ABSOLUT Hydrogen

absolut-hydrogen.com



# **LIQUID HYDROGEN** INNOVATIONS FOR **MOBILITY & ENERGY TRANSPORT** THANKS TO CRYOGENICS EXPERTISE

The production, storage and distribution of hydrogen in a liquid state will be necessary to expand commercial applications. We are capable of decentralized and scalable liquid hydrogen production allowing the operator to maintain a high level of autonomy while reducing financial and environmental costs.

Our mission is to provide a solution for the whole chain with innovative technologies. We handle all types of hydrogen applications : mobility, on-site energy production, energy transportation for hydrogen powered transports.

+ H2 Liquefaction & boil-off management
+ Thermal management for onboard storage
+ Standardized liquid to gas process for fuel cells

# ACCESS TO HYDROGEN ENERGY :

# LIQUID HYDROGEN TECHNOLOGIES FOR MOBILITY SECTOR & ENERGY TRANSITION

**Absolut Hydrogen is a French engineering and industrial SME based in Grenoble. In response to the climate emergency, we devise innovative solutions by building a circular, profitable and low carbon economy.**

To optimize reliability and cost-effectiveness, we try to minimize hydrogen flows and bring hydrogen production, storage and use as close as possible, depending on on-site logistic & economical constraints. Our goal is to help you lower your emission from production to on-site implementation and distribution : this is the best cost-effective solution, with a high level of independency.

By reducing the volume of hydrogen through liquefaction, we increase the storage density. You can produce, store the quantity required for your infrastructure and limit transport cost at the same time.

**With strong partnerships Absolut Hydrogen is devising on site implementation from definition to operation :**

- Specify the hydrogen supply chains specific needs ;
- Procedures, security management and deployment plan ;
- Component and technological procurement, installation, and training ;
- Support to operation.



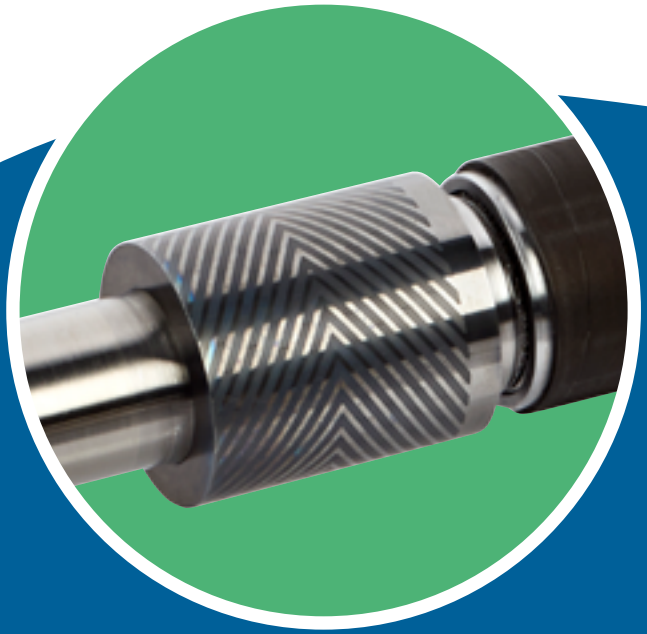
## Our specific skills

Thanks to our technical skills and know-how around hydrogen we have all the resources to design customized solutions. All the technical tools are mastered to carry out all the preliminary studies up to the validation of the concepts to allow the implementation of the solutions on site.

Absolut Hydrogen benefits from more than 20 years of cryogenic system development from its sister-company, Absolut System.

**We answer your needs from liquid hydrogen production, to distribution and use with specific technological know-hows :**

- Thermodynamics, thermal and fluid processes ;
- Internal pressure management with modeling of thermohydraulic behavior and storage lifecycle ;
- Cryogenic storage : Hydrogen management in liquid or supercritical form ;
- Transfer control of liquid hydrogen and recondensation of the boil-off.



## Maintenance-free technologies

Thanks to our contactless bearings technology, we allow minimum maintenance requirement: Absolut Hydrogen's cryopumps & cryofan are using innovative centrifugal technologies, reducing significantly its wear and tear.

**Our liquid hydrogen turbomachines :**

- LH2 pumps ;
- Cold hydrogen vapor compressors.




## PRODUCTION :
### Reinventing tomorrow's circular eco-responsible economy using renewable energy.

**Vehicles and aircrafts need to optimize their operational efficiency and adapt to new environmental standards.**

Absolut Hydrogen invests in designing liquefaction equipment using its cryogenic expertise, to supply liquid hydrogen where it's the most relevant.

**We provide tailor-made solutions at affordable prices thanks to our expertise in :**

- Mobile micro-liquefiers
- Decentralized hydrogen mini-liquefiers
- Engineering services in research and development




## DISTRIBUTION :
### Liquid hydrogen to reduce the cost of energy transportation.

**Absolut Hydrogen is able to support dimensioning of the upstream value chain up to vehicles tank filling, taking into account mutualization possibilities.**

Thanks to our mastering of liquid hydrogen at cryogenic temperature (20K / –253°C) we answer loss problems during transport, storage and transfers :

- Superconductivity
- Boil-off management & reliquefaction
- Thermodynamic compression system
- LH2 pumps for liquid refueling stations




## USE : From LH2 to energy
### Decarbonizing on-ground and air transportation.

**Vehicles end their journey with thermo-hydraulic conditions far from optimal : with high pressure and "hot" liquid hydrogen.**

We provide the thermal and fluidic management, from the LH2 tank to its use by PAC (LtoG). Absolut Hydrogen optimizes thermal flows and synergies between subsystems.

- Onboard component synergies
- Thermo-hydraulic management & standardize process
- Cryo-compression for energy-density management

## Complete liquid hydrogen management :



# LIQUID HYDROGEN & LIQUEFACTION

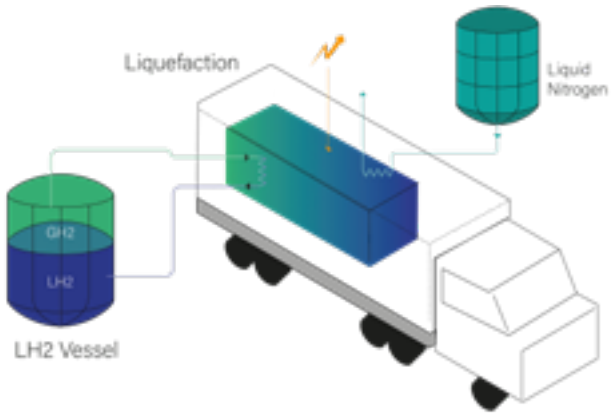
## Liquid Hydrogen will enable the next step towards more sustainable transportation.

At Absolut Hydrogen we believe that liquid hydrogen is currently the **most practical state** for low-carbone mobility development and the energy sector. Absolut Hydrogen gives each customer the technological capabilities to access a liquid hydrogen supply, thanks to our expertise in cryogenics from **Absolut System.**

+ **Liquefaction of LH2 is necessary to contain a larger mass in a smaller volume, allowing for longer distances to be driven without reducing cargo space, suiting better practical and economical needs.**

## MOBILE LIQUEFIER
### Up to 100kg / day

**Absolut Hydrogen provides high density and standardized hydrogen at all times and places using a mobile hydrogen liquefier able to adapt at the last minute and everywhere.**




Liquid hydrogen has special physical properties and expands even when only slightly heated up. Absolut Hydrogen's mobile liquefier provides the best options to keep **maximum density.** In addition, using a mobile liquefier allows the **recovery of GH2** and **LH2** leftovers and also the creation of a virtuous loop within the tank, maximizing LH2 density and guaranteeing greater autonomy.

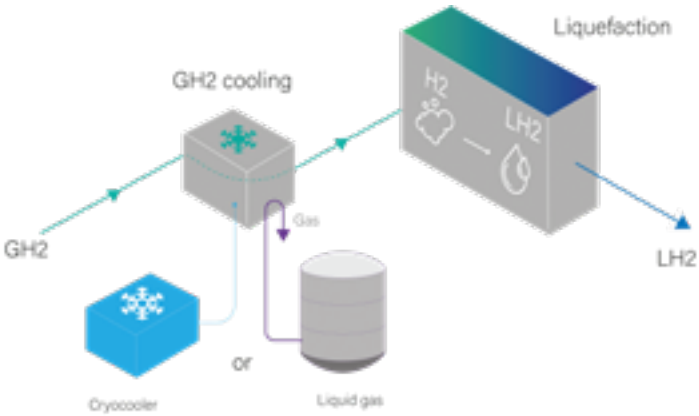
As a result, Absolut Hydrogen mobile liquefier technology leads to repeatable filling at a nominal density close to 70kg/m3, and a low pressure. Perfectly adapted for any intensive transports such as **aircrafts, ships, trucks** and **forklifts.**

**Using a mobile liquefier station :**

+ Provide high density and standardize hydrogen at all time and place.
+ Able to adapt at the last minute and everywhere.
+ Give maximum autonomy while stopped, limiting boil-off and loss.

## DECENTRALIZED LIQUEFIER
### Up to 1T / day
### Adaptable to hard-to-reach areas

**Absolut Hydrogen aims to meet the challenge of accessing on-site production of decarbonized hydrogen in large quantities, with a reduction in OPEX, to supply green hydrogen at fossil fuel prices and accelerate energy transition.**




This hydrogen liquefier enables the storage of large quantities of hydrogen in a limited space, which makes it possible to **decentralized production** of liquid hydrogen very close to production or distribution hubs. Thanks to its compactness, low maintenance costs, high availability and size, Absolut Hydrogen liquefier is ideal for remote areas.

With an electrolyser-liquefier coupling, it allows to obtain a short circuit source of LH2. Directly connected to renewable electricity generator (solar/ wind), our solution gives you access to green LH2.

**Using a 1T/ day decentralized liquefier :**

+ Facilitate green hydrogen production and distribution.
+ Maintenance-free liquefier with or without external cold power.
+ Adapted to intermediate transport hub for LH2 supply.

# REDUCING ENERGY LOSS FOR VIABLE HYDROGEN PRODUCTION AND DISTRIBUTION

## Reducing the cost of distribution and increase the availability of LH2.

The energy transition has to address the economic constraints of companies and be affordable for the end consumer. The only way to achieve this goal is by designing a supply chain that **minimizes energy losses** during production, storage, distribution and use.

+ **Absolut Hydrogen proposes to greatly increase the efficiency of liquid hydrogen by leveraging the unique properties of superconductivity for energy transport.**
+ **We can also meet your needs for evaporation loss management with our reliquefaction systems adapted to logistical issues.**

## SUPERCONDUCTIVITY & ENERGY TRANSPORT

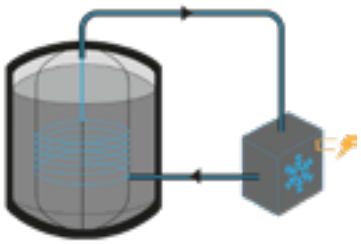
**Absolut Hydrogen is invested in energy transport by superconducting cables (electrical and LH2 combined) to offer a mutualized and efficient distribution of electrical energy and hydrogen.**

The transport of LH2 and renewable electricity offers superior economic competitiveness and allows for a 100% renewable energy transition. Thanks to its cryogenic expertise and strong partnerships, Absolut Hydrogen offers to mutualize LH2 at 20K and electricity to considerably reduce energy loss.






Hydrogen overpressure venting



Reliquefaction of GH2

## RELIQUEFACTION & BOIL-OFF PROBLEMS

**The boil-off phenomena, resulting from the liquid warming up and transitioning to a gaseous state, is traditionally dealt with by venting the gas to the air to avoid overpressure in the tank.**

As hydrogen interacts with methane in the atmosphere and becomes a greenhouse gas 200 times more potent than carbon dioxide, it's crucial to limit venting and minimize hydrogen leaks.

We aim to create a virtuous and circular ecosystem without energy loss, in a world driven by rising energy costs and a better awareness of energy savings to address global warming. Dealing with boil-off through reliquefaction is the best way to maximize reliability of hydrogen use.



# TRANSFERS & REFILLING PROCESS

## Liquid to Liquid | $LH_2$ pumps for liquid refueling stations

In order to refuel a cryogenic tank with liquid hydrogen, one solution consists of pressurising the upstream tank in order to provide a sufficient pressure difference to flow liquid hydrogen to the application tank.

This simple solution could lead to high vaporization and non-optimized thermo-hydraulic conditions in the application tank. Furthermore, the upstream tank will have to support a pressure of 5 to 10 bar. Alternatively, a liquid pump can be used to provide a pressure difference to flow the liquid hydrogen.

+ **Absolut System is developing small and mid-range liquid hydrogen pumps to perform cryogenic tank filling without upstream tank pressurisation. Thus, the upstream tank is maintained at a low pressure and the thermohydraulic state of liquid hydrogen in the application tank is preserved.**






# ON-BOARD THERMAL MANAGEMENT

## Enabling liquid hydrogen use for sustainable mobility

In a decarbonized energy ecosystem, hydrogen must be produced from renewable (wind, solar) or nuclear electrolysis. In the coming transition period, the democratization of its use can only be achieved if it meets economic viability conditions.

However, hydrogen vehicles mainly use fuel cell technologies that rely on compressed GH2 stored in high-pressure composite tanks. This technology is sufficient for fuel cell electric vehicles using gaseous hydrogen for short distances and urban mobility.

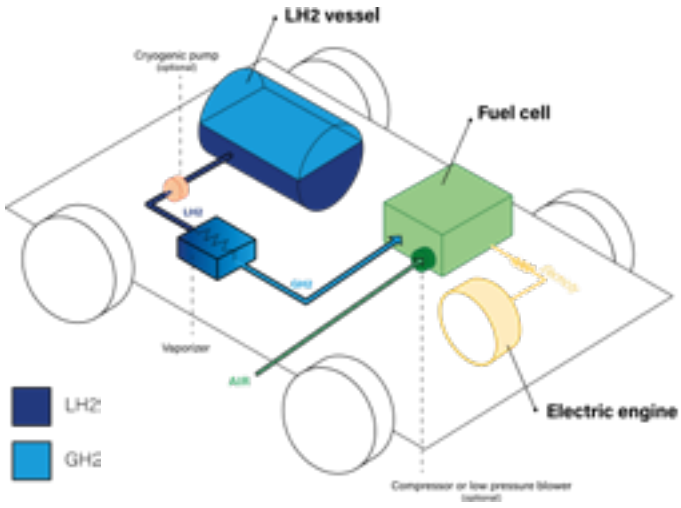
+ **Only LH2 can meet the growing demand for intensive or long-distance transport. Hydrogen engines running on fuel cells are compatible with on-board liquid hydrogen storage, requiring only a conversion from liquid to gaseous state thanks to the synergy of the components.**

# STANDARDIZED LIQUID TO GAS ONBOARD PROCESS

**Absolut Hydrogen designs complete on-board vehicle systems for our customers. The overall management of the hydrogen chain optimizes flows, improves profitability and ensures maximum security.**

As we see an increasing demand on gaseous hydrogen for vehicles, we are looking further afield and already working on tomorrow's solutions. By designing liquid hydrogen tanks as well as the entire circuit integrated into vehicles, we give new opportunities to reinvent zero-emission mobility and act for energy transition.

**We optimize thermal management circuits to create a synergy between in-vehicle fluids and components.** As the LH2 needs to be warmed-up to be used in the fuel cell, and integrated electronics need to be cooled down, Absolut Hydrogen develops and chooses the best heat exchangers and internal hydrogen circuit to offer compact, efficient and smart thermal management.












## ABSOLUT HYDROGEN
### SOLUTIONS FOR ENERGY TRANSITION :

- R&D, preliminary and advanced studies, mobilization of partnerships ;
- **On-site** liquefaction and management of daily quantities ;
- Active or passive storage, thanks to innovative storage tanks and technological bricks, and by managing losses.
- The **transfer** of liquid to applications, either in gaseous form (compressed H2) or in liquid form ;
- **Use of LH2 by PAC :** management of hydrogen on board, from liquid to gaseous state, by ensuring the right mass flow rate, temperature and pressure.

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