BRETAGNE

Hydrogen

STUDY OF THE POTENTIAL FOR THE DEVELOPMENT OF **RENEWABLE HYDROGEN IN BRITTANY**

Overview

Région Bretagne

ADEME Agence de la transition écologique

Bretagne Développement Innovation

CONTEXT OF THE MISSION

Given the climate emergency challenges facing Brittany, the territorial imbalances linked to the concentration of activities, and the need to rethink collaborative and public actions given the lack of interest of so many citizens, the Region began working in 2017 to develop a new territorial project for Brittany: BreizhCOP. The aim is to accelerate the implementation of all transitions in Brittany: Ecological transition, Climate transition, Economic transition, Societal transition but also the Method transition.

In this context, renewable hydrogen is a major development vector for the Energy transition. It provides solutions to the problems of irregularity in renewable energy. Transportable and storable as a liquid or a gas, hydrogen can be used in industrial processes as well as for production, storage, mobility (land, maritime...) and the transport of renewable energy.

The strategic and pre-operational study on the development of the potentials of renewable hydrogen in Brittany by 2050, finalised at the end of 2019, forms part of this approach. It provides a basis for consideration and for developing the Brittany Roadmap for the deployment of renewable hydrogen. For Brittany, it also contributes to the national hydrogen plan and to the European Union's future hydrogen strategy.

This regional study was coordinated by a procurement consolidation uniting Brittany Développement Innovation and the Brittany Region with the support of Ademe Bretagne. Entrusted to Seiya Consulting – Element Energy – Alca Torda, this study was carried out within the partners' committee for the regional study on hydrogen under the collaborative control of 40 structures: public and private, local authorities, academic and businesses, all pioneers on the topic of hydrogen in Brittany.

200 Breton stakeholders were consulted for this study, to identify the challenges and demands, and to take stock of the project opportunities and the short- and long-term potentials for development.

Four missions were carried out:

1. Strategic evaluation of the diffusion by 2050 of renewable hydrogen in the territories and in Breton industries
2. Qualification and quantification of local production and consumption of renewable hydrogen in Brittany
3. Identification and validation of project opportunities and realisation by 2023
4. Map of expertise in the local sector and national, European, or world-wide opportunities for this expertise

Definition of renewable hydrogen for the scope of this study

Commonly known as hydrogen, dihydrogen H2 is a molecule which never or almost never occurs in its pure state in nature. It must therefore be produced by industrial processes.

This study, carried out prior to the regulatory provision governing the traceability and origins of hydrogen production, takes for premise the definition of renewable or green hydrogen as being produced using renewable energies.

THE STUDY DISTINGUISHES TWO MAIN METHODS FOR PRODUCING HYDROGEN, WHICH ARE CONSIDERED TO BE INDUSTRIALLY MATURE:

- **PRODUCTION THROUGH ELECTROLYSIS OF WATER** using electricity produced from renewable energy sources.
- **PRODUCTION THROUGH STEAM REFORMING** of biomethane.

There are other processes for producing renewable hydrogen, at different stages of development, but they were not considered in this regional study as there was insufficient technical or economic data available. Further studies will be carried out on processes such as the production of hydrogen biologically or the use of aquiferous hydrogen (presumed to be renewable) but also the hydrolase/electrolysis of other organic resources.

The study defines "fossil" hydrogen as being produced from fossil energy, and "coproduced" hydrogen, as being produced by a process whose function is not to obtain this H2 (and which could be understood as low-carbon hydrogen on the condition that it is not upcycled elsewhere for a non-energy use).

FOCUS ON

THE LAW ON ENERGY AND THE CLIMATE

The Law of 8 November 2019, relating to energy and the climate, states the target of developing low-carbon and renewable hydrogen and its uses in industry, energy and mobility, with the aim of achieving around 20 to 40% of total hydrogen and industrial hydrogen uses by 2030.

The Law also authorises the government to make a ruling to define the different types of hydrogen as well as a support framework and asks that the government institutes a measure for guaranteeing the origins of renewable hydrogen.

Early 2020, the Directorate for Energy and the Climate launched a consultation for the implementation of measures to guarantee the traceability of renewable hydrogen. The Brittany Region contributed to this consultation.

This study of the potential for developing renewable hydrogen in Brittany was therefore carried out ahead of the future regulations applicable to low-carbon and renewable hydrogen which will be defined during 2020.

A few notions are provided as indications: these regulations on the management of hydrogen, which are still at the project stage at the time of writing this publication, foresee the addition to the Energy code of the following definitions:

-"Hydrogen" is a gas composed of dihydrogen molecules.

- Hydrogen is qualified as "renewable, low-carbon or fossil" depending on the process and the raw energy used to produce it, corresponding to criteria determined by a decree in the Council of state.
- The explanation of the "renewable and low-carbon" criteria is defined in a decree which is pending validation. The greenhouse gasses emitted by the different production processes are calculated according to conditions defined by decree.
- Hydrogen is said to be "fossil" if it is neither renewable nor low-carbon.

I. Strategic evaluation

of the penetration of renewable hydrogen in the territories and in Breton industries by 2050

The figures in this study are from 2019, apart from the map of Hydrogen projects in Brittany which was updated in June 2020.

A. The potential for consumption of renewable hydrogen

1 | LAND TRANSPORT

Method

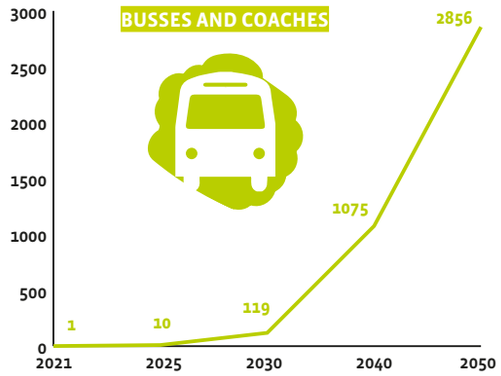
The potential consumption of renewable hydrogen was estimated using the following method:

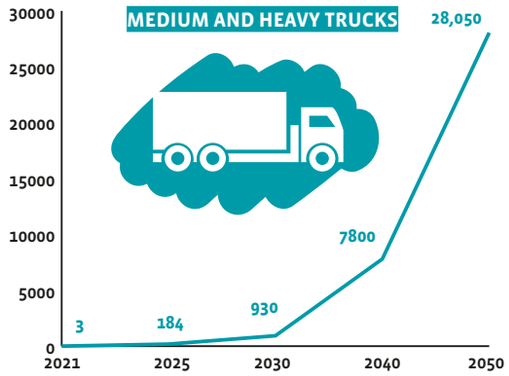
1) Calculation of the scope of the target market (number of vehicles) and the proportion of hydrogen in this market, using different methods respectively: up to 2024 (by extrapolating the growth of the identified projects), by 2030 (by extrapolating the industrial capacities limited to producing vehicles) and by 2050 (a conservative hypothesis taking into consideration the inertia of stock, 2/3 of the fleet presumed to be combustion powered, 1/3 presumed to be 50% electric and 50% hydrogen, or 16.5% of the Brittany fleet).
2) Deduction of hydrogen consumptions per vehicle segment (individual, light utility < 3.5t, medium/heavy trucks, busses/coaches).

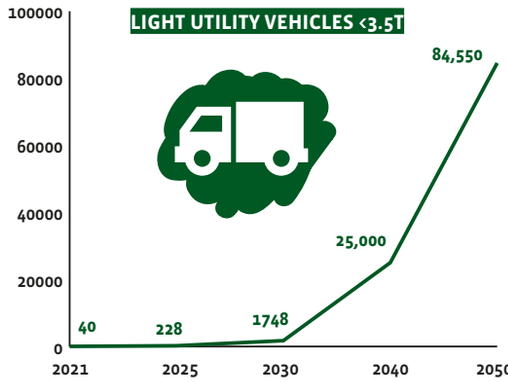
Delanchy, key partner of the Energy Observer since 2017, places hydrogen at the heart of its road transport activities. Port of St-Malo / Photo credit: Sylvain Malmouche – Regards Photographes Laval

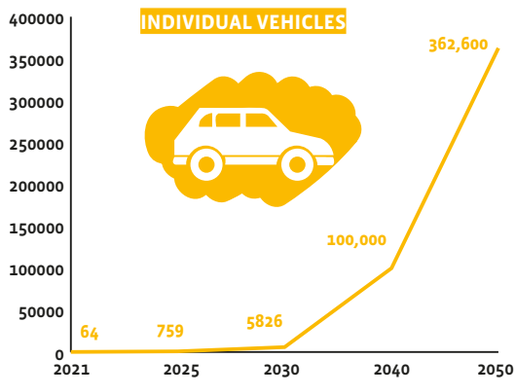
Here you see the Chereau Hydrogen Power H2 semi used by DELANCHY in real conditions of use; a trailer whose cooling unit is hydrogen powered.

ESTIMATION OF THE NUMBER OF FUEL CELL ELECTRIC VEHICLES IN BRITTANY BY 2050



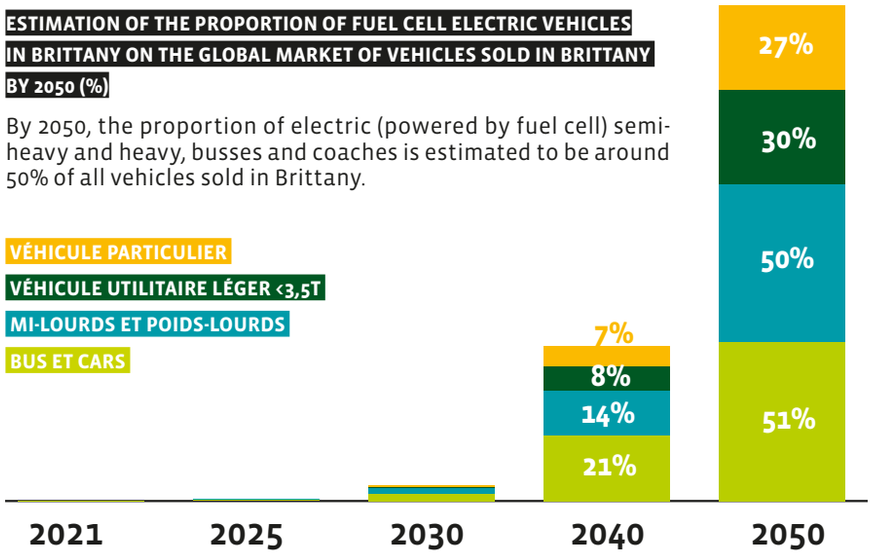






ESTIMATION OF THE PROPORTION OF FUEL CELL ELECTRIC VEHICLES IN BRITTANY ON THE GLOBAL MARKET OF VEHICLES SOLD IN BRITTANY BY 2050 (%)

By 2050, the proportion of electric (powered by fuel cell) semi-heavy and heavy, busses and coaches is estimated to be around 50% of all vehicles sold in Brittany.



2 | PORT ECOSYSTEMS

EXAMPLES OF HYDROGEN APPLICATIONS WITHIN A PORT INFRASTRUCTURE

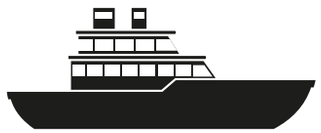
Port de Brest / Credit : © Panoramique / Région Bretagne

Logistics uses | Stationary uses | Transport related uses | Port uses

Genuine **"energy hubs"**, port ecosystems are interfaces in which offloading occurs between the different modes of transport. They focus the entire range of challenges of carbon-free land, maritime or fluvial mobility (consumption of logistics and industrial hubs, consumption of ships while docked or manoeuvring, and road/rail freight transport when relevant).

Port ecosystems will also be the place through which any potential future offshore hydrogen productions are conveyed. These activities generate a high level of energy consumption, concentrated on a defined and controllable surface.

HYPOTHESIS FOR THE CONSUMPTION OF HYDROGEN IN A PORT ECOSYSTEM BY 2040



EUROPEAN CABOTAGE

REFUELLING STATION
SHORE CONNECTION

1,050,000 kg/year

INTERNATIONAL

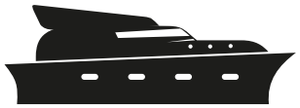
SHORE CONNECTION

175,000 kg/year

FERRY LINKS TO UK AND IRELAND

SHORE CONNECTION

530,000 kg/year



PLEASURE BOATING

REFUELLING STATION

4000 kg/year

OFFSHORE WIND PARK

REFUELLING STATION

1,100,000 kg/year

CRUISERS

SHORE CONNECTION

50,000 kg/year

Method

The estimation of potential consumptions of uses in port and maritime ecosystems considers:

1) The International Maritime Organisation (IMO) agreement decided during the 2015 Conference of the United Nations on Climate Change (COP 21) for the reduction of at least 40% of GHG emissions (per tonne-kilometre) from ships by 2030, and the target of 70% by 2050, and the reduction of emissions by at least 50% by 2050 in relation to 2008, while continuing to work towards complete decarbonation of maritime transport.

2) The Multiannual Energy Plan which aims to achieve the carbon neutrality of state-owned captive fleets, port flotillas and leisure flotillas by 2050, and to develop the infrastructures and measures necessary for refuelling and to meet the demands for carbon-free energy for movement between French ports.

3) Calculation of the market share addressable by the systematic analysis of fleets, based on the extrapolation of a typical cluster (Lorient), segmented on the one hand depending on their home port (maritime transport as opposed to captive fleets from the port in question), and on the other hand segmented depending on the type of use (characterising 3 use types (quayside fuelling, onboard fuelling, propulsion)).

4) The deduction of the power/consumption in diesel/fuel.

5) And the estimation of market share "converted hydrogen power" at between 30% and 50% by 2050.

3 | STATIONARY APPLICATIONS AND NON-INTERCONNECTED ZONE

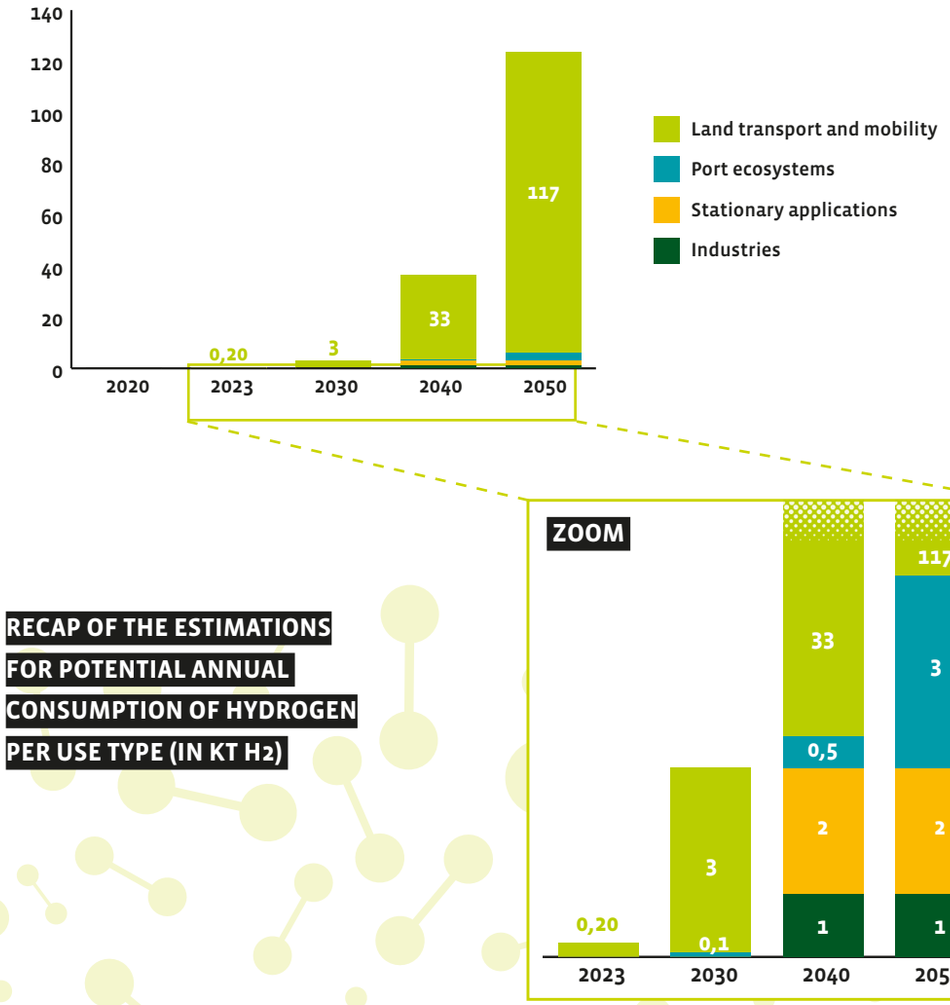
The potential is considered as low across the territory, so no consumption hypothesis is indicated before 2030.

4 | INDUSTRY

The results of the survey indicate that very few Brittany industries are using hydrogen

5 | CONSUMPTION ESTIMATIONS

RECAP OF THE ESTIMATIONS FOR POTENTIAL ANNUAL CONSUMPTION OF HYDROGEN PER USE TYPE (IN KT H2)



B. Estimation of the hydrogen productions required to meet demands

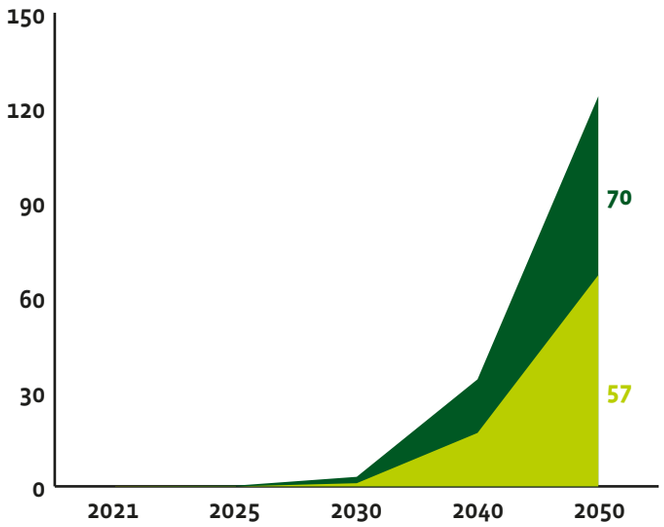
Method

The strategic regional study is based on the analysis of the projection by 2050 of mature industrial hydrogen production technologies, whose technical and economical configurations are already known to us, namely reforming of biogas and electrolysis.

The other technologies under development (hydrogasification, pyrolysis, and other organic procedures for transforming biomass, etc.) have not yet reached a sufficient technical and economical maturity but will also be available by 2030.

The difficulty of integrating future production technologies led to the decision to present a scenario adapted as closely as possible to consumption needs in the table below.

ESTIMATION OF PRODUCTION REQUIREMENTS TO MEET DEMANDS (KT/YEAR)



Biogas reforming
(which could be replaced by other processes)

Biogas reforming is the process consisting of producing hydrogen through the action of overheated steam on natural gas: under the effect of the steam and heat, the atoms in the methane (CH_4) separate and are rearranged as (H_2) and carbon dioxide (CO_2).

Electrolysis

Electrolysis is a process consisting of the production of hydrogen from electricity. It involves using an electric current to dissociate water molecules (H_2O), to produce dioxygen (O_2), and dihydrogen (H_2).

The study showed the consistency with the potential for renewable electricity and biomass resources, available in Brittany.

II. Identification and validation
of opportunities and implementation of projects

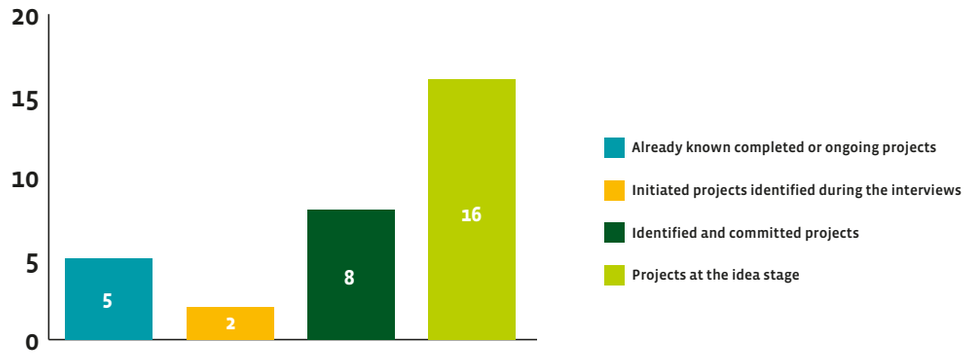
Method

Three types of territory were identified during the study:

1. Territories already implementing concrete projects.
2. Territories expressing an interest in renewable hydrogen in the pre-project or consideration phase.
3. Territories just discovering renewable hydrogen.

Overview of the identified projects

HYDROGEN PROJECTS IDENTIFIED IN BRITTANY (THE RESULTS OF 42 INTERVIEWS)



The projects relating to renewable hydrogen mobility, uses and infrastructures, are the most advanced/mature. Maritime stakeholders, and shipyards in particular, have included renewable hydrogen technologies in their projects, at different stages of progress.

Public authorities and energy syndicates are still considering the topic, with an increasing interest in mobility applications.

MAP OF RENEWABLE HYDROGEN PROJECTS IDENTIFIED IN BRITTANY

SDEF

Green Pig

SUSTAINABLE MOBILITY
CIRCULAR ECONOMY
RESPECT FOR ANIMALS AND THE ENVIRONMENT
RECYCLYING (WATER)
SELF-CONSUMPTION

H2 360°

SUSTAINABLE MOBILITY
HYDROGEN
RENEWABLE ENERGY PRODUCTION

H2-GREMM

SMART BUILDING SMART FACTORY
FLEXIBILITIES RENEWABLE ENERGY
INTEGRATION GREEN MOBILITY

Molène H2 storage

H2 STORAGE
STATIC APPLICATIONS
INTER-SEASONAL
RENEWABLE PRODUCTION
SOLAR ENERGIES
ISLAND SMART GRIDS

H2 au fil de l'eau

RENEWABLE ENERGY PRODUCTION
SUSTAINABLE MOBILITY
CIRCULAR ECONOMY

H2X

SUSTAINABLE MOBILITY
REVENUE GENERATING MOBILITY SERVICE
RENEWABLE ENERGY PRODUCTION
STORAGE

Chantier naval de Bretagne Sud

SHIP CONSTRUCTION
HYDROGEN PASSENGER FERRIES 22M/23T (TRANS-HARBOUR)

EFFI H2 Vannes

PRODUCTION OF RENEWABLE ENERGIES
ENERGY STORAGE
SUSTAINABLE MOBILITY

HYLIAS (Hydrogen for Land, Integrated renewables And Sea)

GREEN HYDROGEN SHIP CONSTRUCTION
ALTERNATIVE HIGH POWER ZERO GHG
HYDROCARBON MOTOR FUELS
QUAYSIDE LOADING INFRASTRUCTURE
STORAGE RENEWABLE ENERGY INTEGRATION

Hydrogen Demonstrator

HYDROGEN SOLUTIONS FOR STORING RENEWABLE PRODUCTIONS
DEVELOPMENT AND PROMOTION OF HYDROGEN MOBILITY
PROMOTING THE HYDROGEN SECTOR AMONGST THE GENERAL PUBLIC

Roscoff
Morlaix
Lannion
Guingamp
Saint-Malo
Île de Molène
Landerneau
Brest
Finistère
Saint-Brieuc
Dinan
Côtes-d'Armor
Carhaix-Plouguer
Edern
Loudéac
Rennes
Ille-et-Vilaine
Fougères
Vitré
Quimper
Pontivy
Crédin
La Roche-aux-fées
Concarneau
Morbihan
Lorient
Belz
Vannes
Redon

Among the highlights of this identification of project opportunities and realisations:

- **EMERGING RENEWABLE HYDROGEN ECOSYSTEMS,** concerning mobility, maritime and fluvial, production, storage.
- **INNOVATIVE INDUSTRIAL PROJECTS** (for biomethane in particular).
- **A PRODUCTION MIX IN PROGRESS.**

The projects approved by the SMILE association (June 2020) can be found online on the smile-smartgrids.fr website, in the projects section.

III. Map of existing expertise

145
STAKEHOLDERS

78
BUSINESSES

44
LOCAL AUTHORITIES
and operators of port and airport infrastructures

15
STRUCTURES
for support and innovation

8
ESTABLISHMENTS
for research and training

Results of a survey carried out in summer 2019

FOCUS ON BUSINESSES

70%
SMBS

48%
OF STAKEHOLDERS
would like to introduce renewable hydrogen in the short term

within 2 years

Expertise identified across all areas of the value chain

DIVERSITY OF STAKEHOLDERS

PROVIDERS OF SOLUTIONS

- Energy production
- Storage
- Transport, distribution
- Conversion
- Services (studies, regulations & safety)

POTENTIAL USERS

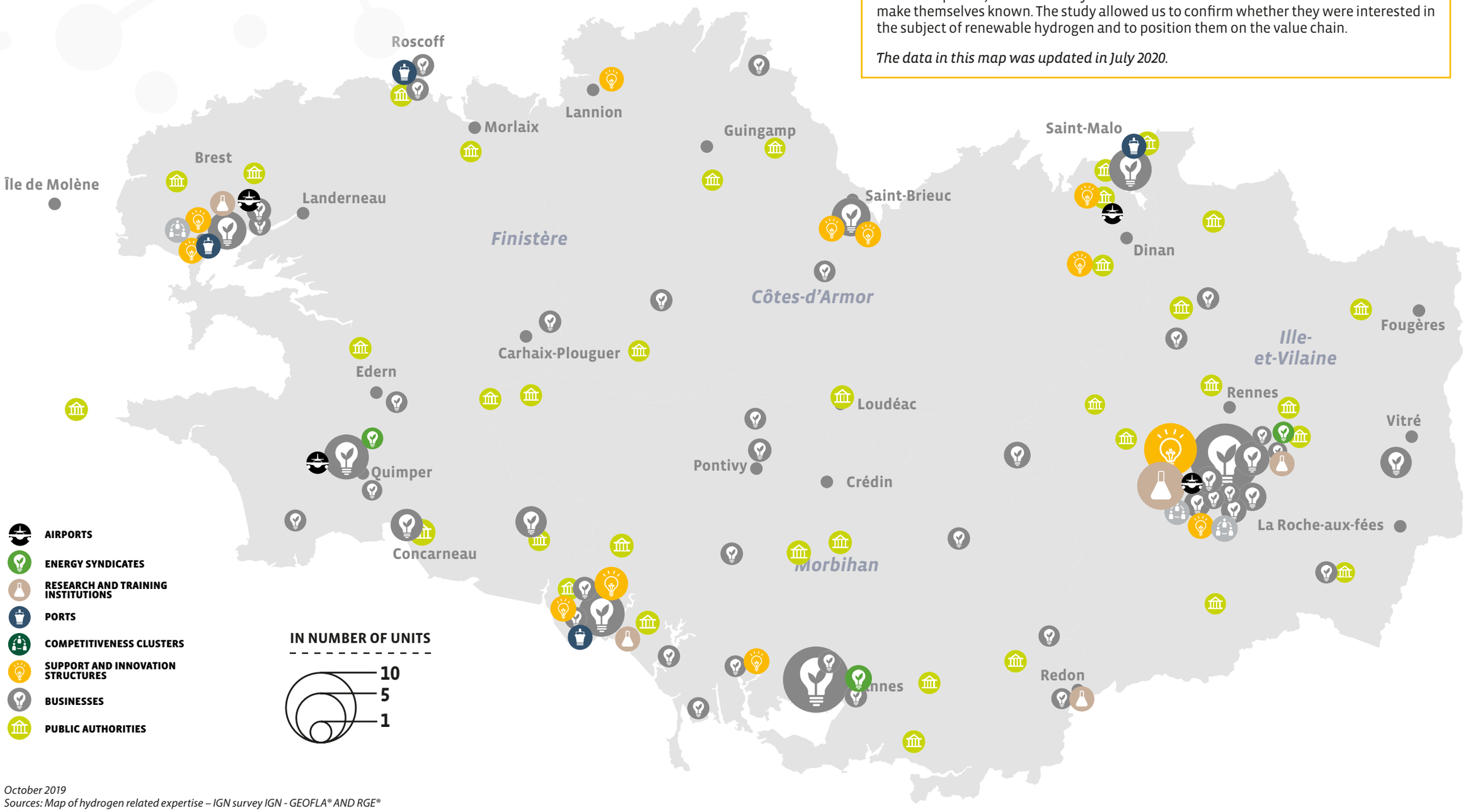
- Road, maritime freight transporters
- Logistics hubs
- Businesses with large fleets of vehicles (light utility vehicles)
- Stationary (supply for non-interconnected zones, sensitive sites) and industrial applications identified

MAP OF THE EXISTING EXPERTISE OF RENEWABLE HYDROGEN STAKEHOLDERS IN BRITTANY

Method

This data was collected during a survey carried out among 400 stakeholders, pre-identified for their expertise, and then widely communicated so that non-identified stakeholders could make themselves known. The study allowed us to confirm whether they were interested in the subject of renewable hydrogen and to position them on the value chain.

The data in this map was updated in July 2020.



October 2019
Sources: Map of hydrogen related expertise – IGN survey IGN - GEOFLA® AND RGE®
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IV. Principal recommendations
of this study

TIMELINE

by **2025**

initiate the territorial ecosystem (starting from projects already identified in the territory).

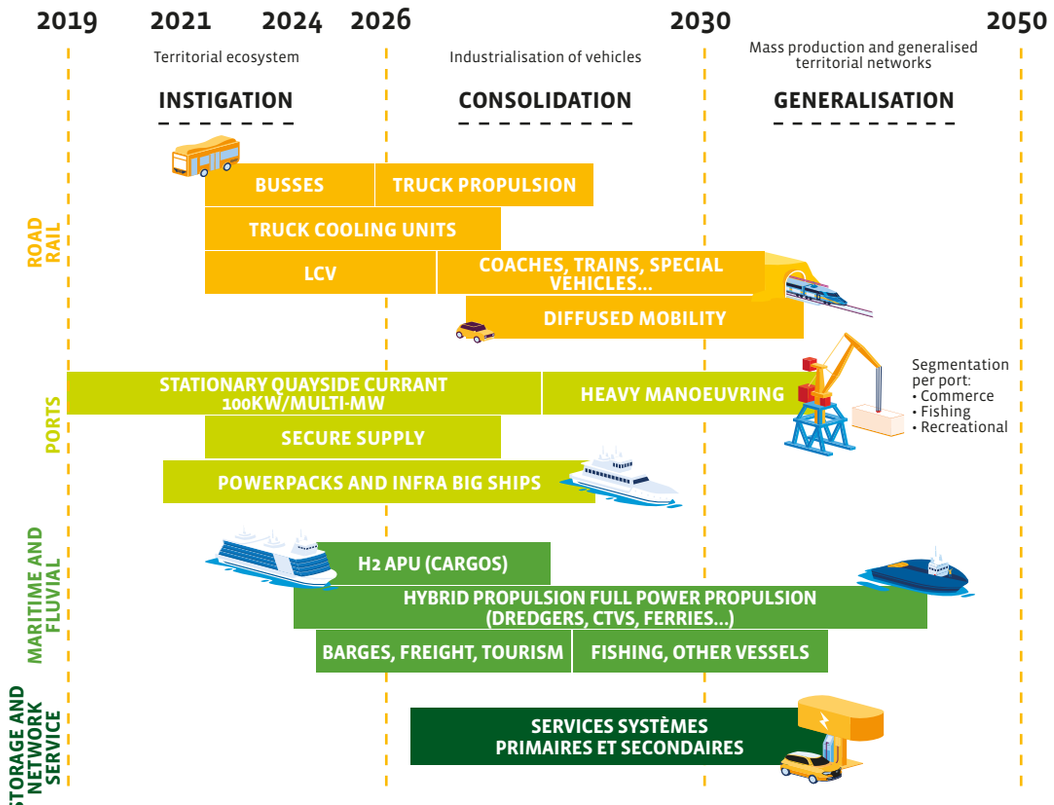
by **2030**

consolidate the market share under the simultaneous influence of public demand and the industrial offer.

by **2050**

accompany the general deployment of production and distribution infrastructures and the industrial offer.

USES AND PRODUCTION
PERSPECTIVES FOR BRITTANY



The potential for cooperative European projects for the development of hydrogen:

SINCE 2019, THE BRITTANY REGION HAS BEEN FEDERATING A FIRST PARTNER CIRCLE OF 17 NORWEGIAN, FRENCH, PORTUGUESE, GREEK, BELGIAN AND NETHERLANDISH REGIONS WITHIN THE EUROPEAN S3 PLATFORM "HYDROGEN VALLEYS". IT ALSO ASSOCIATES THE HYDROGEN EUROPE INDUSTRIAL GROUP AS WELL AS THE EUROPEAN PUBLIC-PRIVATE PARTNERSHIP FCH JU ON A ROADMAP FOR THE DEVELOPMENT OF H_2 PORT, MARITIME, AND FLUVIAL ECOSYSTEMS.

The objectives of this platform, bringing together 31 European regions, is to contribute to the industrial modernisation of the regions in the field of hydrogen, but also to accelerate their transfer from the laboratory phase to the markets by increasing European funding.

The member regions agreed on the principle of mutualising expertise and industrial know-how to rise to the challenges of an emerging, robust and structured, European sector of excellence, capable of demonstrating its competitiveness among international players and in particular Asian stakeholders, and organised from now on around a shared roadmap and project, including:

- The implementation of a large community of port authorities and ship-owners.
- Coordination of public/private investment projects, through the synchronised facilitation of the industries of partner regions to implement appropriate port logistics for fleets of hydrogen ships, in particular for the production of hydrogen in the key maritime and fluvial ports of partner regions.
- The definition and set-up of industrial cooperation initiatives around shared regional, national, European, and private funds, and by proposing and facilitating cooperative projects as European Projects of Common Interest.

GROUP COORDINATION
«ÉCOSYSTÈME MARITIME ET PORTUAIRE H2»

https://s3platform.jrc.ec.europa.eu/hydrogen-valleys

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