France Hydrogène

Engagée pour la transition écologique

A road-map for an ambitious hydrogen strategy by 2030

PART 2

Executive summary

Industry and local governments turn their vision into reality

Study – December 2022

Executive summary

In 2020, France set out an ambitious national strategy which committed it to developing a decarbonized hydrogen sector. Backed by 9 billion euros of public funding to enable the expansion of such a sector on an industrial scale right across France, its objective is to build 6.5 GW of installed electrolyzer capacity by 2030 and in so doing, reduce CO_2 emissions by 6 million tonnes each year.

In 2021, France Hydrogène published the study 'A road-map for an ambitious hydrogen strategy' which divided this strategy into two scenarios: the 'Ambition 2030' scenario with an annual production target of 680,000 tonnes of low carbon or renewable hydrogen and a second scenario, 'Ambition+ 2030' which envisages a significant increase on the first target to 1,090,000 tonnes of low carbon or renewable hydrogen. This aims to meet the regulatory requirements of the 'Fit for 55' package. Seven large clusters were identified which will act as cornerstones for a large-scale roll-out of hydrogen projects where the pooling of production and different end uses of the produced hydrogen will deliver cost reductions.

In this study - part 2 of the 'Road-map for an ambitious hydrogen strategy by 2030', France Hydrogène compares two potential scenarios, Ambition and Ambition+ with the on-the-ground reality of projects already begun or planned by the industrial sector and local and regional governments. The study evaluates the roll-out of the hydrogen sector using the following criteria between the time the study was carried out until 2030:

- Low carbon or renewable hydrogen installed production capacity,
- The various end uses of hydrogen (for industry, energy, transportation),
- The current state of resources and limiting factors insofar as these will act as a brake on the extent to which production capacity can be harnessed.

A method based on the mass collection of data

France Hydrogène has a presence in every single region in mainland France and represents a very wide spectrum of stakeholders in the hydrogen field. This has allowed it to carry out an unprecedented data collection exercise in the 12 regions of mainland France covering **over 250 projects and local distribution networks.** Semi-structured interviews with France Hydrogène's regional delegations and Conseils régionaux (local authorities at the regional level) enabled data to be collected, analyzed and verified.
The large quantity of data featured later in the study derives from projects at very different stages of completion. Some projects are not shown because they were confidential at the time the data was gathered. France Hydrogène has also drawn on open source materials for various categories of the data it has collected (reports and studies, regional and national monitoring units, regional land-use plans and more). The key criteria have been considered **at both national and regional level.**

Applications of hydrogen

Taken together, the projects listed would use a total of approximately **1,070,000 tonnes** of low-carbon and renewable hydrogen **annually between now and 2030 in France**. This is a larger quantity than the target set out in the National Hydrogen Strategy and similar to the targets of the Ambition+ 2030 scenario. The main geographical areas where hydrogen should be consumed are concentrated around industrial areas and inside the geographical 'clusters' identified by the 2021 study.

The decarbonization of industry opens the door to large-scale hydrogen production...

As described in the scenarios of the 2021 study, **the decarbonization of industry will be the main driver of large-scale hydrogen production.** At the same time, we must consider the growth in mobility applications and the emergence of energy storage solutions in the hydrogen sector, albeit these are of very different orders of magnitude:

	Ambition Scenario (tH_2/p.a.)	Ambition+Scenario (tH_2/p.a.)	**Estimated production by 2030** (tH_2/p.a.) – December 2022
Industry	475,000	635,000	815,000
Mobility	160,000	325,000	230,000
Energy	45,000	130,000	25,000
Total	680,000	1,090,000	1,070,000

If we look more closely at the breakdown of industrial applications, it shows on the one hand 'conventional' applications like refining and the production of ammonia, confirms **the important share allocated to steel-making and draws attention to the new – and significant – share devoted to the production of synthetic molecules. In fact, over half of the low-carbon and renewable hydrogen produced is used by projects devoted to making e-methanol and e-fuels amongst others.**

▪ *Refining*	50,000
▪ *'Conventional' ammonia*	20,000
▪ *Synthetic molecules*	425,000
e-methanol	*205,000*
e-fuels such as SAF and e-kerosene	*165,000*
other needs (e-methane, etc.)	*55,000*
▪ *Steel-making*	250,000
▪ *Decentralized industry*	12,000
▪ *Process heat*	6,500
▪ *Not specified*	51,500

... and mobility projects enable the use of hydrogen to spread all over France

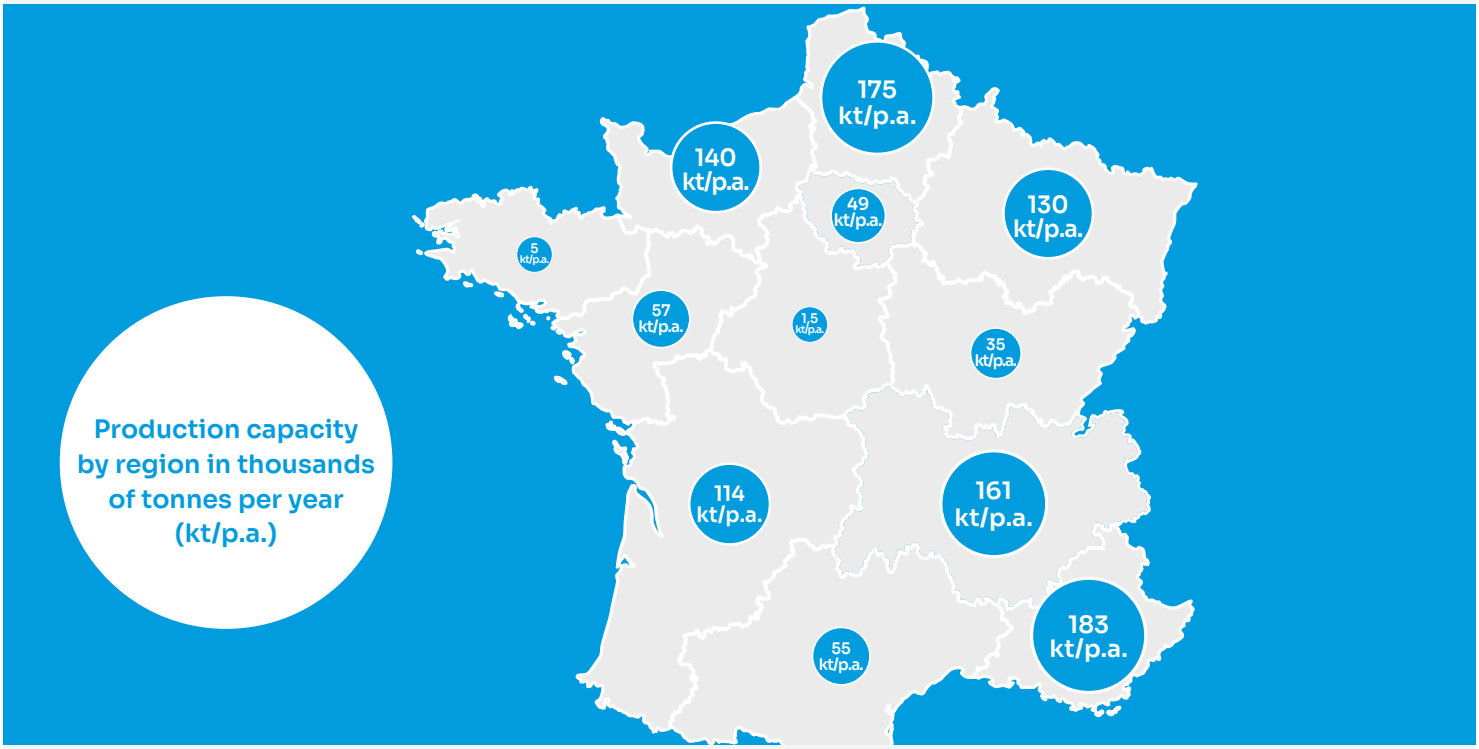
The study shows that **transportation projects, especially road transportation projects, facilitate the spread of the use of hydrogen across the whole country. Some 225 hydrogen refuelling stations will open in France by 2025,** with at least a **dozen or so stations planned for every region**, mostly around the larger cities. Hydrogen mobility projects would account for **around 230,000 tH_2** by 2030, that is, approximately 20% of France's potential output, which is in line with estimates made in 2021.

With regard to rail transport, the introduction of hydrogen-powered trains on the regional, non-electrified rail network is part and parcel of a wider strategy of local development. Fourteen hydrogen-powered Régiolis trains have been ordered by 4 regional governments. They are due to enter service by 2025, replacing today's diesel-powered trains. The new trains will be completely emissions-free and offer the same level of passenger comfort and performance as their predecessors. They have a range of 1,000 km, 600 km of which comes from its 184 kgH_2 onboard hydrogen tank, and a 300 kW fuel cell system. As far as a wide range of **sea and river transportation systems** are concerned, hydrogen and fuel cells are suitable for numerous applications, as demonstrated by the thirty or so projects recorded right across France. These include powering passenger-carrying shuttle boats, small harbour vessels and boats that travel specifically on inland waterways as well as quayside refuelling devices. Solutions currently in development generate power in the range of 200 kW to 2.5 MW and feature onboard reservoirs containing hundreds of kilograms of compressed or liquid hydrogen. There are still many technical and regulatory challenges. **The decarbonization of the air travel industry**, meanwhile, is critical for the future survival of the sector. Although the technical challenge is a difficult one, the French aeronautics industry is exploring several approaches to decarbonization, including hydrogen. This includes its use for propulsion (by turbojet or an electric motor powered by a fuel cell), to operate Auxiliary Power Units, provide emergency back-up power or even to replace kerosene with e-kerosene produced from low-carbon or renewable hydrogen.

Hydrogen also has a role to play in energy-related applications. It is a practical solution to the electrical grid's need for flexibility but can also be used in off-grid applications (stand-alone power systems, remote areas, electric generators, emergency back-up systems etc). This particular application is poorly represented in the list of projects recorded by the study, but several experiments and demonstration projects are currently underway. The changing face of energy and the increasingly important part played by renewable energy in the French electricity generation mix may lead to increased demand for hydrogen in the short term due to its ability to deliver flexibility to the grid, concurrent with the development of hydrogen transportation and storage infrastructure.

Production capacity from identified low-carbon and renewable hydrogen projects has the potential to exceed the goals of the national strategy

At the current rate of project roll-out, the National Hydrogen Strategy's target, set at 6,500 MW of electrolysis capacity in France by 2030, may be achieved or even exceeded. Potential hydrogen production capacity is forecast to be, in tonnage terms, in line with the Ambition + scenario, i.e. approximately **1,070,000 tonnes of hydrogen in the year 2030.** Electrolysis is by far the most popular approach taken by industry players (representing more than 95% of production capacity) but at least a dozen distribution network projects rely on biomass gasification, another hydrogen production method which fits in well with a circular economy approach. The future of hydrogen production looks healthy right across France, with **between 15 and 25 such projects recorded per region.**



There are **really two extremes with regard to hydrogen production in France**. On one hand, the large majority of projects have less than a 3 MW_{eq}. capacity (70% of recorded projects); on the other hand, most of the hydrogen produced is produced by projects with a production capacity of over 100 MW_{eq}. (80% of all hydrogen production comes from only 24 projects).
Mid-sized projects, despite their potential in terms of infrastructure sharing and creating economies of scale, are currently clearly not the favoured option.

The increasing frequency of large-scale projects and the **structuring of local distribution networks confirms the gradual emergence of hydrogen 'clusters'**, as pointed out by the study 'A road-map for an ambitious hydrogen strategy 2021'.

Consider the availability of resources

Whilst not considering every single possible resource, the study offers qualitative insights into building land issues and quantitative data on renewable and low-carbon primary energy and on the availability of the water required to produce more than one million tonnes of hydrogen annually by 2030.

▪ **Availability of primary energy**
The production of over 1 million tonnes of renewable and low-carbon hydrogen would be mostly carried out through electrolysis which would need over 50 TWh of electricity. **This represents 10% of France's total electricity consumption as set out by RTE (the French national grid transmission system operator) in its baseline generation mix scenario (M23) in 2030 (500 TWh)**. This represents a significant proportion of electricity allocated to hydrogen production. Hydrogen production through electrolysis using the French electricity distribution network should be encouraged. The roll-out of renewable energy power generation should be accelerated and the commercial exploitation of biomass and waste supported in order to diversify methods of hydrogen production and the inputs required by this production.

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▪ **Water resources**

The amount of water which would have to be withdrawn to produce a million tonnes of low-carbon and renewable hydrogen is between 10 and 20 million cubic metres[2]. The amount of water which would be consumed (i.e. permanently lost) is around 10 million cubic metres. Compared with the sum quantities of water withdrawn and consumed in France[3], these scenarios would account for less than 0.1% of withdrawals and less than 0.2% of water consumption. **These quantities are significant but not substantial** when judged against the figures for France as a whole or for the energy sector, which currently accounts for half of all withdrawals and a third of all consumption in France[4]. The impact of the hydrogen sector in terms of water stress is therefore not particularly substantial at a national level but local or seasonal factors must be very carefully analyzed, primarily to identify risks which could impact the hydrogen production supply chain.

▪ **Availability of land**

Hydrogen refuelling stations and production units need space. For instance, a refuelling station for a fleet of several dozen buses will require an area of around 900 to 1200 m^2. Furthermore, the kinds of plots the hydrogen sector needs to grow are often located **in areas already subject to specific regulatory constraints** – high-density industrial areas, the areas around harbours and airports, urban areas etc. The availability of land is therefore a significant limiting factor for hydrogen sector projects.

2 - depending on the electrolyzer technology being used, 9 to 20 litres of water must be withdrawn to make one kilogram of hydrogen. Nine litres of this is consumed (not returned directly to the source from which it was withdrawn).
3 - 32 billion cubic metres of water were withdrawn in 2017 and 5 billion cubic metres were consumed on average each year between 2008 and 2017, Eau et Milieux aquatiques, Edition 2020, Ministère de la Transition Ecologique
4 - According to statistics from the Ministère de la Transition Ecologique, on average, between 2008 and 2018, agriculture was the largest consumer of water in France (45%), followed by power plants (for cooling) (31%) and drinking water (21%).

Conclusion and recommendations: What the hydrogen industry thinks is needed to achieve the 2030 road-map's goals

The study demonstrates the dynamism of the players in the hydrogen sector – industry and local governments – and the great variety of projects being undertaken. **Project roll-out is on course to meet the targets of the National Hydrogen Strategy by 2030** as set out in the 'Ambition+' scenario. However, many of the projects being developed right across France as part of local distribution networks and recorded in this study are dependent upon the implementation of a comprehensive, clear and stable legislative and regulatory framework.

To achieve the goals of the 2030 roadmap, the hydrogen sector suggests priority should be given to implementing the following recommendations:

▪ **Secure primary energy supplies and establish the right conditions for competitively priced decarbonized hydrogen production:**

- **Accelerate the roll-out of renewable energy and ensure the long-term viability of low-carbon electricity production capacity.** Long-term supply contracts must be drawn up to provide clarity of outlook, certainty and competitive hydrogen production on the energy market.
- **Devise incentives to boost mid-sized hydrogen projects whether these relate to production** (10-50MW) **or applications.** These projects form a vital link and are particularly relevant to the development of the hydrogen sector through the cluster model. This will principally be achieved by designing tailored support mechanisms for decarbonized hydrogen production and avoiding creating disincentives to investing in these kinds of projects.
- **Diversify decarbonized hydrogen production pathways** to boost resilience, protect primary energy supply over the long-term and increase competitivity. It is vital that calls for proposals and support mechanisms should specifically include the production of hydrogen from biomass or waste, as well as the simultaneous development of various methods of connecting electrolyzers to the electrical supply, which would enable the exploitation of new sources of renewable energy (land and/or sea-based).

▪ **Create an environment which promotes the growth of road transport applications which use hydrogen.** This is needed if we are to cater to the full range of mobilities and vehicle types to meet the challenge represented by the introduction of Low Emission Zones in tandem with battery electric vehicles. This is also needed to capitalize on the French state's long-term industrial investment in hydrogen road transport components manufacturers in the framework of the first IPCEI, Hy2Tech. With this in mind, France Hydrogène will suggest a range of additional initiatives at the beginning of 2023, with a view to orders for the first 50,000 hydrogen-powered light commercial vehicles being placed by the end of 2026. This will involve, amongst other things, setting up ways of coordinating the placing of public and private sector orders to benefit from a group buying approach.

Conclusion and recommendations (continued)

▪ **Accelerate the planning and construction of hydrogen transportation and storage infrastructure, especially cross-border infrastructure**, taking into account the CCUS plan and the strategy for the decarbonization of major industrial hubs announced by the French President on 8th November 2022.

▪ **Complete the implementation of the regulatory framework, a key factor weighing on project start-ups and funding and final investment decisions:**

- **The decree on the definitions of renewable and low-carbon hydrogen, the decree relating** to guarantees of origin and of traceability of hydrogen and the decree implementing the inclusion of renewable hydrogen in the scope of TIRUERT (tax incentives for the use of renewable energy in transport), after January 1st 2023 are keenly expected by the hydrogen sector.
- Clarifications and modifications to the French environmental permitting (ICPE) regulatory framework applicable to hydrogen facilities are also expected. To start with, this is likely to involve the introduction of a 6 MW_{ELY} threshold, below which electrolysis hydrogen production projects (ICPE 3420) will not be subject to an environmental assessment, as well as the establishment of a system requiring registration (simplified authorization) for projects of stored hydrogen weighing one tonne or more to comply with ICPE 4715 (a regulation relating to hydrogen storage). More generally speaking, relevant thresholds and procedures should be adapted to take account of new applications for hydrogen in line with the recommendations of the package of regulatory measures currently being drawn up.

At the same time, it is crucial to ensure that low-carbon hydrogen and renewable hydrogen are treated equally at EU level. This provision is of key importance for the recognition of the soundness of France's hydrogen strategy. To this end, the EU targets focusing on renewable hydrogen use set out in the revised directive on renewable energies (RED III), must be widened to include low-carbon hydrogen. Likewise, production criteria must be applied without differentiating between locally produced hydrogen and imported hydrogen (both renewable and low-carbon hydrogen imports).

Notes

www.france-hydrogene.org

vighy.france-hydrogene.org

France Hydrogène

Engagée pour la transition écologique

50 avenue Daumesnil - 75012 Paris
Contact : info@france-hydrogene.org
Tel. +33 (0)1 44 11 10 04

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