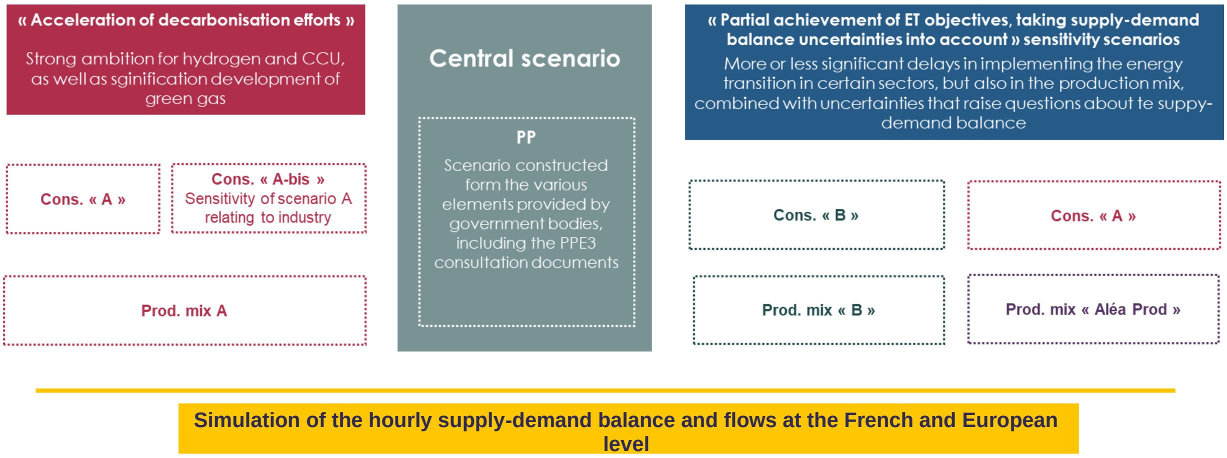
Scenario A represents an acceleration of decarbonisation efforts, with strong ambitions for hydrogen and the use of CO_2 (CCU) and a marked reduction in methane. In line with the preparations for the transposition of the fourth European Gas Package, this scenario shares several fundamentals with the reference scenario in the French gas TSOs' and DSOs' *Gas Perspectives* and the reference scenario in RTE's *Generation Adequacy Report*. The scenario reflects an ambition to achieve the Fit for 55 objectives. A variant of scenario A covers final consumption according to the level of industrial activity (consumption scenario A2).

Two additional sensitivity scenarios describe a narrative in which the energy transition objectives are partially achieved. These scenarios consider varying degrees of delay in the implementation of the energy transition in certain sectors, and in the production mix. Still in line with the preparations for the transposition of the fourth European Gas Package, these scenarios are also based largely on the contingency scenarios in the *Gas Perspectives* and RTE's *Generation Adequacy Report*.

The first scenario in this family (scenario B) is about five years behind scenario A. It involves a reduced and delayed ambition for hydrogen and CCU, as well as a less marked reduction in methane than in the other scenarios.

The second sensitivity scenario (A-Aléa Prod) in this family combines a transition in final uses in line with the acceleration narratives (scenario A) with a delayed change in the production mix, the electricity part of which is taken from the RTE's *Generation Adequacy Report* scenarios.

In summary, in addition to the central "government" scenario, we propose three consumption scenarios (cons. A, cons. A2 and cons. B) and three production mix scenarios (prod. A, prod. B, and Prod. Unc). They are combined as illustrated below :



These consolidated, regionalised consumption and production scenarios will be used to simulate the hourly supply-demand balance and the resulting infrastructure flows in order to feed into several exercises, including the H_2 and CO_2 development plans and the 2025 ten-year development plan (PDD). These simulations will make it possible to refine the intermediate energy consumption values, which are given as a guide (including demand on electricity and heat production plants and demand on electrolysers), as well as the volumes of CO_2 sequestered.

The method used to construct the consumption and production scenarios is illustrated in the following table, using the example of hydrogen and CO_2 consumption for e-fuels and hydrogen production.

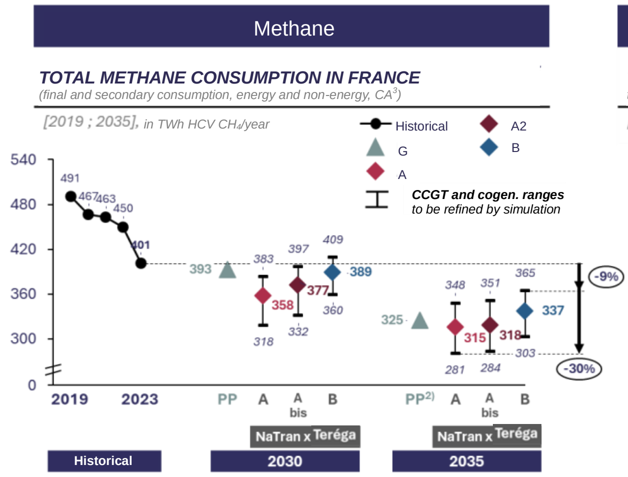
It is important to note that the historical starting points from which the government scenarios and proposed sensitivities are projected may differ. In addition, the climate correction used may significantly vary the climate-adjusted consumption from each source. As an example, the climate-corrected historical figure for methane consumption by operators is 392 TWh HCV in the climate baseline currently used and 417 TWh HCV in the draft of PPE 3 submitted for consultation in March 2025.

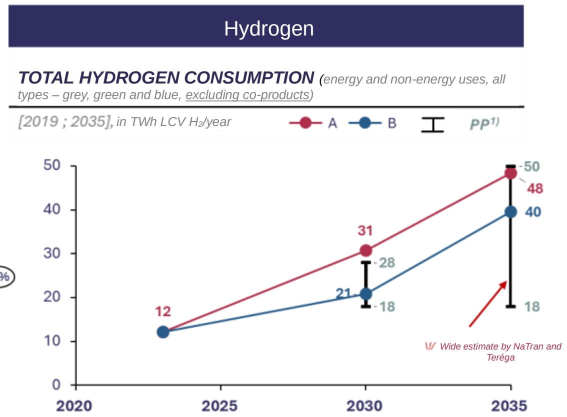
Factors	Description	Scenario inputs	Example application (aviation for energy consumption)
Energy consumption	*Energy consumption, sector by sector, is forecast using:* 1) ***Historical reviews** for each sector* 2) ***Regulatory analyses*** 3) ***Technical and economic analyses*** 4) ***Benchmarks** with other studies*	**Historical review**	• **Current kerosene consumption** in France by airports • **Current logistics** for kerosene transport/production
		Regulation	• **RefuelEU Aviation (2023):** Minimum proportions of sustainable aviation fuels (SAF) and RFNBO from 2025 to 2050
		Technical and economic analyses	• **Fuel production costs** • **Specific consumption of H_2 and CO_2** for the production of bio- and e-fuels • **Kerosene transport costs** (pipeline, truck, rail and barge) • Location of **sources of biogenic CO_2** • **Proportion imported** versus produced in France
		Benchmark with other studies	• **Fuel mix** in aviation (ADEME, RTE, roadmap) • **Growth in air traffic and energy efficiency** • **Production of e-fuels** in France in 2030 and 2035 according to RTE
Energy production	*Example for H_2production, defined on the basis of:* 1) ***H_2 consumption*** 2) ***SMR production*** 3) ***H_2 import rate*** 4) ***Levels of flexibility** of electrolysers* ***Electrolytic production** of H_2 (ktH₂/year) = H_2 consumption – SMR production – H_2 imports* ***Electrolyser capacity** (MW): based on annual production (ktH₂/year) and flexibility levels*	**H_2 consumption**	• Defined sector by sector as explained above
		SMR production	• **Bottom-up scenarios**, based on use, construction date and public announcements in line with the narrative specific to each scenario
		H_2 imports	• **Defined in line with the narrative of each scenario.**
		Level of flexibility of electrolysers	• **Analysis of RTE scenarios (GAR 2035)** • **Industrial feedback** • Organisation of a **workshop dedicated to electrolyser flexibility as part of this consultation process**

1. Do you think the range of scenarios submitted for consultation is appropriate for the tasks and analyses described in the preamble?
2. Do you think the list of sensitivities is comprehensive? If not, what additional variants and sensitivities would you like to see studied to shed more light on the issues involved in balancing supply and demand? What particular uncertainties do you see as requiring alternative solutions?

The range of volumes of hydrogen, methane and CO_2 used (resulting directly from the anticipated e-fuel production and e-methanol production for the chemical industry in the scenarios) is illustrated in the figures below.

Total methane consumption in the scenarios falls by 9% and 30% between 2023 and 2035, while H_2 consumption increases by a factor of 4 over this period





1) *PPE: Based on the PPE document, the planned production of ELY H2 is 9 to 19 TWh H2 LCV/year in 2030 and 16 to 40 TWh LCV/year in 2035. In addition, according to the evolution of "non-energy" methane consumption in the PPE EXCEL, H2 production by SMR could be around 10-11 TWh LCV/year for industry in 2030 (including refineries). In total, H2 consumption under the PPE could amount to 18-28 TWh H2 LCV/year in 2030 and 18 to 50 TWh H2 LCV/year in 2035 (max: 40 ELY + 10 SMR in 2035, min as PPE 2030). To keep the same scope for comparison, the 1 TWh H2 LCV/year per PPE for synthetic gas production has been removed because this consumption will be the subject of a more in-depth study by NaTran and Teréga*

2) *PPE in consultation for 2030 and interpolation between the 2030 figure from PPE 3 and the 2050 figure from SNBC 2, adjusted with the 2035 data in the PPE document (natural gas and biomethane, pages 48 and 82)*

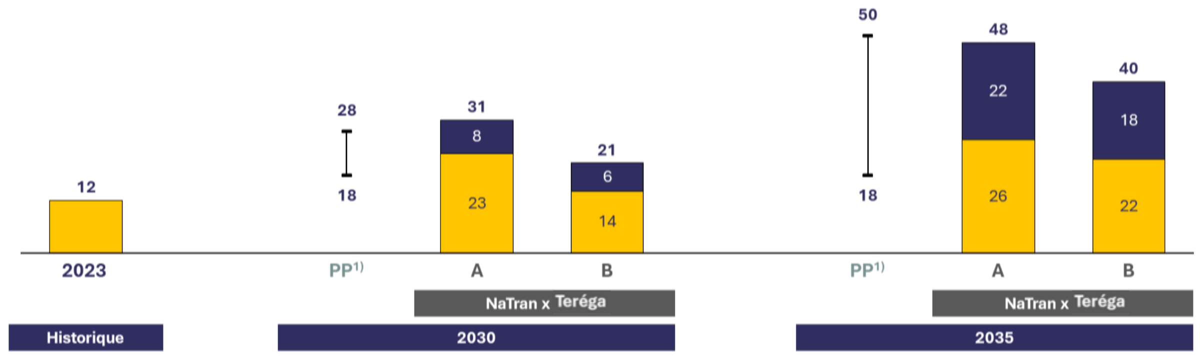
3) ***CA:** climate-adjusted*

The scenarios proposed anticipate a greater role for hydrogen in decarbonising industry and mobility, mainly air and sea transport

TOTAL HYDROGEN CONSUMPTION IN FRANCE (FINAL AND SECONDARY ENERGY, *ALL TYPES, EXCLUDING CO-PRODUCTS)*

[2023-2035], TWh LCV H2/year

- ***Consumption of sustainable fuels (e-fuels) could increase**, in line with the European RefuelEU Aviation and FuelEU Maritime regulations adopted in 2023, and this consumption is estimated to be largely covered by French production*
- ***Hydrogen consumption in industry could increase in fertiliser production, refineries and steel, and to a lesser extent in chemicals** (methanol, phenol, HMD for nylon, hydrogen peroxide, etc.) and industrial heat (pilot projects for hydrogen furnaces for glass and ceramics)*



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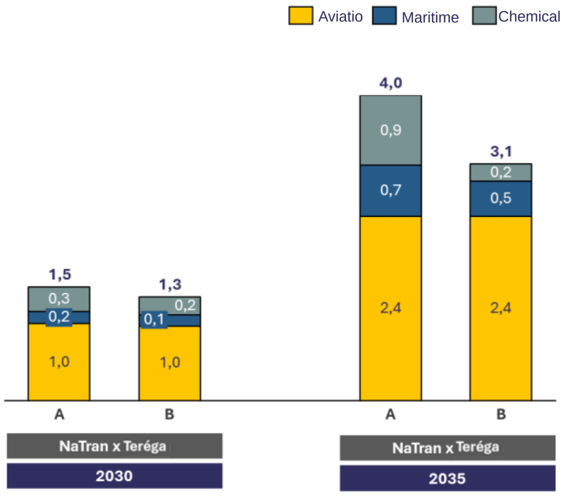
The scenarios for the production of sustainable fuels (e-fuels) or e-methanol for plastics chemicals will result in a growing need for CO_2 – essentially biogenic in the long term

CO₂ CONSUMPTION IN FRANCE BY ACTIVITY SECTOR

[2023-2035], Mt CO_2/year



Growing CO_2 consumption in the transport and chemicals sectors:

- *The European **RefuelEU Aviation and FuelEU Maritime** regulations set decarbonisation targets that will require increasing consumption of sustainable fuels, including **e-kerosene for aviation and e-methane or e-methanol for shipping**, which will consume CO_2 for their production*
- ***In the chemical industry, e-methanol** could be used to produce olefins (e-methanol-to-olefin) and formaldehyde, which are needed to make various plastics and MTBE, a petrol additive. The production of this e-methanol in France for French or European needs would consume CO_2*

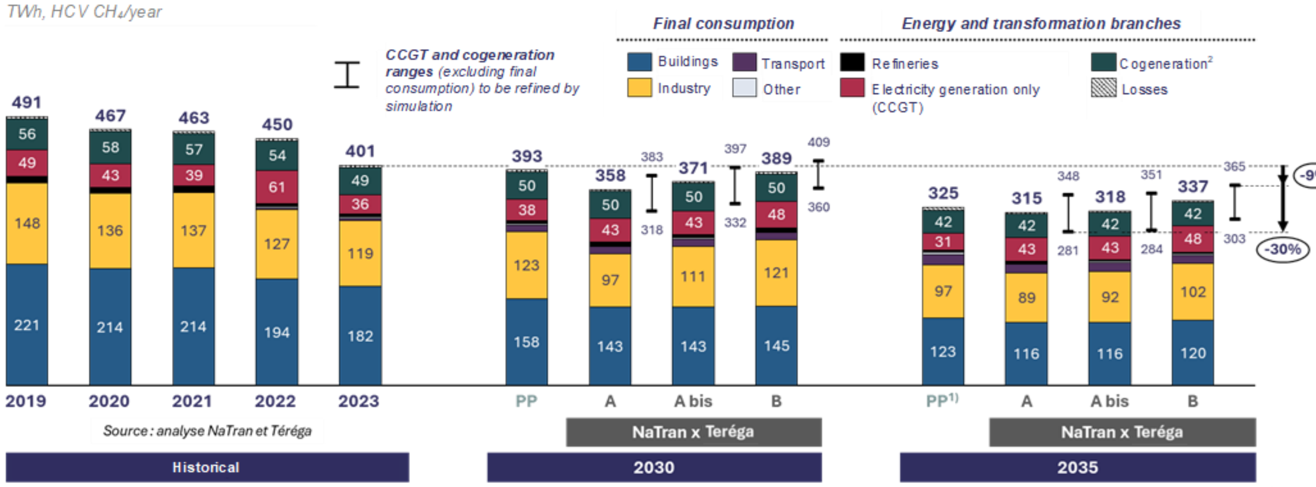
A reminder about "sustainable fuels":

- ***Sustainable fuels** include e-fuels (synthesised from H2), biofuels (from biomass) and the direct use of hydrogen. E-fuels are produced from hydrogen **and, in some cases, CO_2***
- ***RFNBO** e-fuels, for which there are specific targets, refer to e-fuels produced from green hydrogen and CO_2. **From 2041 onwards, CO_2 will have to be biogenic**, according to the delegated acts specifying the methodology for calculating RED III Renewable Fuels of Non Biological Origin emissions.*

Under the proposed scenarios, methane consumption in France could fall by 9% to 30% between 2023 and 2035, reaching 281 to 365 TWh HCV/year in 2035

TOTAL METHANE CONSUMPTION IN FRANCE *(FINAL AND SECONDARY, ENERGY AND NON-ENERGY, CA[3])*

TWh, HCV CH_4/year



1) *"**Government**" data: The data in the "government" scenario corresponds to the PPE in consultation for 2030 and interpolation between the 2030 figure from PPE 3 and the 2050 figure from SNBC 2, adjusted with the 2035 data in the PPE document (natural gas and biomethane, pages 48 and 82)*
2) *"**Cogeneration**" refers to methane consumption for cogeneration units producing heat "sold" and for "heat production [sold] only", both of which are recorded in the "transformation" branch of energy balances and not in "industry" (EUROSTAT definition).*
3) *CA: climate-adjusted*

The spreadsheet available to download here gives details of the scenarios and their underlying figures so that the proposed sensitivities can be assessed. These will be the subject of specific discussions during the workshops dedicated to each molecule (H_2, CO_2 and CH_4).

For industry, NaTran and Teréga propose four trajectories for the evolution of consumption:

- The first scenario is the one submitted for consultation by the government as part of PPE3. It involves serious ambitions for reindustrialisation, combined with significant, rapid electrification.
- Two variants under scenario A. Scenario A is based on a slower increase in industrial production than scenario G and significant improvements in energy efficiency in order to meet the 2030 Fit for 55 target. Sensitivity analysis A2 proposes a version of this scenario with significant reindustrialisation made possible by an effective industrial policy (more or less at the level of PPE3). This scenario is the one with the highest hydrogen penetration rate.
- Sensitivity scenario B considers a delay of around five years compared with scenario A, with a slower change in the energy mix combined with modest reindustrialisation and an improvement in France's trade balance.
- Hydrogen consumption is concentrated in fertiliser production, refineries and steel (direct reduction with hydrogen, DRI), and to a lesser extent in chemicals (methanol, phenol, HMD for nylon, hydrogen peroxide, etc.) and industrial heat (pilot projects for hydrogen kilns for glass and ceramics), with hydrogen production by SMR (steam methane reforming) gradually being replaced by electrolysers. Hydrogen consumption in industry (excluding co-products) varies between 14 and 23 TWh LCV in the proposed scenarios[1] to 2030.
- With regard to reduced steel, the "A" scenarios envisage the commissioning of a hydrogen-reduced steel production plant in 2030, which is delayed to 2035 for scenario B. Additional units are anticipated in the medium term (2040 or later).

It should be noted that all the scenarios proposed expect an increase in final energy consumption in industry as a result of changes in industrial activity, as well as significant efficiency improvements.

[1] Calculation of the volume of hydrogen for the G scenario on the basis of the MAS EXCEL file for the PPE-3 submitted for consultation: total electrolytic (ELY) H2 consumption in 2030 of 9.6 TWh H2 LCV/year, including 1 TWh LCV/year of "non-energy use" (fertiliser production) and 4 TWh LCV/year under "industry", i.e. 5 TWh LCV/year for industry. In the PPE document, mention is made of ELY H2 production of 9 to 19 TWh H2 LCV/year in 2030, i.e. potential production of 10 TWh H2 LCV/year more than in the PPE EXCEL file. By distributing these 10 TWh in proportion to the sectoral consumption of ELY H2 seen in the PPE Excel file, 5 TWh of the 10 could be destined for industry. In addition, according to the evolution of "non-energy" methane consumption in the PPE EXCEL, H2 production by SMR could be around 10-11 TWh LCV/year for industry in 2030 (including refineries). In total, industry H2 consumption under the PPE could amount to 15-20 TWh LCV/year.

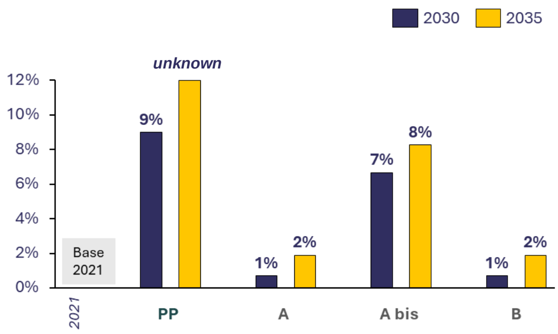
Elements	G	A	A2	B
Origin and inspiration of the scenario's underlying assumptions	• 2030: PPE 3 under consultation • 2035: interpolation between PPE 3 and SNBC2	**SNBC2** **2024 Gas Perspectives** (reference scenario)	PPE 3, ADEME transition plans, SNBC 2, TYNDP26 scenario with RTE	PPE 3, ADEME transition plans, SNBC 2, TYNDP26 scenario with RTE
Scope	Industry (14 sectors) Construction (1 sector)	Same as G excluding construction	Same as G	Same as G
Industrial production	+ + + • Strong reindustrialisation • Improved trade balance	+ • Slow increase in industrial production	+ + • Close to G	+ • Same as A
Energy efficiency	+ + +	+ + *(SNBC2)*	+ + + *(similar to G)*	+ *Slightly lower than A and G*
Energy mix	• Rapid large-scale electrification • Use of hydrogen	• **More sustained development of renewable, low-carbon methane than in G** • Greater drop in methane consumption than in the PPE between now and 2030 as a result of the Fit for 55 targets and moderate industrial activity	**Similar to A and G in 2035 but more gradual between 2025 and 2030**	**Slower change in the energy mix (5 years behind schedule)**

The scenarios all anticipate a greater or lesser degree of reindustrialisation and significant improvements in energy efficiency

"Industrial activity" effect

*Relative change in industry's total final energy consumption compared with 2021, **based solely on changes in industrial production***

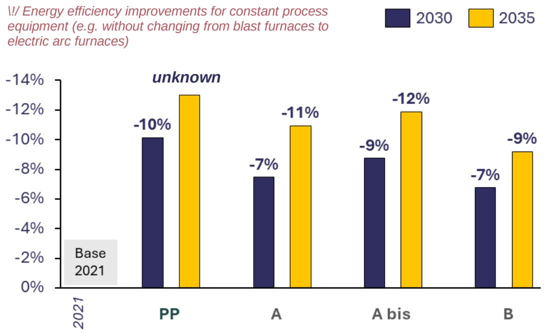
[2021; 2030; 2035], in % (underlying in TWh LCV/year)



"Energy efficiency" effect

*Relative change in industry's total final energy consumption compared with 2021, **based solely on energy efficiency improvements** [1 2]*

[2021; 2030; 2035], in % (underlying in TWh LCV/year)



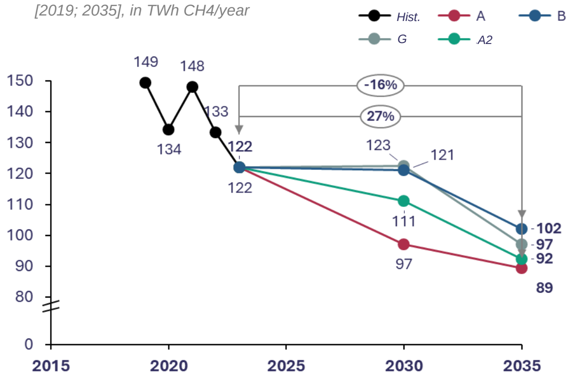
.1) The energy efficiency improvements shown do not include the reduction in industrial energy consumption linked to changes in the steelmaking process (replacing blast furnaces with electric arc furnaces that recycle more and more scrap metal), which enable significant energy savings
.2) The energy efficiency improvements shown include energy savings from the increased recycling of paper and cement clinker, but not from the recycling of aluminium and scrap metal
3) The data "Unknown" is not available in the PPE documents to date.

In industry, the methane consumption forecast could fall by 15% to 30% between 2023 and 2035, while H2 consumption could double

Methane in industry

METHANE CONSUMPTION IN INDUSTRY *(final consumption for energy and non-energy purposes)*

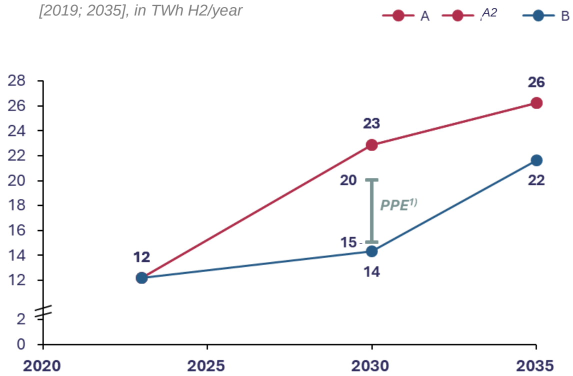
[2019; 2035], in TWh CH4/year



Hydrogen in industry

HYDROGEN CONSUMPTION IN INDUSTRY *(energy and non-energy use, all types – grey, green and blue, excluding co-products)*

[2019; 2035], in TWh H2/year



1) ***PPE:*** *PPE EXCEL file: total electrolytic (ELY) H2 consumption in 2030 of 9.6 TWh H2 LCV/year, including 1 TWh LCV/year of "non-energy use" (fertiliser production) and 4 TWh LCV/year under "industry", i.e. 5 TWh LCV/year for industry. In the PPE document, mention is made of ELY H2 production of 9 to 19 TWh H2 LCV/year in 2030, i.e. potential production of 10 TWh H2 LCV/year more than in the PPE EXCEL file. By distributing these 10 TWh in proportion to the sectoral consumption of ELY H2 seen in the PPE Excel file, 5 TWh of the 10 could be destined for industry. In addition, according to the evolution of "non-energy" methane consumption in the PPE EXCEL, H2 production by SMR could be around 10-11 TWh LCV/year for industry in 2030 (including refineries). In total, industry H2 consumption under the PPE could amount to 15-20 TWh LCV/year.*

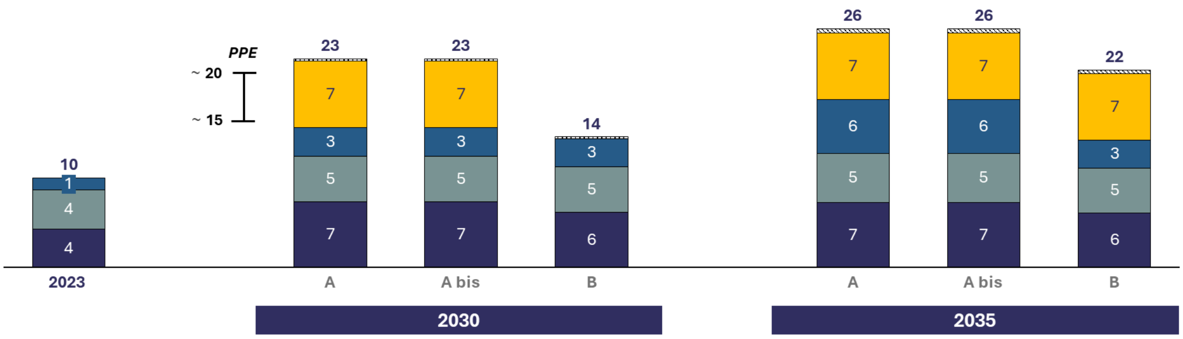
The scenarios anticipate H2 consumption in industry of 14 to 23 TWh LCV/year in 2030, and 22 to 26 TWh LCV/year in 2035

TOTAL HYDROGEN CONSUMPTION IN INDUSTRY, ALL TYPES. OF HYDROGEN (GREY, GREEN, BLUE)

[2019; 2035], TWh LCV H2/year

Fertiliser *Refineries* *Chemicals (excluding fertilisers)* *Steel* *Industrial heat*

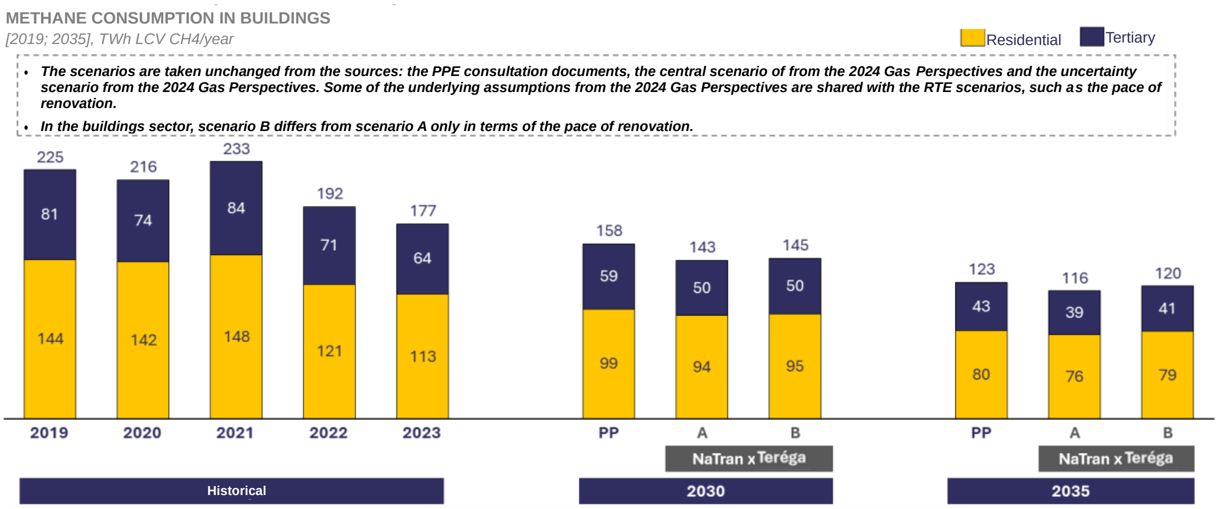
- ***H2 consumption in industry****: fertiliser production, refineries and steel (direct hydrogen reduction, DRI), and to a lesser extent chemicals (methanol, phenol, HMD for nylon, hydrogen peroxide, etc.) and industrial heat (pilot projects for H2 kilns for glass and ceramics)*
- ***Within hydrogen demand****: gradual replacement of SMR (steam methane reforming) hydrogen production with electrolysers, particularly for fertiliser producers and refiners*
- ***Reduced steel:*** *the A scenarios anticipate the commissioning of a hydrogen-reduced steel production plant in 2030, which is delayed to 2035 for scenario B. Additional units are anticipated in the medium term (2040 or later).*



1. Do you think the range covered by the scenarios for industry is appropriate? If not, what additional variants and/or sensitivities would you like to see studied? What particular uncertainties do you see as requiring alternative solutions?
2. Do you think the range of changes in industrial activity is appropriate? What other sensitivities would you like to see studied?
3. Do you think the hypotheses about the penetration of H2 in the industry are appropriate? What analyses can you provide as an input for these scenarios?

For the buildings sector (residential and tertiary), the scenarios are taken unchanged from the sources: the PPE consultation documents, the central scenario from the 2024 *Gas Perspectives* and the uncertainty scenario from the 2024 *Gas Perspectives*. Some of the underlying assumptions from the 2024 *Gas Perspectives* are shared with the RTE scenarios, such as the pace of renovation. In the buildings sector, scenario B differs from scenario A only in terms of the pace of renovation.

The scenarios forecast methane consumption of 143 to 145 TWh HCV/year in 2030 and 116 to 120 TWh HCV/year in 2035 in buildings



1) **"Government" data:** *The data in the "government" scenario corresponds to the PPE in consultation for 2030 and interpolation between the 2030 figure from PPE 3 and the 2050 figure from SNBC 2, adjusted with the 2035 data in the PPE document (natural gas and biomethane, pages 48 and 82)*

	2019	2030			2035		
		PP	A	B	PP	A	B
Number of renovations per year (high-performance renovation equivalent)	230 000	600 00	380 000	280 000	600 00	380 000	280 000
Percentage of homes heated with gas (excluding hybrid heat pumps)	36 %	30 %	33 %	33 %		29 %	29 %

Do you think the range covered by the scenarios for the buildings sector is appropriate? If not, what additional variants and/or sensitivities would you like to see studied? What particular uncertainties do you see as requiring alternative solutions? What analyses can you provide as an input for these scenarios?

The land transport trajectories take account of the changing context, and particularly European regulation 2024/1610 on CO_2 emission standards for heavy road transport, which gradually bans the sale of new internal combustion vehicles, even if they are fuelled with bioNGV or biofuels (from 2035 for buses, beyond 2040 for HGVs and coaches). However, this regulation provides for a review before the end of 2027 on the deployment of electric solutions and leaves open the possibility of reconsidering biofuels including bioNGV, before the end of 2027, as an authorised solution for decarbonising heavy road transport.

For air and sea transport, the consumption of sustainable fuels should increase in line with the European RefuelEU Aviation and FuelEU Maritime regulations adopted in 2023. These regulations impose increasing targets for the incorporation of sustainable fuels, in the form incorporation rates by volume of sustainable fuels (in kerosene equivalent) for air transport and targets for reducing the carbon intensity (GHG) of naval propulsion (in % of gCO2/MJ) for maritime transport.

“Definition of sustainable fuels” box

Sustainable fuels include e-fuels (synthesised from H_2), biofuels (from biomass), including bioNGV, and the direct use of hydrogen. E-fuels are produced from hydrogen and, in some cases, CO_2. E-fuels can be e-kerosene for aviation, e-methane, e-methanol or e-ammonia for shipping, or e-diesel for road and light shipping.

RFNBO[2] e-fuels, for which there are specific targets, refer to e-fuels produced from green hydrogen and CO_2. From 2041 onwards, CO_2 will have to be biogenic, according to the delegated acts specifying the methodology for calculating RED III emissions *(introduction, point 5)*.

Sustainable fuels	Inputs
E-fuels	Hydrogen and CO2 in some cases
Biofuels	Biomass and a little hydrogen
Direct use of hydrogen	Hydrogen

List of sustainable fuels and associated inputs

National demand for sustainable aviation and marine fuels has been determined on the basis of European regulatory targets (RefuelEU Aviation[3], FuelEU Maritime[4]) and assumptions about traffic growth, energy efficiency improvements, renewal of aircraft and shipping fleets, and the associated energy mixes and engines. In this respect, the growth in air and sea traffic and the energy efficiency improvements are higher in the “A” scenarios than in the “B” scenarios.

This national demand is then adjusted according to assumptions about the proportion produced in France and the proportion imported. For air and sea transport, all the e-fuel production projects announced[5] [6] in France seem to cover the national demand forecast for 2030 and 2035, with even the potential for exports in 2030 if all the projects materialise as announced. These exports within the European Union could take place via a system of guarantees of origin on sustainable aviation fuels (book & claim) to separate the “physical” places where the fuels are consumed from the airports where the airlines purchasing these guarantees operate. Based on this observation, the proposed scenarios assume that all the anticipated demand for e-fuels is supplied by French production in 2030 and 2035.

2 Renewable Fuels of Non Biological Origin
3 For aviation, the targets are a minimum 2% rate of incorporation of sustainable fuels in 2025, 6% in 2030 and 20% in 2035, with a specific minimum rate for RFNBO (green e-kerosene) of 1% in 2030 and 5% in 2035. The anticipated aircraft energy mix would follow these minimum rates, bearing in mind that the penalties for airlines are a deterrent if these targets are not met.
4 For the maritime sector, the targets are a reduction in the GHG intensity of naval propulsion of 2% (gCO2/MJ) in 2025, 6% in 2030 and 15% in 2035, with a specific target for RFNBOs (decarbonised e-fuels) of 1.2% of the fuel bunkered in ships in 2030, and 2% from 2034 if the European Commission reports that RFNBOs represent less than 1% of the maritime fuel bunkered in 2031. These reduction targets can be achieved by incorporating biodiesel, LNG, biomethane, e-methane, e-methanol and, in the long term (after 2040), e-ammonia.
5 Aviation e-fuel projects (as of June 2024): KerEAUzen (Engie), Take Kair (EDF, Holcim, IFPen), Hylann (Qair), BioTJet (Elyse Energy, Avril, Bionext), ReUze (Engie, Infinium, Arcelor Mittal), Elyse Energy Epinal (Elyse Energy), Hyf2Gen/H2V at Fos-sur-Mer.
6 Maritime e-fuel projects: eM-CTY (Elyse Energy), eM-Lacq (Elyse Energy), NeoCarb (Elyse Energy), Marseille FOS H2V (H2V), eM-Rhône (Elyse Energy), Hynovi (EDF)

Beyond that, imports may be necessary. In the long term, a study by ADEME[7] estimates that imports of e-fuels could be more competitive than domestic production.

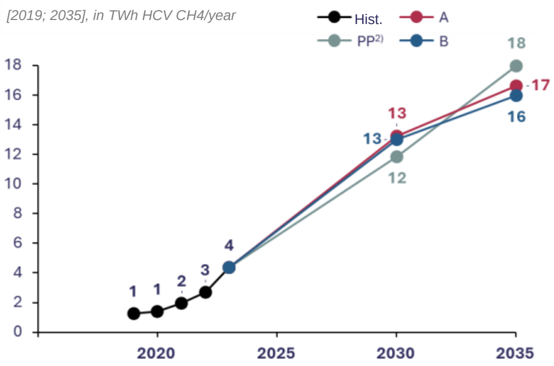
The scenarios are then translated into hydrogen and CO_2 requirements.

In transport, the consumption of methane and hydrogen in the scenarios increases, both as a final energy source (CNG for road transport, methane for maritime) and as a secondary energy source (e-fuel production)

Methane in transport

METHANE CONSUMPTION IN TRANSPORT *(final consumption, including international maritime bunkering)*

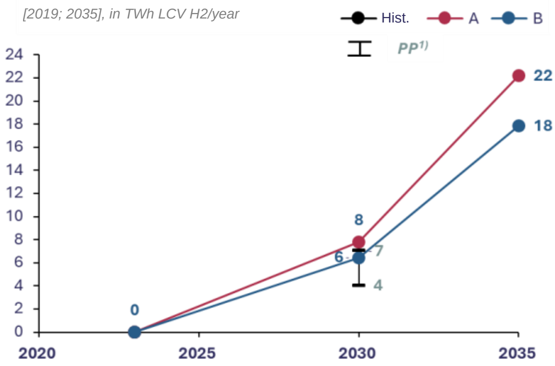
[2019; 2035], in TWh HCV CH4/year



Hydrogen in transport

HYDROGEN CONSUMPTION IN TRANSPORT *(including e-fuel production, all types – green and blue, excluding co-products)*

[2019; 2035], in TWh LCV H2/year



*1) **PPE:** The EXCEL file issued for consultation for the PPE mentions a total consumption of electrolytic H2 in 2030 of 9.6 TWh H2 LCV/year, including 1 TWh H2 LCV/year for "transport" (assimilated into road transport) and 3 TWh H2 LCV/year for e-fuel production (the "energy" branch of the energy balance), as well as 1 TWh H2 LCV/year for "synthetic gas" production (e-methane), a small amount of which could be used for shipping. In the PPE document, electrolytic H2 production is estimated at 9 to 19 TWh H2 LCV/year in 2030, i.e. potentially 10 TWh H2 LCV/year more than estimated in the EXCEL file. Of these 10 TWh H2 LCV/year, around 3 TWh H2 LCV/year could be used for transport (e-fuels in particular), if we consider that this additional H2 production is divided between industry and transport in proportion to the hydrogen consumption anticipated for these sectors in 2030 in the PPE EXCEL file*

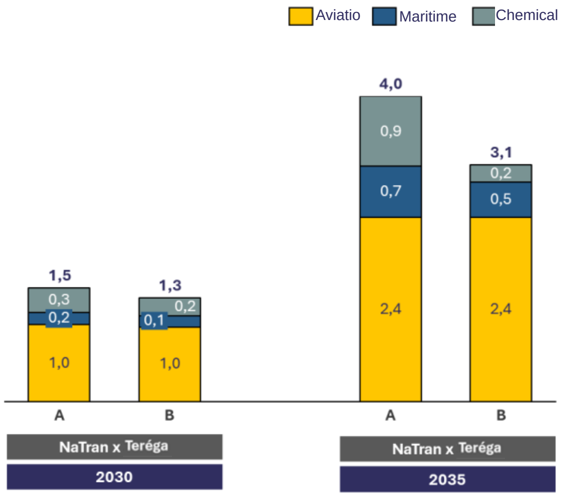
2) PPE in consultation for 2030 and interpolation between the 2030 figure from PPE 3 and the 2050 figure from SNBC 2, adjusted with the 2035 data in the PPE document (natural gas and biomethane, pages 48 and 82)

7 "Importations d'hydrogène et de dérivés de l'hydrogène – Analyse prospective de la compétitivité comparée à une production en France" (Imports of hydrogen and hydrogen derivatives – prospective analysis of competitiveness compared with production in France), ADEME (July 2024)

The scenarios for the production of sustainable fuels (e-fuels) or e-methanol for plastics chemicals will result in a growing need for CO_2 – essentially biogenic in the long term

CO_2 CONSUMPTION IN FRANCE BY ACTIVITY SECTOR

[2023-2035], Mt CO_2/year



Growing CO_2 consumption in the transport and chemicals sectors:

- *The European **RefuelEU Aviation and FuelEU Maritime** regulations set decarbonisation targets that will require increasing consumption of sustainable fuels, including **e-kerosene for aviation and e-methane or e-methanol for maritime applications**, which will consume CO_2 for their production*
- ***In the chemical industry, e-methanol** could be used to produce olefins (e-methanol-to-olefin) and formaldehyde, which are needed to make various plastics and MTBE, a petrol additive. The production of this e-methanol in France for French or European needs would consume CO_2*

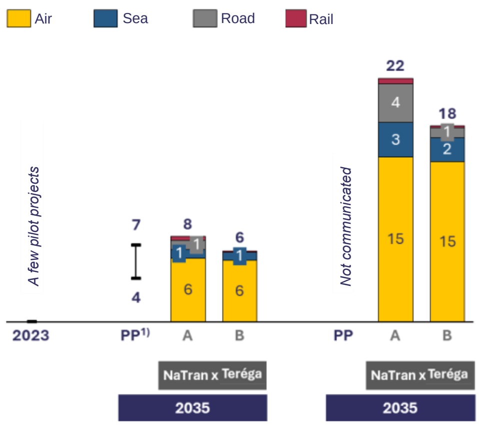
A reminder about "sustainable fuels":

- ***Sustainable fuels** include e-fuels (synthesised from H2), biofuels (from biomass) and the direct use of hydrogen. E-fuels are produced from hydrogen **and, in some cases, CO_2***
- ***RFNBO** e-fuels, for which there are specific targets, refer to e-fuels produced from green hydrogen and CO_2. **From 2041 onwards, CO_2 will have to be biogenic**, according to the delegated acts specifying the methodology for calculating RED III Renewable Fuels of Non Biological Origin emissions.*

Hydrogen consumption in the transport sector could reach 4 to 8 TWh LCV/year in 2030 and 18 to 22 TWh LCV/year in 2035

HYDROGEN CONSUMPTION IN TRANSPORT

[2023-2035], TWh LCV H2/year



Air:
- *Consumption of H2 for e-fuel production (e-kerosene or e-bio-kerosene) and biofuels (bio-kerosene)*

Sea:
- *Consumption of H2 for **e-methanol and e-methane production** for the maritime sector. The e-methanol produced in France could be used for a number of purposes – shipping, chemicals and aviation (e-methanol-to-jet) – only the estimated "shipping" part is shown here.*
- ***Maritime fleet expected to be increasingly equipped with dual fuel** methane or methanol engines that can run on biodiesel, LNG, e-methane, biomethane, e-methanol and bio-methanol to meet the targets in the Maritime FuelEU regulation*

Road:
- *Growing proportion of heavy goods vehicles running on hydrogen, particularly long-distance **goods vehicles**. For medium distances (< 400–500 km), electric trucks could be the market's preferred choice.*

Rail:
- *H2 consumption in **fuel cells on regional trains**. For example, 12 "Régiolis H2" trains have been ordered by 4 regions to enter service in 2026[1]*

1) ***PPE:*** *The EXCEL file issued for consultation for the PPE mentions a total consumption of electrolytic H2 in 2030 of 9.6 TWh H2 LCV/year, including 1 TWh H2 LCV/year for "transport" (assimilated into road transport) and 3 TWh H2 LCV/year for e-fuel production (the "energy" branch of the energy balance), as well as 1 TWh H2 LCV/year for "synthetic gas" production (e-methane), a small amount of which could be used for shipping. In the PPE document, electrolytic H2 production is estimated at 9 to 19 TWh H2 LCV/year in 2030, i.e. potentially 10 TWh H2 LCV/year more than estimated in the EXCEL file. Of these 10 TWh H2 LCV/year, around 3 TWh H2 LCV/year could be used for transport (e-fuels in particular), if we consider that this additional H2 production is divided between industry and transport in proportion to the hydrogen consumption anticipated for these sectors in 2030 in the PPE EXCEL file*

1. Do you think the range covered by the scenarios for the transport sector is appropriate? If not, what additional variants and/or sensitivities would you like to see studied? What particular uncertainties do you see as requiring alternative solutions?
2. Does the assumption that there will be no imports of e-fuels by 2035 because the volume of projects announced is greater than the projected demand in the medium term seem correct to you? If not, what information can you provide as an input for the scenarios?
3. Do you think the bunkering mix for marine fuels is appropriate? What technical or economic information would you be able to provide as an input for the scenarios?

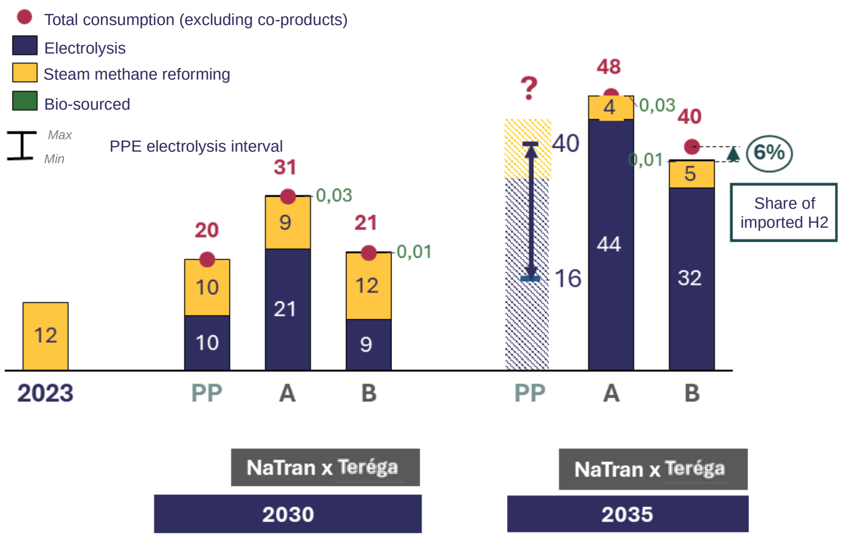
As far as hydrogen production and imports are concerned, the scenarios offer a range of possibilities. The quantities produced in the sensitivity scenarios are given as a guide only, as the volumes will result from multi-energy simulations on a European scale carried out on the basis of the scenarios submitted for consultation.

The G scenario uses the figures from the most recent version of the PPE-3 consultation documents, while scenario A anticipates a greater role for hydrogen in the decarbonisation of energy uses and a quicker start for production via electrolysis. By 2030, 78% of this production will be electrolytic, rising to 97% by 2035.

In scenario B, the energy transition is delayed by around five years. Electrolytic production takes longer to develop, in terms of both installed capacity and flexibility. Biomass-based H_2 production processes emerge slowly, while hydrogen production via steam methane reforming remains significant.

Given France's ambitions in terms of national energy sovereignty, only scenario B considers an imported share of H_2 (6%) in 2035. Unlike the ammonia consumption scenarios for shipping and chemicals, which include a proportion of imports to meet demand, the import of ammonia to produce H_2 (cracking) has been examined, but no volumes have so far been included for the time scales presented. This point could be discussed at the H_2 workshop.

The hydrogen flows in France and Europe will result from multi-energy simulations carried out on the basis of the scenarios submitted for consultation. Specific hypotheses such as the locations of consumption and production, electrolyser flexibility etc. will be discussed during the H_2 workshop.



1. Do you think the range covered by the hydrogen production scenarios is appropriate? If not, what additional variants and/or sensitivities would you like to see studied? What particular uncertainties do you see as requiring alternative solutions?
2. The volumes used in the scenarios for bio-sourced hydrogen production are marginal. Do you think these volumes are appropriate, or are they underestimated? Do you have any information that could be used as an input for the scenarios for these volumes?
3. Imports of ammonia to produce H2 (cracking) have been examined, but no volumes have so far been included for the time scales presented. Do you think this hypothesis is reasonable? If not, can you provide any technical and economic analyses that would allow us to reconsider this position? What volume of ammonia should be added to our hydrogen import scenarios according to your analyses?

In terms of renewable, low-carbon gas production in France:

- The G scenario is characterised by biomethane production from anaerobic digestion in line with the PPE under consultation, with the addition of renewable low-carbon gas production using innovative processes (pyrogasification, hydrothermal gasification, power-to-methane) that are not quantified in the PPE (i.e. in 2030, 44 TWh from anaerobic digestion and an additional 2 TWh from innovative processes, and in 2035, 79 TWh including 8 TWh from innovative processes). The G scenario corresponds to an incorporation rate of ~15% of renewable low-carbon gases in the gas consumed in 2030 and ~25% in 2035, with:
    - Continuation of support mechanisms for anaerobic digestion (sites producing < 25 GWh/year), an ambitious pathway for biogas production certificates (CPB) for 2028–2035, making it possible to achieve an incorporation rate of ~15% in 2030 in the residential and tertiary sectors, and a rate of anaerobic digestion growth sustained by

the rapid emergence of mechanisms for biomethane incorporation via incentives to keep biomethane purchase agreement (BPA[8]) in transport (IRICC) and industry (biomethane decarbonisation grants).

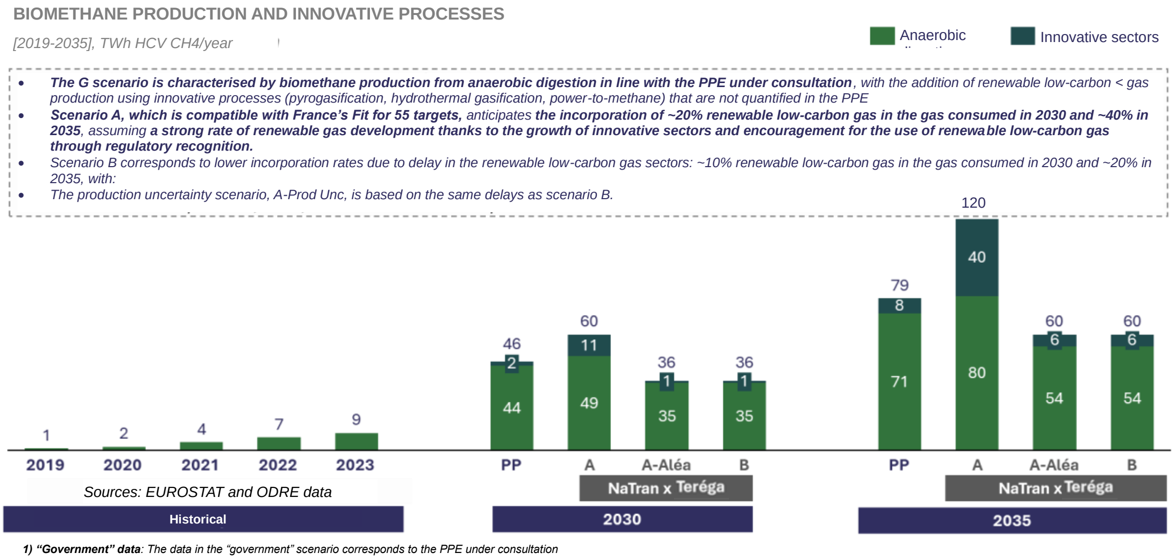
- Rapid emergence of the first industrial production projects in innovative sectors due to the introduction of specific support for these sectors in the very short term (calls for projects and then calls for tenders)

- Scenario A, which is compatible with France's Fit for 55 targets, corresponds to an incorporation rate of ~20% of renewable low-carbon gas in the gas consumed in 2030 and ~40%in 2035, reflecting:
  - A sustained pace of development of renewable gases thanks to the growth of innovative sectors, supported by recognition that low-carbon gases reduce carbon emissions, strong momentum in over-the-counter contracts and the opening up of CPBs to innovative sectors
  - Encouragement for the use of renewable low-carbon gases through regulatory recognition (decarbonisation support mechanism, voluntary approaches – SBTi, ACT, etc.) that purchases of injected biomethane are a lever for reducing emissions from industry and businesses.
  - A desire to use biogenic CO_2 for power-to-methane to optimise the exploitation of the biomass used. In addition, from 2041 onwards, the CO_2 used to produce e-fuels will have to be biogenic, according to the delegated acts specifying the methodology for calculating RED III Renewable Fuels of Non Biological Origin emissions.
  - Increased concern about air and water quality (pollutant emissions from waste-to-energy and wastewater treatment plants), encouraging the use of pyrogasification and hydrothermal gasification

- Scenarios B and A-Prod Unc correspond to lower incorporation rates due to delay in the renewable low-carbon gas sectors: ~10% renewable low-carbon gas in the gas consumed in 2030 and ~20% in 2035, with:
  - Moderate growth in anaerobic digestion.
  - Moderate support from government bodies, resulting in a moderate post-2028 CPB trajectory and calls for projects in innovative sectors only emerging in the medium term.
  - Weak incentives for using biomethane to decarbonise transport and industry, leading to moderate use of BPA contracts

[8] BPA: Biomethane Purchase Agreement

The scenarios anticipate methane production from anaerobic digestion and innovative processes of between 36 and 60 TWh HCV/year in 2030 and between 60 and 120 TWh HCV/year in 2035



The methane flows in France and Europe will result from European-scale simulations carried out on the basis of the scenarios submitted for consultation. Similarly, the demands on gas-fired power stations will be refined by multi-energy simulations carried out on the basis of the scenarios submitted for consultation. The European assumptions will mainly be based on the Ten Year Network Development Plan 2024 (TYNDP24), adjusted to correspond to the National Energy and Climate Plans (NECP) of the individual countries. TYNDP26 data will be integrated as and when data is made available to TSOs.

1. Do you think the range covered by the renewable low-carbon gas production scenarios is appropriate? If not, what additional variants and/or sensitivities would you like to see studied? What particular uncertainties do you see as requiring alternative solutions?
2. Do you think that temperature is likely to influence the level of production from anaerobic digesters? Do you have any analyses that could be used to refine the assumptions about digester production at cold temperatures?
3. Do you have any analyses that could be used to assess the regionalised production of renewable low-carbon gas (anaerobic digestion, pyrogasification, hydrothermal gasification and power-to-methane) for the time scales under consideration (2030 and 2035)?
4. In your opinion, what are the main non-European sources of supply that should be considered when simulating methane flows? Do you have any analyses that could feed into the volume constraints to be applied in the simulations?
5. Do you have any analyses that could be used to refine assumptions about the availability of LNG (Liquefied Natural Gas) for Europe between now and 2035?

In terms of the electricity generation mix, the assumptions relating to renewables and nuclear power have been taken unchanged from the sources: the G scenario is in line with the latest version of the PPE consultation, and the A, B and A-Prod Unc scenarios are based on RTE's 2023 Generation Adequacy Report, respectively the A-ref, B-low and C1 scenarios. Output from thermal power stations will result from simulations.

1. Do you think the range covered by the electricity generation mix scenarios is appropriate? If not, what additional variants and/or sensitivities would you like to see studied? What particular uncertainties do you see as requiring alternative solutions? What technical and economic analyses can you provide on the role of hydrogen power plants up to 2035 and beyond?

Note: workshops specific to each molecule will enable certain subjects to be addressed in greater detail. The consultation will therefore remain open until the end of June 2025, allowing you to supplement your answers to the questions in your own words.

Document submitted for consultation: on the basis of the information presented above, NaTran and Teréga expect feedback from stakeholders in the markets concerned in advance of the workshops in order to frame the discussions in the sessions around the major issues raised. If questions are posed in this document, feedback can also deviate from them, the format being free.

Please use the "Concertations Feedback" document to write your comments, and send them by e-mail by May 2, depending on who you are speaking to, to :

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Teréga: Concertationsch4h2co2@terega.fr