



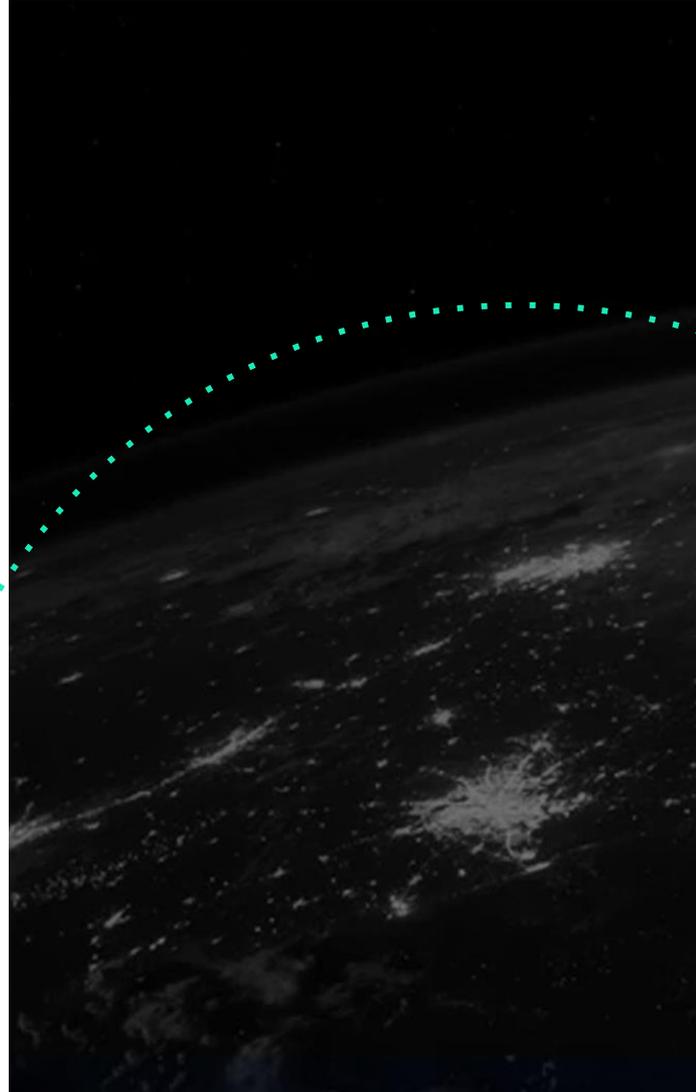
Netherlands Enterprise Agency

March 2021

Hydrogen sector study France

Hydrogen in France, developments and opportunities for the Netherlands

Commissioned by
Netherlands Enterprise Agency (RVO)
Embassy of the Kingdom of the Netherlands in France
Netherlands Business Support Office Lyon & Nantes



Executive summary (1/2)

Context

On 8 September 2020, the French government presented its **national hydrogen strategy**: over 7 billion euros until 2030 will be made available for the development of a low-carbon hydrogen industry on an international scale (of which 2.2 billion between 2020 and 2022). There is general agreement that it is now time to use the **experience and knowledge gained from projects in France**. The research question for this study is therefore: **How are French hydrogen technologies, markets and policies regarding green hydrogen developing and which synergies can be found with Dutch actors in the hydrogen sector?**

Main results

This study has observed that **France has expertise and actors on many parts of the hydrogen value chain**. This large number of players, supported by an **ambitious national strategy** and the **desire to develop a competitive sector**, create opportunities for cooperation. In addition to this, foreign players wishing to participate in public tenders are encouraged by the public authorities to participate in the development of the French sector (local employment, exchange of know-how and technologies). **The three main areas for Dutch actors to find synergies French actors** in the hydrogen sector are:

1

Apply to the regional and national call for tenders

Take the opportunity of the infatuation of French regional and national politics for hydrogen development through the call for tenders and engage in local activity development (e.g. jobs creation)

2

Direct company-to-company cooperation

Utilize market opportunities, addressing the specific needs or knowledge areas in the French or Dutch markets where countries could learn from or complement each other.

3

Apply to EU call for tenders or subsidy programs

Benefit from the multiple financing counters from EU programs (e.g. FCH-JU, IPCEI, FEDER) to build up projects with French companies

Executive summary (2/2)

Recommendations – public and private sector

- 1 We see a need for the Netherlands to **be part of the Franco-German cooperation**
- 2 We see a need to **improve the attractiveness of the business climate for foreign (electrolysis) OEMs** in the Netherlands
- 3 Continue **strong lobbying between ministries with France and the Netherlands**
- 4 The **Dutch subsidy climate should improve in transparency and support of the smaller innovative companies**
- 5 **In our study a navigation/cartography of actors in France has been made** for each hydrogen sector, this could be extended with a digital 'marketplace'.

Highlights cooperation opportunities

- 1 In France there is an enormous **dynamic regional hydrogen activity**. Dutch companies should find opportunities there and learn from this regional development.
- 2 In company to company cooperation we see that the **largest chances** for cooperation is in the **Electrolysis** and **Road Mobility** sector.
- 3 **Cooperation can be on Dutch ground as well as in France**, where we see cooperation with OEMs here as a large opportunity.
- 4 **Participation to European subsidy programs is also an option** though it seems in many cases more suitable for the larger organisations. It is clear which programs are there and which countries or companies participate.

Introduction

On 8 September 2020, the French government presented its **national hydrogen strategy: over 7 billion euros** until 2030 will be made available for the development of a low-carbon hydrogen industry on an international scale (of which 2.2 billion between 2020 and 2022). There is general agreement that it is now time to use the **experience and knowledge gained from projects in France** and to investigate where **possible opportunities lie for Dutch companies and knowledge institutes and where cooperation** between the two governments would be possible.

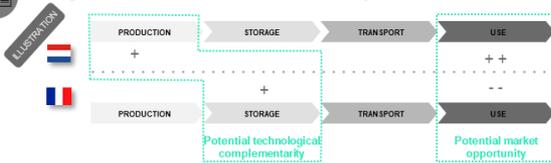
Scope and main research question

How are French hydrogen technologies, markets and policies regarding green hydrogen developing and which synergies can be found with Dutch actors in the hydrogen sector?

Methodology

1. Market Analysis

- National Hydrogen frameworks comparison
- Key actors and key projects identification
- Strengths and weaknesses value chains analysis for both countries



Cooperation Opportunities from market analysis

2. Questionnaire & Interviews

- Global questionnaire
- Key players interviews

Cooperation Opportunities from players' interviews

Final cooperation opportunities

Contributors

Commissioned by

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SIAPARTNERS

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This document contains in total four sections, including the appendix. The first chapter zooms in on the French national hydrogen strategy and provides more context regarding the French hydrogen market. In the second chapter, characteristics of key French hydrogen subsectors are highlighted and a hydrogen sector SWOT analysis for France and the Netherlands is given. Chapter 3 brings together the results from the first two chapters and includes lessons learned from the European hydrogen programs to form market and cooperation opportunities for French and Dutch actors in the hydrogen sector.

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Section 1: Context

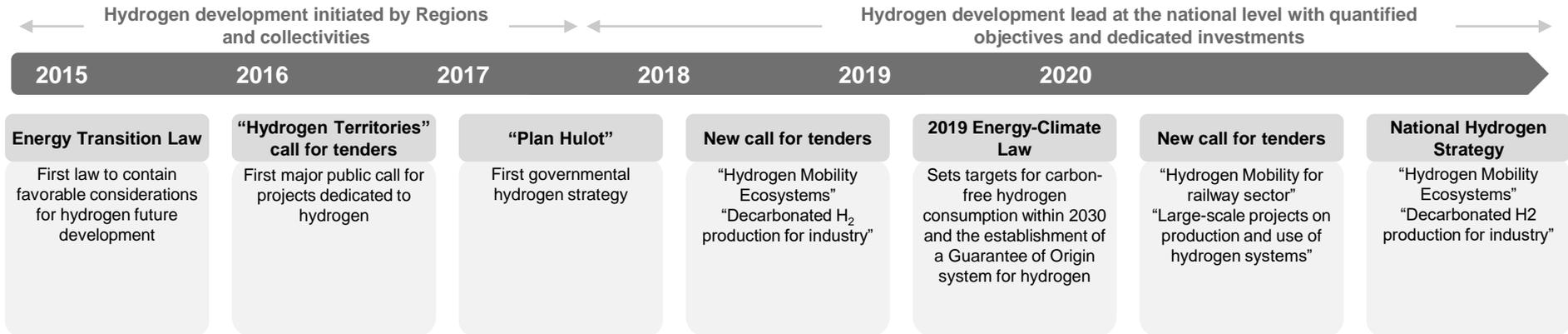
Context

a. The national hydrogen strategy

- b. The role of the territories
- c. Key hydrogen actors

Establishment of the French hydrogen strategy

- The **Energy Transition Law**, published in 2015, sets ambitious targets of achieving within 2030 a rate of 30% renewable energies in final energy consumption and 40% renewable energies in electricity production, reducing the consumption of fossil fuels by 30% in 2030 and decarbonizing 10% of gas. **Hydrogen energy applications are considered as interesting levers for achieving these objectives.**
- Before 2018, hydrogen projects and demonstrators **are initiated by the Regions and collectivities, together with industrials, through public call for projects financed by ADEME**, the national agency responsible for the implementation of public policy in the areas of the environment, energy and sustainable development.
- The "**Hulot Plan**" presented in June 2018, by the Energy Minister N.Hulot, is **the first national hydrogen strategy and aims to support innovation and industrial deployment of carbon-free hydrogen**, to make it one of the pillars of the energy transition. The strategy is **focused on decarbonizing the industry and developing hydrogen mobility**, through an investment of **100m€ through public calls for tenders.**
- The 2019 Climate-Energy Law, sets **targets for carbon-free hydrogen consumption within 2030** and the establishment of a **Guarantee of Origin system for hydrogen.**
- In September 2020, as part of the National Recovery Plan following the COVID-19 crisis, the French government unveils its **Hydrogen Strategy** and sets very ambitious goals accompanied with **7.2bn€ of investments for the next decade** (see focus on the following slide).



The French National Hydrogen Strategy

In the context of the 100bn€ French Recovery Plan, Economy, Finance and Recovery Minister Bruno Le Maire presented the 8th of September the **National Hydrogen Strategy** for the next decade. **Allocated with 7.2bn€, this strategy strengthens the previous 2018 Hulut Plan, and aims to make France a leading nation in green hydrogen production by 2030.** The new strategy is built upon 3 priorities :



1. Decarbonate industry by creating a French electrolysis sector

Target of **20 to 40% low-carbon and renewable hydrogen** in total hydrogen consumption by 2030

Reach **6.5 GW** of installed capacity of electrolysis



2. Develop heavy mobility with carbon-free hydrogen

400 to 1000 in 2028  20k to 50k in 2028
 800 to 2000 in 2028

   Develop hydrogen use in rail, marine and air transport through pilot projects
 Save **6 Mt** of CO₂ emissions in 2030



3. Support research, innovation and education to promote tomorrow uses

Create **50.000 to 150.000 direct and indirect jobs** in France

Objectives

Investments

3.4 bn€ for 2020 - 2023

1.5 bn€ dedicated to the set up of an IPCEI on hydrogen

350 m€ dedicated to a call for tenders "Technological bricks and demonstrators"

275 m€ dedicated to a call for tenders "Territorial hydrogen hubs"

650 m€ dedicated to the **support mechanism to produce carbon-free hydrogen**, by additional remuneration, following the establishment of a mechanism of **guarantees of origin** for hydrogen

65 m€ dedicated to hydrogen research and development programs, lead by ANR

30 m€ dedicated to developing education programs around hydrogen

3.8 bn€ from 2023 to 2030

ADEME call for tenders drive the development of hydrogen projects (1/2)

- Calls for tenders dedicated to hydrogen have regularly been carried since 2016. They are a key pillar of the French Hydrogen Strategy because they involve industrial players, specialized manufacturers, local operators and public collectivities. They enable a public/private cooperation in favor of the hydrogen sector and pave the way for the development of an economically viable and ecologically virtuous model for hydrogen production, distribution and use.
- These calls for tenders target specific areas of hydrogen deployment and are managed by ADEME, the state operator in charge of appraising and financing eco-efficient innovations accompanying the ecological transition.

	Call for Tender Name	 Call for Tender Description	 Projects labeled	 Public subsidies
2016	Hydrogen Territories	<ul style="list-style-type: none"> • Develop an economic model of hydrogen at the scale of a local territory over the entire value chain: production, storage, distribution and final applications • Demonstrate the environmental benefit of hydrogen associated with energy networks and local energy uses: mobility, autonomous power, smoothing of intermittent energies, industrial use, power-to-gas. 	29 projects labeled	undisclosed
2018 - 2019	Hydrogen Mobility Ecosystems #1 & #2	<ul style="list-style-type: none"> • Deploy territorial hydrogen mobility ecosystems, on the basis of the deployment of fleets of professional vehicles. • Support the development of a range of heavy vehicles, whether road or other modes (boats, trains, aeronautics). 	21 projects labeled	18 M€ + 80 M€ of financial support
2019	Decarbonated Hydrogen production for industry	<ul style="list-style-type: none"> • Reduce the impacts of industrial use of carbon hydrogen by joining a path of ecological and energy transition. • Support a competitive approach for the industrial sector. 	5 projects labeled	11.5 M€ of financial support
2020	Hydrogen mobility in the rail sector (EMHYSFER)	<ul style="list-style-type: none"> • Support the emergence of hydrogen mobility in the rail sector via dual-mode trains (electric / hydrogen), making it possible to reduce the impacts associated with diesel rail traction. • Organize authorities of regional rail transport for hydrogen train operations. 	5 pilot Regions selected	22 M€ of financial support

ADEME call for tenders drive the development of hydrogen projects (2/2)

The recent Hydrogen Strategy announced two new specific call for tenders that will be carried over multiple years. Compared to the previous call for tenders they are allocated with significantly increased financements that will lead to the multiplication of hydrogen projects in France and their increase in size.

	Call for Tender Name	 Call for Tender Description	 Projects labeled	 Public subsidies
2020 - 2022	Territorial hydrogen ecosystems	<ul style="list-style-type: none"> Support the deployment of hydrogen uses in the regions, and innovation among equipment manufacturers. Help investments in ecosystems, which combine hydrogen production / distribution infrastructure and uses of hydrogen, particularly in industrial uses(chemistry, metallurgy, electronics), mobility uses (professional fleets, people or goods transport, stationary applications) 	Open to submissions	275 M€ dedicated
2020 - 2022	Technological bricks and hydrogen demonstrators	<ul style="list-style-type: none"> Support innovation work, allowing the development or improvement of components and systems related to the production, transport and uses of hydrogen, among the following 4 thematics: 1 - Innovative technological components and systems, 2 - Innovative industrial pilots, 3 - Design and demonstration of new vehicles, 4 - Large electrolysis demonstrators 	Open to submissions	350 M€ dedicated

- Through the ADEME call for tenders, the government is developing a policy of "territorial hydrogen mobility ecosystems". At the level of each city, community of municipalities or agglomeration, this plan aims to build low-carbon and economically viable hydrogen projects. Local hydrogen production units coupled with green energy sources will be created and made profitable by accelerating the conversion of the most polluting heavy vehicle and / or utility vehicle fleets in the territory.
- The originality of the approach is to involve local authorities alongside large groups and specialized hydrogen manufacturers into hydrogen projects.
- The number of projects continues to increase thanks to the various calls for projects launched by the government and gives hope for a national deployment of new uses of hydrogen.

Context

- a. The national hydrogen strategy
- b. The role of the territories**
- c. Key hydrogen actors

The leading role of the Regions and territories : Regional Roadmaps (1/2)

- In France, the regions are mobilizing alongside industrials and contributing to the development of R&D, demonstration projects and national industrial leadership. Since 2016, many new projects have emerged, following the "Hydrogen Territories" call for tenders. They aim to demonstrate, at the scale of a territory, the techno-economic feasibility and the environmental interest of hydrogen associated with energy networks and local uses.
- In parallel to the multiplication of local hydrogen ecosystems through the ADEME call for tenders, a lot of hydrogen projects are encouraged by the Regional Hydrogen Strategies that have emerged since 2018. These Regional Hydrogen Strategies or Roadmaps set local objectives and are accompanied with dedicated investments.

Hauts-de-France

Dedicated budget undisclosed

The Region has already invested in the development of carbon-free hydrogen, identified as one of the priorities of Rev3, its 3rd industrial revolution project. Published in November 2019, its Hydrogen Plan targets the industrial, building and mobility markets.



Normandie

€ 15m by 2021

Almost a third of the national hydrogen consumption is in Normandy. It was the first to publish a plan for the development of hydrogen in October 2018. Endowed with € 15 million over three years, it primarily targets industrial uses while supporting the hydrogen mobility.



Bretagne

€ 10m for 2020 and 2021

In its roadmap published at the end of October 2020, the Region emphasizes the industrial ambition in the field of naval applications and that of offshore hydrogen production. The sector will develop around other regional specificities such as smart grid projects or renewable marine energies.



Pays de la Loire

€ 100m by 2030

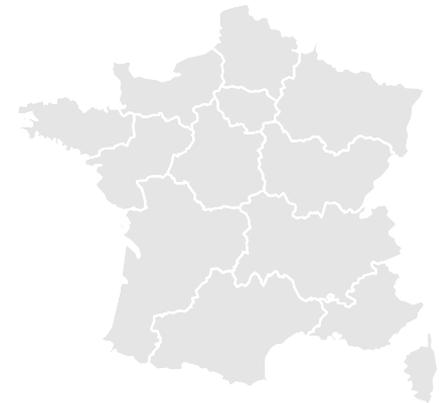
The Region adopted last July its hydrogen roadmap for 2020-2030, with an envelope of €100M. Along with 25 measures targeting mobility, it also targets the emergence of a hydrogen expertise in the river, maritime and port sectors.



Nouvelle Aquitaine

Dedicated budget undisclosed

The region published its roadmap in October 2020 with the objective of structuring and developing a hydrogen industrial sector across the entire value chain.



The leading role of the Regions and territories : Regional Roadmaps (2/2)



Ile-de-France

**CEI up to
€400k**

A "Île-de-France Territoire Hydrogène" was deliberated in November 2019 setting up a charter and a "Hydrogen Club" to resonate initiatives and facilitate synergies between H₂ projects, but also to accompany the signatories of the charter in the development of green H₂ production and an interoperable H₂ network on a regional scale; through calls for projects (CP) and calls for expressions of interest (CEI).



Centre Val de Loire

**Roadmap under
construction**

The Centre-Val de Loire region has for several years been supporting research programs on new energy technologies as well as demonstration projects. Substantial resources for hydrogen projects are expected under the next European Regional Development Fund 2021-2027.



Grand Est

**Dedicated budget
undisclosed**

In December 2020, the Grand Est region unveiled its 2020-2030 hydrogen plan, which is based on 5 pillars: positioning hydrogen in an energy mix covering regional needs, developing decarbonized heavy mobility, engaging industry in the hydrogen sector and decarbonizing its uses, promoting access to knowledge and improving skills, and organizing governance.



Bourgogne Franche Comté

**€ 90m
by 2030**

In its roadmap published in February 2020, the Region plans to invest € 90m by 2030 - in addition to the 12 million already invested since 2016. In a territory which notably shelters an ecosystem of R&D specialized in mobility solutions, the development of the hydrogen sector will also structure stationary uses of hydrogen.



Auvergne Rhône-Alpes

**Dedicated budget
undisclosed**

Committed to large-scale hydrogen mobility with the Zero Emission project Valley, the region is also home to mixed industrial use and mobility projects. It officially voted its hydrogen roadmap in July 2020, with a publication expected soon.



Région Sud

**€52m by
2027**

The regional hydrogen plan, adopted in December 2020, is in line with the objectives of the "une COP d'avance" climate plan and is based on 4 pillars: the decarbonization of mobility, the decarbonization of industry, the production of renewable and low-carbon hydrogen, and the structuring of a sector that creates activity and industrial or operational jobs.



Occitanie

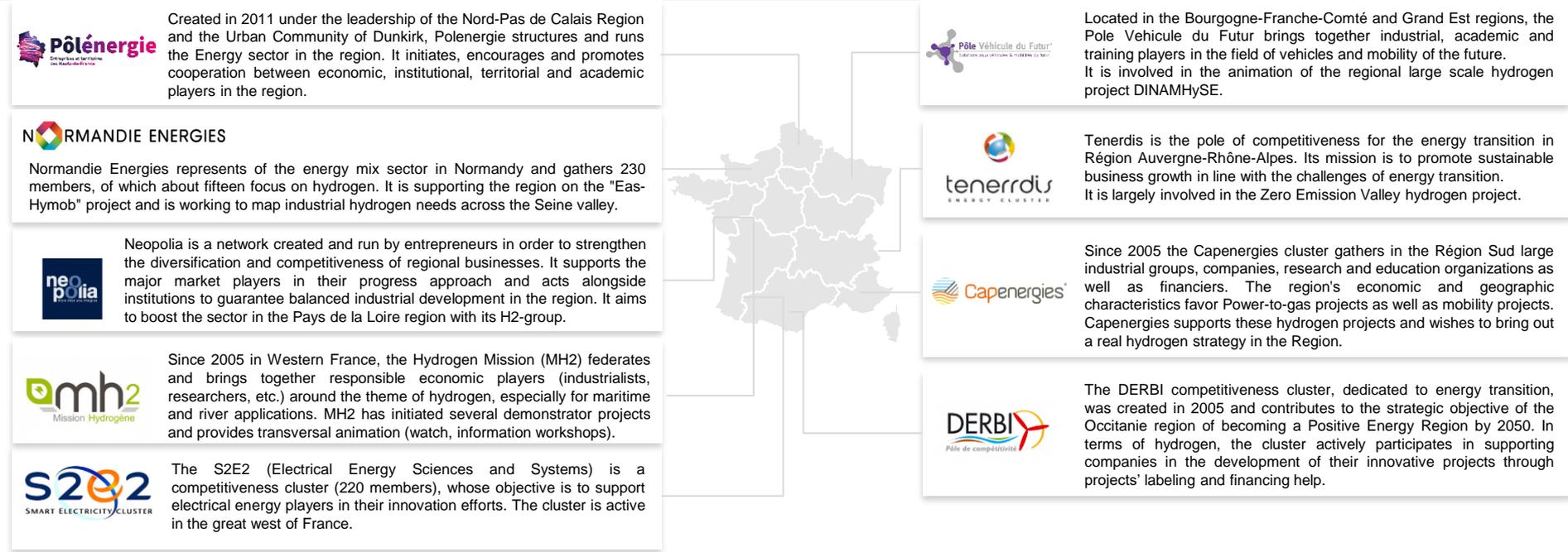
**€ 100m
by 2030**

In this region of high-tech industries, the presence of the hydrogen sector is historically linked to aerospace players. The Hydrogen Plan published in May 2019 aims to develop the sector through all the value chain. It is endowed with €100M of regional investments and €50M of European investments.



The leading role of the Regions and territories : the hydrogen hubs

- The Regions are also supporting the development of the hydrogen sector through 'Hydrogen Hubs' that emerged from already existing competitiveness clusters. These clusters gather, on the same territory, companies, high education establishments and public or private research organizations which aim to work in synergy to implement economic development projects for innovation in the hydrogen sector.
- They participate in the emergence of projects in the territories and label these projects to obtain funding and visibility. They organize workshops around H₂ technologies and projects and contribute to the development of the national research strategy. They offer networks for structuring the sector on a regional scale.



Context

- a. The national hydrogen strategy
- b. The role of the territories
- c. Key hydrogen actors**

Active research partnerships catalyze the development of the new hydrogen technologies

- Research clusters involving start-ups, SMEs, public laboratories, and large manufacturers actively participate in the development of technologies and the emergence of commercial outlets along the whole hydrogen value chain.

National agencies

- They define the national research strategy.
- They participate in the implementation of public policies, the funding of projects and research.
- They provide expertise and advice to project leaders.



- The National Research Agency (ANR) has supported hydrogen public research by mobilizing more than €110 million over the past 10 years.
- Additional € 65 million are dedicated to ANR in the Hydrogen Strategy Plan.

National research centers

- They define R&D priorities and participate in the filing of patents.
- They bring their technical and theoretical expertise on technologies and contribute to the emergence of start-ups based on technologies from their research laboratories.



Symbio is based on technologies developed with the CEA



McPhy has been a partner of CEA and CNRS since its creation



Sylfen is co-developing the SmartHyes demonstrator with the CEA



Hycco, specialized in fuel cell components is supported by the Ecole des Mines d'Albi incubator

University research centers

- They label projects to obtain funding and visibility.
- They conduct research programs aimed at preventing the risks associated with the development of new hydrogen applications.



Faurecia inaugurated in oct. 2020 its global center of expertise for hydrogen lightweight storage systems

Private research centers

- Big companies accelerate their R&D initiatives in order to bring innovations to market and offer competitive hydrogen solutions.
- They work closely with public research centers and smaller companies to develop economically efficient solutions.

Schlumberger, Vicat, Vinci and CEA created in 2020 the joint venture Genvia, specialized in high-temperature electrolysis (SOE)



The CANOE platform brings together automotive suppliers and energy companies to produce materials for hydrogen mobility.

A dense network of start-ups and SMEs is positioned on the new H₂ markets

- A rich and complete tissue of specialized SMEs and start-ups has been created for fifteen years in France. These specialized companies develop technical solutions and services associated with hydrogen energy.
- The dynamic is not weakening: the last few years, new companies specialized in carbon-free hydrogen and mobility emerged. In total, more than 50 specialized companies are present in the hydrogen value chain in France.

Electrolysis manufacturers



Green hydrogen producers



Production systems integrators



Service providers & others



Fuel cell manufacturers



Storage technology providers



Hydrogen mobility manufacturers



Operators & end users



Large French groups are positioning on the new hydrogen markets

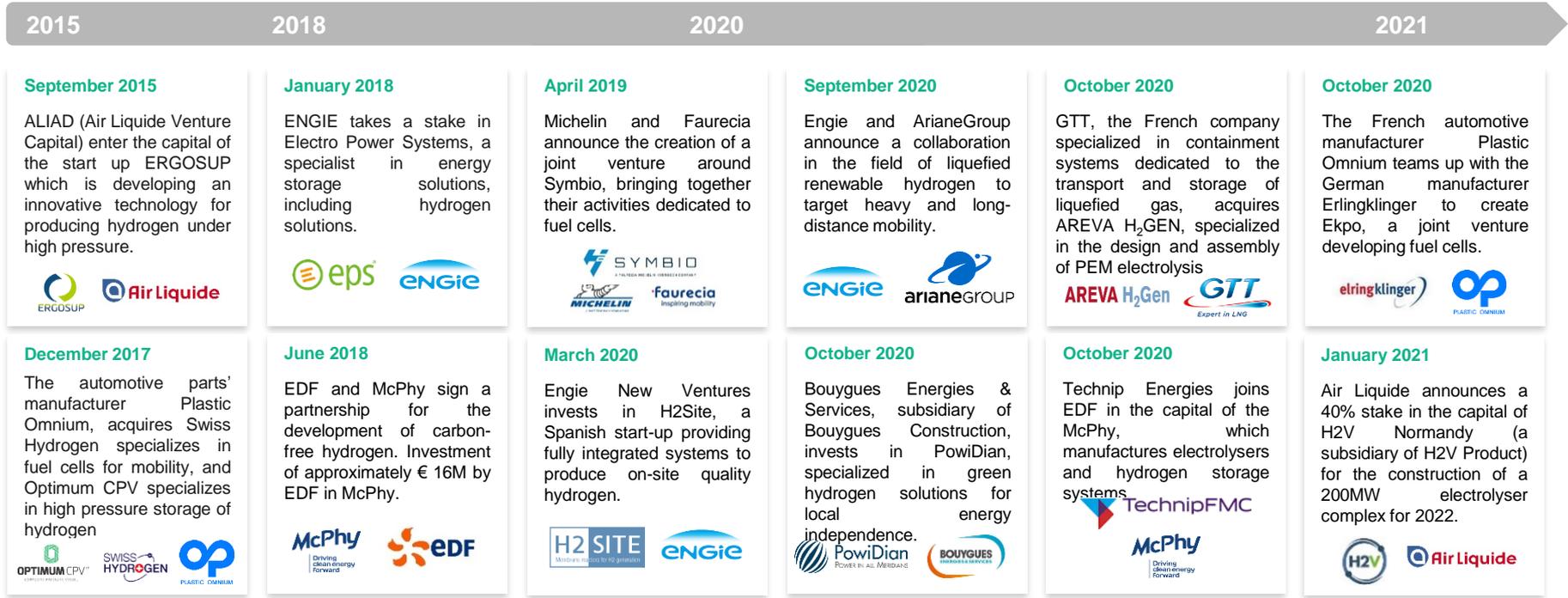
- The long-standing industrial and energy companies and transport manufacturers are multiplying development initiatives for the hydrogen market, by providing innovative solutions along the whole value chain of hydrogen : mobility, network services, storage, transport, distribution and carbon-free production.

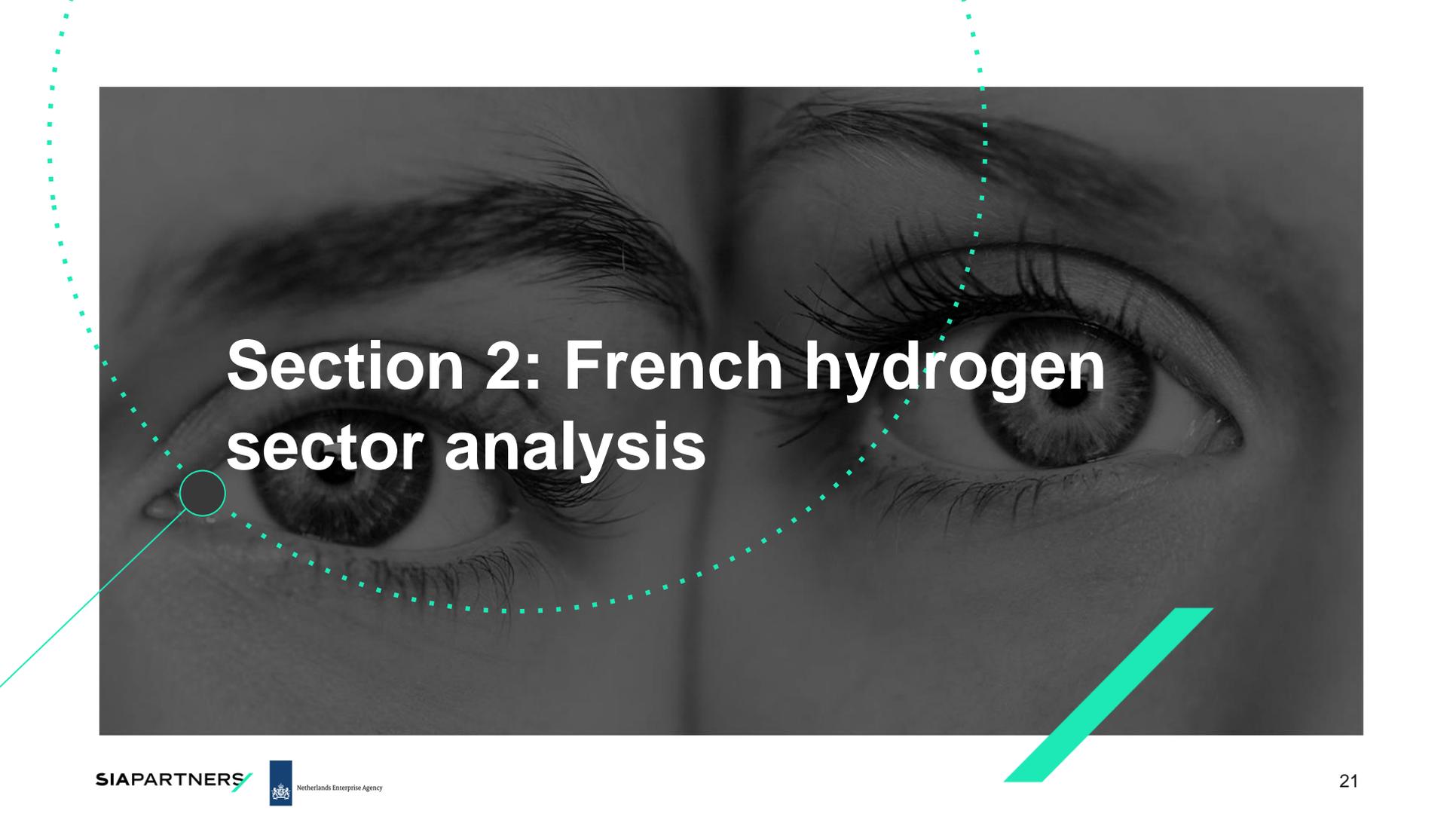
	Groups	Description	Markets
Industrials	Air Liquide	The world's second largest producer of hydrogen, Air Liquide is positioned on new uses of hydrogen: refueling stations (more than 100 stations delivered worldwide) and fuel cells. The company is also developing innovative production facilities for decarbonated hydrogen.	
	ALSTOM	Alstom is positioning itself on the hydrogen rail mobility market with the development of hydrogen trains.	
	Schneider Electric	Schneider Electric is present in hydrogen storage technologies, notably through a partnership with Areva and the development with ENGIE of the SPORE micro-network in Asia.	
Energy specialists	TOTAL	Total is involved in research on hydrogen as a fuel, has invested in the manufacturer of electrolyzers Sunfire to produce green hydrogen and set up hydrogen refueling stations all around the world.	
	EDF	EDF is positioning itself on the hydrogen markets, via a partnership and a stake in the manufacturer of electrolyzers McPhy, and through the creation in 2019 of «Hynamics», its subsidiary dedicated to hydrogen.	
	ENGIE	ENGIE launched a specific hydrogen subsidiary in 2018. Through its subsidiaries, the group has expertise across the entire value chain (green hydrogen production, mobility, refueling stations, distribution, energy storage, etc.).	
	GRTgaz TERÉGA	GRTgaz and Teréga are closely interested in Power-to-Gas and launched in 2015 Jupiter1000, a 1MW demonstration project. GRTgaz also partnered with the German TSO Creos to develop hydrogen transport networks.	
	storengy	The specialist of natural gas storage is involved in many projects of large scale hydrogen storage (Emil'Hy) and Power-to-gas (MetHyCentre).	
Auto and parts manufacturers	STELLANTIS RENAULT	The French auto manufacturers PSA and Renault both announced the development of hydrogen utility vehicles designed in partnership with the fuel cell specialist Symbio.	
	faurecia	Faurecia develops hydrogen tanks in collaboration with Stelia Aerospace and through its participation in ad-Venta. It is also involved in the fuel cell specialist Symbio, a joint-venture with Michelin.	
	MICHELIN	Michelin is investing in the hydrogen transport sector with the entry into the capital of Symbio in May 2015, French specialist in fuel cells for electric vehicles.	
	PLASTIC OMNIUM	World leader in body parts and modules and fuel systems, Plastic Omnium is positioned in hydrogen mobility technologies through its joint venture with the German manufacturer Erlingsklinger.	

Legend Production of H₂ by electrolysis H₂ Distribution (truck, pipeline) Storage of H₂ Power-to-Gas H₂ Refueling stations H₂ Mobility Stationary applications

A growing interest in hydrogen from the big industrial and energy groups

- For the last few years, big and historic industrial and energy companies have been increasing their involvement in hydrogen business through equity investments or partnerships with the hydrogen pure players.
- Several French industrial and energy groups have also set up a subsidiary dedicated to hydrogen.





Section 2: French hydrogen sector analysis

Hydrogen sector analysis

a. Overview of French key hydrogen subsectors

b. SWOT analysis of the French and Dutch hydrogen sector

Electrolysis

1. Key Objectives

- Today, French industry consumes 900,000 tons of grey hydrogen per year. Mainly produced from fossil fuels, this grey hydrogen emits 11.5 Mt of CO₂/year, or 3% of French emissions. Decarbonizing this industry sector with electrolysis is one of the main objectives of the National Hydrogen Strategy.
- The French government has set a low-carbon hydrogen production target of 0.4 Mt/year in 2028. In addition to this, the government wants to install 6.5 GW of green hydrogen electrolysis production capacity by 2030.
- The hydrogen industry and its major players believe they can reach a production target of 1.9 Mt/year by 2030.

2. Key Investments

- 3,8 Mds from the french hydrogen strategy are dedicated to the electrolysis development between 2023 and 2030.
- Between 2020 and 2023, € 650 m are dedicated to the support mechanism to produce carbon-free hydrogen, by additional remuneration, following the establishment of a mechanism of guarantees of origin for hydrogen.

3. Overview of recent and important projects

H2V59

GRHYD *

EFFI H2 Vannes

HYNOCA

Genvia

Jupiter 1000 *

HyGreen Provence



H2V59 – 2019

With 52 electrolyzers and representing a total capacity of 200 MW, the site should produce 28,000 t/year of green H₂. The hydrogen produced will be used for industries of injected into the gas network (under study).

Investment of € 251 m



EFFI H2 Vannes – 2020

Project to produce green H₂ by electrolysis to supply Michelin's industrial site, enabling this site to reduce its CO₂ emissions by 210 t/year

Project of 4.6 m €, including 780 K€ from ADEME



HyGreen Provence – 2018

As part of the territorial HyGreen project, installation of a 12MW electrolysis connected to 120 MW of PV. The objective for 2030 is to produce 10,000 t/year with 435 MW of electrolysis powered by 900 MW of PV.

Initial budget of €300 million (€1 billion required over 10 years)



Genvia – 2021

Genvia is a joint venture created to develop a new high-temperature solid oxide electrolysis technology to produce green hydrogen 3 to 4 times cheaper, thus meeting the industry's competitive expectations.

Investment of 500 M€, incl. 3.7 M€ from the region Occitania



MultiPLHY – 2020

Based in Rotterdam, it is the world's first high temperature electrolysis demonstrator. With a power of 2.6 MW, the electrolysis has a production capacity of 60 kg/h with an electrical efficiency of 85%.

Funding of €6.9 M by FCH-JU



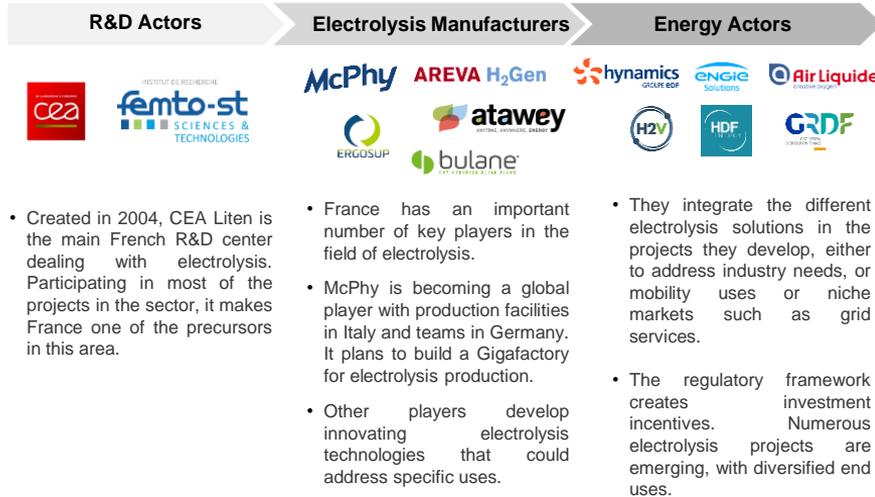
HYNOCA – 2021

HYNOCA produces green hydrogen by thermolysis and steam-cracking of various biomasses. HYNOCA stations are modular, almost plug and play, designed for an outdoor installation and mainly used in the Mobility and Industry sectors.



Electrolysis

4. Main players along the value chain



5. Swot analysis

<p>Strengths</p> <ul style="list-style-type: none"> Presence of innovative players of different sizes, with a positioning of large groups pulling the industry and investing in SMEs. France thus benefits from significant know-how. Very low-carbon energy mix at a competitive price due to the nuclear production capacities. 	<p>Weaknesses</p> <ul style="list-style-type: none"> Lack of competitiveness of H₂ produced, mainly due to low yields and high production costs.
<p>Opportunities</p> <ul style="list-style-type: none"> Regulations provided by the CRE to facilitate electrical connections. A compensation top-up mechanism should emerge quickly to support the sector. EPP* law dealing with the deployment of renewable energies, thus reducing the carbon footprint of the French energy mix. 	<p>Threats</p> <ul style="list-style-type: none"> External threats: dependence on rare metals supplied from abroad. Technologies in strong development in Asian countries Uses :Industrial consumption of H₂ remains very dependent on Air Liquide.

6. Key takeaways

*Energy Pluriannual Program

- France's energy mix, combined with the deployment of renewable energy offers low-carbon electricity for electrolysis in France. With a lot of specialized players, the French value chain is well-structured and should enable the country to place itself among the leaders in the sector, but only if it faces up to the problems of competitiveness and competition from Asia.

Opportunities between the Netherlands and France:

- Dutch actors could benefit from large scale electrolysis expertise to integrate these technological bricks to large scale projects (industry, offshore wind, power-to-gas). McPhy is here the leading example, which already work with Dutch actors via the DJEWELS project.
- Many other French electrolysis players don't have the critical size as McPhy and could develop technologies through partnerships in a logic of import/export of knowledge that could allow them to address foreign markets.
- On the R&D side, France also has a major R&D center, CEA Liten. Research partnerships on new technologies combining Dutch and French expertise seem to be promising.

Injection in gas networks

1. Key Objectives

- The National Hydrogen Strategy does not address specifically the issue of Power-to-Gas.
- Indeed, the transport of hydrogen, and therefore power-to-gas, is not considered by the government as a priority subject before 2050.
- However, some players are convinced of the potential of power-to-gas and are investing heavily in the sector. A study conducted by GRDF, GRTgaz and ADEME, estimates that the PtG will allow to produce between 20 and 30 TWh/year of decarbonated gas in 2050.

2. Key Investments

Despite the absence of government funds dedicated to Power-to-gas, the various project leaders have a few sources of funding:

- Part of the € 625 M AAP envelope will be dedicated to the support of PtG projects.
- French companies can also benefit from the EU's €65 billion investment program to support the hydrogen transportation sector.

3. Overview of recent and important projects

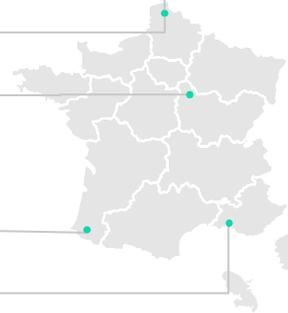
GRHYD

H2V59

Hyaunais

Methamag

Jupiter 1 000



Prenzlau – 2019

Demonstrator, located in Germany, studying different technologies for the separation of H₂ and gas injected into the transportation network. This technology would allow the gas network to be used to supply sites with pure H₂.



Methamag – 2020

Development of a new methanation process based on magnetic induction using ferromagnetic nanoparticles.



Hyaunais – 2019

Objective of recovering fatal CO₂ from a waste landfill site (producing biogas) using green H₂, thus obtaining synthetic methane that can be injected into the transport and distribution network.

Project of € 10,88 m, € 3,43 m funded by PIA



Jupiter 1 000 – 2018

First French industrial PtG demonstrator injecting H₂ and synthetic methane into the transport network while recovering industrial CO₂. Sia Partners participates in supporting the project with GRTgaz.

Project of €31,3 M incl. €6,8 M from Ademe and €2 M from EU



GRHYD

As the first PtG demonstrator in France, this project studies and validates the technical and economic interest of injecting up to 20% hydrogen by volume into the gas distribution network.

Project of € 15 m



H2V59 – 2019

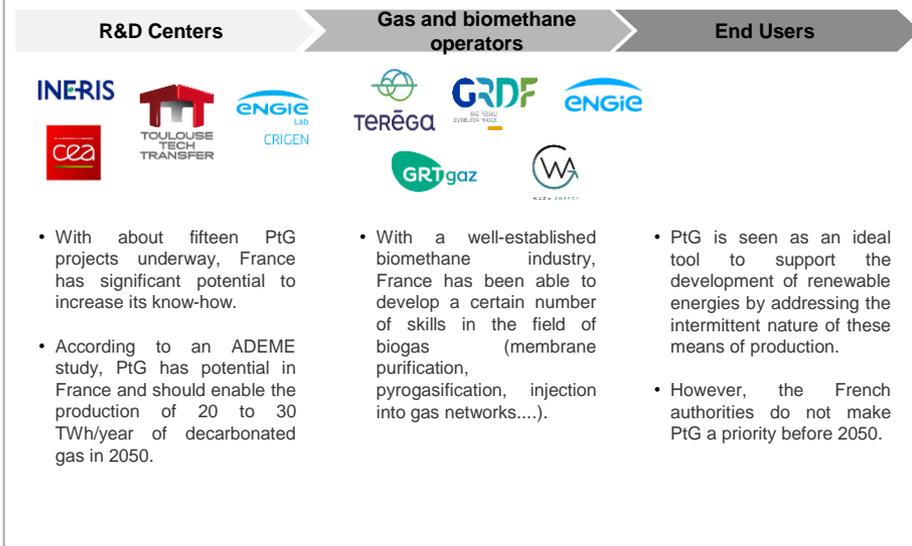
A large-scale H₂ production project, this project, which will start in 2022-2023, will study the feasibility of power-to-gas to deliver its production via the gas network.

Investment of € 251 m



Injection in gas networks

4. Main players along the value chain



- With about fifteen PtG projects underway, France has significant potential to increase its know-how.
- According to an ADEME study, PtG has potential in France and should enable the production of 20 to 30 TWh/year of decarbonated gas in 2050.

- With a well-established biomethane industry, France has been able to develop a certain number of skills in the field of biogas (membrane purification, pyrogasification, injection into gas networks....).

- PtG is seen as an ideal tool to support the development of renewable energies by addressing the intermittent nature of these means of production.
- However, the French authorities do not make PtG a priority before 2050.

5. Swot analysis

Strengths	Weaknesses
<ul style="list-style-type: none"> • France has extensive gas know-how and expert players in gas injection, withdrawal and logistics. • The RE development policy put in place by the EPP and the SNBC makes the PtG a tool of prime importance up to 2050. 	<ul style="list-style-type: none"> • Lack of competitiveness of the synthetic methane produced and injected into the networks • Need for technological development and an increase in the sector in order for it to benefit from the effects of scale.
Opportunities	Threats
<ul style="list-style-type: none"> • Large number of demonstrators currently in progress having tested 20% hydrogen injection. • Development of regional eco-systems based on renewable means of production, thus requiring PtG solutions. 	<ul style="list-style-type: none"> • The deployment of electrolysis to meet French low carbon H₂ production targets will lead to an increase in electricity consumption of 30 TWh/year. However, following the deployment of renewable production capacity supported by the EPP, this excess consumption does not worry RTE, which sees no interest in developing PtoX by 2030.

6. Key takeaways

Despite the lack of a government strategy, Power to Gas is developing through several pilot projects led by several players, mostly gas TSO and DSO, thus positioning France among the leading European countries in Power-to-Gas.

Opportunities between the Netherlands and France:

- France has succeeded in injecting up to 20% hydrogen into gas networks. With 0,5% of H₂ currently mixed in the Dutch network, a partnership around this French know-how seems interesting.
- Both countries have a well-developed pipeline engineering and manufacturing industry, which could connect and share knowledge on infrastructural development projects in the countries.
- Air Liquide operates a private H₂ pipeline from North of France to Rotterdam via Antwerp. At the end of this network, collaborations could be sought between FR / NL actors and lessons can be learned from Air Liquide on operating a H₂ pipeline.

Large Scale Storage

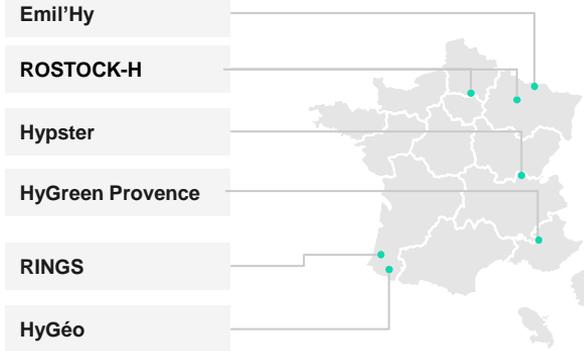
1. Key Objectives

- The French strategy does not provide any plan addressing the issue of large-scale storage, thus threatening the long-term development of the hydrogen infrastructure sector.
- As an example, the French TSO RTE published a study stating that large storage was not needed before 2050.
- However, the question of large-scale storage is tackled by many players: pilot projects, project leaders, private and public funding (region/Ademe)

2. Key Investments

- Consequently, the French strategy has not provided any financing plan dedicated to the sector.
- In contrast, the players involved in the large-scale issues bring their know-how and their capacity in terms of R&D to support the development of the sector.
- The large-scale storage projects are financed by the private players and also benefit from the support of some PIA funds, ADEME's AAP funds and European subsidies.

3. Overview of recent and important projects



Hypster – 2021 – 2023

After a first phase called Stopil-H2, the project enters into a new area. This pilot project is actually studying the storage feasibility condition with injection and withdrawal test into a salt cavern.

Budget of € 13 M, including € 5 M from the EU



RINGS – 2018 – 2021

Research partnership on the behavior of hydrogen mixed with natural gas in order to analyze the different interactions. The objective is to develop new storage solutions



HyGéo – 2020 – Ongoing

Feasibility study for the storage of hydrogen in a salt cavity. Start of the engineering and construction phase in 2022. The operation operation will start in 2024 with a storage capacity of 1,5 GWh.

Budget of € 13,5 M, including € 0,5 from Aquitaine region



ROSTOCK-H – 2016 – 2020

Study of technical and economic risks of storage in a salt caverns and its opportunities. Also aims to study the reactions of hydrogen in a saline environment and the consequences of a hydrogen leak.

Budget of € 3,3 M, 50% funded by the PIA



HyGreen Provence – 2019 – Ongoing

Green hydrogen production system accompanied by a study on storage in a salt cavity in order to create a hydrogen territory;

Estimated budget of € 1 billion over 10 years



Emil'Hy

Starting in 2023 with a production capacity of 5 MW, this project will create a new salt cavity in 2025 to support the increase of the production capacity, wich should be between 50 and 100 MW in 2025

Estimated budget of € 30 M



Large Scale Storage

4. Main players along the value chain

Natural Gas TSO & DSO



Specialized players



R&D centers



- Historically, France has a real experience in gas storage with the presence of specialized historical players.
- It also has a well-developed infrastructure network: 32,500 km of gas pipelines and 16 storage sites, including 4 salt caverns.

- Despite the absence of defined objectives within the French strategy, various players, from SMEs to historical players, are studying the issue of hydrogen storage.
- Study of the storage potential in a salt cavity: 100,000 tons of storage capacity but low potential for the creation of new sites.

Implementation of numerous R&D projects:

- Study of the behavior of H₂ within different storage environments (saline, aquifer mixture)
- Pilot projects for storage and injection into gas networks

5. Swot analysis

Strengths

- Historical know-how in gas storage.
- Particularly developed infrastructure networks.
- R&D centers expert in storage issues and analysis of the behavior of the H₂ molecule in different environments.

Weaknesses

- Only 4 important salt caverns in France, with a low potential for creating huge salt cavities due to the geological nature of the soils.
- Lack of a well-established regulatory framework, setting precise objectives, thus allowing the development of this sector and the development of new projects.

Opportunities

- Even if, the geological nature of the soils does not allow the creation of large cavities, it is still possible to create smaller cavities in France.

Threats

- Storage seems forsaken by the French H₂ policy. It is important not to forget this component of the sector at the risk of getting an incomplete market, not being able to achieve its objectives due to the lack of storage capabilities.

6. Key takeaways

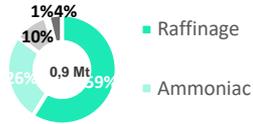
Although the large-scale storage issues are not yet addressed in the Hydrogen National Strategy, the French historical players (mainly gas TSO and DSO) are launching many projects of different scales. These players benefit from strong research capabilities in these areas.

Opportunities between the Netherlands and France:

- Both countries have an important knowledge about the gas storage and its issues. In addition to this, both of them have salt cavities. Consequently, it could be interesting to develop some R&D partnerships. The most relevant parties involved here are Hystock from the Netherlands and Hypster from France, who could explore collaborations on further demonstration of hydrogen storage.

Industry

1. Key Objectives



■ Raffinage

■ Ammoniac

Around 0.9 Mt of hydrogen is consumed in France, mainly for industrial uses. This hydrogen is today produced from fossil sources and need to be decarbonated.

In the National Hydrogen Strategy, industry is identified as a key target to deploy green hydrogen. The government fixed the ambitious objective of

20 to 40% low-carbon and renewable hydrogen in total hydrogen consumption by 2030

This could lead to a production of 0.18 to 0.36 Mt of green hydrogen within 10 years, which is 4 to 8 times the current green hydrogen production (estimated to 0,04 Mt / year).

2. Key Investments

- In 2019, **€ 11.5M have been allocated to 5 demonstration projects for decarbonated hydrogen production in industry**, through a call for tenders.
- Industry uses have been identified as one of the targets for the recently announced call for tenders **“Technological bricks and hydrogen demonstrators”**, granted with **€ 350M between 2020 and 2023**. Many projects related to industrial use should benefit from these investments.
- In parallel, industrials could be incented to deploy green hydrogen production capacities on site through the **support mechanism for carbon-free hydrogen production, announced end of 2020 and granted with € 650M for 2020-2023**. Details of the support mechanism still need to be announced by the government.

3. Overview of recent and important projects

ArcelorMittal

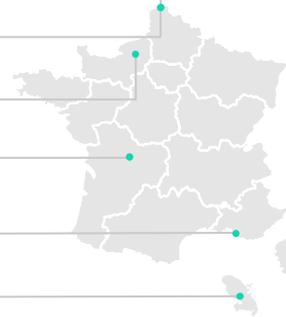
C2Fuel

CryocapH2

Hyflexpower

Kem One

ClearGen



Kem One – 2020



Project of valorization of fatal hydrogen co-produced in chlore electrolysis. This hydrogen will serve a customer in the petrochemical sector near the Kem One site.

Project labeled in the AAP Decarbonated H₂ production for industry

ArcelorMittal – 2020

Launch of a study for the construction of a large-scale DRI (direct reduced iron) plant, combined with an electric steel plant. Based on ArcelorMittal's experience from the DRI-Hydrogen project in Hamburg, this facility could be used with green hydrogen.

Project's costs undisclosed



C2Fuel – 2019

Production of formic acid and dimethylether with renewable hydrogen and CO₂ from blast furnace gas in Dunkrik.

€ 4.1m project incl. € 4m from EU Horizon 2020



CryocapH2 – 2017

Pre-industrial demonstrator of low-carbon hydrogen production on a natural gas steam reforming unit based in Port-Jérôme

€ 30m project incl. € 2.6m from ADEME



Hyflexpower – 2020

Industrial-scale power-to-X-to-power demonstrator : installation of an integrated hydrogen gas turbine to replace the natural gas currently used by combined heat and power plants used to produce paper.

€ 15.2m project incl. € 10.5m from EU Horizon 2020



ClearGen – 2019

Installation of a high-power fuel cell (1 MW) to produce electricity on the Martinican power grid from hydrogen co-produced in a refinery operated by SARA (Société Anonyme de Raffinerie des Antilles).

€ 10m project financed partially by FCH-JU



Industry

4. Main players along the value chain

Green hydrogen Production



- Historic and well established hydrogen producer Air Liquide is experimenting green hydrogen production processes for industry.
- In parallel, electrolysis specialists develop their solutions on industrial locations to replace the grey hydrogen used in facilities.

Providers of green hydrogen



- Historic energy providers (EDF, ENGIE) have set up dedicated subsidies for green hydrogen marketing : Engie Solutions and Hynamics.
- The last two years, they have multiplied the projects with industrials in association with electrolysis manufacturers.

End users



- Cement makers (Vicat), steel producers (Arcelor Mittal), refiners (Sara) and chemistry specialists initiated green hydrogen projects.
- They are experimenting with new ways of integrating carbon-free hydrogen into existing or new production chains.

5. Swot analysis

Strengths

- High objectives set by the government for green hydrogen consumption in industry.
- Strong network of French companies all along the industrial hydrogen value chain: historical hydrogen producers and providers (Air Liquide), as well as electrolysis manufacturers (McPhy, Ergosup).
- Big energy companies (ENGIE, EDF Hynamics) getting involved in the H₂-market for industry.
- High diversity of industrials addressable by the market of green hydrogen

Opportunities

- The financial supporting mechanism for green hydrogen production (€650M for 2020-2023) should help increase cost competitiveness of green hydrogen production.
- Air Liquide's leading position in the production and commercialization of hydrogen for the industry could drive the green hydrogen market

Weaknesses

- Small number of industrial green hydrogen projects compared to the number of mobility projects launched in France the last few years.
- Less involvement and incentives from the territorial authorities, compared to other hydrogen uses, especially mobility.

Threats

- Public players are not very favorable for blue hydrogen (produced with SMR+CCUS), which is more competitive than renewable hydrogen produced by electrolysis.

6. Key takeaways

Hydrogen produced in France is mainly dedicated to industry purposes and is still overwhelmingly produced from fossil fuels. The potential for green hydrogen development in industry is huge and has been set as one of the priorities of the National Hydrogen Strategy, which target 20% to 40% of green hydrogen in the total consumption by 2030. French players are already well positioned on this market, especially electrolysis manufacturers who hope to benefit from a part of the €350m of public investments announced by 2023 to scale their technological solutions and make them competitive.

Opportunities between the Netherlands and France:

- Industrial companies that wish to decarbonate their processes could benefit from the expertise that is setting up in the Netherlands through the multiple projects.
- The Netherlands could learn from the French approach in creating a hydrogen program and related incentives/subsidies to stimulate green hydrogen production.

Road mobility – Light vehicles

1. Key Objectives

The deployment of hydrogen light mobility was identified as one of the main objectives in the first national hydrogen strategy from 2028 (Plan Hulot). The Pluriannual Energy Program (PPE), which defines the energy roadmap for 2019 – 2023, targets :

- 5,000 light H₂ vehicles in operation by 2023,
- 20,000 to 50,000 light H₂ vehicles by 2028,
- 100 new HRS using hydrogen produced locally by 2023, increasing to 400 – 1,000 HRS by 2028.

The government targets one million clean vehicles by 2025 (not specifically H₂ vehicles).

2. Key Investments

Economic recovery plan (May 2020) :

- € 2,000 to € 6,000 bonus for individuals when purchasing an electric vehicle

Hydrogen National Strategy :

- Road mobility projects should benefit from the new ADEME calls for tenders :
 - “Technological bricks and hydrogen demonstrators”, granted with € 350M between 2020 and 2023,
 - “Territorial hydrogen ecosystems”, granted with €275M between 2020 and 2023.

Zero-emission vehicle Strategy :

- The “production, design and use of hydrogen equipment and systems for mobility” will also benefit from the automotive investment fund (150 million euros from 2020 to support research and innovation in the automotive sector).

3. Overview of recent and important projects

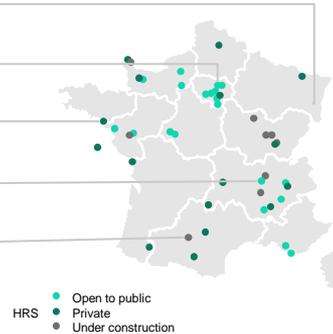
ISTHY

Last Mile

EffiH2

Zero Emission Valley

HyPORT



HRS infrastructure

- Beginning of 2021, there are 30 Hydrogen Refueling Stations (HRS) in operation in France, and 11 HRS are under construction.
- The deployment strategy is based on captive fleet applications with HRS deployed at the same time as the vehicle fleet, thereby securing demand and de-risking early HRS investments. A large number of these HRS are part of regional hydrogen ecosystem projects gathering capacities for production of renewable hydrogen and mobility usages : Zero Emission Valley, Hynovar, HyPort.

ISTHY – National Storage Hydrogen Platform

This project brings together manufacturers, agencies and organizations working in the field of hydrogen. Its objective is to become the French center of expertise for the approval and requalification of storage systems and to be the training and R&D center to anticipate technological developments.

HyPORT – 2016 – 2020

Installation at Toulouse Blagnac airport of a green hydrogen production and distribution station for commercial vehicles, public transport and private vehicles.

€ 15M project incl. € 5M from ADEME funds

HY PORT



Zero Emission Valley – 2018 – 2028

Deployment of 1,200 fuel cell cars, 20 hydrogen refueling stations including 14 electrolyzers to produce hydrogen without CO₂ emissions in the metropolitan areas of Auvergne-Rhône-Alpes

€ 70M project incl. € 10M from UE



Last Mile IDF – 2018 – 2023

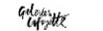
Deployment project for 16 hydrogen refueling stations and 280 hydrogen vehicles (200 utility vehicles, 80 transport vans) in Paris and Région Ile de France.

€ 36M project incl. € 7M from UE

ataway



JCDecaux



EffiH2 – 2017

EffiH2 offers a green hydrogen supply service produced locally as close as possible to uses, within the same sustainable mobility area, in a structuring approach to the circular economy.

€ 36M project incl. € 7M from UE



Road mobility – Light vehicles

4. Main players along the value chain

Hydrogen producers / providers



- The national electrolysis manufacturers develop integrated systems to equip HRS, along with gas compression and storage specialists.

HRS specialists



- French historical oil or VNG refueling stations are getting involved in HRS projects worldwide (Total) or in France (Proviriadis).
- Big energy players such as Air Liquid and Engie Solutions also multiply the HRS projects

HRS Operators

Solution integrators & parts manufacturers



- They develop fuel cell and energy management system solutions for heavy road mobility

Vehicles' manufacturers



- Renault announced the launch of Kangoo Z.E Hydrogen, which will precede that of the Master Z.E Hydrogen. PSA Group will launch a fleet of hydrogen utility vehicles at the end of 2021.

Operators



- Hype operates a fleet of more than 100 hydrogen taxis in Paris (Toyota Mirai) and has signed a partnership with Toyota to increase it to 600 vehicles by the end of 2021.

5. Swot analysis

Strengths

- Near-term and mid-term objectives set by the government and large amounts of public investment announced to support hydrogen mobility growth as part of local ecosystem gathering green production and uses.
- French car manufacturers that announced commercialization of hydrogen vehicles.
- French parts manufacturers that provide H₂ solutions and technologies (tanks, fuel cells) for the car manufacturers worldwide.

Weaknesses

- French car manufacturers tend to be more focused on battery electric vehicles development and are a bit late in hydrogen technology developments within their portfolios, especially compared to Japanese manufacturers.
- Public policies related to zero-emission light vehicles are more oriented toward the development of battery electric vehicles.

Opportunities

- Political will to develop urban zero-emission zones, which could accelerate the development of hydrogen vehicles.

Threats

- Uncertainties about the perennity of the subsidies for buying the hydrogen vehicles, whose costs still largely exceed those of thermal engine vehicles and electric battery vehicles.
- Social acceptance of hydrogen use in mobility is subject to a strict control of safety issues.

6. Key takeaways

The deployment of hydrogen light vehicle mobility in France is based on captive fleet applications with HRS deployed at the same time, as part of regional hydrogen ecosystem projects gathering capacities for production of renewable hydrogen and mobility usages. French companies are involved all along the value chains : from electrolysis production for HRS to car manufacturers. National policies and car manufacturers historically focused on battery electric vehicles, but the French OEMs are innovating in tanks, fuel cell and energy management solutions for road mobility.

Opportunities between the Netherlands and France:

- With its expertise in developing refueling infrastructure and having multiple dedicated players to this, France could help the further rollout of hydrogen refueling stations in the Netherlands.

Road mobility – Heavy vehicles

1. Key Objectives

In the National Hydrogen Strategy, heavy road mobility is identified as one of the main development objectives. The Pluriannual Energy Program (PPE), which defines the French energy roadmap for 2019 – 2023, targets :

- **200** heavy H₂ vehicles in operation by **2023**,
- **800 to 2,000** heavy H₂ vehicles by **2028**.

At a regional scale, the municipalities are very interested in hydrogen for public transport and are launching hydrogen bus fleets. The Energy Transition Law from 2015 imposes them to buy at least 50% of low-carbon emission vehicles when they renew their fleet.

The European Green Deal plans to reduce GHG emissions in transport by 90% by 2050. It imposes truck manufacturers to produce 8 to 10% of zero-emission vehicles in 2025 and 20% in 2030. To achieve these goals, manufacturers will have to offer hydrogen heavy vehicles in their portfolio. Which opens the door to a massive growth for hydrogen heavy vehicles.

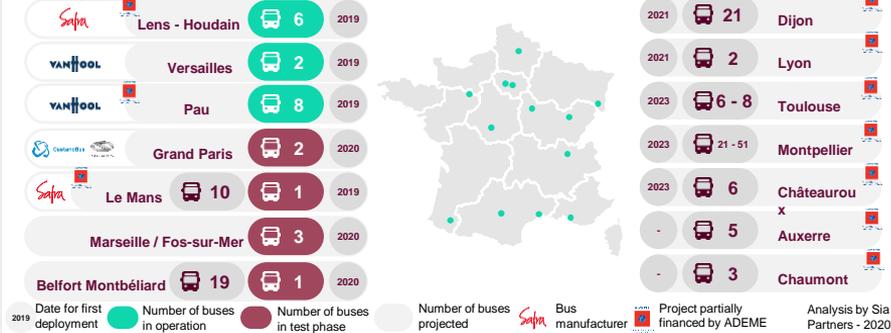
2. Key Investments

Hydrogen National Strategy :

- Road mobility projects will benefit from the new ADEME calls for tenders :
 - “Technological bricks and hydrogen demonstrators”, granted with € 350M between 2020 and 2023,
 - “Territorial hydrogen ecosystems”, granted with €275M between 2020 and 2023.

3. Overview of recent and important projects

Deployment of hydrogen buses for metropolitan public transport



- The year 2019 was marked by the operation of the first hydrogen buses in France. Many local authorities and transport unions have announced projects for experimentation, or even commissioning by 2023.
- Many of these initiatives are supported by public funding within the framework of the “Hydrogen mobility” calls for tenders launched by ADEME in 2018 and 2019.
- Mobilité Hydrogen France, a consortium specializing in H₂ mobility within France Hydrogène, plans to deploy 1,000 buses by 2024.

Businova H2 - 2019

Development by Safra of an electric bus equipped with a hydrogen 30kW fuel cell range extender manufactured by Symbio.



€ XM project incl. € 0.2M from ADEME

HyAMMED – 2020 – ongoing

Part of the HyAMMED project (H2Haul FCH-JU program), Air Liquide will install the first high pressure hydrogen station dedicated to heavy mobility in Europe. In service in 2022 and with a capacity of 1t/day, the station will be used for refueling eight 44T trucks as well as buses and utilities.



CATHYOPE – 2017 - 2021

Development of a hybrid hydrogen-electric propulsion group dedicated to heavy vehicles that require large autonomy. Field operation and testing started for supply of shopping centers.



€ 9.7M project incl. € 4.2M from PIA funds

Faurecia – Hyundai – 2021

Faurecia, a French automotive supplier, will supply the Korean Hyundai with more than 10,000 hydrogen tanks from 2021, which will equip 1,600 heavy goods vehicles with regional deliveries.



Road mobility – Heavy vehicles

4. Main players along the value chain

Solution integrators & parts manufacturers



- They develop or certify fuel cell, hydrogen tanks and energy management system solutions for heavy road mobility.

- Many French players are already involved in the deployment of hydrogen heavy vehicles. If there is a lack of a major industrial player in the truck segment, the ecosystem is quite large and already exports its technological solutions abroad.

Vehicles' manufacturers



- There is no national truck manufacturer in France, but several players involved in specialize heavy vehicles refrigerated trailers (Chéreau), buses (Safra) and handling equipment for ports or warehouses (Gaussin).

Operators



- Municipalities for passengers' transport
- Materials transport
- Industries for manutention vehicles

5. Swot analysis

Strengths

- Already a strong interest from municipalities for hydrogen buses – many projects launched in 2019.
- French companies specialized in niche market for heavy vehicles : Safra specialized in manufacturing H₂ buses, and Gaussin specialized in manutention vehicles.
- French parts manufacturers that provide H₂ solutions and technologies (tanks, fuel cells) for the heavy vehicle manufacturers.

Opportunities

- Involvement of public authorities to decarbonate the public service fleets they operate (buses, garbage truck).
- Political will to develop urban zero-emission zones, which could accelerate the development of hydrogen heavy vehicles.
- Interreg project in Occitanie to develop heavy mobility corridors with Spain.

Weaknesses

- Few French manufacturers in the truck segment.
- Lack of refueling infrastructure to expect a near-term deployment of hydrogen trucks for goods transportation along the French highway corridors.

Threats

- Uncertainties about the sustainability of the public subsidies dedicated to purchasing the hydrogen heavy vehicles, whose costs still largely exceed those of thermal engine vehicles and electric battery vehicles.
- Social acceptance of hydrogen use in mobility is subject to a strict control of safety issues.

6. Key takeaways

Heavy road mobility is responsible for a lot of CO₂ emissions and is one of the key targets for hydrogen development in France. Many French OEM are already investing this sector and exporting their solutions (tanks, fuel cells). The French industry lacks a global truck OEM, but benefits from many specialized companies (buses, handling vehicles) and a strong political and financial support from the Regions and municipalities.

Opportunities between the Netherlands and France:

- France has no national truck OEMs, meaning it has to import hydrogen trucks from international companies. Leading heavy vehicle OEMs in the Netherlands (e.g. DAF, VDL, Hyzon Holthousen) could benefit from this and look at partnerships with for example Symbio, Faurecia, Plastic Omnium
- As France has a lot of agricultural landscape, agriculture vehicle OEMs in the Netherlands (e.g. H₂Trac) could explore their market opportunities further in France.

Rail mobility

1. Key Objectives

- In France, about 14,000 km of the 30,000 km national railway lines are not electrified - the electrification of a line costs roughly €1M per km - and 20% of the railway traffic is solely relying on regional diesel trains. Dual-mode electricity-H₂ trains are part of the SNCF's decarbonization plan (full renewal of the diesel fleet by 2035) by at first building new prototypes before extending that to the retrofiting of existing diesel trainsets.
- To date, despite the national willingness to develop the hydrogen sector, there are no quantified, clear and precise objectives for the hydrogen rail sector. However, 14 trains will serve as demonstrators on the territory to validate the performance of the French hydrogen train to pave the way for a more massive nationwide deployment by 2030-2035.
- On an economic and strategic level, French expertise in the hydrogen train can be leveraged internationally.

2. Key Investments

- In 2020, €4M have been granted for each 4 participating regions from the call for expression of interest "Emergence of hydrogen mobility in the rail sector" by the ADEME.
- For the years to come, rail mobility can be one of the eligible uses for one of the new ADEME call for tenders :
 - "Technological bricks and hydrogen demonstrators", granted with €350M between 2020 and 2023.

3. Overview of recent and important projects

Grand Est

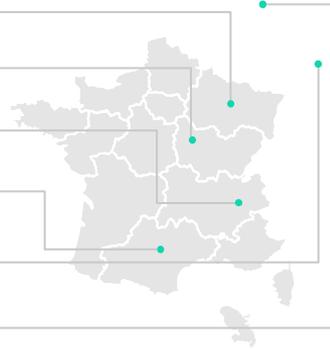
Bourgogne Franche-Comté

Auvergne Rhône-Alpes

Occitanie

Coradia iLint first prototype

Coradia iLint in Netherlands



Auvergne-Rhône-Alpes

Three hybrid TER (electric/hydrogen) trainsets were purchased from Alstom. This could benefit from the H₂ production units from "Zero Emission Valley" project in Chambéry.



Netherlands – H₂ passenger train

Demonstrator project of a hydrogen passenger train in 2020 after the successful trial of the Coradia iLint in Germany.



Bourgogne Franche-Comté

Three hybrid TER (electric/hydrogen) trainsets were purchased from Alstom. An H₂ production unit under construction in Auxerre to refuel both buses and trains. Tests in 2023.

€51.9 million for the trains



Occitanie

Three hybrid trainsets purchased. Creation of an H₂ hub in Toulouse airport to mutualize H₂ production and use.

A part of the €150M regional investments in H₂ are dedicated to the purchase of the trains



Grand Est

Five hybrid TER (electric/hydrogen) trainsets were purchased from Alstom. Part of the 2020-2030 hydrogen strategy of the Grand Est region.



Project / Collaboration

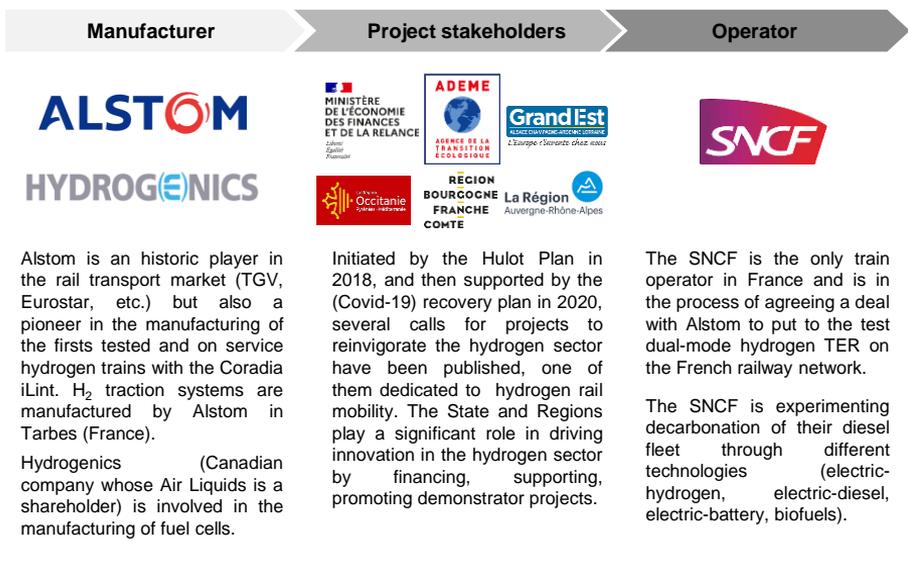
Successful completion of a 1.5 years trial for two Coradia iLint, manufactured by Alstom, on the Weser-Elbe network. An order of 27 trains for fahma and 14 for LNVG by 2022.

€81M for 14 Coradia iLint order by LNVG



Rail mobility

4. Main players along the value chain



5. Swot analysis

<p>Strengths</p> <ul style="list-style-type: none"> Alstom is at the cutting edge of the technology Cheaper at longer distance than electrifying all the network, dual mode (elec-H₂) can take advantage of the already electrified portion of the railway network Alstom's manufacturing plant located in France Experimentation in progress in 4 regions 	<p>Weaknesses</p> <ul style="list-style-type: none"> 80% of the traffic occurs on electrified rail lines Lack of proper hydrogen production, distribution infrastructures and hydrogen refueling stations High CAPEX and high OPEX (hydrogen fuel, O&M) resulting in a 10-40% additional cost of ownership depending on the fleet size No experience feedback
<p>Opportunities</p> <ul style="list-style-type: none"> Capitalizing infrastructures in hydrogen mobility (car, buses, trucks, trains, ...) which is in line with the territorial deployment strategies Retrofitting existing diesel regional trains (TER) to hydrogen Achieving economies of scale, opening to the competition Experimentation with port railway operators nearby industrial sites, valorizing residual H₂ 	<p>Threats</p> <ul style="list-style-type: none"> Safety measures in handling hydrogen (explosive nature of the gas, vibration and shock resistance) Maturity and economic feasibility of other dual-modes trains (electric-diesel, electric-battery), biofuels and biogas Governance issues on the hydrogen distribution network

6. Key takeaways

Alstom is a French multinational company at the forefront of the hydrogen train with the world's first hydrogen powered train Coradia iLint. The SCNF, the French railway operator placed an order for 14 dual-mode hydrogen trains with the participation of 4 regions to replace diesel trains on unelectrified train lines (20% of the traffic). However, the uncertainties related to the safety and the O&M costs, the lack of hydrogen infrastructures and high capital costs are obstacles to the development of the hydrogen rail mobility.

Opportunities between the Netherlands and France:

- A share of experience between train operators in France and Netherland could accelerate the development hydrogen within rail mobility. For example: ProRail has the ambition of implementing a Hydrogen train before 2025, this can be done in collaboration with Alstom/Linde. However, rail transport is mainly electric-powered in the Netherlands, so expectations should be limited.

Marine mobility

1. Key Objectives

In the National Hydrogen Strategy, maritime transport is identified as one of the mid term development objectives, even if there is no specific number of hydrogen boats targeted in the roadmap.

However, some of the French maritime Regions have set objectives to renew their vessel fleets with hydrogen technologies :

- Pays de la Loire
- Bretagne
- Normandie

2. Key Investments

- Maritime and fluvial mobility can be one of the eligible uses for the two new ADEME call for tenders :
 - "Technological bricks and hydrogen demonstrators", granted with € 350M between 2020 and 2023,
 - "Territorial hydrogen ecosystems", granted with €275M between 2020 and 2023.
- This should increase the number of new projects in the field of maritime and fluvial mobility.

3. Overview of recent and important projects

H2SHIPS PM-13

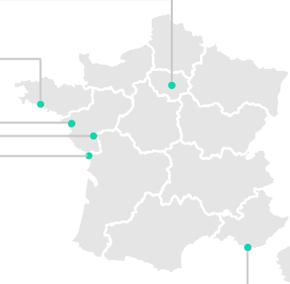
Piriou CTV

Pacboat

NavhibusH2

Yélo H2

Hynovar



Hynovar – 2019

Part of the creation of a hydrogen ecosystem, the project aims at developing a 2x300-kW fuel cell powered vessel for carrying passengers near Toulon. Project labeled in the AAP Hydrogen Territories.



€ 5.8M project incl. subsidies from ADEME

Piriou Crew Transfer Vessel – 2020

The shipbuilder Piriou intends to develop a Crew Transfer Vessel (CTV) with hybrid hydrogen propulsion. The ship will be equipped with two 140-kW fuel cells.



Project's costs undisclosed

NavibusH2 – 2017 - 2019

25 pax electric river shuttle project powered by fuel cells stored on board. Launched in summer 2018 for a 24-month test.

Project supported by ADEME and the region



Pacboat – 2019 - 2024

integration of a SOFC demonstrator on board a cruise ship, the first ship in the World Class series, whose delivery to the shipowner MSC Cruises is scheduled for 2022

CHANTIERS DE L'ATLANTIQUE



€ 8.3M project incl. € 2.3M from PIA funds

ABB & HDF Partnership

The world leader in boat electrification, ABB, has signed an agreement with HdF (Hydrogen de France) based in Bordeaux for the manufacture of a megawatt fuel cell to power ocean-going vessels.



€ 15M invested in a new production plant

H2SHIPS – PM-13 – Cemex - 2022

Construction of a "zero emission" river pusher with hybrid propulsion (fuel cells and batteries). The 13m boat with a power of 2x280kW will be assigned to the maneuver of barges of materials on the Seine



Part of the €6.33M H2SHIPS project (incl. €3.47M EU funding)

Marine mobility

4. Main players along the value chain



5. Swot analysis

Strengths	Weaknesses
<ul style="list-style-type: none"> • Already a strong ecosystem of players with expertise thanks to a high number of demonstrators or operational projects • Large seafront with many specialized ports, which are already engaging in hydrogen projects for combined land and marine uses. 	<ul style="list-style-type: none"> • The price of hydrogen is not competitive with diesel, especially without public subsidies. • To date, there is no project of developing a port hub infrastructure for hydrogen
Opportunities	Threats
<ul style="list-style-type: none"> • Ambitious targets for SOx emission reductions imposed by the International Maritime Organization. • Involvement of public authorities (Regions, municipalities) to decarbonate the vessels they operate. • Expected growth in river freight. • Development of renewable hydrogen production dedicated to production of renewable ammonia used for maritime fuel. 	<ul style="list-style-type: none"> • Competition with ammonia or natural gas, due to the complexity for hydrogen storage. • Need for hydrogen refueling infrastructure in every port.

6. Key takeaways

Maritime and river mobility is identified as one of the mid term development objectives in the National Hydrogen Strategy, even if there is no specific number of hydrogen boats targeted in the French roadmaps. Several maritime demonstrator projects have already been carried out by the main French shipbuilders, and some new river projects are expected for the next years.

Opportunities between the Netherlands and France:

- France as well as the Netherlands are known for their expertise in ship manufacturing and ports. Therefore, partnerships between the relevant actors in these sectors could be developed to share knowledge on the role and commercial development of hydrogen in these sectors.
- The Netherlands could use the expertise of France on fuel cell integration in hydrogen ships and hydrogen refueling station (operational) expertise

Air mobility

1. Key Objectives

- Responsible for 2,5 to 3% of global GHG emissions, the sustainability of air transport is called into question with the development of "flygskam": the shame of flying
- Aware of the issue and wishing to maintain its position as a world leader and perpetuate the development of this economic sector (€ 58m turnover in 2018 and 300,000 jobs), France wants to keep its leader position by anticipating the emerging technological breakthrough.
- Through the aeronautics support plan, the development of a zero-emission aircraft by 2035 has become one of the key objectives of the French government.
- To reach this objective, we have to develop some innovative solution, on one hand for the propulsion (hydrogen combustion or cell fuel) and on the other hand for the integration of cell fuel powering embedded systems

2. Key Investments

- The aeronautics support plan, implemented in June 2020 in the context of Covid , mobilizes a budget of € 15 billion in order to protect this priority sector of the French economy and to make France the leader in the aircraft of tomorrow:
 - SMEs : development of a financing capacity of € 1 billion
 - € 1.5 billion in public aid between 2020 and 2023 to support R&D and technological innovation in the service of zero emissions aircraft
- Some projects might be able to benefit from the subsidies granted by ADEME via the AAP and the theme "design and demonstration of new vehicles".

3. Overview of recent and important projects

Alerion M1h
Alcyon M3c

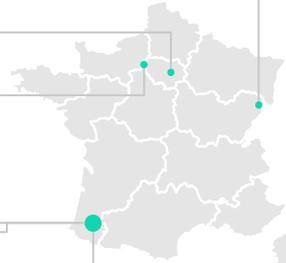
HYCARUS project

ArianEspace / Engie

Delair

Project ZEROe

Aerospace Valley



Project ZEROe – 2020

Development by Airbus of 4 models of commercial planes using hydrogen combustion or an electric motor with a fuel cell. The development of those models aims to bring a zero emission commercial aircraft to the market by 2035.

Budget of € 10-12 m

AIRBUS

Arianespace and Engie – 2019

European spatial operator, ArianEspaces is using hydrogen within his launchers since more than 40 year. Consequently, they are in partnership with Engie to develop liquid H2 solutions for maritime and air mobility.

Several tens of millions, application to benefit from IPCEI



HyDrone – 2019

Delair is developing a high endurance drone for the French Army. This project, called HyDrone is dedicated to the battlefield observation. As a demonstration, the drone will cross the Atlantic Ocean.

Budget of € 1,2 m, incl € 0,6 m from the Defense



Project HYCARUS – 2013 – 2019

European research project aiming to use PAC H2 to power the different electronic systems within an airplane.

Budget of € 12m including € 5.2m subsidies from FCH-JU



Alerion M1h & Alcyon M3c – 2020 – 2029

French aircraft manufacturer, Mauboussin is developing two planes using fuel cell to assure regional transportation. The first test is expected for 2022.

€ 1m investments with € 500m from public subsidies



Aerospace Valley – 2005

Major competitiveness cluster supporting over 598 projects in the sector space, aeronautics and embedded services. This is the French center of excellence in the sector.

€ 2 billion funding of projects dedicated to the 3 sectors , 1/3 of workforce aeronautics French



Air mobility

4. Main players along the value chain



5. Swot analysis

Strengths	Weaknesses
<ul style="list-style-type: none"> • With a historical know-how and a world leader position, France wants to use these advantages to become a leading player in hydrogen aviation. • The plan of support come give a frame regulatory stable and Goals good defined , consolidating so the sector and reassuring the investors and carriers of project. 	<ul style="list-style-type: none"> • Private investments and projects might be slow down by the Covid crisis, due to the fear of a collapse of the sector.
Opportunities	Threats
<ul style="list-style-type: none"> • Consolidate the leading position of France, develop and support one of the most important industrial sector. • Fight against the " flygskam " by using green hydrogen in order to get a sustainable means of travel. 	<ul style="list-style-type: none"> • The main threat is characterized by a continuation of the global pandemic. The air traffic is expected to return to normal in 5 to 10 years. • A pursuit of the crisis could aggravate the situation of the sector and will disturb the development of the hydrogen air mobility

6. Key takeaways

Involved on the entire value chain, France is one of the world leaders in aeronautics. Aware of the environmental threats striking this sector today, France has high ambitions for zero-emissions air mobility and is encouraging its players to take part in this technological upheaval through a € 1,5 billion investment plan. In February 2021, Airbus and The Netherlands Aerospace Industry announced their collaboration on sustainable aviation research.

Opportunities between the Netherlands and France:

- With its strong presence within the aviation sector, a lot of development is happening in this sector. An interesting addition to this development would be the expertise of Dutch SkyNRG on (production of) Sustainable Aviation Fuels

Offshore wind

1. Key Objectives

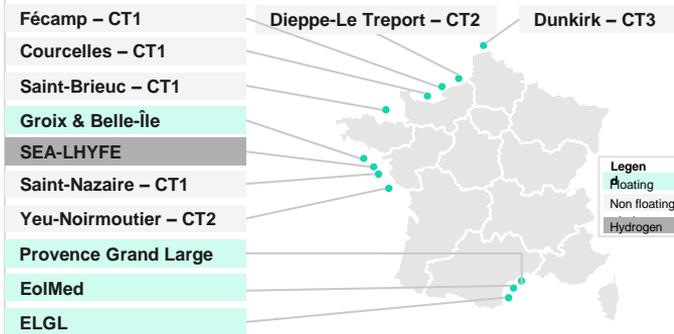
France has the second largest wind potential in Europe, due to a lot of available on- and off-shore area. Nevertheless, France has been a relatively late developer in wind power.

- **April 2020:** The French government has lifted its offshore wind procurement target to a **maximum of 8.75 GW from 4.7 GW-5.2 GW** previously, planning to bring this capacity online **by 2028**. The plan envisages the installation of **2.4 GW** of capacity with targeted commissioning **by 2023**, while **between 5.2 GW and 6.2 GW** of wind farms are planned to become operational **by 2028**.
- **2030:** France is expected to be Europe's **fourth-largest offshore wind power producer** in 2030, with 7.4 GW of capacity in operation, according to [Rystad Energy](#).
- While the focus remains on fixed-bottom installations, there is a goal for 750 MW of Floating offshore wind in 2022

2. Key Investments

- In France, an offshore wind project is awarded after a competitive bidding process. The winner of this competitive bidding procedure then benefits from a support mechanism, which enables the producer to cover the costs of its installation and ensure the project's normal profitability.
- The first six wind farms (issued from the first two call for tenders) will benefit from a purchase obligation at €150/MWh.
- The 7th wind farm at Dunkirk, and the following ones will benefit from the compensation remuneration plan: a bonus compensates for the difference between revenues from the sale and a reference remuneration level.
- Floating wind farms demonstrator projects will benefit from the PIA (innovation for the future program) with up to €150M and from a purchase obligation at €240/MWh.

3. Overview of recent and important projects



3.1 General Developments

To date, France has **7 offshore wind farm projects** issued from 3 call for tenders (CT: 2011-2012, 2013-2014, 2016-2019), **4 floating pilot wind farms** issued from call for projects (CP) and **1 floating wind turbine demonstrator**. A 4th call for tender is planned, with the competitive dialogue in 2021, prior to the designation of the winner in 2022, for a 1,000MW offshore wind turbine farm near the Cotentin.

All projects totaling for more than 3.6 GW

SEA-LHYFE

The project aims to validate Lhyfe's concept of offshore green hydrogen production at the SEM-REV site, before considering massive deployment by 2024. To date, Lhyfe's first green hydrogen production site under construction in Bouin.



Fécamp Offshore Wind Farm

The 500 MW Fécamp offshore wind farm will be composed of 71 wind turbines located between 13km and 22km from the coast of northwest France.

Project commissioning is scheduled in 2023.



The floating wind turbines of Groix & Belle-Île Offshore Wind Farm

The Groix & Belle-Île pilot wind farm comprising three floating wind turbines was selected as winner of the ADEME's EOLFLO call for projects in 2016

Three 9.5 MW turbines that are scheduled for 2022



Offshore wind power in the Dunkirk region (third call for tenders)

EOLOS was awarded with a contract for turn-key floating LiDAR services with near immediate deployment following permitting success and availability of new-build and validated units

Up to 600 MW wind farm expected in 2027



EolMed Offshore Wind Farm

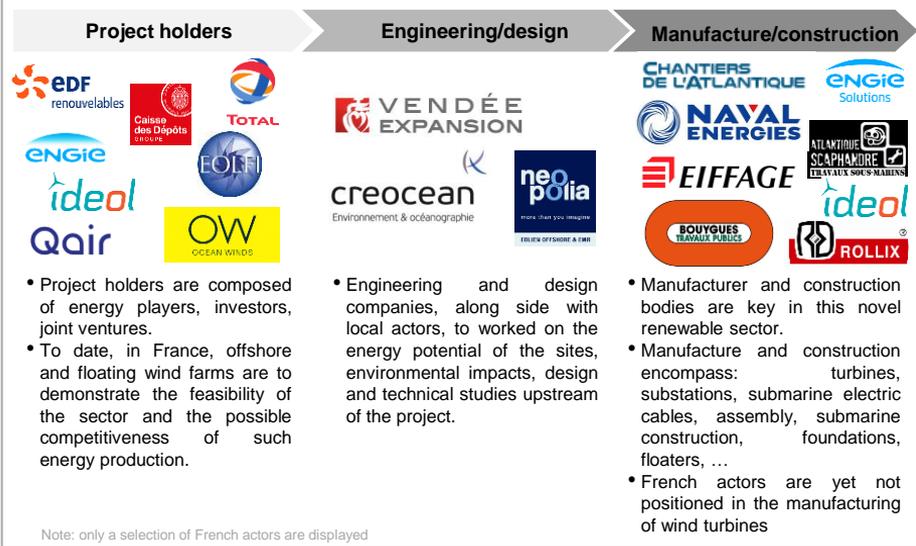
Within the frame of a call for project, the French Government has selected Eolmed for the development of a Mediterranean offshore wind farm (3 wind turbines) 15 km off the coast.

30MW capacity expected in 2021-2022



Offshore wind

4. Main players along the value chain



5. Swot analysis

<p>Strengths</p> <ul style="list-style-type: none"> • Large offshore wind potential due to France's geographical location. • France has set ambitious goals from 2020 onwards, with the target of reaching a maximum of 8.75 GW by 2028 • Several pilot projects have been authorized and upcoming call for tenders will carry on the dynamic 	<p>Weaknesses</p> <ul style="list-style-type: none"> • France entered the offshore wind market relatively late compared to other European countries. • France has a lot of offshore wind plans, but most of the plans have not reached the construction phase yet.
<p>Opportunities</p> <ul style="list-style-type: none"> • Due to France's recent focus on off-shore wind upscaling, there are ample opportunities of combining offshore wind with offshore hydrogen production, which combine optimally 	<p>Threats</p> <ul style="list-style-type: none"> • If the demonstrator projects do not prove financial profitability or competitive pricing • Cost overruns, cabling problems, and permit delays • Both hydrogen and offshore/floating wind are very expensive technologies that require strong incentives

6. Key takeaways

While France has been a relative late developer in wind power compared to other Western European counterparties, recent developments suggest that the country is now picking up the pace. France reached a total of 16,260 MW installed wind power capacity (statista, 2019). From 2024 to 2028 the French government plans to award 1 GW of capacity per year, which can be grounded, floating, or a mix of both. These plans up to 2028 suggest that there will be ample opportunity to combine the recent surge in hydrogen projects with the recent upscaling of offshore wind plans, since these two complement each other optimally.

Opportunities between the Netherlands and France:

- France could benefit from lessons from the first offshore green hydrogen production – PosHYdon – carried out in the Netherlands.
- In France, Lhyfe's short term project aims to develop Offshore Green Hydrogen Platforms in a standardized and cost effective manner using offshore wind farms.

Hydrogen sector analysis

a. Overview of French key hydrogen subsectors

b. SWOT analysis of the French and Dutch hydrogen sector

Conclusion for the French Hydrogen sector: Overall SWOT



Strength

- 1 The national strategy has come to meet the expectations of the sector through a major investment plan of € 7,2 billions and the definition of ambitious objectives in particular for the decarbonisation of industry and heavy mobility. The French players have become one with this strategy, thus forming a structured sector, composed of pure players, SMEs and the main energy companies and historical industrial hydrogen players, covering the entire value chain. The diversity of the projects and end uses addressed is also to be underlined
- 2 France has developed a real expertise in the design and manufacture of electrolysers. Players such as Attaway, ErgoSup or Bulane thus bring their expertise and enable France to position itself as a key actor, especially abroad where some French actors are in demand. In addition, France is currently developing several gigafactory projects aimed at setting up large-scale electrolysis production sites benefiting from the scale effects necessary to get a competitive price for green hydrogen.
- 3 France also has a low-carbon energy mix supported by a large nuclear fleet and the ongoing development of renewable energies. The development of renewable energies carried by the EPP will make it possible to satisfy the needs for carbon-free electricity in the hydrogen sector from 2030 onwards.
- 4 A historic land of innovation, France has real expertise in terms of R&D with high-level engineers and numerous recognised research clusters (such as the CEA Liten or the Aerospace Valley) enabling it to be at the cutting edge of technology in various sectors such as aviation, electrolysis and the injection of H2 into the gas network.



Opportunity

- 1 Willingness of the country to become one of the leaders of the sector in order to achieve its energy transition objectives while protecting certain sectors of prime importance (Industry, Aviation ...). This will be supported by strong measures and ambitious aid programs:
 - > Support for the deployment of zero-emission urban areas favouring hydrogen road mobility
 - > A compensation top-up mechanism should emerge quickly to support the hydrogen production via electrolysis.
 - > Important potential of decarbonation in the industry which is a priority and represents a great opportunity for the development of "clean" hydrogen.
 - > Aeronautical support plan including funds for the development of H2 mobility
- 2 The regions that participate in the development of the sector by setting up regional hydrogen ecosystems mobilising the entire value chain. ADEME also plays an important role in this area by mobilising its experts to support the deployment of these projects. Through IPCEIs and interconnection projects, Europe also offers an environment conducive to the development of the sector.
- 3 As a historical gas player, France has a solid network of natural gas infrastructure. Numerous R&D and demonstration projects are currently underway to use these infrastructures for hydrogen and to position itself in the longer term as one of the key players in midstream activities, notably via LNG terminals and Hydrogen Backbone through France.



Weakness

- 1 Hydrogen champion needs to emerge, and the sector needs to be restructured, although the large number of SMEs are encouraging innovation, agility and competition, this diversity of actors poses a number of challenges:
 - > Too many SMEs and projects creating a vagueness and difficulty in identifying promising projects.
 - > Uncertainties about the economic viability of some of the SMEs without government subsidies, thus weakening the sector in the event of a cessation of aid.
 - > These SMEs find it difficult to grow in an environment dominated by the Pure Players, who often buy out these small players.
- 2 This phenomenon is underlined by the lack of industrialization in certain sectors, particularly in the injection of H2 into the gas network or the electrolyser sector (except for McPhy). In fact, the current prices of green hydrogen (and related uses) are not competitive and slow down the development of the sector, requiring industrialization to benefit from the effects of scale.
- 3 Debate on the use of nuclear power plants for clean hydrogen production is currently controversial at the European level in particular with Germany, which is strongly opposed to it. A decision must be taken in order to stabilise the sector.
- 4 French administrative processes that lack flexibility and agility and have the impact of slowing down the time to market of projects and initiatives



Threat

- 1 Foreign competition with countries evolving very rapidly through massive support of their industries:
 - > China: ahead of some technological bricks, particularly gifted in the industrialization of processes.
 - > Countries with highly competitive RE capacity that can produce green hydrogen at low cost (Norway, Spain, Portugal ...)
 - > Rare earths issue: France is subject to the import of these resources.
- 2 Due to the lack of competitiveness of the hydrogen produced, the sector remains dependent on subsidies. The cessation of the latter could destroy the sector. The promise of a drop in the price of green hydrogen must be kept in order to reach an economic balance as quickly as possible.
- 3 Lack of public interest in hydrogen transport and storage infrastructures. Poorly developed, these infrastructures will not be able to support the development of hydrogen.
- 4 Safety issues: a major accident such as the one that occurred in Norway in June 2019, would have disastrous consequences on public opinion and could completely halt the development of the sector.
- 5 Lack of commitments on the part of certain French players causing a loss of market share with the case of the French car manufacturers and the arrival of Ballard on the European market or the partnership between Plug Power and Renault

Conclusion for the Dutch Hydrogen sector: Overall SWOT



Strength

- 1 The Netherlands has **5 industrial clusters** which foster a need for development, have good interconnectivity due to a good network infrastructure, and bode as good landing areas due to their geographical location. This combination is **good for hydrogen production, distribution, storage and usage**.
 - > The Dutch industry represents the second largest European production of (grey) hydrogen.
- 2 The Netherlands is **historically an important (natural) gas producer**, which has led to expertise, infrastructural- and logistical optimization.
 - > Knowledge and experience of gas and process technology, availability of knowledge and organization (s) regarding (natural) gas.
 - > Gas assets and infrastructure, availability of high-quality (natural) gas infrastructure.
 - > Efficiency, productivity and added value.
- 3 The overall **geographical location, including the location next to the North Sea and its harbors**, of the Netherlands provides the necessary resources and makes it suitable for international collaboration.
- 4 The **(Northern) Netherlands has positioned itself as a test ground for hydrogen**. In 2017, the area received the largest European grant (TSO2020), which has unofficially made the area the first Hydrogen Valley of Europe.



Opportunity

- 1 Due to its **geographical location, expertise and (gas) infrastructure** the Netherlands has the possibility of becoming a **hub-country: a central import- and export country** by building an **interconnective hydrogen value** chain using its current gas infrastructure.
 - > Green chemistry and refining can offer a large new market.
- 2 The **Dutch Climate Agreement emphasized on the development of offshore wind, which combines optimally with green hydrogen**.
- 3 The Netherlands has **ambitious hydrogen ambitions, which align with the broader European scope and policies** on hydrogen development.
- 4 Local hydrogen electrolysis as a **solution to electrical network congestion**, which is one of the key challenges for Dutch system and transport operators in the entire Netherlands
- 5 A high **potential for underground storage** due to relatively much capacity (salt caverns / gas fields in the North Sea).



Weakness

- 1 There are a **limited amount of Original Equipment Manufacturer's (OEM)** in the hydrogen sector over the entire hydrogen value chain (except for maritime sector).
- 2 The **current available subsidies are often complex and difficult to receive**, from financial incentives to legislative/tax incentives. Most notably, the **SDE++ subsidy seems to be insufficient** for large-scale hydrogen projects.
 - > Relatively low investment in research and development;
 - > Limited NL fundamental research;
 - > Limited trial / demo environments.
- 3 A **concrete of specific hydrogen program** is yet to be defined for NL (Expected to be published mid 2021)
- 4 The Netherlands is still **lagging behind in percentage of Renewable Energy** supply, which is essential for green H₂.
- 5 There are uncertainties about responsibilities within the hydrogen value chain, resulting in a **lack of first movers**.
- 6 **Filling infrastructure is lacking** for mobility, which is enhanced by the, supply-demand dead-lock, since there are still not that many hydrogen vehicles on Dutch roads.



Threat

- 1 A large amount of all Dutch hydrogen projects are **still pending an investment decision**
 - > These project may become financially infeasible due to the unprofitable top.
 - > Standards and laws may be sorted out (too) late.
- 2 Foreign **OEMs could build their own capabilities** for critical components.
- 3 Sectors with the largest CO₂-reduction potential have a **large influence on the GDP**. This can make the government or the actors involved resistant to change (incumbent's curse), which can slow the transition.
- 4 Offshore **congestion in the electrical network** can inhibit onshore electrolysis, since green hydrogen requires large amounts of (renewable) electricity.
- 5 Dutch **geographical characteristics favor Electric Vehicles** for light mobility, due to the shorter distances, the ever increasing range of batteries and an extensive charging infrastructure.



Section 3: Opportunities for cooperation

Opportunities for cooperation

- a. **European (hydrogen) programs**
- b. Recommendations for cooperation
- c. Final recommendations and follow-up advice

Important Project of Common European Interest - Overview

An 'Important Project of Common European interest' (IPCEI) is a specific possibility to find aid compatible with the internal market. Next to being eligible for EU subsidy, the IPCEI will serve as a market protection, providing countries with less border cross-border risk to promote national subsidies. This concerns large-scale research, demonstration and implementation projects of European interest, whereby the unprofitable top can be reimbursed up to 100%. In contrast to other programs, the first commercialization up to industrial deployment (between pilot and start of mass production) is also eligible for subsidy at IPCEI.

IPCEI on Hydrogen: developments

- An IPCEI on Hydrogen is being prepared, with 23 European countries signing a manifesto, paving the way for a cleaner hydrogen value chain including a significant number of projects in all the areas important for Hydrogen (Generation/electrolysis, Transmission/Transportation, mobility/fuel-cells, energy storage/conversion).
- The IPCEI should serve as the initial step of a Hydrogen launch platform in order to better determine the most promising applications and to bring together the relevant industrial actors in the EU as well as the relevant financing sources from all the regions of the EU.
- The IPCEI for hydrogen is being prepared under the name [Hydrogen for Climate Action](#). This IPCEI includes sub-projects on all parts of the hydrogen chain, which are listed in the next section

IPCEI on Hydrogen: objectives

- Generation of green hydrogen from renewable energy sources
- Transport of hydrogen in different forms and by different means
- Mobility applications such as heavy commercial vehicles, buses, trains, ships, etc., with hydrogen filling stations on roads, ports and bus depots
- Industrial applications such as steel production, fertilizer, cement or industrial heat (mixed with natural gas in different percentages), as well as refineries and hydrogen use in the chemical sector
- In the energy sector applications such as temporary and seasonal storage, use of peak power to relieve the electricity grid, aggregates on residual hydrogen
- In the housing sector for CHP applications, to replace natural gas in specific applications
- Applications for end users such as supermarkets that want to make their logistics greener or cruise ships that want to offer their customers clean travel

Summary of the 11 hydrogen IPCEI projects



Important Project of Common European Interest – Key projects

The European Union launched a hydrogen IPCEI on the 17th of December, with 23 European countries signing a manifesto paving the way for a cleaner hydrogen value chain. With the commitment of the 23 countries, the following indicative schedule for a first wave of the IPCEI on hydrogen is envisioned:

Match-making workshops:	February and March 2021
Drafting of chapeau:	Starting immediately after the match-making
Pre-notification:	May 2021
Notification:	Possibly in November 2021 (aiming at final decision by the end of 2021)
Start of project implementation:	2022

Key existing IPCEI projects*

Project name	Sector	Countries	Key actors
Rainbow UnHycorn			
Green octopus			
Green flamingo			
Green spider			
H2GO			
Blue Dolphin			

Pitched IPCEI projects

Project name	Sector	Actor(s)	Looking for
Energy Park Bad Lauchstädt			- Component OEMs - Research partners
Regional hydrogen ecosystem			- Component OEMs - Research partners
EAF and hot rolling mill plant			- Partners and synergies with industrial sectors
Beehive			- Ship builder companies - H2-producers and transporters
Golden Flamingo			- Synergies with other IPCEIs - Players interested in joining forces (Gas TSOs, port authorities, industry, clusters..)

Production of H₂ by electrolysis
 H₂ Distribution (truck, pipeline)
 Storage of H₂
 Maritime
 H₂ Refueling stations
 H₂ Mobility
 Whole value chain

European subsidy programs

Fuel Cells and Hydrogen Joint Undertaking (FCH JU)

The financial possibilities stem from the perspective of the FCH JU and are related to the Technological Readiness Levels and the degree of "bankability". For projects in the market launch phase, Europe makes a combination of subsidies and other forms of financing (blending) possible. The subsidies available are based on the TRL phases of projects, as shown in the table below:

EU Fund & Financing sources VS Tech Stage	Pre-commercial development (R&D)	Demonstration / First-of-a-kind	Uptake / Market ready / Roll out of technology
Horizon 2020			
ESIF (ERDF, ESF & CF; grant & FI)			
Interreg			
CEF (grant & FI)			

Below is further elaborated on Horizon 2020 and Interreg.

Horizon 2020

This **public-private program** has a budget of **€700 million in the current period of 2014-2020**, which is matched with private investments. By coordinating the activities of stakeholders, both nationally and internationally, this initiative **helps to overcome technological and non-technological barriers**.

- > The program is **open to all organizations** (industry, knowledge institutions and other organizations) **engaged in scientific research, technological development and innovation**. Co-financing from the industry is a prerequisite. Furthermore, the initiative **stimulates the participation of SMEs**.

It is **expected that a large budget will again be available** to help fulfil the European ambitions of the announced Clean Hydrogen Alliance, part of the new industrial strategy of the European Commission.

- > An **overview of projects** funded by FCH JU can be found [here](#).

Key Horizon 2020 projects

France Netherlands Both

Cosmhyc Combined hybrid Solution of Energy Compressors for energy storage and refueling stations	Insight Implementation in real SOFC Systems of monitoring and diagnostic tools	H2ME 2 Hydrogen Mobility Europe 2 (H2ME 2) brings together action in 8 European countries (incl. France and the Netherlands) to address the innovations required to make the hydrogen mobility sector truly ready for market.	Djewels Delfzijl Joint Development of green Water Electrolysis at Large Scale	HEAVENN Hydrogen Energy Applications for Valley Environments in Northern Netherlands
Pretzel Modular stack design for high pressure PEM water electrolyser technology with wide operation range	Reflex Reversible solid oxide Electrolyser and Fuel cell for optimized Local Energy mix		H2Future Hydrogen meeting future needs of low carbon manufacturing value chains	HySTOC Hydrogen supply and transportation using liquid organic hydrogen carriers

European Clean Hydrogen Alliance

The last calls for FCH JU were settled this year and the new programming period is being prepared. It is expected that a large budget will again be made available to help fulfil the European ambitions of the announced **Clean Hydrogen Alliance**, part of the new industrial strategy of the European Commission.

- > The Clean Hydrogen Alliance will act as a platform that enables close cooperation and coordination along the value chain.
- > The work of the Alliance will be structured around six industrial pillars, connecting supply and demand for clean hydrogen:
 - Residential Applications, Transmission & Distribution, Mobility, Hydrogen Production, Industrial Applications, Energy Sector



500 Companies

2020



2000 Companies

2050



€ 5-9 billion

2024



€ 26-44 billion

2030

INTERREG

INTERREG is a **European subsidy scheme for spatial and regional development** where parties from different countries work together on the projects. There are 3 different Interreg programs:

1. The first focuses on cooperation in the border regions (Interreg A),
2. The second on cooperation between regions in different countries and
3. The third on cooperation interregional and Europe-wide (there are four Europe-wide programs).

The **INTERREG program** for the 2014-2020 period is nearing its end. Because it was unclear for a long time how Brexit would be realized, the preparation of the new programming period has been delayed.

- > **Netherlands:** €309 million for the 2014-2020 period for the programs in the border regions.
- > **France:** €3.8B budget for all 23 cooperation programs involving France.

Key Interreg Developments

France Netherlands

- > France participates in **9 cross-border programs**, **5 transnational programs (excluding overseas)**, **4 interregional programs including INTERREG Europe**. Amongst these programs, France is involved in hydrogen-related projects such as:

- **H2SHIPS:** to demonstrate the application of hydrogen to power ships.
- **ISHY:** to demonstrate the implementation of hybrid and hydrogen fuel cell technologies in vessels and ports.
- **ORCEPAC:** to manufacture fuel cells with less expensive materials.
- **HECTOR:** to demonstrate that fuel cell garbage trucks provide an effective solution to reduce emissions from road transport.
- **H2PIYR:** to demonstrate the use of H2 refueling stations.

- > The Netherlands participates in **4 programs in the border regions**. INTERREG Flanders-Netherlands, for example, has financed various WaterstofNet projects.
- > The Netherlands also participates in **2 transnational programs (Northwest Europe and North Sea Region)**.

- Ireland, the United Kingdom, the Netherlands, Germany, Belgium, Luxembourg, France and Switzerland work together in the **Northwest Europe program**.
- An **example of a hydrogen project** in the Northwest Europe program is **H2SHIPS**, which demonstrates the application of hydrogen to power ships.
- > An example of a hydrogen project in INTERREG Europe (one of the four European-wide programs), is **SMART HY AWARE**, in which the Province of South Holland participates.

Franco – German cooperation: opportunities for collaboration

The Governments of Germany and France have agreed on a [new treaty](#) (22 January 2019) under international law concerning the Franco-German cooperation and integration. In the treaty, France and Germany underline their joint endeavor to facilitate cross-border mobility in the regions by, among other things, better interlinking rail and road transport, ensuring climate change mitigation in all policy areas as well as cooperating closer with regard to digital change.

Franco – German cooperation: hydrogen

- France and Germany intend to become the world champions for green hydrogen together and are planning to set up a “gigafactory” with state support.
- In concrete terms, the plan is to set up a “gigafactory” to produce green hydrogen through electrolysis on a GW-scale (to help supply hydrogen to themselves and their neighbours), for which both countries could provide €1.5 billion and which is to apply to the EU for the status of “Project of Common European Interest” (IPCEI) in order to receive state subsidies.

Franco – German: hydrogen topics of collaboration



Rail transport

France and Germany are working together on the development and implementation of hydrogen-powered trains:

Linde & Alstom: Cooperation to develop and implement the first hydrogen-powered train.

- This project was born in Germany and has been a success story for Europe. The train has also been tested in the Netherlands.
- Lower-Saxony is interested in implementing these trains as well.
- Alstom has the strategic goal of developing regional [refueling stations](#) for trains

Other OEMs are building hydrogen trains as well.

- One general challenge is that the lifetime of the electrolyser membrane needs to be extended.



Road mobility

French and German companies are collaborating in order to complement each other and to tackle the chicken-egg problem together:

Opel (now part of Stellantis): The strategic focus is on bringing down the total cost of ownership on fuel cell technology, to serve interested customers.

- Pivotal to ramp up as quickly as possible; this is where international collaboration (incl. IPCEI) comes in.
- The H2mobility initiative has made strides in overcoming the chicken-egg problem.

Plastic Omnium & Eirong Klinger: Together they are creating a strong European champion to support development of first vehicles to come to market.

- Eirong Klinger will be looking for collaboration with truck manufacturers, such as VDL and DAF to build trucks at the end of 2021.



Infrastructure

Due to the border-region between France and Germany there are ample opportunities for lucrative partnerships regarding the gas infrastructure:

GRTgas, OGE & Gasunie: A consortium of European gas operators published (July 2020) a paper proposing the [European Hydrogen Backbone](#) (“the EHB”) connecting hydrogen supply and demand from north to south and west to east.

GRTgas SA & Creos Deutschland GmbH: These grid operators are [collaborating](#) to create a 100% pure hydrogen infrastructure, connecting the Saar (Germany), Lorraine (France), and the Luxembourg border. The focus is on conversion of two existing pipelines into a 70-km pure hydrogen infrastructure.

Storengy wants to use existing infrastructure to find industrial customers to scale up afterward. They are operating within France, Germany and Luxembourg.



Electrolysis

Within the electrolysis sector, France and Germany are collaborating closely:

McPhy has business partners in Germany, with 10 MW of capacity in Germany at the moment.

- They are a collaborator in the Gigawatt factory that is planned (40GW electrolysis) and have a second one planned in Germany before 2027.

Hynamics has been allocated funds (internally from EDF) to promote hydrogen production. They are collaborating with Britain, Germany, France, Belgium and Italy.

- Hynamics has stated that it wants to help McPhy become a big European player.



Opportunities for cooperation

- a. European (hydrogen) programs
- b. Recommendations for cooperation**
- c. Final recommendations and follow-up advice

Opportunities for Dutch players

France has independent and all-encompassing capabilities across the value chain

This study has observed that **France has expertise and actors on many parts of the hydrogen value chain**. This large number of players, supported by an **ambitious national strategy** and the **desire to develop a competitive sector**, create opportunities for cooperation. In addition to this, foreign players wishing to participate in public tenders are encouraged by the public authorities to participate in the development of the French sector (local employment, exchange of know-how and technologies).

Possibilities for Dutch players to address/enter the French market:

1

Apply to the regional and national Call for tenders

Take the opportunity of the infatuation of French regional and national politics for hydrogen development through the call for tenders and engage in local activity development (e.g. jobs creation)

2

Direct company-to-company collaboration

Utilize market opportunities, addressing the specific needs or knowledge areas in the French or Dutch markets where countries could learn from or complement each other.

3

Apply to European call for tenders or subsidy programs in consortia with French players

Benefit from the multiple financing counters from EU programs (e.g. FCH-JU, IPCEI, FEDER) to build up projects with French companies

Apply to the regional and national Call for tenders

The French regions play a key role in the development of the sector. Complementary to the government's AAPs and PIAs supervised by ADEME, the regions are supporting ambitious regional ecosystem projects, thus offering a favourable framework and opportunities for the various players in the hydrogen value chain. The Sia Partners study identifies these projects as sources of cooperation and partnerships between France and the Netherlands.

The regions, a key player for the French Hydrogen

On top of the ADEME national call for tenders, the French Regions defined ambitious hydrogen roadmap with dedicated investments that complement the national strategy of creating hydrogen territorial ecosystems:

- Development of large hydrogen territories covering all the links of the value chain, from production to end uses, including transport and storage infrastructures.
- Interface of connection with the European Union, through the IPCEI or collaboration projects between European regions (3S Platform, Hydrogen Backbone).
- Showcase for regional players: the regions support the various players in drawing up their business plan, raising funds and seeking financing, but also in their export strategy when the latter wish to reach foreign markets. They also play an incubator role, as was the case for McPhy with the Auvergne-Rhône-Alpes region.

How to win a region's call for tender for a Dutch company

Our exchanges with various regional players have enabled us to identify certain key factors favouring the emergence of partnerships within these projects:

- The competitiveness of the offer linked to the economic constraints and the advanced deadlines prevails. However, regions want to promote local activity and therefore turn more naturally to local businesses, that are mostly French
- However, the regions are ready to develop win-win collaborations with Dutch actors. The project must not be exclusively commercial, the Dutch actor must also offer a benefit to the region, for example by setting up in the region, which will create jobs and wealth.
- Most of the projects are built within regional competitiveness clusters. The Dutch players must turn to the latter in order to make themselves known to local players and present their innovations that can benefit the French sector.

Direct company-to-company collaboration opportunities (1/3)



Electrolysis

France has an important ecosystem of players positioned on electrolysis, players whose activity is growing in scale, particularly abroad.

In a context of emerging Asian competition, it is interesting to establish a collaboration between our two countries, especially on large electrolyzers.

Global
Context

- 1** NL can benefit from France's large scale electrolysis expertise to integrate in national large scale projects;
- 2** Both countries could benefit from collaboration on the topic of small scale electrolysis.

Market
Opportunities

- 1** Explore cooperation opportunities with French specialized (large scale) electrolysis companies, such as McPhy.
- 2a** To develop Dutch Electrolysis expertise from R&D cooperation French specialists (R&D Research Centers)
- 2b** To help French companies scale-up and address new markets (Netherlands).

Cooperation
opportunities



Road Mobility

France is well positioned on light mobility, with a large number of equipment suppliers and manufacturers, while the Netherlands is better positioned on heavy mobility.

This complementarity can be a source of partnership, all the more so in view of the stoppage of the sale of thermal vehicles scheduled for 2030 in the Netherlands.

- 1** France could benefit from Dutch expertise on (hydrogen) truck OEMs, due to a lack of dedicated French OEMs;
- 2** France could benefit from Dutch expertise in building agriculture (hydrogen) vehicles for its large agricultural sector;
- 3** The Netherlands can use French HRS operational expertise to expand and further optimise road mobility HRS infrastructure.

- 1** Dutch hydrogen heavy vehicle OEMS (such as VDL, DAF and Hyzon Holthausen) could explore cooperation with French OEMs that are involved in hydrogen for heavy mobility solutions (e.g. Symbio, Faurecia, Plastic Omnium);
- 2** Dutch agricultural vehicle actors (e.g H₂Trac) could explore the French market for international collaboration;
- 3** Collaboration with French HRS infrastructure organizations (such as Pitpoint and Air liquide) can be explored.



Marine

Both France and the Netherlands have a large maritime frontage and have thus developed a great deal of expertise, particularly in shipyards.

Although having already initiated the conversion of existing fleets, French ports are particularly interested in their Dutch counterparts by seeking to initiate the hydrogen solutions implemented in Dutch ports.

- 1** Both countries could benefit from a share of knowledge between FR & NL ports;
- 2** The Netherlands can use French expertise in onboard fuel cell integration and other component level OEMS;
- 3** The Netherlands can use French HRS operational expertise to expand and further optimise marine mobility HRS infrastructure
- 1** Many French and Dutch ports are launching studies/projects on hydrogen (e.g., the Port of Rotterdam);
- 2** Collaborations between large dutch ship OEMs and French component OEMs can be explored;
- 3** Collaboration with French HRS infrastructure organizations (such as Pitpoint and Air liquide) can be explored.

Direct company-to-company collaboration opportunities (2/3)



Gas infrastructure

Both countries are historical experts in the gas chain who can collaborate with each other through knowledge sharing. Moreover, the current context (geographical situation of the countries within Europe, end of exploitation of the Groningen field), creates a vocation to collaborate between the two countries, a phenomenon reinforced by two projects on a European scale: Hydrogen Backbone and HyDeal.

Global
Context

- 1 Dutch DSOs could benefit from French DSO expertise on the topic of grid mixing;
- 2 Both countries could benefit from collaboration on the topic of hydrogen pipeline infrastructure, due to the ongoing debates regarding the optimal layout.

Market
Opportunities

- 1 R&D Partnerships between DSOs in NL and France. For example: Enexis, Stedin, GRFD, and GRTgaz;
- 2a Knowledge sharing from e.g., Air Liquide on H₂-pipeline operation and design from their private H₂-pipeline (North France - Rotterdam);
- 2b Look into collaborations between FR/NL actors at the ends of the Air Liquide H₂-pipeline.

Cooperation
opportunities



Storage

France has set up the first salt cavity storage demonstrator with Hypster. Feedback can be considered to support the Netherlands in their storage projects. Moreover, the Dutch storage potential remains higher than that of France, which could lead to a cooperation, but on the longer term.

- 1 Both countries can benefit from sharing expertise and experience about large scale storage in salt caverns;
- 2 France can benefit from the large storage capacity that is available in Salt caverns in Northern Netherlands (only in the long-term).

- 1 (R&D) Partnerships between demonstrators (e.g. Hystock, Hypster, Storengy) Knowledge sharing on the output of the projects (e.g. feasibility, economics, technicals constraints);
- 2 Partnerships can be formed between French Hydrogen producers (such as Engie, McPhy) and Dutch hydrogen storage providers (such as Gasunie, Energystock).



Industry

Representing 18% of the Dutch GDP, industry plays a major role in the economy. Moreover, it is also a priority development sector for H₂. However, the support mechanisms in the Netherlands remain rather weak, unlike France, which is thus able to share its expertise in this area.

- 1 The Netherlands could use the French approach in creating a hydrogen programme and related incentives/subsidies to stimulate hydrogen projects;
- 2 Dutch and French industrial actors can benefit from collaboration due to both countries' industry sector experience with hydrogen usage and ambitious hydrogen goals.
- 1 High-level political contact between Dutch and French responsible organs for developing a hydrogen programme;
- 2 Dutch actors (e.g. Nouryon, Tata Steel) and French actors (e.g. Air Liquide, Total) can collaborate to complement each other's needs and exchange knowledge to further optimize operations and develop hydrogen projects.

Direct company-to-company collaboration opportunities (3/3)



Offshore wind

This sector is developed in the Netherlands while France is still in its infancy. However, France is moving towards a different model, that of the floating wind turbine, with a good number of calls for tenders recently. It is possible to envisage a R&D collaboration, in particular on offshore electrolyzers but over a rather long-time horizon.

- 1 France could benefit from the Dutch expertise in the offshore wind sector.

1a Develop industrial or R&D partnership between French electrolysis company and Dutch offshore wind operator to build offshore suitable solutions (Example: PosHyDon Project (Neptune Energy, Gasunie, TNO, etc)).

- 1b** On the long-term, use Dutch expertise in offshore wind to support in French offshore wind projects.



Air Mobility

France is particularly advanced on the subject through its historical expertise. As France controls the entire value chain, there are few opportunities for cooperation. However, the implementation of H2 aircraft must be accompanied by partnerships between airports in order to set up refueling stations. Paris and Amsterdam airports, both major European airports and hubs for Air-France-KLM could cooperate on this subject.

- 1 France operates the complete air mobility value chain, which bodes the potential for demonstration projects for components in the Netherlands.

1 France and NL have important expertise about H2 air mobility. R&D that could for example be explored are between Aerospace Valley and SkyNRG.



Rail Mobility

Alstom is the undisputed leader in hydrogen-powered trains in Europe, following the success of the Coradia iLint in Germany and then in the Netherlands, and the hydrogen-electric hybrid demonstrators in France. Although these trains differ in design, a reflection on refueling, maintenance and business needs may be of interest.

- 1 Plans of the Netherlands to deploy hydrogen train(s) before 2025.

1 Dutch rail organizations such as ProRail and NS could explore deployment of French hydrogen train(s) by cooperating with e.g. Linde or Alstom.

Apply to European call for tenders or subsidy programs

The European Union plays a major role in the hydrogen industry by supporting the development and structuration of its players. The framework of the European Union is mainly ensured through major aid and funding programs, including the FCH-JU, the ERDF Fund and the Hydrogen IPCEI.

Cooperation programs from the EU...

EU subsidies (Horizon, ERDF)

- New program, **Horizon Europe**, in consultation should run from 2021 to 2027 with a much larger budget, allowing the funding of more projects.
- With a budget of €1.1 billion between 2014 and 2020 for France, the **ERDF** funds aim to support and develop European territorial cooperation.

Hydrogen IPCEI

In 2020, **11 hydrogen IPCEI projects** have been selected ranging from the entire value chain. The **Netherlands** is currently involved in **6 projects**, whereas the **France** is involved in **2 projects**. These projects contribute to the EU's objectives and are very **crucial for the development of partnerships**.

Franco – German cooperation

France and Germany have agreed to a **joint endeavour to facilitate cross-border hydrogen development** in the countries, which has resulted in several international partnerships. Joining the Franco – German cooperation could be a crucial step for the development of new partnerships for the Netherlands.

...a way to access the French Market

Displaying a desire to build a European hydrogen industry, **the European Union is an excellent gateway for foreign players**, a phenomenon perfectly illustrated by the strong relations existing today between German and French players.

- **French players have fully understood the role of the European Union** and are active in these European funding windows. This relationship is **even stronger for the French regions**, which support their players in their dealings with funding windows, develop relationships with other European regions (3S Platform) and support their players in their projects abroad.
- Therefore, **these funding platforms are excellent means for foreign players to:**
 1. **Apply to (in a consortium) with French actors;**
 2. **Discover projects developed in France;**

Opportunities for cooperation

- a. European (hydrogen) programs
- b. Recommendations for cooperation
- c. Final recommendations and follow-up advice**

Final recommendations and follow-up advice

The Netherlands has a **good starting position to play a central role in the development of the (international) hydrogen sector** in Europe. Being in an early stage of development, the Dutch hydrogen sector **still requires some key decisions need to be made that could foster the hydrogen sector development and strengthen the international hydrogen position of the Netherlands.**

For the public sector

- 1 We see a need for the Netherlands to **be part of the Franco-German cooperation**, next to the existing pentilateral consultation including BeNeLux, France, Germany, Switzerland and Austria. The Netherlands needs to have a clear message and underlying evidence towards France / Germany as to why it is beneficial to have our country participate in this cooperation.
- 2 We see a need to **improve the attractiveness of the business climate for foreign (electrolysis) OEMs** in the Netherlands. This could lead to expertise and knowledge built up in the Netherlands. It can incur domestic component suppliers to contribute to this emerging industry.
- 3 There is a **need for stronger lobbying between ministries with France and the Netherlands** (also with Germany for the Franco-German relationship). Higher political levels should promote the hydrogen strategy and foreign cooperation. Successfully working with French companies means also good connections between the ministries.
- 4 The **Dutch subsidy climate should improve in transparency and support of the smaller innovative companies**. Current regulations will have to be further developed to kick-start the many initiatives in the sector. We see for example an importance for innovative start-ups or smaller SMEs to receive financial assistance in scaling up their innovations.

For the private sector

- 1 Topsector Energy designed a very exhaustive list of Dutch companies working on Hydrogen in different industries. In addition, now with the NBSO study a **navigation/cartography of actors in France has been made**. One can learn from the regions in France and how they develop Hydrogen.
- 2 We see opportunities to **develop innovation hubs between Dutch and French companies** in some sectors. With a combination of a technology institute such as TNO, a start-up with special technology and a few larger companies that can apply it (e.g. Vopak).
- 3 We see an **importance for innovative start-ups or smaller SMEs to receive financial assistance** in scaling up their innovations. This also provides an opportunity to get in touch with larger companies, in France or vice versa. Important roles are here defined for the NFIA and regional support agencies such as the Brabantse Ontwikkelings Maatschappij.
- 4 A **dashboard could be created listing innovative (hydrogen) companies by sector**. This list could include the needs of companies when it comes to connecting with foreign cooperation partners (technology institutions or companies), which can ultimately be published in NL (e.g. via TKI) but also in France (by NBSO).