DECLYC



The results of the studies carried out as part of the Low-Carbon Industrial Zones (ZIBaC) program reflect above all the collective vision of the involved industrial stakeholders. These pathways provide a structuring contribution to the development of national decarbonisation strategies, but do not constitute an established or official vision of those strategies.

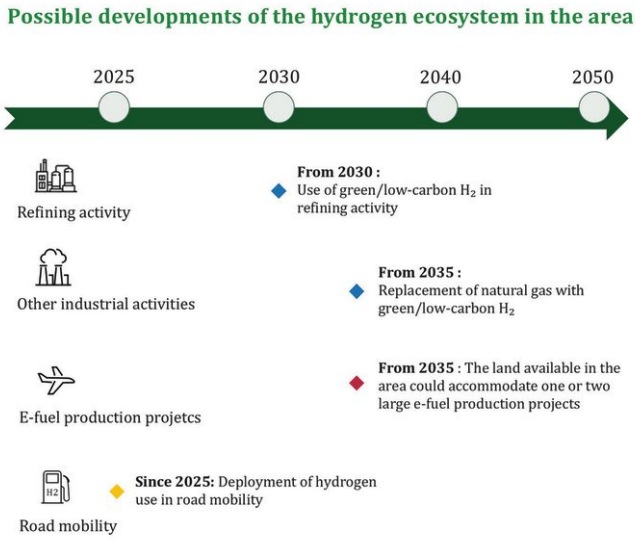
The DECLYC project aims to define decarbonisation strategies to reduce CO_2 emissions and the environmental footprint of the Chemistry Valley and neighbouring areas, to establish governance models for potential shared solutions that may emerge, and thereby to maintain the competitiveness and long-term sustainability of industrial and R&D centers.

Work Package 3
Hydrogen

Context and Objectives

The hydrogen technical studies carry particular strategic significance, owing both to the existing consumers of fossil-based hydrogen and to the decarbonisation potential that low-carbon hydrogen offers across the Vallée de la Chimie.
The area is indeed home to long-standing industrial hydrogen consumers, accounting for volumes that are significant at the scale of the zone, in petrochemical applications among others, where hydrogen is used in a range of processes and notably for the desulphurisation of sulphur-bearing products.

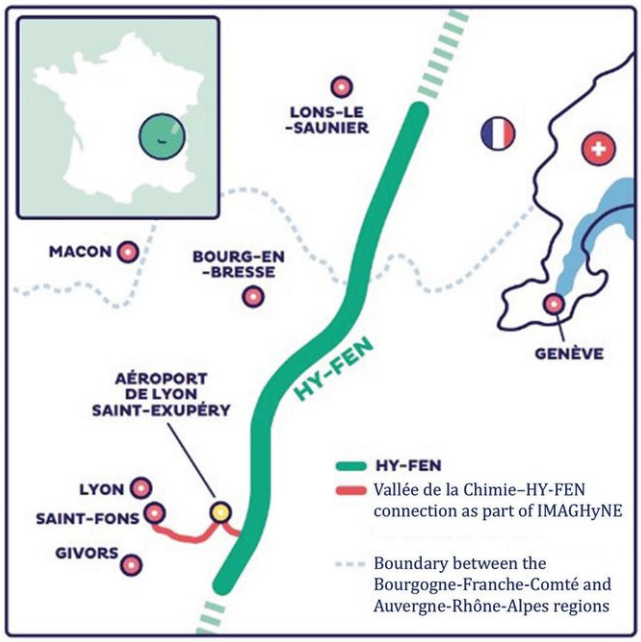
The study sets out to identify the optimal configurations for the use of clean hydrogen in decarbonising industrial activity in the Vallée de la Chimie, by analysing the conditions required to establish a hydrogen ecosystem spanning the entire value chain - from hydrogen production through to end use - and capable of integrating into the national hydrogen infrastructure network.



Methodology

The study applied a shared, consultative approach to the analysis of requirements and potential synergies, and proposed a hydrogen infrastructure development plan aligned with medium- and long-term decarbonisation scenarios.

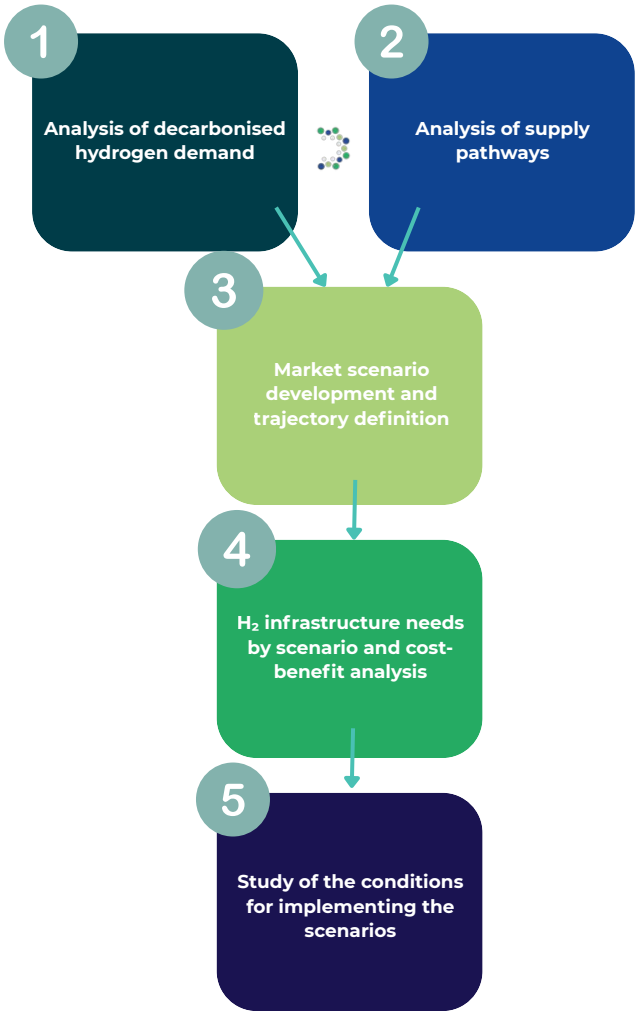
A market is where supply meets demand. Accordingly, the study first characterised current demand and projected future demand for low-carbon hydrogen, then examined the supply options available to meet it. Three supply scenarios were assessed: local production, imports from the Iberian Peninsula, and a mix of the two. This initial step made it possible to delineate the potential market and to define a set of market scenarios, from which the requirements for pipeline transport and storage infrastructure were derived. A cost-benefit analysis was then carried out to determine whether investment in hydrogen infrastructure is warranted and to identify the optimal configurations. Finally, complementary analyses were proposed on the valorisation of electrolysis co-products (heat and oxygen), and a deployment plan was established for a pipeline connection between the Vallée de la Chimie and the HY-FEN backbone, the south-to-north hydrogen corridor for France developed by NaTran.



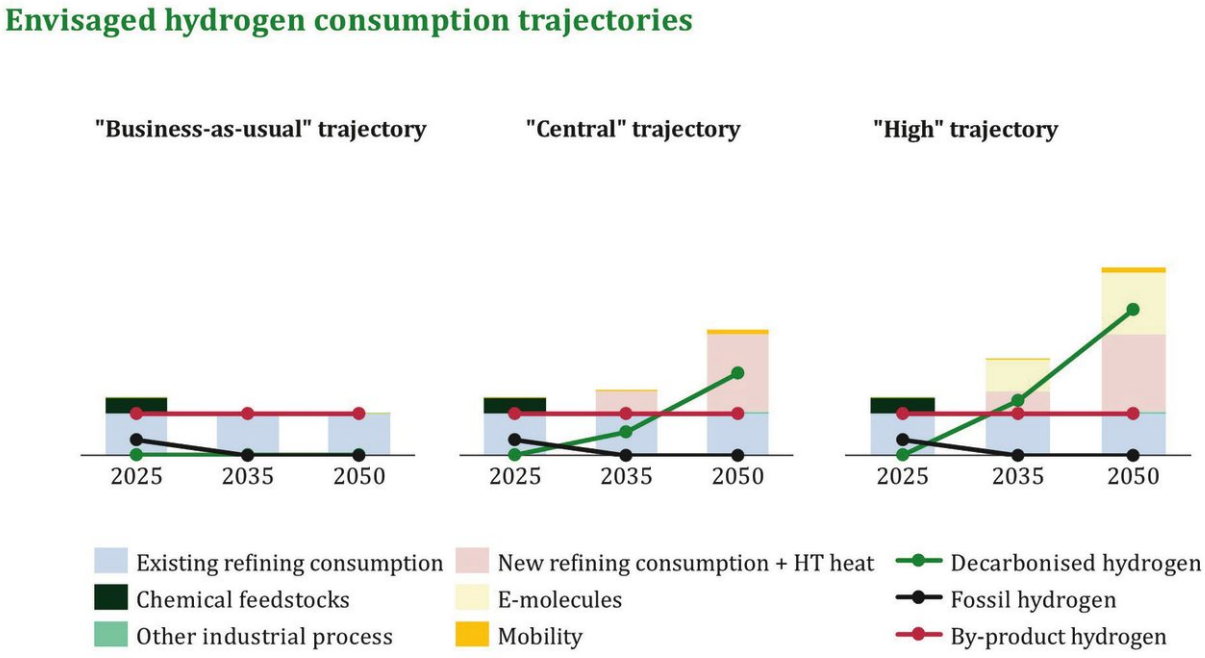
Key Steps

The main stages of the study are summarised below:
1) Demand analysis: establishing hydrogen requirements for industrial and mobility uses across the Vallée de la Chimie through to 2050, in consultation with the key stakeholders of the area;
2) Supply analysis: identifying known low-carbon hydrogen production projects and assessing how far the various supply options can meet demand, including the potential for additional production of hydrogen and its derivatives within the Vallée de la Chimie, having regard to local constraints such as electricity, water, biogenic CO_2 and land availability;
3) Scenario building: determining the resulting market (the intersection of supply and demand) and constructing alternative supply trajectories for the Vallée de la Chimie to serve that market;
4) Infrastructure requirements: identifying the transport, distribution and storage infrastructure needed to enable market development and to deliver the scenarios identified, comparing the optimal hydrogen supply configurations against technical, economic and environmental criteria;
5) Delivery conditions: examining the conditions for realising that infrastructure so as to connect production and consumption hubs, and sizing it against the various production and demand scenarios.

Lastly, the opportunities for valorising electrolysis co-products such as oxygen and heat within the area were assessed, together with their potential impact on the business case for electrolytic hydrogen production projects.



Results



Low-carbon hydrogen emerges as a significant decarbonisation lever for the petrochemicals installations and opens up potential avenues of growth for the area, notably in the production of e-molecules and the decarbonisation of high-temperature heat. Deploying electrolysers also offers balancing services and reduces electricity system management costs, which could generate additional revenue and ultimately lower the price of the molecule for consumers.

Demand for low-carbon hydrogen in the Vallée de la Chimie was assessed through two trajectories: a central trajectory, driven by industrial demand, and a high trajectory, which incorporates additional volumes for e-fuel production. Demand is estimated at between 20 and 40 ktH_2/yr by 2035, and could rise to approximately 90 ktH_2/yr by 2050 should an e-fuel production project materialise. In the central trajectory, this demand stems primarily from refining activity and, to a lesser extent, from the decarbonisation of high-temperature heat applications.

The area further possesses genuine assets - available land and biogenic CO_2 volumes - for the hypothetical e-fuel production project set out in the high trajectory. Such a project could add some 40 ktH_2/yr by 2050 relative to the central trajectory.

Comparison of the three supply configurations to answer to the central demand trajectory, based on indicators calculated and averaged over the 2030–2050 period

	Local Production Scenario	Mix Scenario	Import Scenario
Achievement of the demand trajectory *% of trajectory achieved*	72% - 100%	100%	65% - 95%
Tonnes of CO_2 avoided *In $MtCO_2$, over the 2025 – 2050 period*	3,4 – 5,3 Mt	3,4 - 7,2 Mt	3,1 – 6,9 Mt
Economic competitiveness *Average price of hydrogen consumed*	5,45 €/kg	5,25 €/kg	4,70 €/kg
CO_2 abatement cost *In €/tCO_2 avoided*	770 €/t	617 €/t	676 €/t
Direct investment required *CapEx needed to deliver the scenario*	435 - 890 M€	175 - 850 M€	~ 35 M€
Security of supply			
Minimising stress on resources *Water, land, electricity*			

- competitive ◄——► + competitive

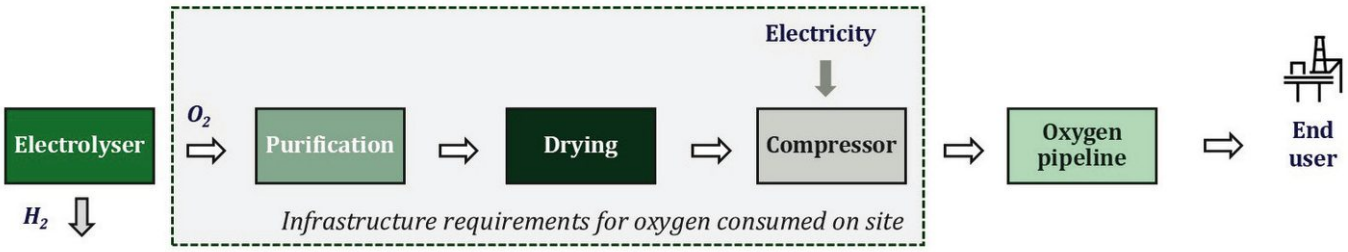
Preferred scenario

To meet this growing demand, the area could draw on several supply levers: local production, imports, or a combination of the two. The OphelHy project developed by Hynamics (formerly HyDom), with its 80 MW electrolyser, could represent the first step towards decarbonised local production. Any further local production will depend on the ability to mobilise new investment and to put the available land to productive use. From 2032 onwards, supply could be supplemented by hydrogen imported via the HY-FEN pipeline and a dedicated connection to the Vallée de la Chimie, giving access to volumes from the Iberian Peninsula at a price that appears, a priori, €0.5 to €1/kg below that of locally produced hydrogen.

The analysis conducted in this study shows that a mixed supply scenario - combining local production in the near term with imports once connections to the national transmission network are in place - constitutes an attractive configuration. It maximises security of supply, delivers a "relatively" attractive supply cost, and maximises the reduction of CO_2 emissions over time. It nonetheless presupposes close coordination between public and private stakeholders, together with rigorous planning of investment in production, transport and storage infrastructure.

Hydrogen infrastructure, comprising pipelines and storage, generates two categories of economic benefit: a reduction in the cost of low-carbon hydrogen supply for local consumers, amounting to as much as €280 million by 2050 under the high demand trajectory; and the potential generation of additional revenue for local hydrogen producers through the participation of electrolysers in electricity system balancing. Recourse to low-carbon hydrogen would, in addition, reduce the carbon cost borne by sectors subject to the EU ETS.

The potential for valorising electrolysis co-products remains limited or uncertain. Co-produced oxygen could compete with conventional O_2 production methods over pipeline distances of up to 50 km, but few regional uses currently exist at meaningful volumes - above 10 kt/yr - within that radius. The potential for heat valorisation is significant, in the order of 300 GWhth/yr by 2040, but the heat available is low-grade. The most promising outlet is injection into a district heating network; both the valorisation route and its integration remain to be studied in greater detail.



Outlook

Several avenues of further work could be pursued in order to: (1) situate the choice of hydrogen within the broader set of solutions available for a given end use, such as heat decarbonisation; (2) analyse how European and national incentive mechanisms and regulations shape technology choices and market development; and (3) identify how the green premium attached to decarbonisation solutions can be passed along the value chain on behalf of the party deploying it, and reassess the resulting economic balance, particularly for refining. It would also be valuable to (4) align the deployment of a local low-carbon hydrogen ecosystem with regional dynamics and with developments at Fos-sur-Mer, and (5) examine the potential for valorising electrolyser waste heat within a district heating network.

Lead

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Co-financing partners

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