NATIONAL CONSULTATION OF LOW-CARBON AND RENEWABLE HYDROGEN MARKET STAKEHOLDERS

FINAL FEEDBACK REPORT
MARCH 2022

GRTgaz

Teréga

CONTENTS

EXECUTIVE SUMMARY

In June 2021, within the context of significant ongoing legislative and regulatory developments for hydrogen, GRTgaz and Teréga launched the first national consultation of the renewable and low-carbon hydrogen market, to **identify the needs of stakeholders in the hydrogen market, particularly in terms of logistics.** Addressed to all stakeholders in the hydrogen market – industry, energy suppliers, producers and shippers, public and institutional stakeholders, associations, infrastructure operators and academic experts – this first consultation highlighted the real interest among stakeholders in hydrogen as an energy carrier, but also in the associated logistics. As a result, the two gas transport grid operators received **133 contributions** enabling them precisely to identify **90 production and/or consumption sites.**

In-depth analysis of the responses to the consultation led by GRTgaz and Teréga, enriched by discussions with stakeholders and interested parties from the hydrogen market, particularly during three territorial workshops, has provided some **insights into the conditions needed for the emergence of the future low-carbon and renewable hydrogen market.**

This first exercise confirmed the **significant need among stakeholders for hydrogen to decarbonise their activities.**

As an energy carrier with multiple uses, hydrogen is widely identified as **one of the decarbonisation solutions for industrial sectors** which are high emitters of greenhouse gases, and for whom conversion to electricity is not a foreseeable option in the short to medium term, sometimes alongside carbon capture and storage technologies (CCS). There is also a huge **appetite for hydrogen in mobility,** in the medium term (2030-2040), particularly among territorial institutional actors, who see it as a lever for making their public vehicle fleets greener. In addition, the challenge of decarbonising the air transport sector has highlighted a significant requirement for hydrogen from 2030-2035, either in liquid form, or for the production of synthetic fuels.

Stakeholders also have hydrogen in their sights for the production of renewable and recovered energy, heat production, for **use as a material**, and as a way of **offering greater flexibility in the electricity system.**

Hydrogen production, meanwhile, is chiefly envisaged to utilise **electrolysis of water, from as early as 2025,** but also the **reforming of natural gas with capture and storage** of the carbon. The gasification of biomass is also mentioned.

The results show that **producers and consumers are working on different timescales. Production volumes are in line with the targets in the national hydrogen strategy for 2030. They outstrip needs up to 2040. Needs, meanwhile, are clearly quantified in the long term (by 2050, in particular), but are made less explicit in the short to medium term.**

Industrial hubs are where current and future large consumers for low-carbon and renewable hydrogen are concentrated, along with the majority of hydrogen production projects. The consultation revealed **seven hydrogen valleys**, confirming those identified by France Hydrogène and the Sector Strategic Committee (Comité Stratégique de Filière) in their respective studies, with **imbalances between potential production and projected demand.**

Similarly, the consultation confirms the idea of a three-stage development of the hydrogen market, with deployment in the short term within local ecosystems favourable for its production and consumption, organisation in the medium term of a regional grid within hub areas linking the different ecosystems and possible storage, and creation in the long term of a national grid linking those areas and interconnected at the European level, with the incorporation of mass storage.

The consultation has shown that the **vast** majority of stakeholders stress **the importance of logistics** in meeting their challenges, namely **guaranteeing secure access to the most competitively priced hydrogen for consumers and an outlet serving a large catchment for producers.** In this regard, **90% of contributors to the consultation imagine hydrogen transport being via a network of pipelines.**
Access to storage also turns up in responses as being essential for guaranteeing **security of supply and providing a flexibility mechanism to balance the gas and electricity systems.**

The **planning of those logistics,** with proposals for a grid connected as appropriate to storage facilities, came up in territorial workshops as the **most effective way of creating and cementing the links between potential supply and demand.**

In the workshops, all the stakeholders acknowledged the great expertise that exists among transport grid managers in this field. The consultation was also an opportunity to **identify dynamic areas where logistics projects could be launched in the short term** (Alsace, for example). But there are other less mature areas where the first steps could be taken in planning participative hydrogen transport and storage projects (areas like Marseille or Dunkirk).

It should be noted that some stakeholders mentioned CO_2 capture and storage to decarbonise their activities, indicating that a **clear picture of future logistics is just as important for CO_2 as for hydrogen** to bring projects to fruition.

One really good thing about the exercise is that it will be repeated, so that transport needs, which are bound to change over time, can regularly be reassessed, to ensure the jointly constructed network will **properly serve the needs of a developing high-performance hydrogen market.**

INTRODUCTION

HYDROGEN AS AN ENERGY CARRIER TO ACHIEVE CARBON NEUTRALITY IN FRANCE AND IN EUROPE

The energy transition is the core of European and French policies to combat climate change, with the aim of achieving carbon neutrality by 2050. Hydrogen is an essential vector for energy integration, allowing the storage of electricity from intermittent sources. It is a key tool for decarbonising industry as well as land, river, maritime and rail transport, all of which are high emitters of greenhouse gases. With a massive development in the production of renewable electricity in prospect, hydrogen production would make it possible to convert surplus electricity and make a contribution to the optimisation and flexibility of the energy system as a whole.

At the European level, in 2021 the European Commission put forward its "Fit for 55" package, to reduce the EU's net greenhouse gas (GHG) emissions by at least 55% between now and 2030 compared with 1990 levels, particularly through the increased use of renewable energies including hydrogen.

In July 2020, it also adopted a hydrogen strategy to support the decarbonisation of hydrogen production and develop its deployment across the sectors of industry, transport, electricity generation and buildings.

The strategy foresees development following a three-phase trajectory. From 2020 to 2024, the target will be to decarbonise existing hydrogen production for current uses. In the second phase (2024-30), hydrogen will be an integral part of the EU's integrated energy system, with electrolyser capacity of at least 40 gigawatts. From 2030 to 2050, technologies using renewable hydrogen should reach maturity and be deployed on a large scale across all sectors that are hard to decarbonise.
The Commission estimates cumulative investment in renewable hydrogen production capacity of between 180 and 470 billion euros by 2050, and around 3 to 18 billion euros for low-carbon hydrogen.

At the French national level, in September 2020 the Government established its own ambitious national strategy for the development of decarbonised hydrogen to make industrial processes and heavy transport greener, leading to the emergence of a French electrolysis sector with the aim of having 6.5 GW of electrolyser capacity in place by 2030. The strategy underlines the importance of partnerships between local authorities and industry in mutualising supply and developing uses, to create large-scale territorial projects.

A FAVOURABLE CONTEXT FOR STAKEHOLDER CONSULTATION

The deployment of a future low-carbon and renewable hydrogen grid is an integral part of the development of the energy mix of tomorrow. It must be carefully designed, considering its **complementarities with other renewable and low-carbon energy carriers, and at the least possible cost to the end consumer.** The drop in volumes linked to gains in energy efficiency and the local consumption of renewable gases mean we can anticipate that part of the pipelines belonging to French natural gas transport grid managers could be converted at low cost and made available for transporting hydrogen. That convertible pipeline capacity is an opportunity for users of renewable and low-carbon hydrogen or other gases to benefit from substantial savings over the deployment of a dedicated hydrogen grid. The *European Hydrogen Backbone* report[1] estimates that investment costs are about 5 to 6 times higher for the deployment of a new hydrogen transport pipeline than for the conversion of an existing gas pipeline.

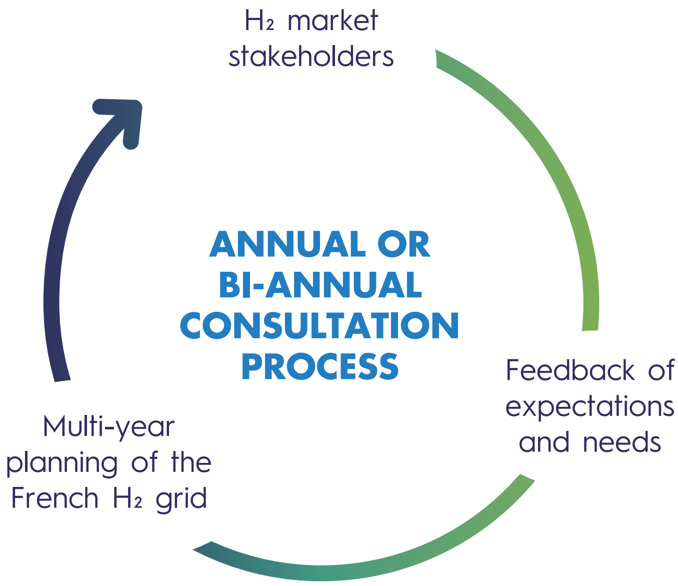
Since **investment in and deployment of hydrogen transport and storage infrastructures are long-term commitments**, their planning must be anticipated well in advance, in line with the current and future needs of the hydrogen market. Indeed, the development of transport and storage overcapacity would lead to a risk of unnecessary cost for a certain period of time. Conversely, the development of capacities adjusted to match short-term needs only would quickly lead to congestion, which would be detrimental to the roll-out of the hydrogen market. To cite one example, the refurbishment or construction from new of a pipeline is estimated to take between 4 and 7 years.

It was in this context, and driven by those convictions, that GRTgaz and Teréga launched a **1st national consultation of stakeholders in the French low-carbon and renewable hydrogen market, on 1 June 2021.** The aim is to support stakeholders in coalescing around a shared, consolidated vision of stakeholders' expectations in terms of infrastructure for optimal deployment of hydrogen as an energy carrier in the short, medium and long term.

GRTgaz and Teréga intend to set up a **continuous dialogue with stakeholders in the market.** That consultation is therefore intended to be repeated at regular intervals to support the development of the sector and to include the necessary hydrogen-related logistics requirements.

[1] *European Hydrogen Backbone*

AN ONGOING CONSULTATION PROCESS



The first round of that consultation, aimed at **all stakeholders in the low-carbon and renewable hydrogen market**: industry, energy suppliers, producers and shippers, public and institutional actors, associations, infrastructure operators and academic stakeholders. Everyone was able to respond via an online questionnaire, available from the pages dedicated to the consultation on the respective websites of GRTgaz and Teréga. The data collection and qualification of needs phase closed on 10 September 2021. GRTgaz and Teréga published a press release on 6 October 2021, feeding back the initial findings of that consultation to interested parties[2].

Since then, hydrogen was validated as an energy carrier by the 4th Gas Package, presented on 15 December 2021 by the European Commission, proposing the establishment of a hydrogen market favourable for investment and the development of infrastructures, integrated at the European level. The market rules will cover access to hydrogen infrastructures, the separation of hydrogen production and transport activities and the setting of tariffs. Most notably, the proposal stipulates that national grid development plans should be founded on a common scenario for electricity, gas and hydrogen. That scenario should be in line with national integrated energy and climate plans, as well as the Ten Year Network Development Plan at EU level. Gas grid managers are expected to provide information about infrastructures that could be dismantled or reassigned, and distinct reports will be established concerning the development of the hydrogen network to guarantee that construction of the system is based on a realistic projection of demand.

[2] GRTgaz, Teréga, *Press release - Hydrogen Consultation: Feedback of initial findings and next steps, 6 October 2021*

That consultation falls fully within the framework defined by the European Commission and will feed into the work undertaken by GRTgaz and Teréga with adjacent energy infrastructure operators to contribute to planning of the European hydrogen grid of tomorrow.

It should also be noted that since the consultation was launched, a study into "the role of hydrogen transport and storage infrastructures: an industrial competitiveness challenge", published in November 2021 and developed within the sector's strategic committee - New Energy Systems[3], underlines the role played by infrastructures in reducing the cost of the hydrogen delivered for the consumer. Thus, by pooling production capacities, the deployment of hydrogen infrastructures between industrial areas could reduce the cost of the renewable and low-carbon hydrogen delivered by 10% by 2030, and cumulative investment costs by 9% in 2030, compared with a no-infrastructure scenario.

The quality of responses to the consultation allowed GRTgaz and Teréga to get a better grasp of the needs of the different stakeholders and to identify **a strong and specific requirement for practical structuring of the hydrogen logistics of tomorrow.** The data collected were generally qualitative and a source of insights into the stakeholders' decarbonisation strategies and their hydrogen transport requirements. Given that this is an emerging market, and that the consultation is non-binding, the quantitative data received still need to be studied in greater detail in future rounds of the consultation. GRTgaz and Teréga have therefore analysed all the data sent, favouring an aggregated and trends-based approach, allowing them to draw conclusions, while ensuring the confidentiality of the information sent and the anonymity of contributions.

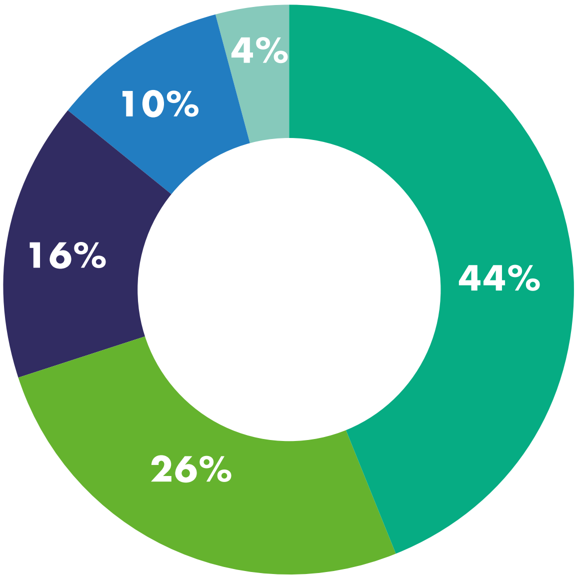
[3] The role of hydrogen transport and storage infrastructures: a challenge for industrial competitiveness and new energy systems

CHAPTER 1

HIGH LEVEL OF INTEREST AMONG LOW-CARBON AND RENEWABLE HYDROGEN MARKET STAKEHOLDERS IN THE CONSULTATION PROCESS

A large number of stakeholders in the low-carbon and renewable hydrogen market involved themselves in this first national consultation. As a result, GRTgaz and Teréga received **133 responses**, allowing them to cover around 90 hydrogen production and/or consumption sites across the whole of France. Some stakeholders wanted to go beyond the questionnaire, seeking two-way exchanges with GRTgaz or Teréga[4], to set out in detail their needs and expectations in respect of transport and decarbonisation.

The significant number of responses and exchanges with stakeholders in the low-carbon and renewable hydrogen industry demonstrates how interested they are in the issue of hydrogen logistics as a response to their energy transition needs. Their responses supported GRTgaz and Teréga's perception of the dynamism within the industry and the need to bring all stakeholders together to imagine and plan together the hydrogen grid of tomorrow.



TYPES OF CONTRIBUTOR TO THE HYDROGEN CONSULTATION

- Industry
- Energy shippers / suppliers / traders / producers / energy infrastructure operators
- Public / Institutional / Local authority stakeholders
- Engineering companies / consultancies / research organisations / Suppliers of equipment or technological solutions
- Transporters: goods / passengers

Industry, particularly those sectors that are high consumers of energy and emitters of CO_2, make up nearly half of the contributors to the consultation. Among other types of stakeholder: 26% are energy shippers / suppliers / traders / producers / storage operators, 16% are public stakeholders: chiefly regional authorities and EPCIs[5].

The responses to the consultation, as a whole, therefore reveal the main principles of decarbonisation over different timescales.

[4] GRTgaz and Teréga received nearly 70 requests for two-way exchanges to look in greater depth with the stakeholders at their vision for the hydrogen market.

[5] Public Inter-commune cooperation establishments (Établissements Publics de Coopération Intercommunale).

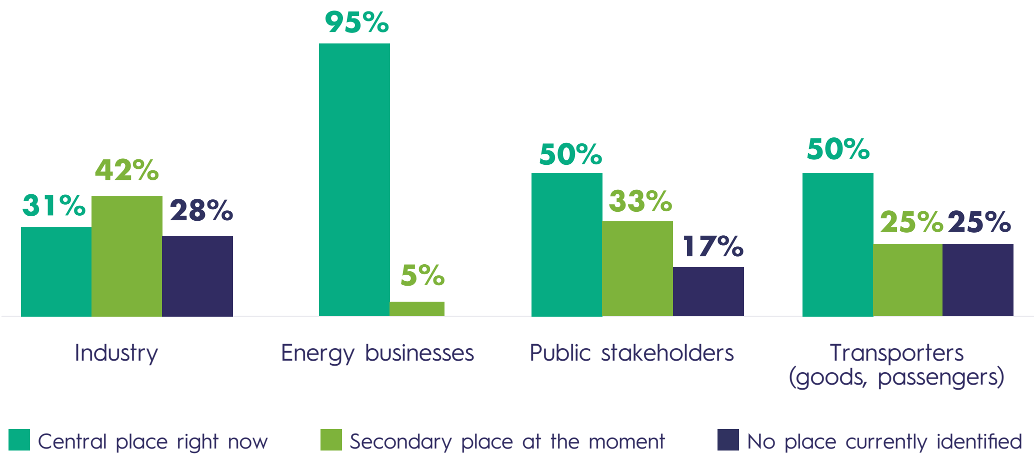
DECARBONISATION STRATEGIES OF CONTRIBUTORS TO THE HYDROGEN CONSULTATION

Beyond the energy efficiency actions already in place, **a change of energy carrier lies at the heart of stakeholders' current strategic thinking on decarbonisation.** That includes the use and production of renewable and recovered energy as a substitute for carbon-based energy.

In the medium term, industry, public stakeholders, energy businesses and transporters of goods and passengers envisage more structural technological breakthroughs in their decarbonisation strategies. That includes the development of new processes and/or the use of low-carbon and renewable hydrogen, as well as the development of CO_2 capture, utilisation and/or storage technologies.

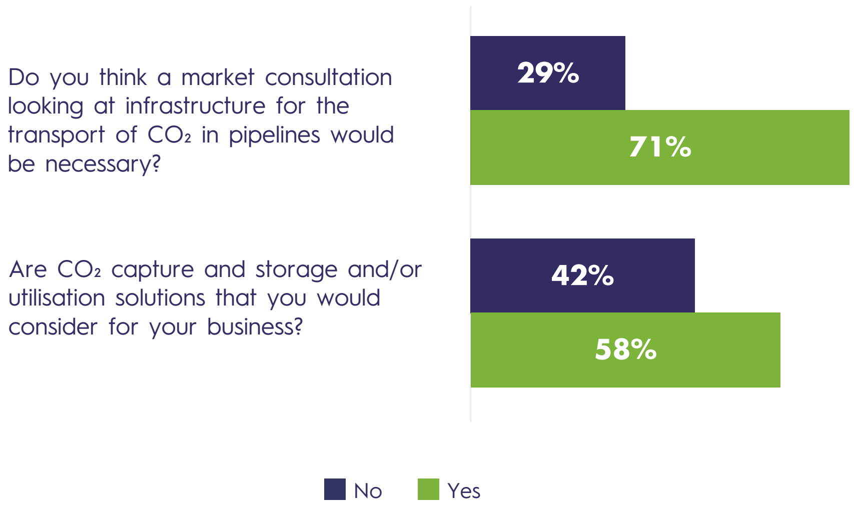
Although stakeholders as a whole have identified hydrogen as a lever for decarbonisation, its importance varies from one contributor to another, depending on the stakeholder's maturity and forward vision of their own hydrogen consumption or production requirements in the future.

HYDROGEN'S PLACE IN DECARBONISATION STRATEGIES



The use and production of low-carbon and renewable hydrogen is **not the only solution identified** by stakeholders in their decarbonisation strategies. A majority of them are also considering CO_2 capture, utilisation and storage (CCUS) at this stage. **Indeed, nearly 60% of industrial respondents are very interested in CCUS solutions, the majority of them in the short (<5 years) to medium (5 to 10 years) term.** More than 70% of them feel that a market consultation dedicated to that technology ought to be conducted jointly with the one on hydrogen, to plan a possible dedicated infrastructure.

RESPONSES FROM INDUSTRY TO THE CO_2 QUESTIONS

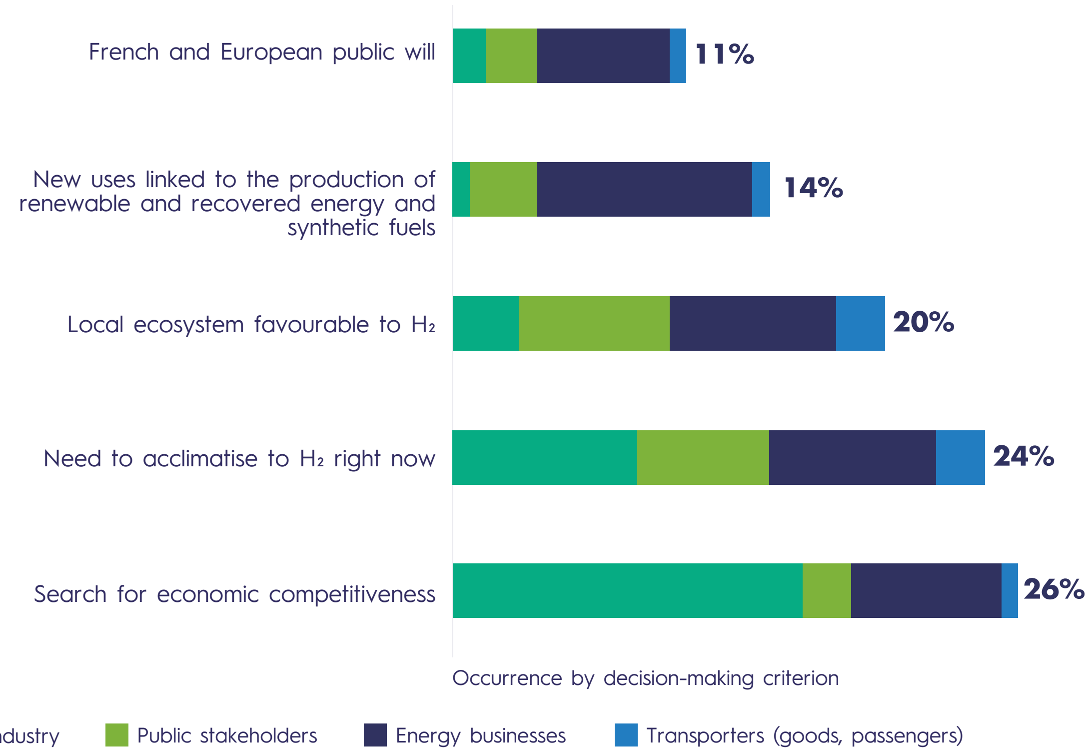


That choice of CCUS technologies can also play a part in the hydrogen market stakeholders' strategies, concurrently, in competition, or additionally to a switchover to hydrogen, to achieve long-term carbon neutrality targets.

"Studies are under way to identify opportunities for the use of hydrogen as a means of exploiting the CO_2 emitted by our activities to produce substitute products for oil-based products, such as fuels or plastics. Co-produced oxygen from hydrogen production can equally be used as a lever for improving energy efficiency at cement plants, thus helping reduce emissions." - An industrial respondent (Cement works)

Hydrogen is therefore one of many decarbonisation solutions which play a part in resolving the wider issue of how to decarbonise industrial activities. There are many different criteria for adopting hydrogen as part of decarbonisation strategies, as shown in the chart below.

MAIN DECISION-MAKING CRITERIA IN FAVOUR OF HYDROGEN



Generally speaking, hydrogen market stakeholders hold the conviction that the energy carrier will play an essential role in decarbonising their activities. They stress the need to **get accustomed to hydrogen as an energy carrier right now**, through experiments, to integrate it into their industrial processes, test its reliability and productivity, check its economic costs and benefits and define the scope of its application.

"Tests on the integration of hydrogen and biofuels into the industrial process are under way to power the turbines" - An industrial respondent (Iron and steel industry)

"From 2025: development of the first tests with a gas/hydrogen mix on an industrial plant" - An industrial respondent (Transport)

For industry, the quest for economic competitiveness remains the most frequently mentioned criterion when decisions are made about using hydrogen as an energy carrier.

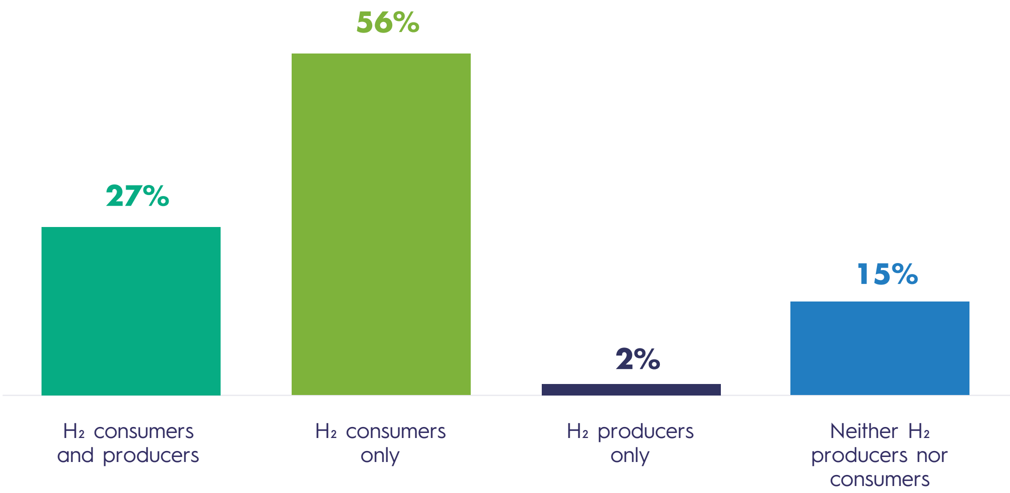
That quest will extend over the longer term, against a backdrop of growing pressure associated with carbon quotas and the potential competitiveness of low-carbon and renewable hydrogen compared with other carbon-based energy carriers. That competitiveness has not been achieved thus far, since the advertised costs of low-carbon and renewable hydrogen to the end user still remain too high, according to those same industrial respondents.

"Given the difficulty of getting a clear picture of the energy sources that will be available tomorrow to enable us to decarbonise, hydrogen remains one possible route, even though its price at the present time does not make it attractive" - An industrial respondent (Agri-food)

"Our hydrogen consumption is aimed at meeting the technical needs of our industrial sites, taking into account both the economic constraints and the achievement of our carbon neutrality objective." - An industrial respondent (Refining)

Among those industrial actors contributing to the consultation, 56% of them predict that they will consume hydrogen, whereas 27% envisage being both producers and consumers at the same time. To summarise, **more than 80% of industrial respondents identify hydrogen as a decarbonisation vector** for their activities, and are already looking to integrate it into their decarbonisation strategies for use in the medium term.

PROFILES OF INDUSTRIAL RESPONDENTS TO THE HYDROGEN CONSULTATION

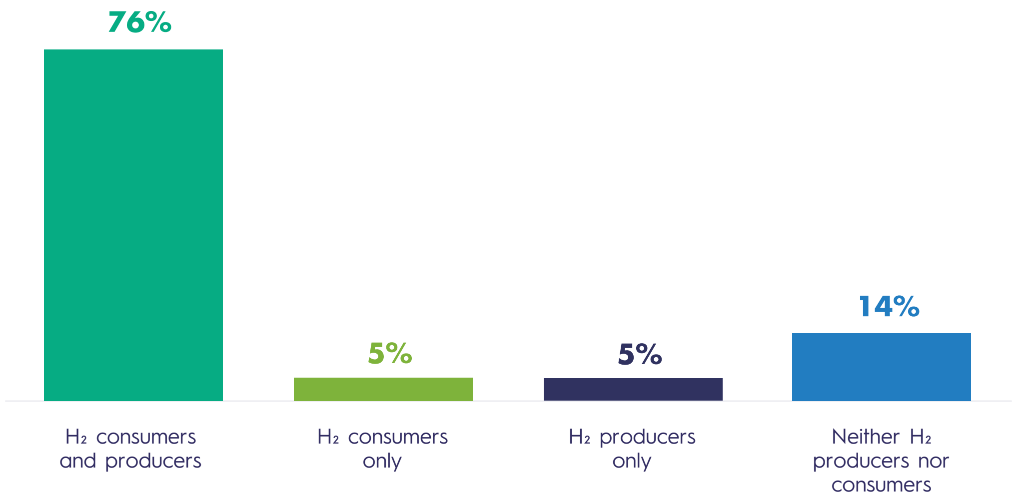


Public stakeholders and local authorities see hydrogen as a way of strengthening the industrial attractiveness of their territory, while at the same time contributing to them reaching their decarbonisation targets. Some of those public stakeholders want to position themselves as active participants in the production of low-carbon and renewable hydrogen in their territory, to achieve energy autonomy and to supply the industrial and transport requirements of those within their jurisdiction. They identify a **local ecosystem favourable for the deployment of hydrogen as a decisive criterion in encouraging certain local economic actors to choose hydrogen as a solution for decarbonising their activities.** To that end, they are particularly committed to supporting local initiatives to use and produce low-carbon and renewable hydrogen, particularly in the area of transport. Their low-carbon and renewable hydrogen consumption and production targets are generally set out in their planning documents (PCAET (territorial climate-air-energy plan), SRADDET (regional planning, sustainable development and territorial equality scheme)).

"THUS far, all emerging industrial projects directed towards decarbonisation in the territory are reliant on hydrogen for their development. There are many demands, encouraging the territory to mobilise itself and bring suitable solutions.
Having hydrogen resources in the territory would constitute an opportunity to maintain and diversify existing activities, but also to welcome new innovative activities looking to the future and encouraging the development of new inter-industrial synergies and a reduction in emissions." - A public stakeholder (Transport).

Among those public stakeholders, most of them territorial authorities and EPCIs (inter-commune cooperation establishments), 76% of them describe themselves as both producers and consumers of hydrogen. The 14% who do not claim to be producers or consumers of hydrogen are actors involved in research, or business and citizens' associations.

PROFILES OF PUBLIC STAKEHOLDER RESPONDENTS TO THE HYDROGEN CONSULTATION

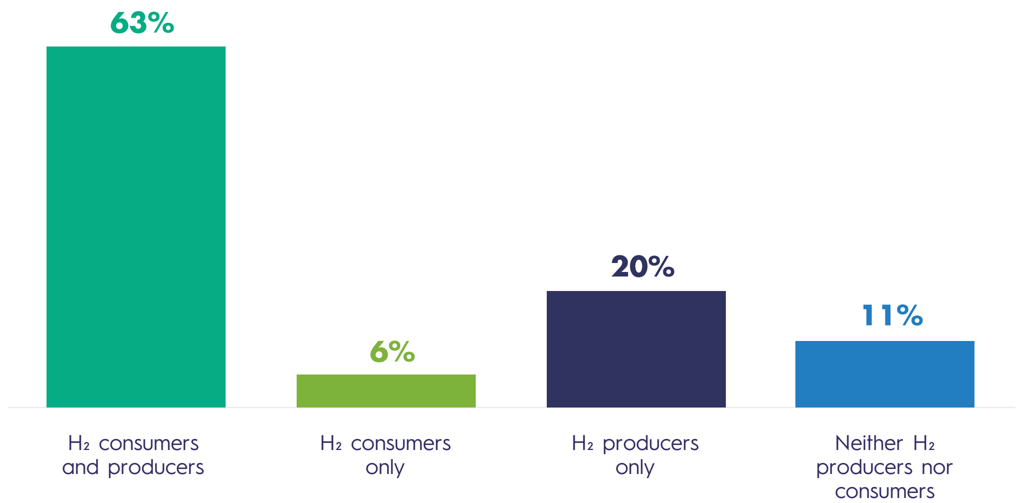


For energy businesses (Energy producers and suppliers, and energy infrastructure operators), **hydrogen is a solution for decarbonising the energy mix and for the storage of intermittent renewable energy**.

"As a producer of renewable energy, the problem of the intermittency of our solar and wind power generation and the variability of prices needs to be answered, and will become a crucial issue. Hydrogen produced by electrolysis will allow an additional outlet, both for storing our energy and for selling it on in the form of gas to local industry."
- An energy business (Energy producer)

Among those energy businesses, 63% describe themselves as both producers and consumers of hydrogen energy.

PROFILES OF ENERGY BUSINESS RESPONDENTS TO THE HYDROGEN CONSULTATION



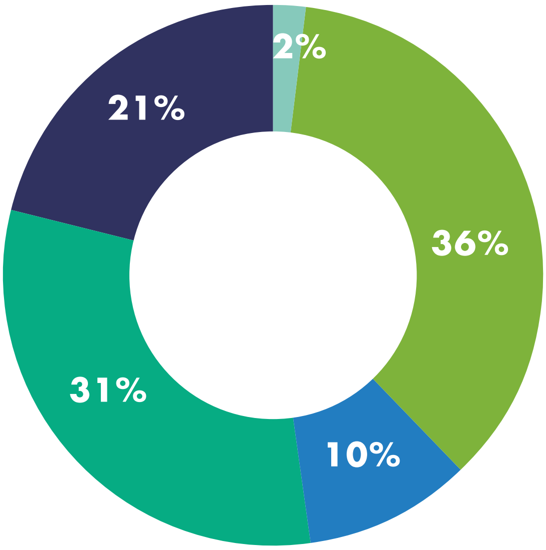
CHAPTER 2

HYDROGEN TO DECARBONISE INDUSTRIAL AND TRANSPORT USES IN THE FIRST PLACE

USES OF LOW-CARBON AND RENEWABLE HYDROGEN CLEARLY IDENTIFIED BY RESPONDENT TYPE

The responses to the consultation also enabled us to **explore uses of hydrogen** in industry, the territories, transport and energy production.

The chart below illustrates the frequency with which the different uses appeared in the responses. It does not correspond to the volumes consumed by each use.



OCCURRENCES OF USES IN RESPONSES TO THE CONSULTATION

- New industrial uses (process transformation, industrial heat, energy source, CCUS)
- Traditional use as raw material (raw material / co-product)
- Transport uses
- Uses for electricity production
- Residential/tertiary uses

NEW INDUSTRIAL USES

The number of responses from industrial actors enabled us to identify more accurately what uses each sector has in mind for hydrogen. It seems that a great many industrial actors who have not historically used hydrogen in their processes are wondering about integrating it in its renewable and low-carbon form into their decarbonisation strategy. Indeed, the “new industrial uses” make up 36% of occurrences among responses to the consultation.

Those uses include:

- Transformation of processes (introduction of hydrogen for the transformation of products);
- Replacement of a carbon-based energy source;
- Heat generation;
- Recovery of the CO_2 emitted by activities, including methanation.

They crop up particularly in the following sectors of industry:

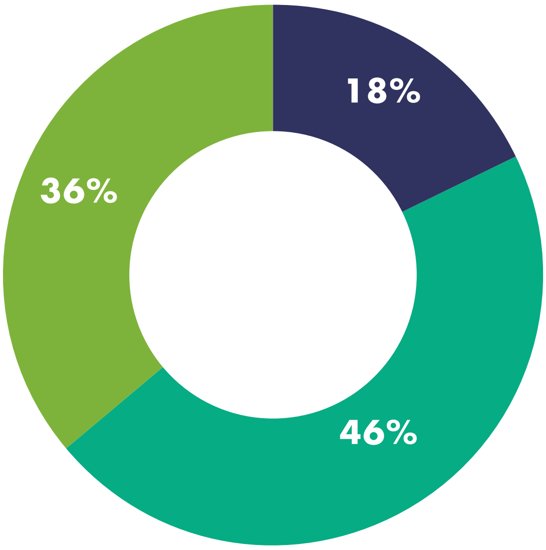
SECTOR	ENVISAGED USES FOR HYDROGEN
Agri-food	Replacement for a carbon-based energy carrier Transformation of processes
Chemistry	Industrial heat
Building materials	Industrial heat CCU
Glassmaking	Industrial heat
Refining / petrochemicals	Replacement for a carbon-based energy carrier CCU
Iron and steel / metallurgy	Transformation of processes Industrial heat Replacement for a carbon-based energy carrier CCU
Paper & cardboard	Industrial heat

HISTORIC USES IN INDUSTRY

Industries which already use fossil-based hydrogen in their activities envisage simply using low-carbon and renewable hydrogen as a substitute material, particularly in sectors such as refining, petrochemicals and chemicals, where energy consumption is intensive and where the financial effects associated with decarbonisation become a real issue for competitiveness.

MOBILITY USES

Uses for hydrogen in the transport of goods and passengers are also strongly anticipated in the medium term (2030-2040). They make up 31% of occurrences in responses to the consultation. Those uses particularly target heavy transport (land, sea or river), but also – an in significant volumes over time – aviation, particularly for short- and medium-haul transport of passengers and goods.



TYPES OF RESPONDENT WITH TRANSPORT USES FOR HYDROGEN

- Public stakeholders
- Industry
- Transporters (goods / passengers)

Public stakeholders with expertise in the organisation of local transport chiefly envisage hydrogen being used for public transport (buses, sea and river shuttles, trains). Similarly, local authorities based in maritime industrial areas envisage using low-carbon and renewable hydrogen for the transport of goods (on land and at sea). Finally, they are planning to use hydrogen for their own fleets (particularly domestic refuse vehicles) and use public orders to act on demand and encourage the emergence of territorial ecosystems.

"The development of hydrogen in our territory requires a plan to be put together to supply public transport via hydrogen-powered long-distance buses, with heavy goods vehicles following on and, finally, light vehicles"

Some stakeholders in the passenger and goods transport sector envisage decarbonising their vehicle fleets (lorries, shuttles, buses) by switching to hydrogen-powered mobility.

Similarly, some industrial stakeholders with internal fleets envisage switching over to hydrogen-powered vehicles.

SECTOR	ENVISAGED USES FOR HYDROGEN
Air transport	Gas for ground vehicles and for e-fuel production, and liquid for direct use as aircraft fuel
Maritime or river transport	Gas or liquid depending on engine type[6]
Road transport	Gas for direct use and for e-fuel production

[6] Information not specified in responses to the consultation, but taken from external literature.

More specifically, **the challenge of decarbonising the aviation sector has revealed a significant need for hydrogen by 2030-2035,** either in liquid form (possibly with liquefaction on the airport site) in association with the roll-out of hydrogen-powered aircraft for short- and medium-haul flights, or for the production of synthetic fuels (SAF[7] and e-fuels such as e-kerosene[8]). By 2050, according to the responses received to the consultation, volumes could make up to 30 TWh of hydrogen consumption. In the shorter term, and with a view to preparing for the deployment of the hydrogen aircraft, the challenge for decarbonising the aviation business is to massify uses of gaseous hydrogen on the ground (shuttles, trucks etc.) as for the taxis already running on hydrogen to serve airports.

USES ASSOCIATED WITH THE PRODUCTION OF RENEWABLE AND RECOVERED ENERGY.

This use includes flexibility and storage services rendered to the electricity system, thus contributing to decarbonisation of the energy mix and the integration of intermittent renewable electrical energy. It is driven principally by **energy producers and suppliers**, as well as by energy **infrastructure operators**. It should also be noted that local authorities envisage this type of hydrogen use associated with decentralised production of electricity, particularly through their energy syndicates who are already active in the production of renewable energy.

"In the local area, we envisage having electrolysis stations with injection into the gas grid at the foot of our wind farms, plus increasingly large storage infrastructures." - Public stakeholder (A metropolitan authority)

RESIDENTIAL / TERTIARY USES

Although there were a small number of responses talking about use in the residential/tertiary sector, all the same they did mention the use of hydrogen for the production of synthetic methane (via the methanation process) which, injected into the gas grid, would serve the heating needs of the residential and tertiary sectors. However, the major challenge for that use would be allow delivery of the gas produced through methanation at a price close to that of other renewable methane gases, particularly biomethane, to ensure its competitiveness.

[7] Sustainable Aviation Fuel

[8] Synthetic kerosene with the hydrogen produced by electrolysis powered with renewable – or, in any case, decarbonised – electricity.

INDICATIONS ABOUT THE QUALITY OF HYDROGEN NEEDING TO BE SPECIFIED FOR EACH USE

Expected pressure ranges for industrial uses are generally around 30 bar, and about 350 to 750 bar for transport use.

Contributors also talked about the **envisaged purity level of the hydrogen for their use**. For transport, a purity level of greater than 99% was identified. On the industrial stakeholders' side, out of the 58 who responded to the hydrogen consultation, only 25 of them expressed a purity requirement, 15 being in favour of purity of 99% or higher, particularly for use as a material.

On the issue of **trace compounds**, only 24 responses were received, and they were very disparate. Even though acceptable concentrations were not set out in detail, submissions did however flag up some critical impurities such as oxygen, water and sulfurated compounds, particularly for use as a material. A number of industrial respondents talked of analysis work under way on this issue within their organisations.

Those responses need to be studied and developed in greater detail through the standardisation work going on within European bodies, but also through a specific process between GRTgaz and Teréga and **French industrial actors to obtain further details about the effect of impurities on their process** and to fine-tune the acceptable concentration levels of trace compounds.

CHAPTER 3

DEPLOYMENT ROADMAP NOT YET IN PLACE FOR THE HYDROGEN MARKET, BUT LOGISTICAL RESOURCES ARE REQUIRED

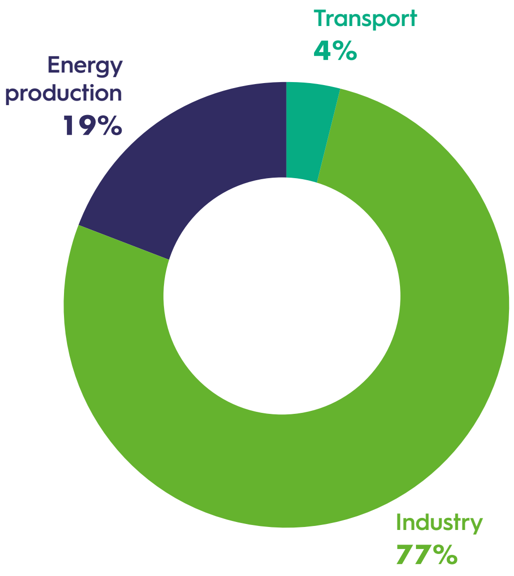
LONG TERM NEEDS CLEARLY DEFINED FOR MAJOR INDUSTRIAL PLAYERS IN THE FACE OF A STILL-EMERGING SUPPLY OFFER

The emerging nature of the low-carbon and renewable hydrogen market makes it difficult for stakeholders accurately to anticipate how their consumption will change.

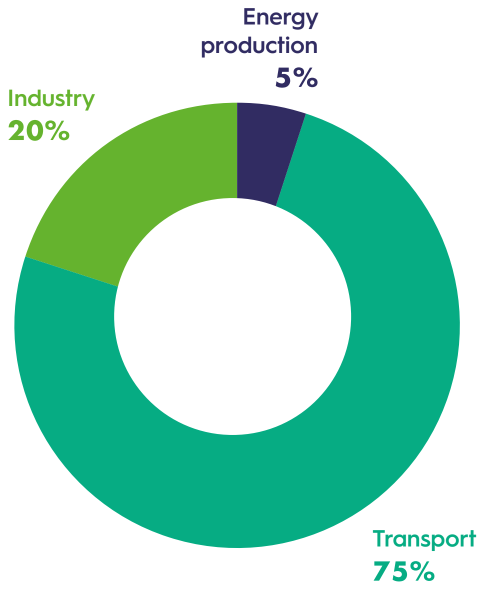
The volume of the demand for hydrogen is relatively well identified by the major industrial stakeholders in their strategies for decarbonising their activities with a view to carbon neutrality in 2050. However, the definitive date for converting industrial facilities to hydrogen still remains uncertain.

Based on the quantitative data submitted by market stakeholders, we can see that the volumes of renewable and low-carbon hydrogen are mostly destined for industrial use in the short to medium term, and aviation by 2050.

DISTRIBUTION BY USE OF HYDROGEN VOLUME REQUIREMENTS BY 2030, AS COMMUNICATED BY CONTRIBUTORS



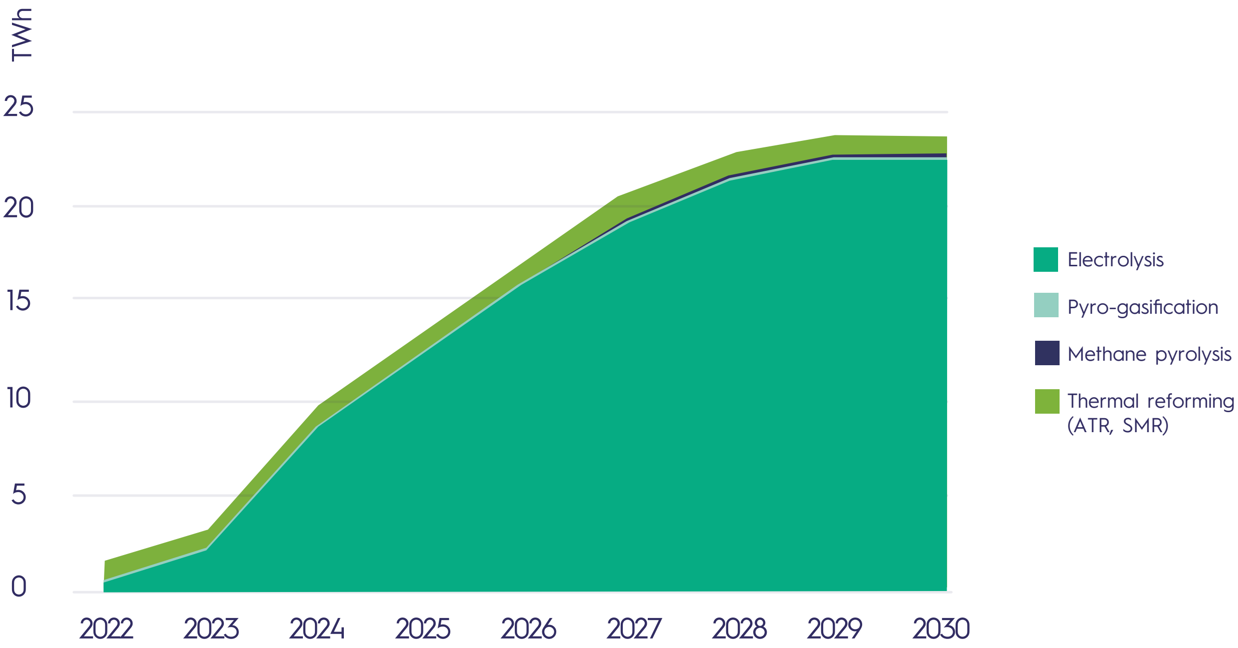
DISTRIBUTION BY USE OF HYDROGEN VOLUME REQUIREMENTS BY 2050, AS COMMUNICATED BY CONTRIBUTORS



When it comes to projected hydrogen production, responses to the consultation better reflect **potential production volumes from the first projects which are currently in the development phase.** Indeed, the production volumes of renewable and low-carbon hydrogen quantified by the stakeholders do not change any further after 2030, settling at about **25 TWh/yr).** Those volumes are in line with French hydrogen strategy targets, i.e. 6.4 GW of electrolysis capacity installed by 2030, corresponding to the production of approximately 600,000 tonnes of hydrogen (23.4 TWh).

The absence of additional volumes beyond 2030 is probably explained by the current uncertainties weighing on the hydrogen market, linked in particular to demand, as mentioned previously, but also to the finance and support conditions. The main concerns among producers who contributed to the consultation cover the short term and the realisation of those first projects. Some mention the problems of securing land, financial support and the difficulty of accessing renewable electricity.

GROWTH IN FORECAST HYDROGEN PRODUCTION VOLUMES, BROKEN DOWN BY TECHNOLOGY

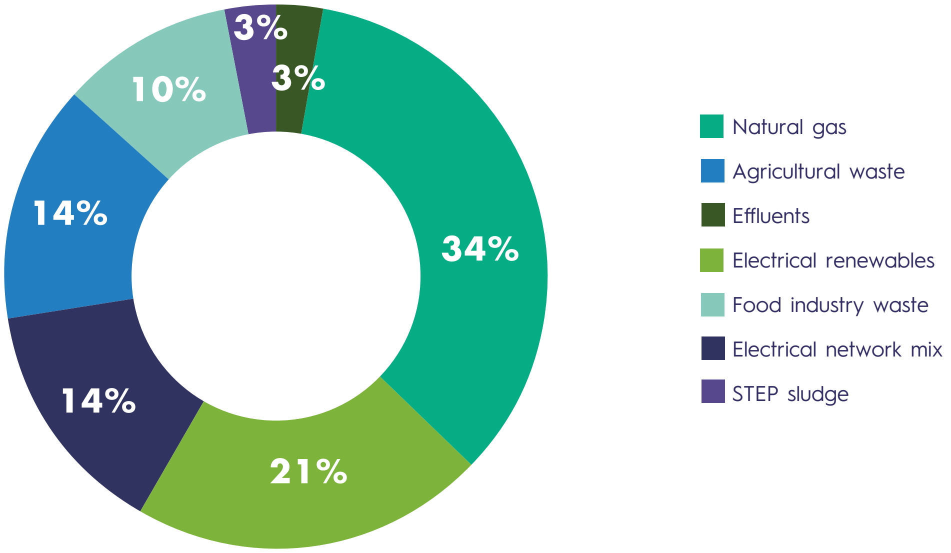


Concerning hydrogen production technologies, the responses identify electrolysis of water using electricity from renewables or a mixed network as the main technology for producing hydrogen by 2025.

Thermal reforming technology involving the capture and storage of the carbon is also envisaged. A few pyrolysis projects are envisaged, with marginal volumes by 2030.

Some contributors also mention the potential of agricultural waste, the agri-food business, STEP sludges and effluents, using still-emerging technologies such as pyro-gasification and hydrothermal gasification. It should be noted that the number of occurrences does not reflect planned volumes.

OCCURRENCE OF ENERGY SOURCES ENVISAGED FOR H_2 PRODUCTION IN RESPONSES TO THE CONSULTATION



Geographically speaking, the market's responses to the consultation broadly confirm the hydrogen production and consumption areas identified when the consultation was launched.

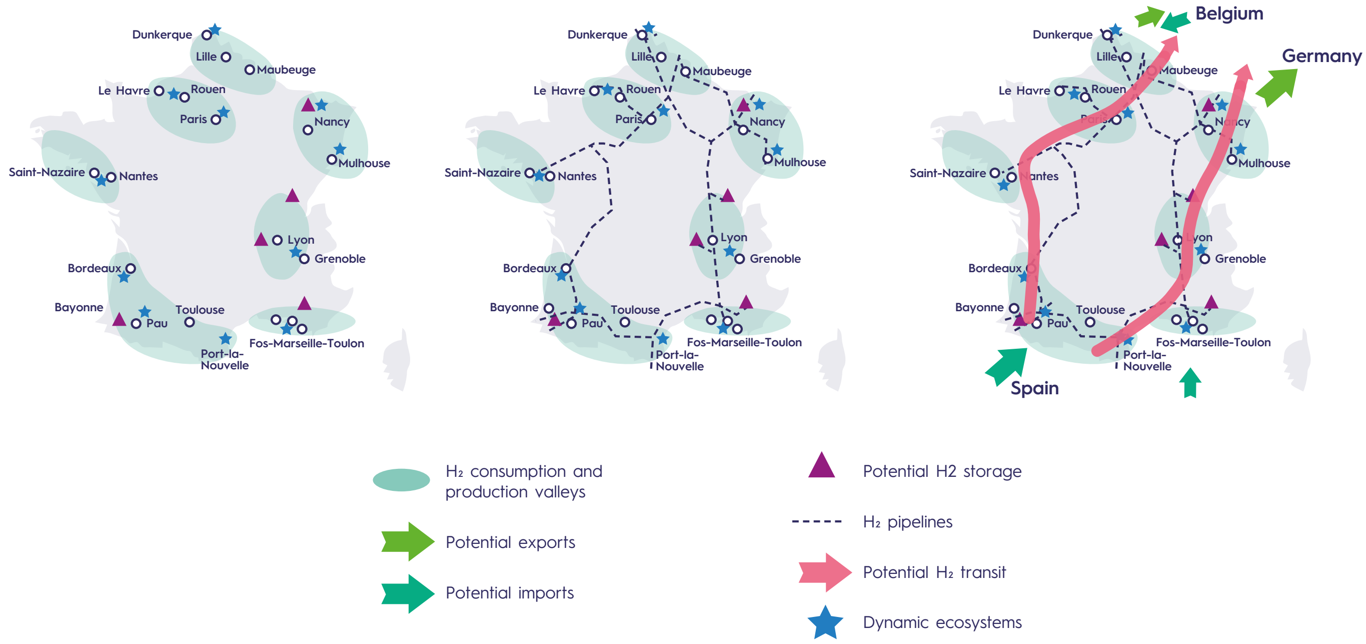
Industrial participants in the consultation mostly have activities located in the major industrial areas. These industrial hubs are where current and future large consumers for low-carbon and renewable hydrogen are concentrated, along with the majority of hydrogen production projects, forming clusters of local ecosystems.

When these local ecosystems are grouped together, seven hydrogen valleys emerge within France, in line with those identified by France Hydrogène[9]:

- The **"Nord" hydrogen valley**, with a dynamic ecosystem structured around the industrial port zone in Dunkirk, following recent announcements of hydrogen production and usage projects, particularly in the iron and steel and e-fuel sectors.
- The **"Vallée de Seine" hydrogen valley**, with three ecosystems identified in the Le Havre industrial port zone, the Rouen industrial hub and the airport business areas in the Ile-de-France.
- The **"Grand Est" hydrogen valley**, with notable ecosystems around the industrial hubs in Moselle, Carling, and along the Rhine, where a number of production and consumption projects have been announced towards Chalampé, particularly in the field of chemicals and fertilisers.
- The **"Centre-Est" hydrogen valley**, with ecosystems along the chemicals valley.
- The **"Sud-Est" hydrogen valley** chiefly centred on the Fos-Marseille industrial port zone, which includes a number of key industries for the hydrogen sector: refining, iron and steel, and petrochemicals.
- The **"Grand-Ouest" hydrogen valley**, with the significant industrial port zone of Nantes-Saint-Nazaire.
- The **"Sud-Ouest" hydrogen valley**, covering the industrial port zones of Bordeaux and Port-la-Nouvelle, and passing through the Lacq industrial basin, birthplace of the French gas industry.

9 Study: "Trajectoire pour une grande ambition Hydrogène" ("Roadmap for an ambitious hydrogen strategy"), France Hydrogène, September 2021.

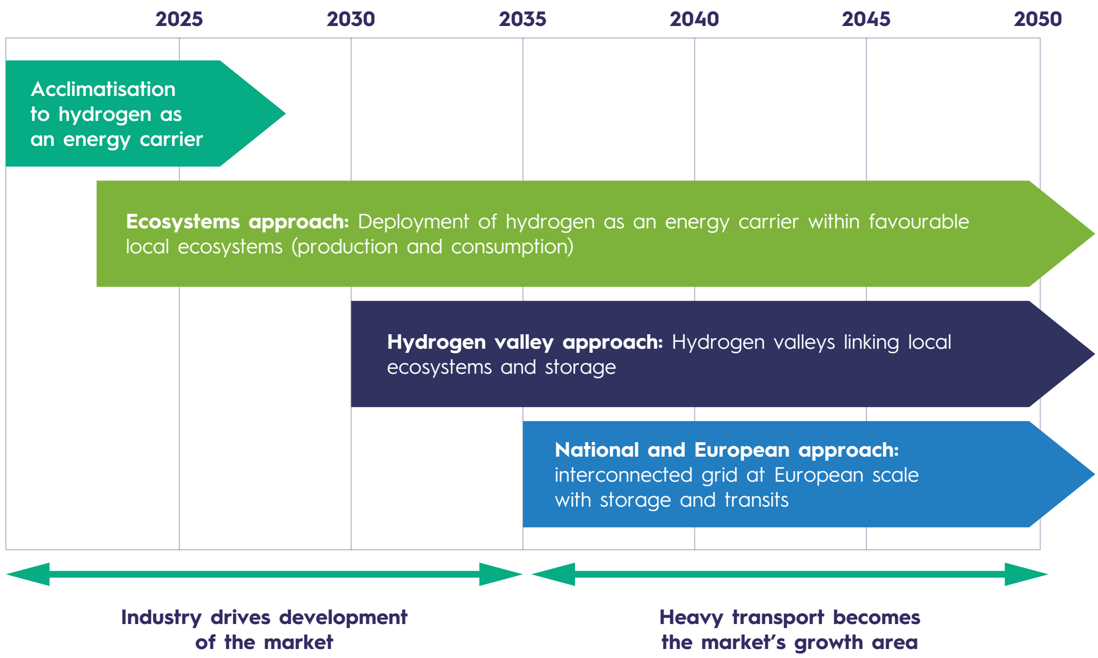
DEPLOYMENT OF HYDROGEN AS AN ENERGY CARRIER



From the timing point of view, responses flagged up a vision of the market developing in stages:

- In the very short term – and already under way – a period of **acclimatisation** among stakeholders to hydrogen as an energy carrier. This need for acclimatisation can be seen in stakeholders' involvement in pilot projects, demonstrators and prototypes, to test hydrogen's reliability in all its components, to check its economic model and to define an appropriate field of application in industry and mobility.
- In the short term, deployment of hydrogen as an energy carrier within **local ecosystems favourable** to its production and consumption, particularly for industrial and transport uses;
- In the medium term, the creation of **hydrogen valleys** interlinking local ecosystems via a regional pipeline-based transport grid, integrating hydrogen storage infrastructures from the very outset, to facilitate balancing and security of supply;
- In the long term, the structuring of an **interconnected grid at European level** for pipeline-based transport, incorporating storage infrastructures and ensuring transit into neighbouring countries.

DEPLOYMENT OVER TIME OF HYDROGEN AS AN ENERGY CARRIER



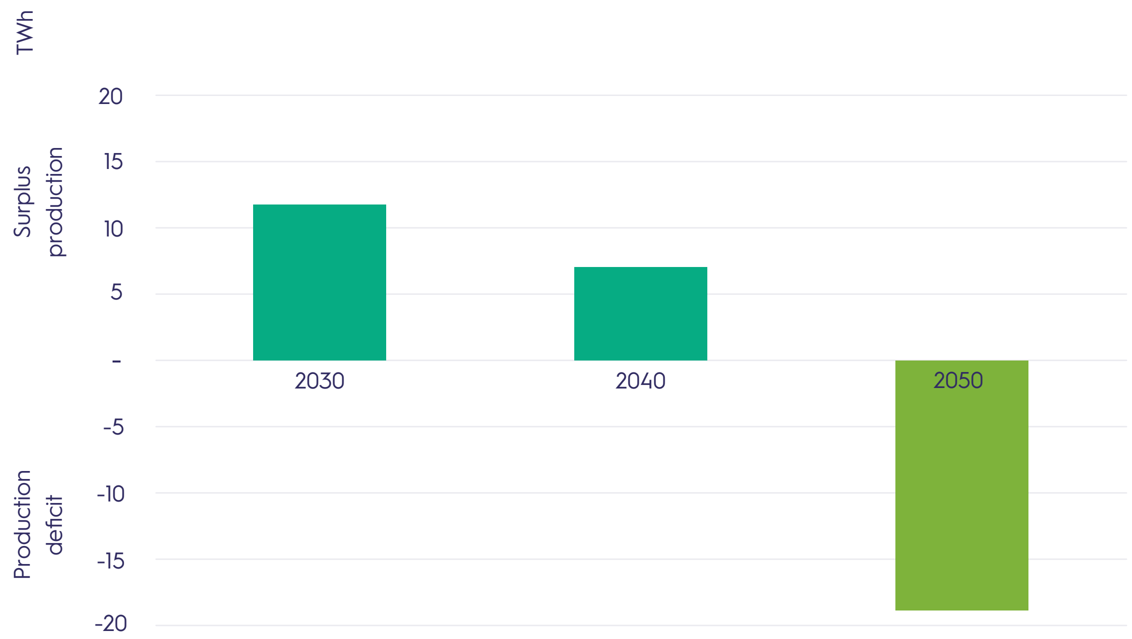
This staged approach confirms the vision set out by the European Commission in its hydrogen strategy[10] and the view of the European gas transport operators in their work on the *European Hydrogen Backbone*[11].

In terms of volume, responses to the consultation reveal an **imbalance between hydrogen supply and demand**, probably explained by the time lag between the different long-term forecasts of demand and short-term hydrogen production potential. Based on the data sent in by contributors, hydrogen production potential outstrips national needs up to 2040. Nevertheless, should aviation usage end up developing as envisaged by stakeholders in the sector, then the production capacity presently identified through this consultation would not be enough to cover demand by 2050.

[10] European hydrogen strategy

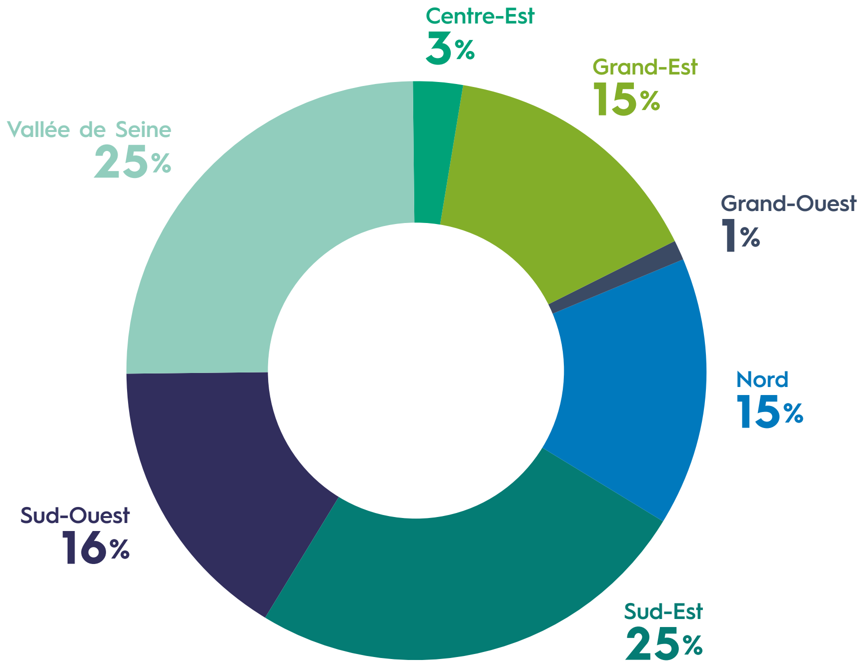
[11] *European Hydrogen Backbone*

DISCREPANCY BETWEEN PRODUCTION POTENTIAL AND FORECAST DEMAND IN FRANCE



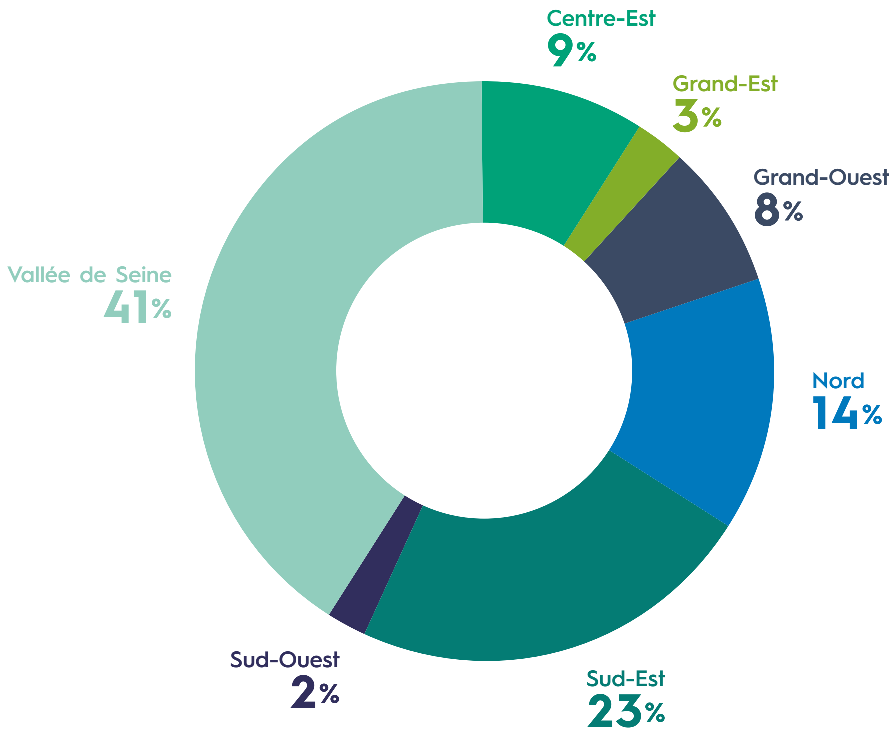
This first consultation has shown a **fairly uniform distribution of the potential production volumes envisaged across the different hydrogen valleys up to 2030.**

DISTRIBUTION OF HYDROGEN PRODUCTION VOLUMES UP TO 2030



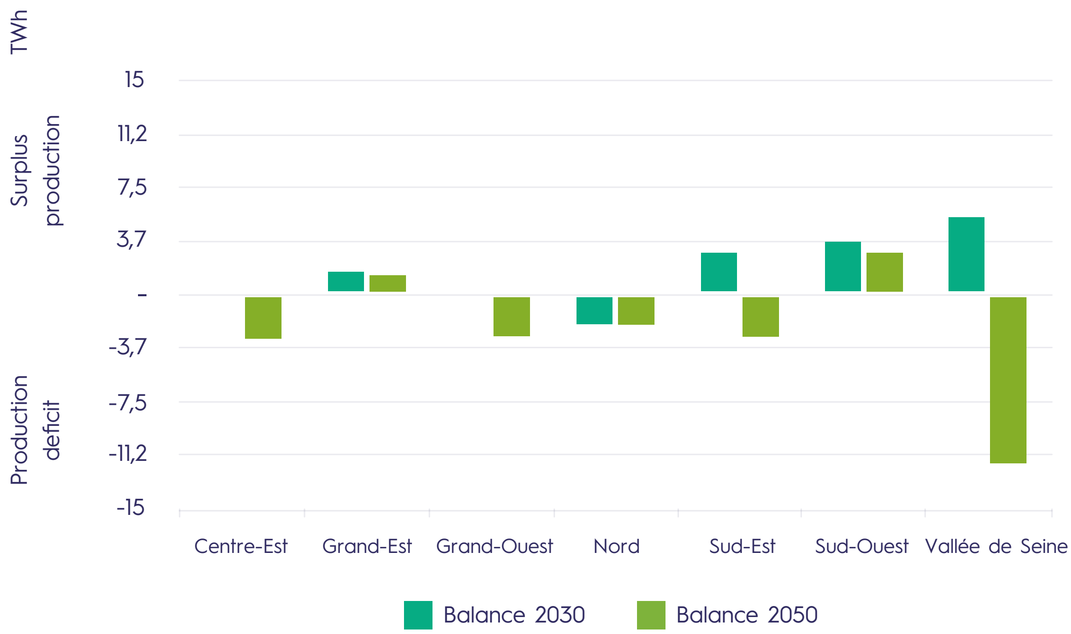
On the demand side, the **volumes submitted by market stakeholders by 2050 are marked by ambitious forecasts for the aerospace sector,** which accounts for the Vallée de Seine's large share.

DISTRIBUTION OF HYDROGEN PRODUCTION VOLUMES UP TO 2050



Imbalances between potential production and projected demand within the seven hydrogen production and consumption areas can also be seen. The Nord hydrogen valley shows a hydrogen production shortage in respect of demand from 2030. There is a more stark picture in the Vallée de Seine hydrogen valley, which shows a significant deficit in hydrogen production volumes due to the forecasts concerning air transport. By 2050, hydrogen valleys with an imbalance increase in number, with significant volumes of hydrogen consumption expected without any current plans for production assets. Nevertheless, by that time an interconnected grid at national, or even European, level will make it possible to respond to and cover the various local production deficits that may arise.

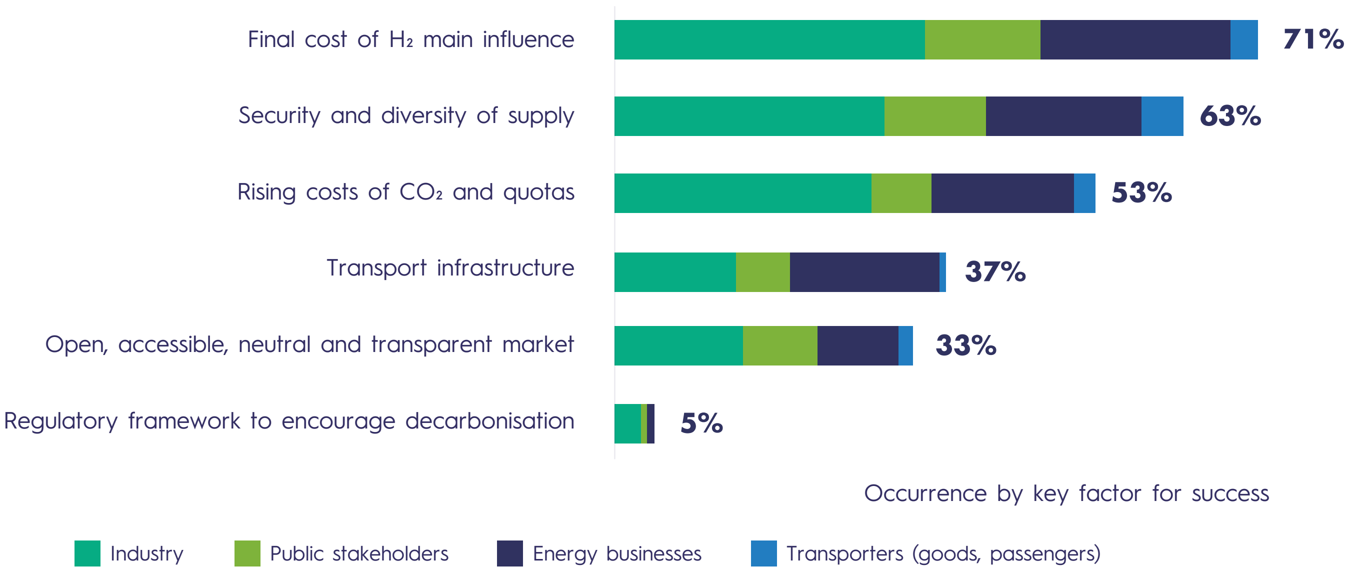
DIFFERENCES BETWEEN PROJECTED HYDROGEN PRODUCTION AND CONSUMPTION VOLUMES BY REGION IN 2030 AND 2050



STAKEHOLDER CONCERNS ABOUT HYDROGEN'S COMPETITIVENESS AND SECURITY OF SUPPLY

For market stakeholders, hydrogen's economic competitiveness compared with other carbon-based forms of energy remains the main factor for the emergence of this new energy carrier. They factor into that competitiveness the costs of the whole value chain, but particularly highlight the price of renewably generated electricity, which alone makes up 50% of the cost of producing hydrogen by electrolysis, and the price of carbon quotas could have a significant impact on the competitiveness of projects and their economic viability. Market stakeholders foresee a decrease in production costs over the medium and long term, with the scaling up of uses and production assets, along with access via transport infrastructures to cheaper production. **In the shorter term, they are waiting for the public authorities to provide significant assistance for the deployment of hydrogen production assets.**

KEY FACTORS FOR SUCCESS IN THE HYDROGEN ROLL-OUT



Alongside this, hydrogen consumers also talk of the need for security and diversity of supply. They want to be able to rely on stable supply which is not subject to production setbacks. At the same time, they want access to the most competitive hydrogen at all times. The diversity of the supply, which even extends outside national borders, is also underlined as a way of enjoying more attractive hydrogen production costs. Those expectations can be seen in the requirement for a transport and storage infrastructure that is accessible to third parties (transparent and non-discriminatory) and presents a level of reliability that is equivalent to that of natural gas infrastructures. That level of requirement crops up particularly among industrial respondents

That need for competitiveness and security of supply can also be seen in the requirement for consumers to have easy access to producers and for producers to have access to a diverse panel of consumers. Here, a number of stakeholders underline the role of hydrogen infrastructures in meeting that need. They say **transport and storage logistics must be used to reconcile diversified supply and demand.**

Stakeholders also express a **need for a clear forward view of the deployment of such an infrastructure so that development of the sector is not held back.** They need to plan their investment in these changes of energy carrier for their activities, which are major industrial transformations for them. Some large industrial consumers (particularly heavy industry) have small and infrequent windows of opportunity. The transformation and conversion of their processes to hydrogen must be planned well in advance.

Among producers, a clear forward view of the deployment of hydrogen infrastructure would enable them to envisage a bigger catchment area, and the deployment of their assets over a wider portion of the national territory.

The interconnection of hydrogen valleys on a national and European scale, and access to renewable and low-carbon hydrogen storage seem essential in meeting the expectations of market stakeholders. Hydrogen logistics would also play their part in the larger-scale connection of hydrogen producers and consumers, **guaranteeing security and diversity of supply.** Those logistics would also support a certain expansion of production assets, encouraging competition between producers across the country and, therefore, the economic competitiveness of hydrogen as an energy carrier. Finally, it would help ensure balancing of a system that risks becoming more complex very quickly.

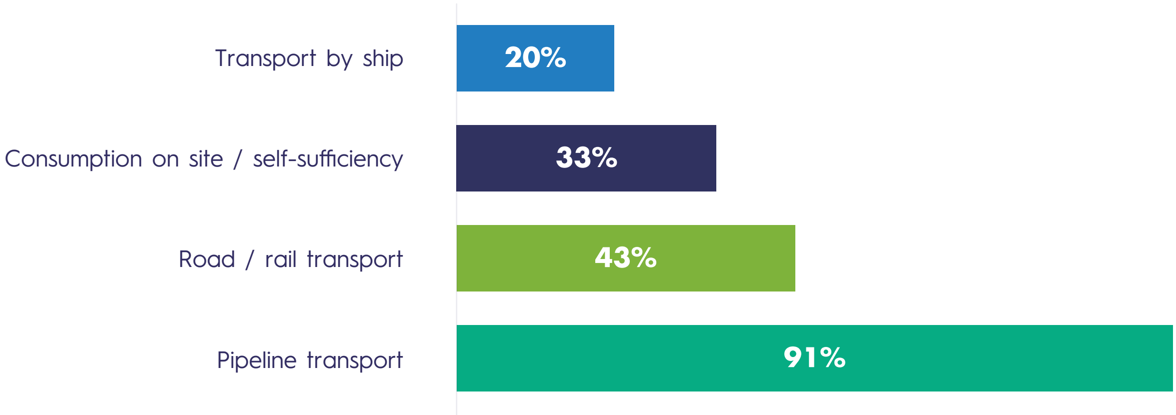
Furthermore, some operators of adjacent grids have spoken of their **need to interconnect with the future French hydrogen grid.** In this regard, 58% of "multi-site" contributors to the consultation are also present in West European countries and are therefore affected by European hydrogen infrastructure planning. This is also a question of competitiveness and the attractiveness of the country. **Adjacent operators would like to enter quickly into cooperation on joint planning of the grids, and to work together on technical, commercial, legal and interoperability aspects, particularly in the eventuality of the potential conversion of existing natural gas grids.**

STAKEHOLDERS IN FAVOUR OF AN OPEN SHARED INFRASTRUCTURE OVER THE LONG TERM

A PIPELINE TRANSPORT GRID PREFERRED OVER LONG DISTANCES

Contributors to the consultation spoke about the modes of transport they envisage from the low-carbon and renewable hydrogen production site to the consumption site.

TRANSPORT METHODS ENVISAGED FOR HYDROGEN FROM THE PRODUCTION SITE TO THE CONSUMPTION SITE



Thus more than **90% of respondents** to the consultation **envisage hydrogen transport from the production site to the consumption site via a network of pipelines.** Nevertheless, some stakeholders envisage self-sufficiency or the use of road or rail transport. That logistical choice probably reflects short-term needs, given the large majority mentioning the need for access to a pipeline transport infrastructure in the medium to long term.

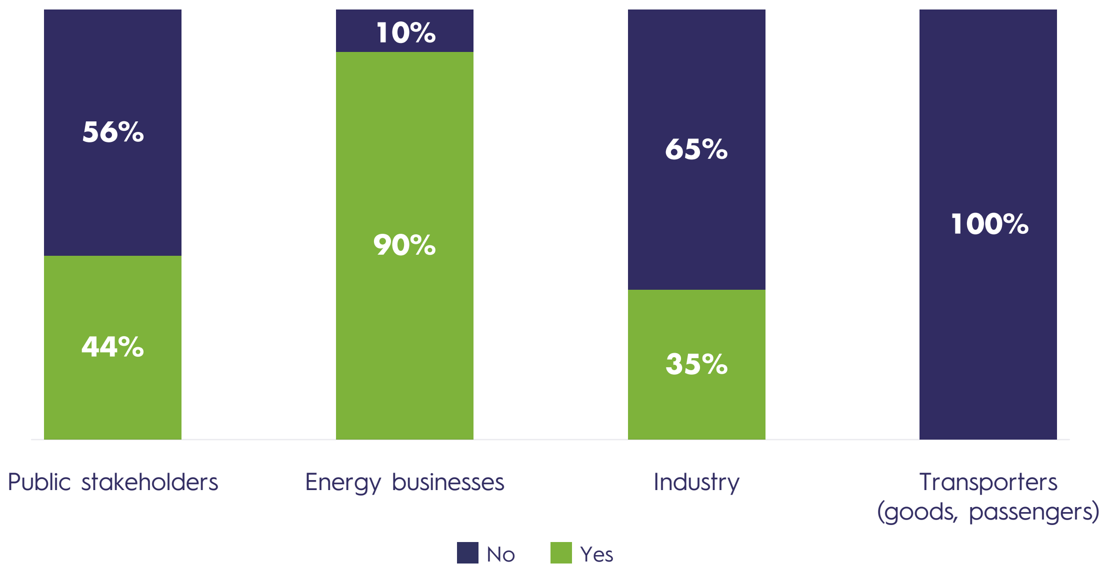
Industrial respondents are more inclined to commit themselves to short contract periods (around 5 to 10 years) for the transport of low-carbon and renewable hydrogen. That can most certainly be explained partly by the fact that these potential large consumers of hydrogen have high expectations in terms of the economic competitiveness of hydrogen as an energy carrier and the security and diversity of supply as shown above, and partly by the low level of maturity in their hydrogen volume requirements in the short to medium term. They therefore aim for a shorter commitment when reserving transport capacities, so that they can vary the volumes of hydrogen consumed, but also so that they can benefit from the potential volumes of hydrogen produced at low cost and accessible via the possible development of a transport grid.

By contrast, energy producers are more concerned with longer contract periods (above 15 years) for hydrogen transport, allowing lasting access to outlets for the low-carbon and renewable hydrogen they produce.

ACCESS TO STORAGE INFRASTRUCTURES TO MEET BALANCING NEEDS

When it comes to flexibility, respondents have diverging feedback on their capacity to adapt their low-carbon and renewable hydrogen consumption or production for balancing purposes. Thus, among contributors, **48% are unable to adapt their hydrogen production/consumption for balancing purposes.**

CAPACITY TO ADAPT HYDROGEN PRODUCTION / CONSUMPTION FOR BALANCING PURPOSES



On the flexibility of demand side, **nearly two-thirds of industrial consumers tend to show an unwillingness to adjust their hydrogen consumption,** insofar as it leads to complex constraints in production processes. Nevertheless, some of them, who have access to multiple energy sources, do not rule out the possibility of switching their fuel from one energy source to another to suit balancing requirements.

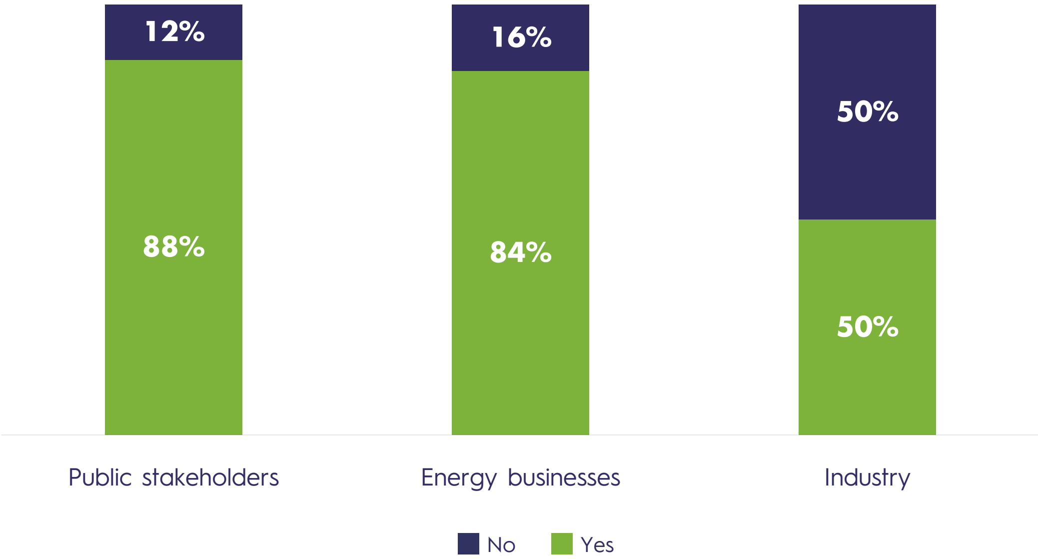
The majority of **Energy producers and energy infrastructure operators, meanwhile, are able to adapt their hydrogen production for balancing purposes.** To that end, they envisage adapting their production via electrolyser reduction mechanisms.

"We can adapt our hydrogen production by slightly oversizing the electrolysers and/or connecting part of them to the gas grid, with a mix between electrical grid balancing/hydrogen injection into the gas grid where possible." - An energy business (Hydrogen producer)

All the same, **access to mass hydrogen storage infrastructures is the solution envisaged by the majority of contributors for balancing the system.** A less mainstream option envisaged by some is on-site storage. It is interesting to note that all these solutions come back to mobilising storage capacity for the substance (hydrogen or methane).

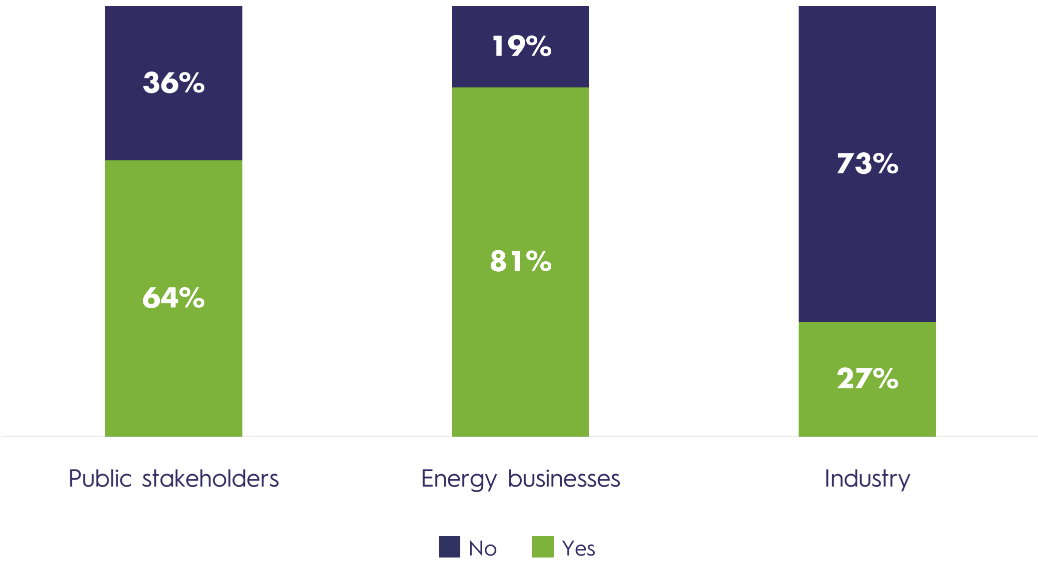
"For the hydrogen sector, storage will contribute to balancing, allowing the producer to produce when it is most appropriate, and offering the consumer security of supply." - An energy business (Infrastructure operator)

ENERGY STORAGE SERVICE NEEDS



Finally, the injection of volumes of hydrogen into the gas network in a mix or by methanation is also envisaged for balancing purposes. Producers see it particularly as being a potential outlet to create value from surplus production and fatal production.

PREDICTIONS OF HYDROGEN INJECTION INTO THE NATURAL GAS GRID



HYDROGEN INFRASTRUCTURE OPERATORS CENTRAL TO PLANNING SECURITY OF SUPPLY

Respondents to the consultation shared their visions of the role that could be played by energy network operators in the deployment of the hydrogen market in France.

ACTION EXPECTED FROM THE ENERGY NETWORK OPERATORS TO SUPPORT THE DEPLOYMENT OF HYDROGEN

The contributors' main demand was for energy network operators to drive the creation of a **hydrogen pipeline transport grid, accessible to third parties in a transparent and optimised manner.** Among them, 30% already identify reconfiguration of the present gas grid as being something to investigate further, to transport low-carbon and renewable hydrogen within the country.

"TSO should be an active part of the energy transition and its debates - Assuring available infrastructure in due time including transportation and storage - Integrate hydrogen infrastructure development in the National Development plans (TYNDP) - Engage closely with potential producers and consumers of hydrogen." - Energy business (Hydrogen producer)

Energy transport operators are also expected to act on security of the hydrogen supply through a grid that cross-connects territories and is fully integrated into European grids. Hydrogen logistics would play their part in the larger-scale connection of hydrogen producers and consumers, which would underpin the security and diversity of supply to the benefit of greater competitiveness for hydrogen as an energy carrier.

"Accessibility to existing pipelines and early assessment of future hydrogen pipeline projects is essential for reducing costs and envisaging coherent projects as close as possible to consumption centres." - An energy business (Energy production)

"With renewable energy having a growing share in the future, meaning increasingly intermittent production, mass storage will become necessary. The grid operator can help develop European infrastructures such as the hydrogen pipelines and connect them to storage sites (e.g. salt caverns). - An energy business (Energy production)

"Energy network operators are expected to provide infrastructures to connect producers and consumers in an industrial basin and at a later date to orchestrate the possibility of imports, transits and inter-regional connections." - An industrial respondent (Refining)

"As they managed to do with natural gas, grid operators will know how to adapt to the hydrogen market and to its technical peculiarities [...] and can make hydrogen available to all, drawing on the natural gas distribution infrastructures." - An industrial respondent (Iron and steel industry)

Contributors also expect operators to ensure there is a high and uniform **quality standard for supply and safety** which is at least equivalent to the levels of reliability seen with the current gas system.

"Operators are expected to provide totally safe hydrogen transport, with cooperation between national operators to facilitate the movement of hydrogen at the European level (because supply and demand are often far apart), offering clear rules (particularly between countries) and offering dedicated hydrogen networks, once this is possible, at the most competitive price." - An institutional stakeholder (Investment)

"In the eventuality of hydrogen being produced at a distance from airports (in areas where renewable energy is directly available, for example), the transport of the hydrogen produced to the airports through pipes seems to be the option that offers the greatest capacity and security. Security of the hydrogen supply and resilience of the logistical chain will be key elements." - An airport infrastructure operator

Respondents expect particularly that energy transport operators will take on the **role of facilitator between hydrogen producers and consumers.** Indeed, they note that greater planning of the market will be necessary, and that a neutral operator should be appointed to organise the market and enable greater reconciliation between supply and demand for low-carbon and renewable hydrogen in those territories favourable to the deployment of this energy carrier, particularly when pooling of uses is possible.

"By offering a consolidated and reliable marketplace, a one-stop shop for hydrogen transport facilitating delivery to customers and based on the model used by existing transporters such as GRTgaz and RTE. By optimising transport costs to make them more compatible and consistent with the reality of markets. By ensuring reliability in a secure national transport grid, serving consumption hubs as a priority." - A public stakeholder (Transport)

Finally, stakeholders underline the role of infrastructure operators as a link between the sector and the legislative and normative bodies at the national and European levels.

Given the capital intensive and long-term nature of gas transport infrastructures, this need for pipeline logistics, identified by the market, confirms the need to plan tomorrow's hydrogen grid today.

In short, contributors clearly identify logistical infrastructures as one of the solutions to their needs in relation to the deployment of hydrogen as an energy carrier over time and across the country. For all that, while the national consultation has made it possible broadly to confirm the need for hydrogen logistics, and to clarify certain qualitative characteristics, it has not made it possible to map out flows at a sufficient level of detail and to define the structures needed and plan their construction.

GRTgaz and Teréga feel that a top-down national approach such as the consultation questionnaire will make it possible to gain an overview of volumes across the country. It is however necessary to envisage some initial local grids, adopting a complementary bottom-up approach, getting **as close as possible to the hydrogen stakeholders in those ecosystems that have been identified as being favourable for the initial roll-out of the energy carrier.** That is the objective set by GRTgaz and Teréga through their organisation of **territorial workshops** to delve deeper into the precise needs of local stakeholders and to understand more accurately their expectations in terms of infrastructure type, geographical scale and timescale.

CHAPTER 4

MEETING STAKEHOLDERS FROM LOCAL ECOSYSTEMS FAVOURABLE TO THE DEPLOYMENT OF LOW-CARBON AND RENEWABLE HYDROGEN

SO WE CAN JOINTLY FINE-TUNE EXPRESSED NEEDS FOR HYDROGEN LOGISTICS AND TRANSPORT INFRASTRUCTURE

There is agreement around the development of the hydrogen market, initially at the level of local ecosystems favourable to its production. Some of those ecosystems were particularly strongly represented in responses to the consultation.

The **major local hydrogen ecosystems** identified via the consultation are:

- The industrial port zone (IPZ) of Dunkirk, home to industries emitting large quantities of CO_2, particularly in the iron and steel sector, which envisages CO_2 capture, storage and utilisation, alongside the use of hydrogen, in its decarbonisation strategies.
- The Fos-Marseille hydrogen valley: industries in the area are particularly interested in issues around decarbonisation, as they are the source of the large volumes of CO_2 emitted in the area. Industrial and institutional stakeholders (Provence-Alpes-Côte d'Azur region, Aix-Marseille-Provence metropolitan authority, Department of Alpes-de-Haute-Provence) are particularly proactive on the issue, most notably through their involvement in demonstrator projects such as Jupiter 1000, the French industrial Power-to-Gas demonstrator.
- The Sud-Ouest hydrogen valley with its surrounding ecosystems:
  - projects driven by industrial actors in the Lacq, Pau and Tarbes industrial territory, and those in Port-La-Nouvelle.
  - the Occitan mobility corridor and the HyPort initiative for the deployment of hydrogen filling stations in the airport zones of Toulouse and Tarbes, where high production capacity is associated with ambitious regional public authority action, making up for the absence of intensive industrial consumers by placing public orders and developing hydrogen mobility;
  - the IPZ at Grand Port Maritime in Bordeaux, which is aiming to install 1 GW of production on its site
- The IPZ at the Grand Port Maritime in Nantes-Saint-Nazaire.
- The IPZ at Le Havre and the Seine valley ecosystem more widely.
- The Moselle-Sarre-Luxembourg ecosystem which, at the crossroads of European transport and energy infrastructures, is home to the mosaHYc[12] project to develop a cross-border hydrogen transport grid, largely as the result of converting natural gas transport pipelines.
- The Bâle-Mulhouse-Colmar-Fribourg-en-Brisgau ecosystem with the Chalampé area, currently the second-ranked hydrogen consumption area in France, with potential interaction with Germany and Switzerland.

[12] mosaHYc

IDENTIFICATION OF DYNAMIC ECOSYSTEMS

A proportion of industrial contributors envisage CO_2 capture, storage or utilisation (CCUS) playing a part in their decarbonisation strategy, simultaneously, in competition with, or as an addition to the changeover to hydrogen. Moreover, some of the ecosystems identified are favourable both for the deployment of hydrogen as an energy carrier and also for the deployment for CCUS solutions, particularly due to their proximity to geological storage areas. The two decarbonisation strategies seem necessary to reach carbon neutrality targets by 2050.

As a consequence, it appeared appropriate to hold workshops within the ecosystems, tackling the subject of hydrogen in a broader manner and including possible synergies with CO_2.

The first territorial workshops were held by GRTgaz in the industrial port zone of Dunkirk on 16 November 2021, with the assistance of Euraenergie, the France Hydrogène Regional Delegation and Pôlénergie. They brought together forty or so participants.

In the Fos-Marseille hydrogen valley, workshops were held on 17 November 2021, led by GRTgaz jointly with the France Hydrogène Regional Delegation, and about thirty participants were there.

The aim of those workshops was to **study existing or future CO_2-H_2 complementarities at ecosystem level and to consolidate stakeholders' needs and expectations in terms of hydrogen and CO_2 transport infrastructures**[13]. It gave territorial stakeholders (industries in the IPZ, local authorities, energy infrastructure operators and energy producers) a chance to speak out, and to examine with them their needs, expectations and potential level of commitment in setting up hydrogen and CO_2 logistics.

These two territorial workshops firstly confirmed **the maturity of hydrogen needs in the Dunkirk territory and the Fos-Marseille hydrogen valley, driven in particular by the large industrial actors present in those places.**

[13] Full reports of those workshops are available in the annex to this report.

Lacq Pau Tarbes industrial territory. They were also an opportunity to revisit three projects illustrating the different topics of interest identified in the questionnaire responses in this hydrogen valley. Thus the issue of hydrogen storage was discussed, taking the example of the Hygéo project, for CO_2 storage, and its complementarity with hydrogen, through the PYCASSO project. Regarding cross-border complementarities, the DH2 company mentioned the Lacq-Hydrogen project, which provides for competitive mass production of hydrogen by electrolysis in Spain.

During the workshop discussions - enriched by the number and variety of stakeholders - a number of lessons were learnt.

The first was that, in the absence of clearly identified outlets and consumers thus far, producers may experience difficulties in advancing their production plans.

However, there are synergies between the territory and its Spanish neighbour, so it is possible to consider the issue of transport and storage infrastructure more generally. That interface with Spain is also an asset for the production of primary renewable energy, and the availability of land to develop renewable energy projects.

Stakeholders are also wondering about the availability and design capacity of electrical infrastructures, which remain central to hydrogen production in the short term (5 to 10 years). The issue is having sufficient electrical power for the smooth running of electrolysers close to areas of renewable electricity production.

For transport uses, needs are basically being identified from the heavy land and captive fleet point of view.

That use is currently being pushed forward by the Occitanie region, which anticipates massive expansion, particularly in view of European regulations aimed at decarbonising land transport by 2050. So, from 2025, public transport operated by the territorial authorities (buses, regional express trains) will be targeted first, then the approach will be widened to take in goods vehicles and other captive fleets from 2030 (lorries, domestic refuse vehicles etc.).

The Occitanie and Nouvelle Aquitaine regions enjoy strong public support in this: the "H_2 Corridor", the HyPort operation, the call for hydrogen road and sea transport hub projects, along with the Nouvelle-Aquitaine regional hydrogen roadmap, as well as the Lacq-Pau-Tarbes industrial territory strategy, are good examples.

As with industrial requirements, different problems need to be resolved to allow the deployment of hydrogen-powered land transport.

First of all, although there is now technological maturity around the production of hydrogen-powered vehicles, the cost of investing in this type of vehicles remains starkly higher than for fleets of traditional internal-combustion powered vehicles. European finance mechanisms have been requested by territorial local authorities to invest in these hydrogen fleets, but subsidies are still not enough to step up an overhaul of the fleet.

Furthermore, transport stakeholders attending the workshop have identified a lack of vehicle availability from manufacturers and a weak offer of refuelling infrastructure. The deployment of those infrastructures is still dependent on wider demand, which itself is held back by the absence of hydrogen infrastructures to allow security of supply, diversity and, as a result, competitiveness.

Finally, regulations, particularly concerning sections of ICPE (classified installations for the protection of the environment) regulations, are not yet appropriate for the wide use of hydrogen-powered vehicle fleets and general public use.

SO WE CAN MAKE PRACTICAL JOINT PLANS FOR THE HYDROGEN TRANSPORT GRID LEAVING LOCAL ECOSYSTEMS

Over the course of these territorial workshops, local stakeholders confirmed the high expectations expressed in the consultation in terms of structuring ecosystems around an open, shared pipeline-based transport grid.

STARTING PLANNING OF THE HYDROGEN INFRASTRUCTURE

The central issue in these three territories was **finding a way of getting energy infrastructure operators, users and institutions engaged in a practical process to deploy these grids** so that they can quickly respond to all the decarbonisation targets. A repeat of the methods used in gas for planning transport by pipelines, through a series of increasingly binding consultations was favoured by workshop participants. Indeed, by flagging up practical schemes to interconnect potential producers and consumers, it helps encourage projects and speed up the reconciliation of supply with demand. These methods also allow the shape of the most appropriate network and storage projects to be refined repeatedly over time.

Workshop participants were keen for a similar process to be put in place quickly in their territories, so that the practical roll-out of shared and open hydrogen – and even CO_2 – logistics could begin.

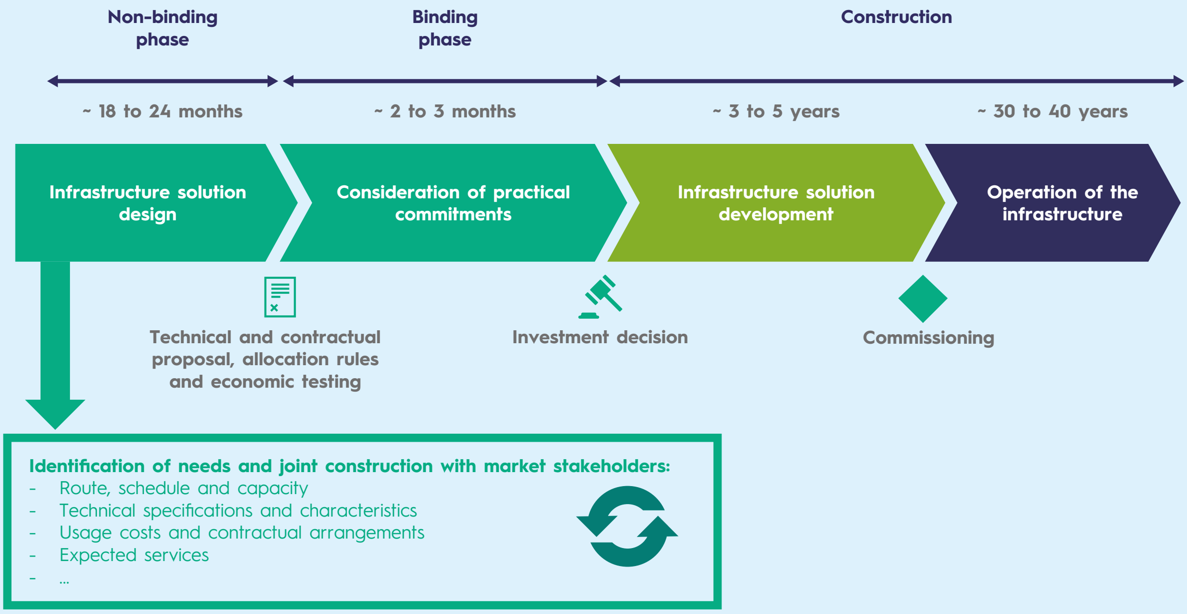
The final objective in this planning work with territorial stakeholders is to allow development of a hydrogen infrastructure within these local ecosystems, if the economic, technical and regulatory conditions are satisfied.

GAS INDUSTRY PIPELINE TRANSPORT PLANNING METHODOLOGY APPLICABLE TO HYDROGEN

Over the course of these workshops, practical experience of planning gas transport by pipelines was presented by the gas operators, since it can be transferred over to the planning of a low-carbon and renewable hydrogen pipeline-based transport grid.

The methodology used allows optimal deployment of a grid at various levels, with the benefit of transparent and non-discriminatory third party access, and it allows market stakeholders to be involved throughout the process of planning the transport grid. That process is in two stages: a non-binding expression of interest phase, followed by a binding phase resulting in an investment decision.

TRANSPORT GRID PLANNING PROCESS



THE NON-BINDING EXPRESSION OF INTEREST PHASE

This first phase makes it possible to identify and qualify transport requirements, including particularly the predicted consumption, production, import and export locations. An initial estimate of quantities consumed, produced and transported, along with profiling of the various parties, is analysed, along with the requirements in terms of security of supply and service levels expected by the future users. TSOs work out storage needs, a basic route, a technical design, an initial estimate of investment costs, a possible deployment schedule and the depreciation period for the structures.

Based on one or two rounds, design capacity options and associated costs are shared with the parties involved.

Adjustments to trading arrangements and agreed methods are confirmed with potential users. Similarly, the economic test criteria allowing the operator to initiate investment are confirmed with future users.

At the end of the non-binding phase, and once the stakeholders involved have reached an agreement around a local optimum, by bringing together all the requirements and capacity undertakings from actors within the ecosystem, the operator submits a technical and contractual design proposal to all the potential users, along with the rules on capacity allocation and the economic test criteria for the decision to invest. This stage marks the end of the non-binding phase and the start of the binding phase.

THE BINDING PHASE

In the second stage, future users of the grid submit and commit themselves to volumes and capacities, over a stated period of time, in accordance with the rules defined during the non-binding phase.

The grid operator considers those commitments from users and other contributors, along with any possible third-party assistance.

The economic test is then performed, and if it is validated, the design capacity option is chosen and the decision to invest goes ahead through a contractual commitment from the parties involved.

The work realisation phase can then begin.

FIRST STAGES COMPLETED IN LOCAL ECOSYSTEMS

Over the course of the territorial workshops, local low-carbon and renewable hydrogen market stakeholders stated their desire to be consulted, to define a hydrogen – and even a CO_2 – infrastructure, including elements of its design capacity, but also usage costs. They showed themselves to be in favour of the rapid implementation of this kind of process in multiple rounds over the long term.

On the Dunkirk side, bilateral and multilateral meetings have been taking place since the end of 2021 with the territory, allowing the support process for planning of a pipeline-based hydrogen transport grid to get under way.

In the Fos-Marseille hydrogen valley, the work has already started, driven on by Mrs Violaine Demaret, Prefect for Alpes-de-Haute-Provence, and Mr Jean-François Carenco, President of the CRE, through an “infrastructures laboratory”. It will continue in cooperation with the H_2 Bassin working group until mid-2022. This process is embodied in the GRTgaz project known as HYnframed.

HYNFRAMED

- Significant consumption potential in key industrial sectors (Iron and steel, refining, petrochemicals)
- Numerous emerging production projects
- A dynamic ecosystem structuring itself around the hydrogen valley
- Proximity to developing hydrogen storage infrastructures

In partnership with stakeholders in the area, GRTgaz has launched a feasibility study on a shared hydrogen transport grid in the area around Fos-Sur-Mer and its connection in Manosque.

Given the importance of the Chalampé hub in terms of hydrogen consumption, production and consumption projects identified in the area and the presence of multiple GRTgaz pipelines, a further project known as RHYn will soon be launched by GRTgaz around the Bâle-Mulhouse-Colmar ecosystem. This project will be presented officially by GRTgaz on 5 April 2022.

RHYn

- Chalampé: currently the second-ranking hydrogen consumption area in France.
- A number of low-carbon hydrogen consumption and production projects announced in the area.
- Interest from several local authorities in developing hydrogen mobility solutions.
- Project owners who have indicated their interest in hydrogen transport pipelines.
- Potential interconnections over time with Germany and Switzerland.

GRTgaz has decided to launch the project to develop a hydrogen transport grid by converting existing gas transport pipelines and laying a new grid, and to contribute to the development of the local ecosystem.

GRTgaz envisages holding new territorial workshops in 2022 to address the need for planning of local grids dedicated to hydrogen within the dynamic ecosystems of Normandy (Le Havre-Rouen) and the IPZ of Nantes Saint-Nazaire.

GRTgaz is continuing its commitment to the work of planning the hydrogen transport grid, and during 2022 will submit its first proposal for a hydrogen logistical chain in Alsace-Sud around the Bâle-Mulhouse-Colmar ecosystem and in the Fos-Marseille hydrogen valley, in cooperation with local stakeholders.

For the Sud-Ouest hydrogen valley, a number of projects presented at the workshop and associated with local initiatives will also allow work to begin on designing the capacity of a future hydrogen transport infrastructure. That is the case with the Lacq Hydrogen cross-border project, and also the Hygéo project. The subject of transport and the creation of a large hydrogen ecosystem is also being handled and driven by the Lacq-Pau-Tarbes industrial territory.

Lacq Hydrogen

- Reindustrialisation and decarbonisation of the Lacq Basin
- Access to the underground storage volumes that are essential for developing industrial projects at scale
- A number of renewable and low-carbon hydrogen consumption projects announced in the basin
- European partnership with DH2, ENAGAS, Teréga and GazelEnergie thus connecting France and Spain.

To contribute to the development and decarbonisation of the basin, Teréga Solutions has decided to launch a hydrogen transport and storage solutions development study, converting existing gas infrastructures and laying new pipelines. For the industries, this represents a real opportunity for reindustrialisation, having renewable hydrogen available at a competitive price.

Hygéo

- Partnership with complementary stakeholders in the hydrogen value chain: HDF / BRGM / Teréga
- Existing salt cavern storage site
- Launch of a feasibility study on the re-use of one of the caverns on the site, incorporating technical, environmental, economic, regulatory and societal aspects

HDF / BRGM / Teréga have decided to launch this development project in order to capitalise on the existing site and define the conditions for replicating such a project in Europe. The complementarities between the actors make it possible to develop French expertise and skills in this field.

Transport - Pyrénées Hydrogène

- Creation of a hydrogen ecosystem for transport and industry within the Lacq Pau Tarbes industrial territory
- Centralised renewable hydrogen production and distribution across different industrial sites and 3 transport filling stations (Lacq, Pau and Tarbes)
- Teréga Solutions is involved in the hydrogen logistics and the operation of the stations in Lacq and Tarbes.
- First development of the H_2 ecosystem in Lacq Pau Tarbes

Through this Pyrénées Hydrogène project, Teréga Solutions is working on the development of the H_2 ecosystem with industrial and transport use. By bringing a renewable hydrogen supply, this first stage will help initiate other projects needed for the decarbonisation and reindustrialisation of the basin.

The Teréga Group is continuing its work to develop renewable gases and to join up grids. The first stages of ecosystem development are already leading to thoughts about the planning of developments in hydrogen transport and storage infrastructures. Although these first grids are local in the short term, project owners are interested in them and are already making medium term plans for interconnected European infrastructures.

OUR PRACTICAL STEPS

ANNEXES

REPORT ON CO_2-H_2 TERRITORIAL WORKSHOPS – DUNKIRK, 16 NOVEMBER 2021

HYDROGEN REQUIREMENTS AND CO_2 OUTLETS IN THE DUNKIRK IPZ

The territorial workshops in the Dunkirk IPZ were first and foremost an opportunity to study in greater depth and describe in greater detail, alongside stakeholders in the territory, their approach to hydrogen and CO_2 outlet needs, and assess their maturity and exhaustivity.

CLEARLY IDENTIFIED MATURE HYDROGEN REQUIREMENTS IN THE TERRITORY

First of all it must be made clear that the **maturity of hydrogen and CO_2 outlet requirements differs from one stakeholder to the next**, and according to the technologies envisaged by the industries in the IPZ within their decarbonisation strategy (electrification, hydrogen as an energy carrier, CO_2 capture/utilisation). Some stakeholders have relatively well-defined strategies, while others are more on the lookout for opportunities.

The **maturity of hydrogen and CO_2 outlet requirements** also differs within some stakeholders, according to the different options for modifying their processes (use of hydrogen: heat, combustion, raw material, or CO_2 capture etc.).

Having made that clear, we can however note that **hydrogen requirements are clearly identified in the short to medium term (now until 2030-2035)** among large industrial actors, particularly to replace carbon-based energy carriers or materials. Hydrogen users generally have a “baseload” type consumption profile (8500-8700 hours per year), which requires a robust and diversified supply, suited to continuous production.

Large industrial consumers will really drive the hydrogen ecosystem.

For heat users, electrification and hydrogen combustion are two of the technical decarbonisation solutions being envisaged. **Requirements have yet to be specified through feasibility studies, or will be subject to decision based on the opportunities offered within the IPZ.**

In the case of hydrogen combustion, what is probably envisaged is replacement of the current fossil fuels, particularly through the increasing injection of hydrogen mixed with gas. Requirements for hydrogen, in a mixture with or as a replacement for natural gas, mean that technical testing needs to be undertaken, and this is now widely under way in industry.

For cement works, the issues with hydrogen are partly around combustion, but also the possibility of utilising CO_2 from the process (calcination: see below in the section on CO_2-H_2 complementarities).

For **transport uses, requirements are relatively well known,** as an addition to electrical power, for heavy and captive vehicles. The main brake on the changeover to hydrogen for road transport use remains the **high price and low availability of hydrogen-powered vehicles.** However, this use is being boosted by the strategy to develop port logistics at GTMD over to hydrogen use.

The **issue of RTE infrastructure and land availability in the IPZ** remains a central concern for stakeholders envisaging the production of hydrogen by electrolysis in the short term (5 to 10 years). Indeed, it is all to do with having the space needed to construct electrolysers and sufficient electrical power for them to operate correctly.

CCUS, IN THE MATURATION PROCESS, BUT WITH HIGH POTENTIAL IN THE DUNKIRK IPZ.

There is **currently no single optimal solution.** The change of energy carrier or fuel (electrification, hydrogen) does not seem sufficient to reduce CO_2 emissions completely; we also need to envisage CO_2 capture and a CCU chain to utilise the fatal CO_2 in order to achieve carbon neutrality in 2050 and meet certain needs (e-fuels etc.).

CCU projects are in the process of deployment by 2030-2035 among large industrial emitters in the territory (iron and steel/metallurgy, cement works in particular) **which could be supplemented by CCS projects currently being developed.** Tests currently under way will help identify at what point users can change over to these technological solutions: hydrogen, CCU, CCS.

The vast majority of less-emitting stakeholders, whose cumulative CO_2 emissions are still significant, have not reached that same level of maturity in terms of their decarbonisation strategy.

Finally, **regulatory aspects need to be specified** regarding CCS and CCU, particularly the characterisation of captured CO_2 and its link with the ETS.

REAL CO_2-H_2 COMPLEMENTARITIES IN THE TERRITORY

Uses of hydrogen and CO_2 are complementary, particularly in respect of methanisation opportunities in the territory for e-fuel and e-methane production in particular.

Indeed, carbon is still necessary in a certain number of industrial processes in the IPZ (steelworks in particular) and coming uses for aviation are significant by 2035-2040.

That recovery of the CO_2 could be a source of business and GDP across the country.

SUITABILITY OF CO_2 / H_2 LOGISTICS IN THE DUNKIRK IPZ

The first part of the workshops thus reveal a synergy in requirements between the different stakeholders in the territory: **big industry is driving the market and the need for hydrogen and CO_2 infrastructures in the territory.** Following on in the wake of the main actors, other actors will contribute to the economy of such a shared infrastructure and may deploy their energy transition more easily.

Territorial stakeholders, the Communauté Urbaine de Dunkerque, the Region, the Grand Port Maritime de Dunkerque, with the assistance of Pôlenergie and Euraénergie, seem to be in phase and able very soon to start planning hydrogen transport infrastructures, in order to speed up the realisation of decarbonisation commitments in the territory.

DEPLOYMENT OF CO_2/H_2 LOGISTICS: A GUARANTEE OF INDUSTRIAL COMPETITIVENESS

The **presence of CO_2/H_2 logistical infrastructure in the territory represents a major consideration for the establishment of new industrial actors, and for the territory's competitiveness** compared with Belgian and Dutch IPZs, particularly in the context of reindustrialisation. Take, for example, a cement manufacturer in the hinterland, actively looking for solutions to ship the CO_2 they emit to the IPZ.

In addition, the need for a connection between the CO_2 hub in Dunkirk and areas of cheap hydrogen production was underlined, particularly so that it would allow competitive e-fuel production.

That logistical infrastructure could be **interconnected** in the relatively near future, in view of the **maturity of adjacent TSOs** (Belgian, Dutch, German). That interconnection would allow the market to benefit from competitive advantages between countries (hydrogen production at the best price, CO_2 storage in the North Sea etc.), offering greater competitiveness for the Dunkirk IPZ. That need for infrastructures is identified for 2030-2035, to take advantage of the first marketplaces, expected at that time, and to respond to the expansion in use by that time.

It should be noted that the interconnection of a French hydrogen transport grid with the hinterland, including with adjacent countries, raises the question of **harmonisation of standards and regulation of hydrogen transport activities.**

A MAJOR NEED FOR STORAGE AND FLEXIBILITY WITH HYDROGEN

Hydrogen storage is needed to ensure security of supply and, hence, the good performance of hydrogen production facilities.

Information is expected about storage capacity in pipelines for a future hydrogen transport grid. That buffer storage is still very likely to be limited in respect of needs.

It is therefore a question of **thinking now about the connection between the Dunkirk IPZ and hydrogen storage infrastructures** (further south in salt caverns, or further north, requiring a long distance transport grid and interconnected with the neighbouring countries).

In addition, the LNG terminal in Dunkirk could be envisaged as a hydrogen storage terminal, but technical problems still need to be investigated. Furthermore, CO_2 storage is easier to manage and could be envisaged in a shorter timeframe in this situation.

QUICKLY EMBARKING ON STAGED PLANNING

An **initial hydrogen and CO_2 transport infrastructure scenario is needed** to allow industrial actors and energy producers/operators in the IPZ to establish their positions in respect of these decarbonisation solutions.
That scenario must make it possible to inform actors in the IPZ very quickly about **usage cost details for those infrastructures, along with an initial route (priority links, secondary links).**

This scenario must also include **details about hydrogen injection in a mixture into the gas grid** (technical specifications, European regulation), while waiting for the dedicated hydrogen grid.
To decide on their choice of CO_2/H_2 logistics, stakeholders in the territory want discussions with GRTgaz as part of economic studies **of the competitiveness of transport solutions according to quantities/distances at regional level.**

In addition, stakeholders in the territory are calling on **GRTgaz in its role as planner and trusted third party** to enable the pooling of needs among local stakeholders and to meet those needs to the benefit of all stakeholders in the territory.

MATTERS CONNECTED TO OXYGEN AND FATAL HEAT IN THE DUNKIRK IPZ

OXYGEN

The **synergies between** oxygen and hydrogen and CO_2 need further study. Oxygen, a co-product in the production of hydrogen by electrolysis, makes electrolysis facilities profitable, being exploited for oxy-fuel combustion. An important aspect of the process is that it creates greater CO_2 concentrations in fumes, thus facilitating its capture.

FATAL HEAT

CO_2 recovery and hydrogen production, most notably through the processes of methanation and electrolysis, both produce **heat which can be utilised in the surrounding territory.**

NEXT STEPS TO BE TAKEN BY GRTGAZ FOLLOWING THE TERRITORIAL WORKSHOPS

In response to the needs and expectations arising from territorial workshops, **GRTgaz is continuing its work to plan the hydrogen transport grid,** and will present its first proposal for hydrogen – and even CO_2 – infrastructures to territorial stakeholders in 2022.

This **first draft, including details about the route, design capacity, and also usage costs, will be refined through interaction with stakeholders in the Dunkirk IPZ** according to their needs and their commitment capacities.

Bilateral and multilateral meetings will take place with the territory until the end of December, and will reveal the GRTgaz support process for planning of a pipeline-based hydrogen transport grid.

REPORT ON "SHARED NETWORK NEEDS AND SUITABILITY" TERRITORIAL WORKSHOPS – FOS-MARSEILLE HYDROGEN VALLEY, 17 NOVEMBER 2021

NEEDS FOR HYDROGEN AND CO_2 OUTLETS IN THE FOS-MARSEILLE HYDROGEN VALLEY

The Fos-Marseille hydrogen valley territorial workshop was an opportunity to ask stakeholders in the hydrogen and CO_2 value chain about their needs for hydrogen and CO_2 outlets to assess their maturity and exhaustivity, in addition to the responses provided as part of the consultation initiated by GRTgas since 1st June last year.

RELATIVELY WELL IDENTIFIED HYDROGEN NEEDS

It seems necessary first of all to point out that the **maturity of hydrogen and CO_2 outlet requirements is relatively disparate according to the stakeholder in question** and the solutions adopted, or being considered, among industrial stakeholders in the IPZ for the decarbonisation of their activities. Those differences may also be found within a single stakeholder across different parts of their process.

Having made that observation, **hydrogen requirements seem generally to be well identified in the short and medium term (up to 2030-2035)** by the big industrial stakeholders in the area, particularly as a replacement for carbon-based fuels. decarbonisation is also envisaged by means of the electrification of processes and the use of biogas, which may come into competition with uses for hydrogen.
Hydrogen users generally have a baseload type consumption profile (8,500 – 8,700 hours per year), requiring carefully planned design capacity to prevent production interruptions.
These top-ranking hydrogen consuming industrial stakeholders should drive hydrogen production in the hydrogen valley.

For **transport uses, needs are basically being identified from the heavy and captive fleet point of view.**
This use is being boosted by the Aix-Marseille metropolitan area, which anticipates expansion by 2050 to the long-distance logistical areas which are already well known (Fos, Miramas, Vitrolles, Marignane, and as far as Saint-Martin-de-Crau). The first heavy vehicle prototypes are expected in 2022-2023, with multiplication of the fleet by a factor of 5 to 10 from 2025.
The major problems of hydrogen road transport remain, as with NGV, the availability of vehicles from manufacturers and the provision of refuelling infrastructures.

It should be noted that refining presents a special case in the area, both for its longevity and for its hydrogen requirements in anticipation of the end of CO_2 quota allocations expected in 2025.

Hydrogen consumption and production areas seem to be clearly identified within the territory. A major piece of work undertaken by Capenergies has enabled those needs to be qualified and gauged. That work needs to be continued in **further rounds, to provide a more accurate idea of hydrogen consumption needs over time** within the territory.

The **availability and correct design capacity of RTE infrastructures** are still central to hydrogen production in the short term (5 to 10 years). Indeed, the issue is having sufficient electrical power for the smooth running of electrolysers close to areas of renewable electricity production (permitting challenges).

CCUS: AN EMERGING ISSUE IN THE FOS-MARSEILLE HYDROGEN VALLEY

CO_2 emissions are well known in the Fos-Marseille hydrogen valley and represent a significant argument for the deployment of CO_2 capture, storage and utilisation/exploitation projects in the area in the medium to long term.

Ten or so **CCUS projects, led by major industrial stakeholders in collaboration with territorial local authorities, are currently being put together** and will have **quite an organisational effect on the territory.**

They are based on a wider territory, the Industrial Territory (Aix, Rousset, Gardanne, Istres, Fos, Marignane and Etang de Berre). Those projects are getting started and are still at the preliminary study stage. The same is true of the Vasco programmes, co-financed by ADEME, guided by developmental research into an economic sector turning CO_2 into a raw material. A first CO_2 storage project in the Mediterranean is also emerging, but for the moment it is the very early stages, and targeted on studying a potential site.

The Aix-Marseille metropolitan area, in collaboration with the Region, is preparing a PIA 4 (future investment programme) application to co-finance engineering on these CCUS projects over 5 to 10 years.

In industry, there is less maturity on issues of CO_2 storage and exploitation, although they are still being investigated alongside the deployment of hydrogen use in their activities. They will probably apply to the proportion of emissions remaining after conversion to hydrogen, biogas and electricity.

There are also regulatory aspects still to be determined on CCS and CCU, and on e-fuels (particularly methanol) arising from CCU, and for which there will be strong demand from the aviation sector by 2040.

As the **challenges of accessing renewable energy** increase, other applications such as CO_2 recovery will probably be prioritised.

In the longer term, **the need for carbon remains** in a certain number of industrial processes in the IPZ (steelworks in particular) and means thought should be given in advance to a circular carbon economy.

All these challenges need local experimentation to continue through a diversity of demonstrators and the provision of ad-hoc engineering.

THE SUITABILITY OF CO_2/H_2 LOGISTICS IN THE FOS-MARSEILLE HYDROGEN VALLEY

The territorial workshop held in the Fos-Marseille hydrogen valley highlighted a number of findings around which there was a consensus:

- Top-ranking industrial actors in the hydrogen valley should drive the market in the territory. The deployment of infrastructures and the associated milestones, will depend on their strategic orientation.
- The need for shared hydrogen infrastructures in the territory seems to be shared by the whole of the participants. This represents a guarantee of security of supply in the area. Strong expectations were expressed in terms of reliability of the supply. In this respect, reliability equivalent to that of today's natural gas transport grid is expected.

It should be noted that territorial stakeholders, the Aix-Marseille Provence metropolitan authority and the regional council, seem to be in phase and able very soon to start planning hydrogen transport infrastructures to realise their decarbonisation commitments in the territory.

TERRITORY FAVOURABLE FOR THE DEPLOYMENT OF A HYDROGEN TRANSPORT INFRASTRUCTURE

The presence of hydrogen logistical infrastructure in the territory represents a major consideration for the establishment of new industrial actors, and for the territory's competitiveness. Since the territory already has a certain number of the necessary infrastructures (salt caverns in Manosque, gas pipe, Air Liquide pipe, hydrocarbons pipe), it seems favourable for deployment in the medium term of a pipeline-based open shared hydrogen transport grid.

A TERRITORY OFFERING HYDROGEN STORAGE POSSIBILITIES

Hydrogen storage is needed to ensure **security of supply** and the **good performance of hydrogen production facilities.**

Hydrogen producers have particularly flagged up the fact that an open shared pipeline-based transport grid is **essential for expanding hydrogen usage,** and requires work to start now, given the time scales involved in commissioning production infrastructures (4-5 years).

Hydrogen users generally have a baseload type consumption profile (8,500 – 8,700 hours per year), requiring a **carefully planned design capacity to prevent production interruptions,** which requires a storage infrastructure to secure the supply.

Furthermore, the local hydrogen market is driven by a small number of large industrial actors, so the **question arises of outlets for hydrogen production in the event of temporary interruptions to their activities,** be they planned or unplanned.

Information is expected about **the suitability of a future pipeline-based transport grid to store hydrogen.** That storage in pipelines, foreseeable to some extent by adjusting the pressure, will nevertheless fall far short of covering all needs. Moreover, **buffer storage at hydrogen production assets remains limited** for installations which are not SEVESO classified.

The presence of storage infrastructure in relative proximity to the industrial area, including salt caverns in Manosque, is an asset for the Fos-Marseille hydrogen valley.

It can in particular play a part in the **competitiveness of hydrogen as an energy carrier compared with the electrification** of uses, particularly as part of a green hydrogen production scheme.

To achieve that, **additional information on the part of hydrogen producers and RTE** is expected on the troughs in electricity production enabling hydrogen production in conjunction with other outlets for renewable electricity within the territory.

To gauge storage requirements correctly, information about hydrogen consumption and production profiles must be supplied to energy infrastructure operators within the territory. Uncertainty may remain, however, in the modelling of those profiles which may change according to future technological evolutions. **Envisaging and open shared hydrogen transport grid would enable requirements to be built up collectively,** thus reducing the risk associated with changes in combined consumption.

The HyGreen Provence project may provide the first indications on how to optimise the costs of hydrogen production by modelling the possibilities for storage, the use of intermittent renewables for hydrogen production, and hydrogen use in the territory.

The need for interconnection may arise in the medium term with the predicted expansion of hydrogen production from bordering countries producing large amounts of renewable energy at low cost.

Moving toward an **interconnected hydrogen grid at regional, European and Mediterranean level** raises the question of **harmonisation of standards and regulation of hydrogen transport activities.**

PLANNING WORK TO START WITHOUT DELAY, WITH A STAGED APPROACH

An **initial hydrogen transport and storage infrastructure scenario is needed** to allow industrial actors and energy producers/operators in the Fos-Marseille hydrogen valley to establish their positions in respect of this industrial decarbonisation solution. In particular, this will involve starting with the existing infrastructures that can be converted to hydrogen (hydrocarbon pipes, gas pipes, salt caverns).

That scenario must make it possible for actors in the hydrogen valley to have **usage cost details for those infrastructures, along with an initial route (priority links, secondary links).**

That scenario must also include **details about hydrogen injection in a mixture into the gas grid** (technical specifications, European regulation).

To decide on their choice of hydrogen logistics, stakeholders in the territory expect **economic studies from GRTgaz of the competitiveness of transport solutions according to quantities/ distances at regional level.**
Stakeholders in the territory are calling on **GRTgaz in its role as planner and trusted third party** to enable the pooling of needs among local stakeholders and to meet those needs to the benefit of all in the territory.

To embark upon the study of a shared hydrogen transport grid at hydrogen valley scale, GRTgaz will make **bilateral contact with industrial stakeholders** who lead projects accounting for the large volumes of hydrogen production and/or consumption in the short, medium and long term.

That study will be subject to **regular progress reviews at meetings of the Fos-Marseille hydrogen valley working group,** in accordance with each participant's terms of confidentiality.

MATTERS IN CONNECTION WITH O_2 AND FATAL HEAT IN THE FOS-MARSEILLE HYDROGEN VALLEY

OXYGEN

Oxygen synergy required more detailed study. Indeed, the O_2 co-produced in the production of hydrogen by electrolysis, makes electrolysis facilities profitable through oxy-fuel combustion, enriching the fumes and thus facilitating CO_2 capture.

FATAL HEAT

CO_2 recovery and hydrogen production, most notably through the processes of methanation and electrolysis, both produce **heat** (1 MWh of heat at 200 °C per tonne of CO_2 captured, 70 to 80 °C at low temperature for an electrolyser) **for use in the surrounding territory will be studied.**

REPORT ON "HYDROGEN INFRASTRUCTURE DEVELOPMENT" TERRITORIAL WORKSHOPS - SOUTH WEST HYDROGEN VALLEY, 14 JANUARY 2022

LOGISTICAL CHALLENGES IN HYDROGEN DEVELOPMENT – WORKSHOP HELD BY VIDEOCONFERENCE

The South West hydrogen valley territorial workshop was an opportunity to ask stakeholders in the hydrogen and CO_2 value chain about their needs for hydrogen associated logistics to assess their maturity and exhaustivity, in addition to the responses provided as part of the consultation initiated by Teréga and GRTgaz since 1st June 2021.

HYDROGEN SUPPLY AND DEMAND IN THE INDUSTRIAL BASIN

HYDROGEN REQUIREMENTS FOR INDUSTRIAL USE TO BE SPECIFIED...

Hydrogen requirements seem generally to be well identified in the short and medium term (up to 2030-2035) by the big industrial stakeholders in the area, and transport stakeholders, particularly as a replacement for carbon-based fuels.

The industrial consumers identified are, for the most part, from the iron and steel, fertilisers, refinery and cement production sectors. However, uses and needs are not currently clearly expressed, particularly in terms of the volumes consumed in the short and medium term.

Industrial use will be supported by a drop in CO_2 emission quotas and the resulting increased cost of carbon credits. Industrial players therefore aim massively to decarbonise production. In the short and medium terms that will particularly be by replacing the use of a carbon-based energy carrier in their processes with decarbonised energy carriers, including low-carbon or renewable hydrogen. They are already factoring this into their planning so that their competitiveness does not suffer.

... BUT VARIOUS BRAKES NEED TO BE RELEASED FIRST

However, major problems persist for the expansion of low-carbon or renewable hydrogen usage in industrial sectors.

In the current absence of clearly identified outlets and consumers, producers may encounter difficulties in developing production assets.

However, the vision coming back from them is of a market expanding strongly in the medium to long term, and they are already wondering about the capacity of **electrolyser manufacturers to provide equipment that is adequate to supplying the expected volumes.**

Moreover, the issue of **access to cheap green electricity is also a factor in hydrogen's financial competitiveness,** which at the moment is hardly guaranteed with the high prices of electricity. In addition, to avoid the stress on water resources associated with hydrogen production, the use of desalinated seawater may technically be envisaged for hydrogen production. Even so, that desalination requires high electricity consumption. Hydrogen production infrastructures in southern Europe (Spain, Morocco, Portugal) would provide the benefit of mass production of solar or wind-powered renewable energy at lower cost.

Added to which, synergies exist between the territory, particularly its Hygeo[14] project for the conversion of a salt cavern to hydrogen, and the need for additional outlets for the expected mass production of low-carbon or renewable hydrogen on the Spanish side.

Finally, issues concerning the availability and correct design capacity of electrical infrastructures (particularly the RTE grid) are still central to hydrogen production in the short term (5 to 10 years). Indeed, the issue is having sufficient electrical power for the smooth running of electrolysers close to areas of renewable electricity production.

SPECIFIC NEEDS EXPRESSED FOR TRANSPORT USE

For **transport uses, needs are basically being identified from the heavy land and captive fleet point of view.**

That use is currently being pushed forward by the Occitanie region, which anticipates massive expansion, particularly in view of European regulations aimed at decarbonising land transport by 2050. The transport framework law includes a number of additional measures to reach that target, particularly the obligation on public and private legal persons managing a fleet of significant size to incorporate a growing proportion of low-emission vehicles when renewing their fleet, whether by purchasing or hiring. **So, from 2025, public transport operated by the territorial authorities (buses) will be targeted first, then the approach will be widened to take in goods vehicles and other captive fleets from 2030 (lorries, domestic refuse vehicles etc.).**

The Occitanie and Nouvelle Aquitaine regions enjoy strong public support in this: the "H_2 Corridor", the HyPort operation, the call for hydrogen road and sea transport hub projects, along with the Nouvelle-Aquitaine regional hydrogen roadmap, as well as the Pau-Lacq-Tarbes industrial territory strategy, are good examples.

As with industrial requirements, different problems need to be resolved to allow the deployment of hydrogen-powered land transport.

First of all, although there is now technological maturity around the production of hydrogen-powered vehicles, the **cost of investing in this type of vehicles remains starkly higher than for fleets of traditional internal-combustion powered vehicles.** European finance mechanisms have been requested by territorial local authorities to invest in these hydrogen fleets, but subsidies are still not enough to step up an overhaul of the fleet.

Furthermore, transport stakeholders attending the workshop have identified a **lack of vehicle availability from manufacturers and a weak offer of refuelling infrastructure.** The deployment of those infrastructures is still dependent on wider demand, which itself is held back by the absence of hydrogen infrastructures to allow security of supply, diversity and, as a result, competitiveness.

Finally, regulations, particularly concerning sections of ICPE (classified installations for the protection of the environment) regulations, are not yet appropriate for the wide use of hydrogen-powered vehicle fleets and general public use.

[14] Hygeo

THE CHALLENGE OF REPLACING METHANE WITH HYDROGEN FOR RESIDENTIAL OR TERTIARY USES

When it comes to the use of hydrogen for the production of synthetic methane for injection into the gas grid for residential or tertiary use, requirements are estimated to be considerable from 2030-2035. Indeed, part of the gas passing through the distribution grid would be produced by that time from low-carbon or renewable hydrogen via the process of methanation. The major challenge for that use would be allow delivery of the gas produced through methanation at a price close to that of other methanes, particularly biomethane, to ensure its competitiveness.

Hydrogen consumption and production areas across the territory are still being identified. Work needs to be done to qualify requirements, in **stages, so that a more accurate picture of hydrogen production – and particularly consumption – over time will emerge, along with** the associated geographical locations.

CCUS: AN EMERGING ISSUE IN THE SOUTH WEST HYDROGEN VALLEY

CO_2 emissions are well known in the Pau-Lacq-Tarbes Industrial Territory, and represent an argument in favour of the deployment of CO_2 capture, storage and utilisation/exploitation projects in the area in the medium to long term. Synergies technically exist between hydrogen and CO_2[15], but would need to be delved into further in the territory because, at the moment, just 1% of CO_2 emissions in the Nouvelle-Aquitaine and Occitanie regions are recovered (chiefly in the production of firefighting foam and fizzy drinks).

Stakeholders attending the workshop reported difficulties in bringing forward projects for CO_2 capture, storage and utilisation.
Particular questions remain about certain regulatory aspects awaiting clarification for CCS and CCU.
Despite that, the PYCASSO project offers prospects in this field. It pursues the objective of creating a cross-border CO_2 transport grid, a recovery hub on the Lacq site, and finally a storage site in one of the geological reservoirs that exist locally.

E-fuel production will moreover, and in the longer term, be a major lever for expanding the combined use of low-carbon or renewable hydrogen and CO_2. That production actually needs large volumes of hydrogen, but also electricity for the e-fuel manufacturing process.
Challenges with accessing renewable energy may arise, other applications such as CO_2 recovery will probably be prioritised.
Finally, **issues concerning the availability and correct design capacity of electrical infrastructures** (particularly the RTE grid) are still central to e-fuel production.
Finally, in the absence of a CO_2 or hydrogen transport grid, that production would need to be located around CO_2-H_2 hubs in industrial areas.

All these challenges need local experimentation to continue through a diversity of demonstrators and the provision of ad-hoc engineering.

[15] H_2 production via thermal reforming could be envisaged, with carbon capture and storage or utilisation. CO_2 utilisation also enjoys synergies with H_2 production by electrolysis. O_2, a co-product in the production of H_2 by electrolysis, makes electrolysis facilities profitable, being exploited for oxy-fuel combustion. An important aspect of the process is that it creates greater CO_2 concentrations in fumes, thus facilitating its capture. H_2 and CO_2 are complementary, particularly in the methanation process for the production of e-fuels and e-methane.

THE SUITABILITY OF CO_2/H_2 LOGISTICS IN THE SOUTH WEST HYDROGEN VALLEY

The territorial workshop highlighted a number of findings around which there was a consensus:

- Top-ranking industrial actors in the hydrogen valley should drive the market in the territory. The deployment of infrastructures and the associated milestones, will depend on their strategic orientation.
- The need for shared hydrogen infrastructures in the territory also came out of the discussions. This represents a guarantee of security of supply in the area. Expectations were expressed in terms of reliability of the supply.

The deployment of those infrastructures is still dependent on wider demand, which itself is held back by the absence of hydrogen infrastructures to allow security of supply, diversity and, as a result, competitiveness (a "chicken and egg" effect). The **presence of hydrogen logistical infrastructure in the territory thus represents a major consideration for the territory's competitiveness and the deployment of hydrogen-powered land transport and the industrial use of hydrogen.**
The availability of land and sunshine will be decisive factors in the installation of assets producing hydrogen by electrolysis close to areas of mass renewable energy production, through a cross-border approach. Low-carbon or renewable hydrogen production areas will therefore probably be far away from consumption areas.
Hydrogen transport infrastructures, shared and interconnected at the European level, will therefore be needed to link hydrogen production areas to consumption areas and to guarantee access to competitive low-carbon or renewable hydrogen. Ports will also remain strategic places for maritime transport of hydrogen.

Hydrogen storage infrastructures also seem necessary to ensure **security of supply and to ensure the flexibility of the energy system**, particularly to compensate for differences between periods of massive hydrogen production (essentially in the summer) and consumption which is evenly spread across the year. The HYGEO project to convert an existing salt cavern located on the old propane storage site at Carresse-Cassaber to store renewable hydrogen looks promising in this respect.

Coexistence between gases (methane, biomethane, low-carbon or renewable hydrogen and CO_2) does not seem to be an issue for transporters and distributors. The challenge remains to **maintain synergies between those gases and to identify needs at territory level to respond to them in the best way.**

The work of zoning needs and production, carried out for biomethane, has already enabled adjustment of the pipeline-based transport and distribution logistics. That work remains to be done for hydrogen and CO_2.

Engaging in a planning process for a pipeline-based transport system through a series of consultations therefore seems crucial, if the roll-out of these low-carbon or renewable hydrogen transport logistics is to get underway, and so that industrial and public stakeholders can obtain a rapid response to their decarbonisation objectives.

GRTGAZ AND TERÉGA PRESENTATIONS

ABOUT GRTGAZ

GRTgaz is the 2nd largest European gas transporter, boasting 32,500 km of pipelines and 640 TWh of gas transported. The business employs 3000 staff and achieved a turnover of nearly 2.3 billion euro in 2020. GRTgaz has a mission statement that runs: "Together, we make possible an energy future that is safe, affordable and climate neutral". An innovative business undergoing profound transformation to adapt its grid to the new ecological and digital challenges, GRTgaz is committed to a 100% carbon neutral gas mix in France by 2050. It supports the hydrogen and renewable gas (biomethane and gas from solid and liquid waste) industries.

GRTgaz carries out public service missions to guarantee security of supply to its 945 customers (shippers, distributors, industry, power stations and biomethane producers). With its subsidiaries Elengy, the European leader in methane tanker terminals, and GRTgaz Deutschland, operator of the German MEGAL transport grid, GRTgaz plays a key role on the European stage. The business exports its expertise internationally, particularly those services developed by its research centre, RICE.

GRTgaz

FIND US AT:

https://www.grtgaz.com/ et

Twitter Facebook LinkedIn

GRTGAZ press contact:

Chafia Baci
@: chafia.baci@grtgaz.com - T: +33 (0)6 40 48 54 40

ABOUT TERÉGA

A major actor of the energy world in Europe, Teréga has been established in South-West France for over 75 years. The company operates over 5,000 km of pipelines and two underground storage facilities, representing 16% of the French gas transport grid and 26% of national storage capacities. Meeting its public service obligations, Teréga ships natural gas to over 400 delivery stations, under optimal conditions of safety, cost and reliability. In 2020, the company generated revenues of €460 million and it has more than 660 employees.

Teréga enjoys a strategic position in Europe, where the company provides the interconnections which guarantee security of supply, and with Spain in particular. Aware that renewable gas has a vital role to play in the energy transition, Teréga intends to establish itself as an accelerator of this green revolution by increasing its involvement in the biomethane, hydrogen (including Power-to-Gas) and natural gas for vehicles sectors.

TERĒGA

FOR MORE INFORMATION, VISIT:

https://www.terega.fr/ et

Twitter Facebook LinkedIn

TERÉGA PRESS CONTACT:

Céline DALLEST
@: celine.dallest@terega.fr - T: +33 (0)6 38 89 11 07