ENGIE × HYDROGEN

Speeding up carbon neutrality

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1

Why has ENGIE chosen hydrogen?

OUR HYDROGEN TARGETS FOR 2030

4 GW
of green hydrogen production capacity

700 km
of dedicated hydrogen networks

1 TWh
of installed storage capacity

Over
100
refuelling stations in operation

Why have we chosen hydrogen?

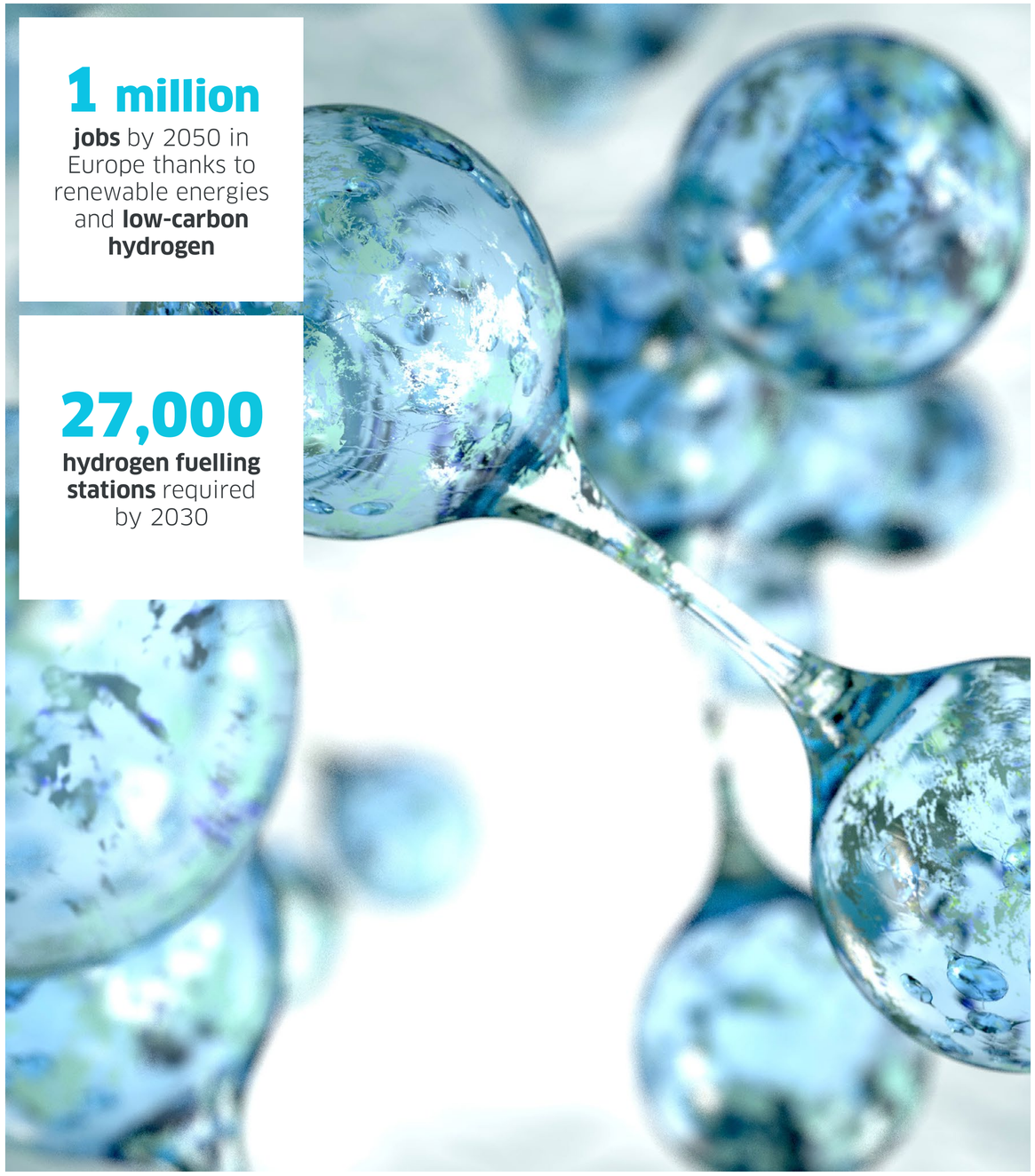
At ENGIE, we believe that a diversified energy mix is the key to a carbon-neutral future. For our business, public and private clients.

We invest in all renewable energy sources – wind, solar, biogas, biomass, etc. and we are now also undertaking **an ambitious programme to develop our hydrogen production, transport, storage and distribution capacities.** Due to the intermittent nature of renewable energies, clients may hesitate to develop them. Green hydrogen storage presents the solution to this equation.

Whether renewable, low-carbon or produced from natural gas whose CO_2 is captured, this gas can be stored in underground salt caverns over long periods of time. It can then be injected in the gas network **for multiple uses, particularly for industry and mobility, or converted into low-carbon electricity.**

Industry, heavy mobility, etc. We are ready to invest in order to allow these sectors which produce heavy amounts of greenhouse gases to decarbonise their production and uses thanks to hydrogen.

Valérie RUIZ-DOMINGO,
GROUP HYDROGEN VICE PRESIDENT



1 million
jobs by 2050 in Europe thanks to renewable energies and **low-carbon hydrogen**

27,000
hydrogen fuelling stations required by 2030

Because green hydrogen promotes short energy supply chains and local jobs

We believe that green hydrogen has introduced a paradigm shift. Instead of importing fossil fuels, we can produce this gas from locally-established renewable energy sources. **Industrial companies and local authorities can use it for their production or to decarbonise their uses,** which they can pool by creating hydrogen ecosystems.

The development of green hydrogen represents the promise of a new industrial sector along with the associated jobs. ENGIE possesses major assets to stimulate its development. Firstly, we rely on detailed knowledge of the regions in which we operate. Secondly, **we operate across the entire value chain, from the development and financing of hydrogen projects** to the sale to end clients, bringing together all local players through adapted solutions.

2

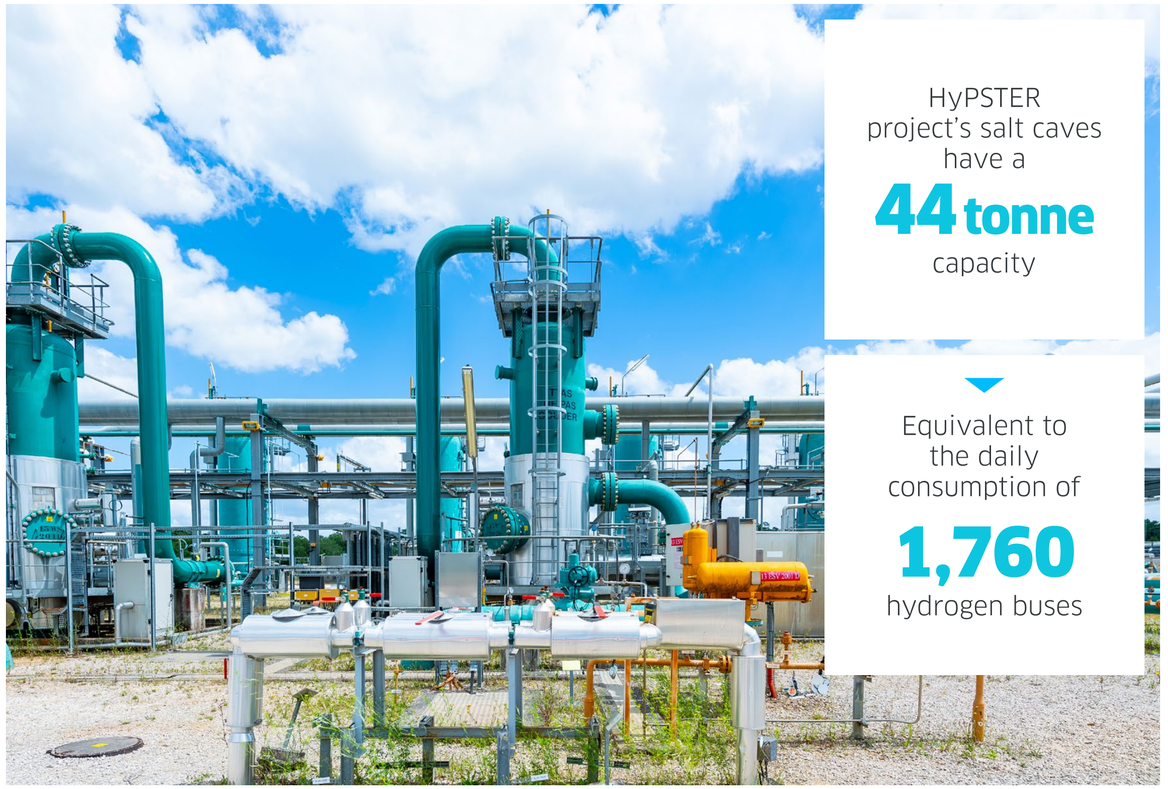
How ENGIE is decarbonising thanks to hydrogen

STORING & PRODUCING DECARBONISED ENERGY

As a long-standing expert in the storage of natural gas, ENGIE has the capacity to efficiently manage hydrogen stored in salt caverns. As such, thanks to **"Power-to-Gas"**, we can produce electricity according to our clients' needs. Within the Group, our Storengy subsidiary is deploying this technology: renewable hydrogen is produced from green electricity, stored locally and then re-injected into the gas network to meet industrial (production process, electricity, etc.) and mobility needs.

Developed by Storengy, **HyPSTER** is the first EU-supported salt cavern storage project. Combining renewable hydrogen production, storage and destocking, the demonstrator will be commissioned in 2023 in an area close to the Zero Emission Valley, at the crossroads of multiple uses, and which prefigures a European hub.

Storengy, a subsidiary of ENGIE, is France and Europe's leader in storage and the commercialisation of energy storage capacity.



HyPSTER project's salt caves have a

44 tonne

capacity

Equivalent to the daily consumption of

1,760

hydrogen buses

The shift to hydrogen at an industrial scale requires the development and adaptation of not only our storage infrastructures, but also those of transport in the energy system of the future. At ENGIE, we are preparing their transformation in order to transport hydrogen to areas where renewable energy sources are less developed. The key to successfully developing green hydrogen lies in our capacity to maximise our large-scale economies and to further R&D on compression and storage.

H_2 MOBILITY

The development of hydrogen is driven by its promising uses in all types of mobility. ENGIE participates in the creation of this new energy alongside equipment manufacturers and industrial players.
ENGIE is already getting ahead with several experimental projects and demonstrators on heavy mobility (HGVs, trains, ships) and intensive mobility (heavy plant utility vehicles), both in France and worldwide:

2017

Launch of the **Zero Emission Valley (ZEV) project** in the Auvergne-Rhône-Alpes region, with the construction of three hydrogen fuelling stations to supply the energy for a fleet of 1,200 vehicles by 2023.

2019

Energy supply for **hydrogen buses in Pau** (Pyrénées-Atlantiques) at France's first ever hydrogen charging station for buses.

2020

Energy procurement for the **first renewable hydrogen train** in the Netherlands, during a pilot test which paves the way for large-scale rollout in the rail sector.

2020

Partnership with ArianeGroup to optimise the renewable hydrogen liquefaction technology for maritime and river mobility.

2021

Joint development of a supply chain alongside **the Anglo American mining group** in South Africa, to bring the world's first green hydrogen mining truck into service.

2025

Large-scale deployment of renewable hydrogen in industry, transport and energy production.

H_2 IN INDUSTRY: RAW MATERIAL AND ENERGY SOURCE

By developing the use of renewable hydrogen as an energy source in industry, we contribute to the decarbonisation of its production and promote the development of new industrial sectors in the region and internationally:

2019

Yuri project in Australia: Conversion of the Yara fertilizer manufacturer plant in Pilbara to produce renewable ammonia from green hydrogen (instead of grey hydrogen). Commissioning date: 2024

2020

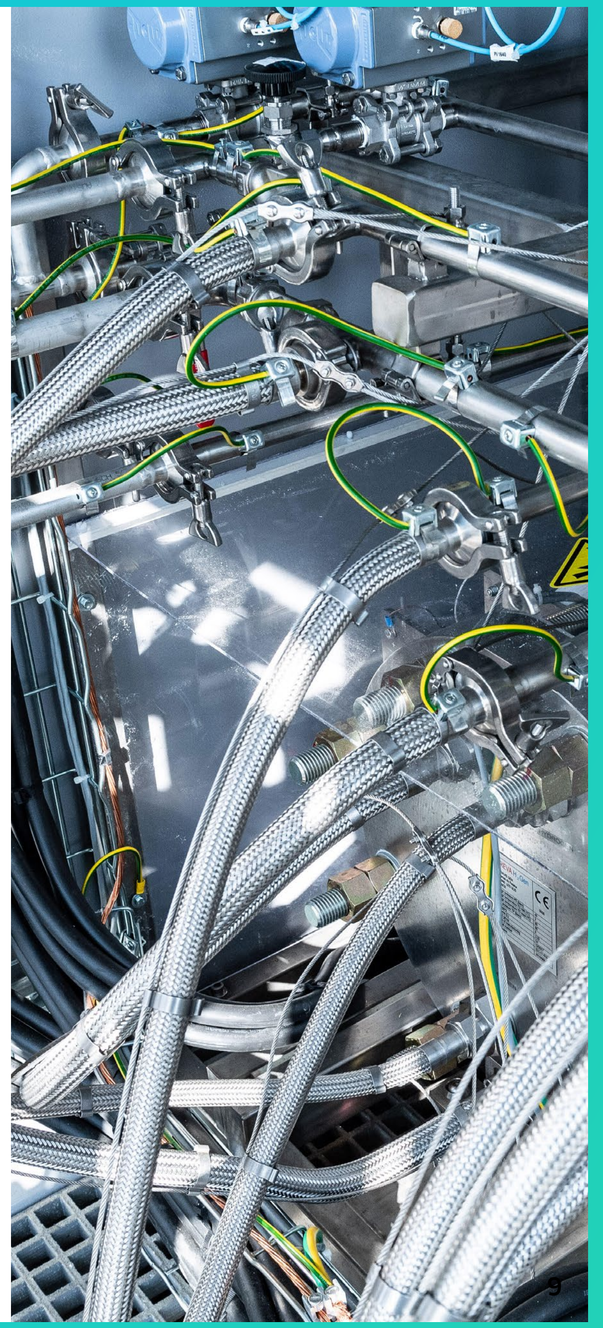
HyNetherlands project: deployment of an electrolyser at Eems power plant near Groningue and produce renewable hydrogen for industry and heavy goods transport The electrolyser will be built in stages: 100 MW as of 2025, then an additional 750 MW by late 2020, up to 2 GW by 2030.

2021

Masshylia, in partnership with TotalEnergies and supported by the Sud-Provence-Alpes-Côte d'Azur region: development, design, construction and operation of one of the largest renewable hydrogen production sites in France at the La Mède bio-fuel refinery. Commissioning date: late 2024 - early 2025.

2021

HyEX project with Enaex in Chile: production of green hydrogen to supply an ammonia plant. Commissioning date: 2025.



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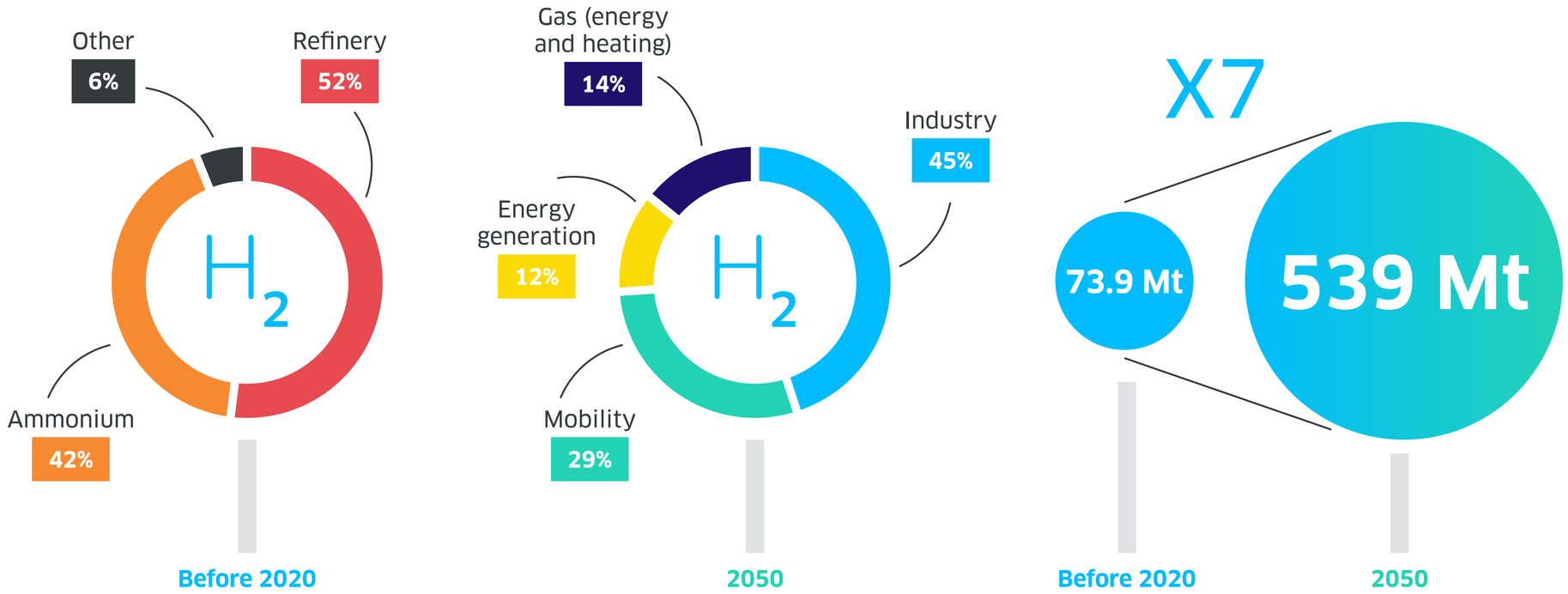
Hydrogen energy in the future

HYDROGEN USES



Sources: IAE and Hydrogen Council.

H_2 R&D AND INVESTMENTS!

Renewable hydrogen is also our researchers main focus at ENGIE Lab CRIGEN, our R&D centre dedicated to green gases and new technologies for the energy transition. They are notably involved in standardising the protocols for filling vehicle hydrogen tanks and conducting research to ensure the high level of purity of the hydrogen required for use in fuel cells. They also support regions by assessing scenarios for reducing CO_2 emissions from transport and proposing appropriate solutions.

The challenge for environmentally-conscious innovations such as methanisation, pyro-gasification and hydrogen is to transition into the industrialisation phase.

Adeline DUTERQUE,
MANAGING DIRECTOR ENGIE LAB CRIGEN

95%
decrease in CO_2 emissions thanks to hydrogen

Liquid hydrogen production is expected to be **distributed at service stations**
by 2025

FOCUS

IN SINGAPORE, OUR EXPERIMENTAL LAB FOR H_2 AND RENEWABLE ENERGIES

We are heavily investing to improve hydrogen production techniques and to make this industrial sector viable. Our **REIDS-SPORE initiative** in Singapore is part of this goal. On the small island of Semaku, in the City-State, we have set up a test and research platform for low-carbon energy. Our goal is to demonstrate how energies complement one another. REIDS-SPORE is made of a micro-grid of 550 kW, including, amongst others, a 100 kW wind turbine and a complete hydrogen chain with an electrical capacity of 50 kW/2 MWh. Notably, this network includes a hydrogen fuelling station with a fuel cell electric vehicle.

REIDS-SPORE meets the Group's ambition to tirelessly look for the most efficient low carbon energy solutions. In a tropical climate such as this one, we provide a framework for our industrial customers, research centres and our partner, Nanyang University, to grow with us in terms of energy decarbonisation, smart grids, energy efficiency and smart cities.

Loic VILLOCEL,
DIRECTOR OF ENGIE LAB SINGAPOUR

FOCUS

H_2SITE, REVEALING AMBITIONS

We are an internationally-recognised energy company with historical expertise in gases, including hydrogen. We support the players in the hydrogen value chain, in the development of this promising sector, and we invest in strategic assets. For example, our venture capital subsidiary ENGIE New Ventures has **invested in H_2SITE**, a company that has created a system based on a membrane reactor capable of producing, on a client's site, high-purity hydrogen from methane, and in particular from biomethane and ammonia.

We have a very broad view of production technologies; we are looking into all options that can help develop low-carbon hydrogen.

Secil TORUN,
HYDROGEN LAB TEAM LEADER,
ENGIE LAB CRIGEN

Over
20
ongoing European
research projects

2 questions

Andrés GALNARES,
CEO OF H_2SITE

What does the H_2SITE reactor bring to the hydrogen sector?

It allows the production of cheap, local and renewable hydrogen for industry and mobility. The goal is to trigger a transition to a hydrogen economy on a world scale. We estimate that this transition will take place within ten years.

How did H_2SITE come to be?

The company was created through a collaboration between the Tecnalia research and technology centre (Spain) and the Eindhoven University of Technology (Netherlands). Together, they sought out an industrial partner to help them market this technology. And it is ENGIE who, after assessing the system, decided to back it up. ENGIE also acquired a share of H_2SITE, and ENGIE Lab CRIGEN has since strengthened its R&D partnership with Tecnalia and the Eindhoven University in order to further develop the emerging applications of this technology.

Help the sector take off in order to increase the competitiveness of low-carbon hydrogen

The challenge for the general industry is to replace the current production of hydrogen (390,000 t/year in 2019, at 95% grey) with green hydrogen. However, the latter remains more expensive to produce, at over €4/kgH according to ADEME. Conditions for cost reduction: lowering industrialisation investment costs, extending the life of electrolysers, improving yields, and pooling industrial and mobility uses to improve the profitability of projects. In this pre-industrialisation phase, European public authorities are backing the emergence of a hydrogen economy. To date, 23 countries have joined the European Alliance for Clean Hydrogen, while several countries have also announced hydrogen plans, such as Germany and France, who will allocate 2 billion over 5 years of its France 2030 plan to help speed up the hydrogen sector.

BETTER UNDERSTANDING HYDROGEN THROUGH VIDEO

https://youtu.be/gl6lBnX4xoQ

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