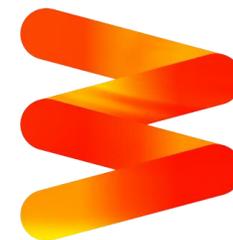


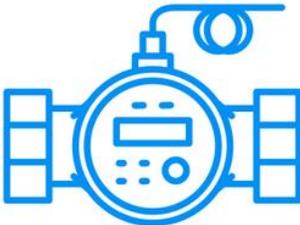
# Hydrogen Solutions Guide

of the electrodigital industry



Edited by **GIMELEC**

As part of its partnership with  **France Hydrogène**  
Engagée pour la transition écologique



**White paper**  
**Instrumentation**



# Introduction



## About the GIMELEC Hydrogen Commission

GIMELEC Hydrogen Commission brings together more than 50 manufacturers and solutions providers active across the entire hydrogen value chain, from production to transport, storage and use (industry, mobility, H<sub>2</sub>-to-Power, etc.). Their solutions allow project developers to optimize the operation, safety, costs and environmental footprint of hydrogen installations.

<https://gimelec.fr/hydrogene>



## About this guide

This publication is intended for project developers and integrators. It has been redacted by GIMELEC as part of its partnership with France Hydrogène. **The first part is a "white paper"** identifying the challenges and constraints for each link in the hydrogen value chain; the [second part](#) presents the solutions to meet them and is a directory of GIMELEC companies.

GIMELEC companies offer solutions for electrolyser power supply, automation and instrumentation. This part of the guide is dedicated to instrumentation. Find the two other sections at the following [link](#).



## About GIMELEC

GIMELEC brings together companies from the French electronics and digital sector. Our 210 members design, manufacture and deploy electrification, automation and digitalisation solutions for industry, buildings, mobility, energy and digital infrastructures.

<https://gimelec.fr>



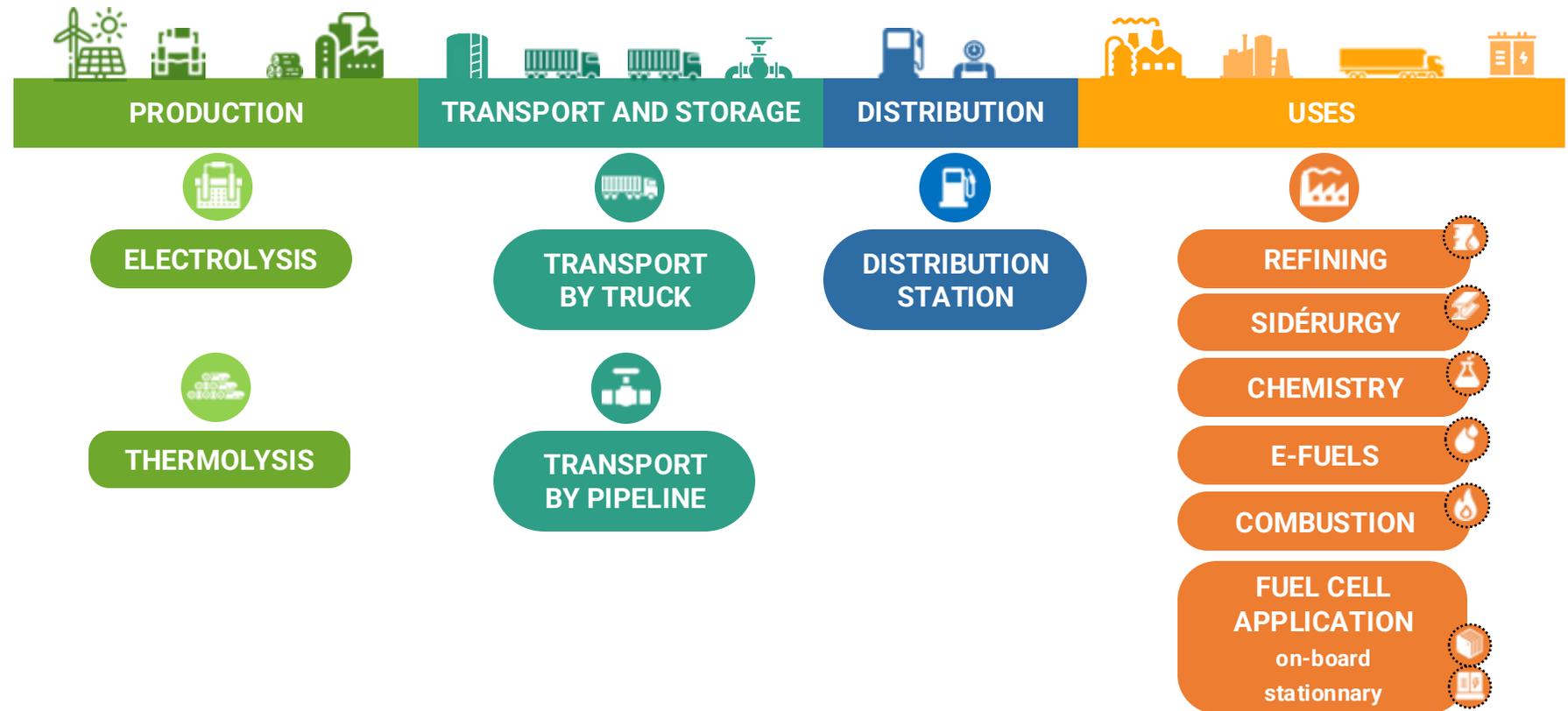
## About France Hydrogène

With 450 members, France Hydrogène brings together the players of the French hydrogen industry along the entire value chain: large industrial groups, SMEs, start-ups, laboratories and research centres, associations, competitiveness clusters and local authorities.

GIMELEC is a partner of France Hydrogène and this document follows and complements the [Panorama of Hydrogen Solutions](#) published by France Hydrogène.

## Instrumentation challenges in the H<sub>2</sub> value chain

The first part of this catalogue **introduces the instrumentation challenges of several mature hydrogen systems**. GIMELEC members support developers and manufacturers by offering **measurement and analysis solutions** tailored to meet the challenges of hydrogen control, performance, durability, reliability, quality, purity, safety and compatibility. The technologies and systems in the H<sub>2</sub> value chain covered in this catalogue are **divided into the following applications**:



## Use cases – Table of contents

p. 5		Water Electrolysis	p. 11		Siderurgy
p. 6		Thermolysis	p. 12		Chemistry
p. 7		Storage & Transport by truck	p. 13		E-fuels
p. 8		Storage & Transport by pipeline	p. 14		Combustion
p. 9		Distribution station	p. 15		Fuel cell
p. 10		Refining	p. 16		Main European regulations
			<a href="#">link</a>		Solutions and GIMELEC companies directory

## Product ranges

Each application may correspond to one or more product families. This guide lists the following **6 product families**:

	<b>Pressure measurement</b>			<b>Liquid analysis</b>	
	<b>Temp. measurement</b>			<b>Gas analysis</b>	
	<b>Flow measurement</b>			<b>Level measurement</b>	

These product families are systematically used for the applications presented in the following pages.

# Water Electrolysis

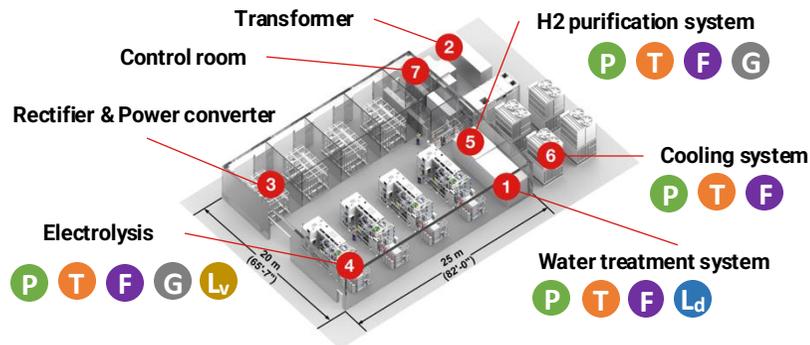


« Instrumentation adapted to the scale-up and performance levels required »

Water electrolysis is a method of **separating the water molecule into hydrogen and oxygen** by applying an electric current. There are 4 main technological families, each with its own maturity, advantages and disadvantages: Alkaline, PEM, High-Temperature, AEM.

The **multi-physical characteristic** of electrolysis systems induces new safety and control issues for operators who, as the industry ramps up, are looking for **hydrogen-specific instrumentation** to optimize their process.

## System diagram of a PEM electrolysis unit (PEM)



### LEGEND

- P** Pressure measurement
- T** Temperature measurement
- F** Flow measurement
- G** Gas analysis
- Ld** Liquid analysis
- Lv** Level measurement

Electrolysis units are divided into **2 levels** :

- **The electrolyzer, comprising the electrolysis stack** (the heart of the production unit, where the electrochemical process takes place).
- **The "balance of-plant", comprising auxiliary equipment** (fluid treatment and management, cooling, purification, electrical components, etc.).

## Challenges for electrolysis technology



### Control/Performance

Simultaneous control of pressure, temperature and flow ensures performance (efficiency, durability) and **reduces energy & maintenance costs**.



### Hydrogen and water quality

The extreme sensitivity of PEM fuel cells places stringent demands on the **purity of the H2** leaving the electrolysis unit, and on the **purity of the water** used. Water is the only input to an electrolyzer, so its purity is critical **to ensure lifetime performance**. The demand is for conductivity <2µS/cm for most customers (PEM & ALK) and sometimes <0.1µS/cm. This requires the use of several analytical instruments.



### Safety

Appropriate instrumentation prevents the build-up of high concentrations of O2 in the H2 stream (and vice versa), over-pressurization and overheating of the electrolyzer.

### Induced requirements

**H2 requirement:** 99.97% (mobility), gas measurement of 14 critical impurities

**Water requirement :** Conductivity < 0.1µS/cm / 0 hardness, 0 particle

**Sensor material issues:** corrosion, hydriding, hydrogen embrittlement, hydrogen permeation, resistance to temperature and pressure cycles.

**Certifications :** ATEX, MID-002, ISO 14687, ISO 19880-8

# Thermolysis



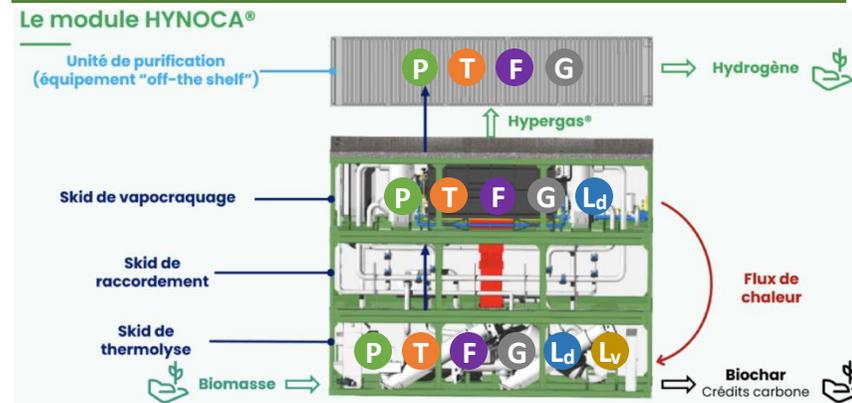
« Instrumentation adapted to the expected level of quality »

There are two main ways of producing biomass :

### Pyrogasification and thermolysis.

Pyrogasification is the succession of two processes: pyrolysis (thermal decomposition process) and gasification (transformation process of the carbonaceous and liquid part produced by pyrolysis), **producing a synthesis gas (syngas) mainly composed of H<sub>2</sub>, CO, CO<sub>2</sub> (and H<sub>2</sub>O).**

### System diagram of a thermolysis unit



#### LEGEND

- |                                  |                                      |  |
|----------------------------------|--------------------------------------|--|
| <b>P</b> Pressure measurement    | <b>G</b> Gas analysis                | <b>F</b> Flow measurement              |
| <b>T</b> Temperature measurement | <b>L<sub>d</sub></b> Liquid analysis | <b>L<sub>v</sub></b> Level measurement |

Thermolysis is a special process (more mature than pyrogasification) which involves **heating biomass to 500 °C** in the absence of oxygen, to **produce syngas and biochar (solid residue)**. The syngas is then heated to 1000°C in a cracking furnace to obtain hypergas (syngas particularly rich in hydrogen). After processing this hypergas (separation and purification), mobility-grade hydrogen is obtained.

### Challenges for biomass thermolysis



#### Gas quality

The characteristics of the material supplied must be particularly homogeneous. Indeed, **the quality and specification of inputs** (moisture, particle size, PCI, dust content, etc.) will determine the smooth operation of processes and the quality of the energy compounds produced.

In addition, the gas leaving the thermolysis process (hypergas) undergoes several operations: scrubbing stages (to remove traces of undesirable compounds such as residual soot, benzene and H<sub>2</sub>S), then purification steps (WGS<sup>1</sup>) and PSA<sup>2</sup>) to obtain pure H<sub>2</sub> for fuel cell application.



#### Safety

Sensors measure the amount of carbon monoxide. As soon as the threshold is exceeded, personnel are alerted and the system is immediately shut down. This virtually **eliminates the risk of toxic or flammable gas leaks**.

#### Induced requirements

**H<sub>2</sub> requirement:** 99.97% (mobility), gas measurement of 14 critical impurities

**Water requirement :** Conductivity < 0.1µS/cm / 0 hardness

**Sensor material issues:** corrosion, hydriding, hydrogen embrittlement, hydrogen permeation, resistance to high temperature.

**Certifications :** ATEX, MID-002, ISO 14687, ISO 19880-8

*Nota:* 1) WGS = Water Gas Shift Reaction ;  
2) PSA : Pressure Swing Absorption

# Conditioning & Transport by truck



« Instrumentation adapted to intrinsic characteristics of hydrogen »

Transporting hydrogen from production to end-use is a challenge due to its low volumetric energy density. The most widespread solution today for storing and transporting hydrogen is its **compression into gaseous form**.

The **most commonly used steel tube trailers carry around 380 kg**, their load capacity being limited by the weight of the steel tubes. Nevertheless, the mass of hydrogen transported per day and the distance covered are essential parameters in the choice of transport mode. These parameters can justify the choice of more costly transport (e.g. liquid transport).

## Challenges for hydrogen truck transport

100 kg

### Pressure Transport Truck

Hydrogen is compressed to between **200 bar and 300 bar** in cylinders or tubes of varying volumes and technologies (steel or composite). The cylinders or tubes are transported by truck and loaded/unloaded at the point of consumption. This type of transport becomes less competitive from 1t of hydrogen upwards, and beyond a logistical **radius of 150 km**.



P T F G

1 ton

### Liquid transport by truck

The hydrogen is cooled so that it condenses into a liquid phase. A suitable tanker truck can transport a larger volume than a cylinder of gaseous hydrogen. Transport capacity is a few tons, and can be carried out within a **500 km logistical radius**.



P T F L<sub>d</sub>

#### LEGEND

- P Pressure measurement
- G Gas analysis
- F Flow measurement
- T Temperature measurement
- L<sub>d</sub> Liquid analysis



#### Hydrogen compatibility

Instrumentation must use hydrogen-compatible materials to minimize hydrogen **permeation and embrittlement**.



#### Durability

The service life of a hydrogen storage tank depends mainly on factors such as the resin used, storage pressure and temperature, and frequency of use and maintenance. The **quality of the stored hydrogen** is also an important factor.



#### Safety

Due to hydrogen's wide range of flammability and combustion characteristics, it is essential to address the safety concerns associated with hydrogen transport, requiring regulatory approval.

#### Induced requirements

**H2 requirement:** 99.97% (mobility), gas measurement of 14 critical impurities  
Pressure up to 300bar

**Sensor materials issues:** corrosion, hydriding, hydrogen embrittlement, hydrogen permeation, high-pressure, vibration resistance, mechanical strength and fatigue resistance in an on-board environment.

**Certifications :** ATEX, MID-002, ISO 14687, ISO 19880-8, PED, TPED

# Pipeline transport & Network injection

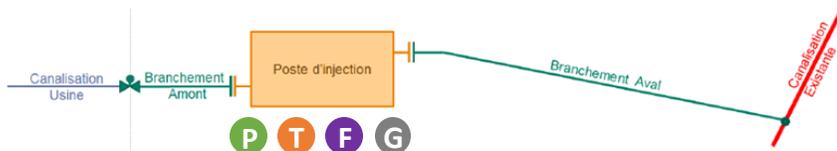


« Instrumentation adapted to intrinsic characteristics of hydrogen »

A hydrogen pipeline is an industrial pipeline that transports hydrogen **in gaseous form through dedicated pipes**. To date, these infrastructures are mainly used in the north and south of France, in industrial zones with high hydrogen consumption.

## Grid injection or « POWER-TO-GAS »

The installation of a 100% hydrogen pipeline transport network faces a number of challenges: economic (high installation costs), technical (conversion of existing networks) and safety (hydrogen embrittlement). As a result, hydrogen is initially valorized by being injected into natural gas networks. This is known as “Power to Gas”. The content depends on the infrastructure and downstream uses. At present, **the maximum content (by volume) that can be injected is estimated at 20%**.



### LEGEND

-  Pressure measurement
-  Temperature measurement
-  Gas analysis
-  Flow measurement

## A 100% H2 European pipeline network by 2040

In Europe, the “European Hydrogen Backbone” (EHB) initiative brings together **33 gas infrastructure operators**. By 2040, this initiative aims to deploy **53,000 km** of hydrogen pipelines, 60% of which will come from reconverted existing gas infrastructures, and the remaining 40% will be new pipelines required.



## Challenges for grid injection and pipeline transport



### Hydrogen compatibility

**Embrittlement** under hydrogen and risk of leaks. Conversion of existing pipelines will require **major adaptations**.



### Network performance modification

The addition of 1% hydrogen to the hydrogen + natural gas mixture causes a **reduction in calorific value** of around 0.7%, influencing the supply-demand regulation capacity. This requires appropriate measuring equipment.



### Quality control and safety

The presence of hydrogen in gas networks can have **consequences in terms of risk and equipment wear**. The injection station contains all gas quality control, metering and odorization equipment. Its role is also to secure and regulate gas injection into the network.

## Induced requirements

**Requirement H2:** Distribution network: 5-6 bar / Transmission network: 50-80bar  
**Sensor material issues:** hydriding, H2 embrittlement, H2 permeation.  
**Certifications :** ATEX, MID-002, ISO 14687, ISO 19880-8, PED



# The distribution station



« Instrumentation adapted to very high pressure »

Distribution is the last phase before final use. **The deployment of mobility requires a network of distribution points and their availability.** There are various types of hydrogen distribution stations, adapted to the target markets.

## Diagram of a hydrogen station (aerial view)



### LEGEND

-  Pressure measurement
-  Temperature measurement
-  Gas analysis
-  Flow measurement

Each station includes at least :

- H2 storage, compression unit, distribution terminal(s).
- A cooling unit to compensate for expansion heat and enable rapid filling at high pressure.
- Control systems, real-time monitoring and safety devices: pressure, temperature and flow measurement devices, shut-off and purge devices, valves, TPRD<sup>1)</sup>.

## Challenges for hydrogen station



### Hydrogen quality

The extreme sensitivity of PEM fuel cells imposes stringent purity requirements on H2 prior to filling, necessitating the use of several analytical instruments.



### Hydrogen compatibility & Safety

Hydrogen permeation not only leads to **material embrittlement**, but can also cause **structural changes to the sensor**, resulting in signal drift that has an impact on the instrument's long-term reliability and accuracy.

In addition, high temperatures and pressures accelerate permeation and embrittlement. Sensors must be made from hydrogen-resistant alloys to ensure the expected safety and efficiency.

### Induced requirements

**H2 requirement:** 99.97% (mobility), gas measurement of 14 critical impurities  
 450-500bar : pressure required to fill to 350bar,  
 900-1000bar : pressure required to fill to 700bar.

**Sensor materials issues:** corrosion, hydriding, hydrogen embrittlement, hydrogen permeation, high pressure, vibration resistance, resistance to very high pressure.

**Certifications :** ATEX, MID-002, SAE J2601, SAE J2578, ISO 23273, ISO 14687, ISO 19880-8, PED, TPED

*Nota: 1) TPRD = Thermal Pressure Relief Device*

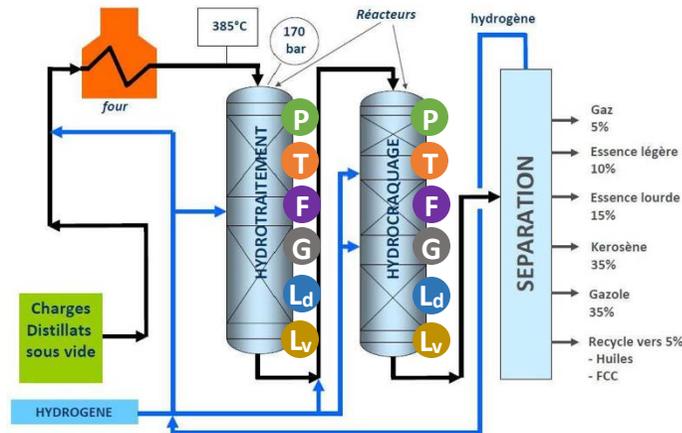
# Oil refining



« Instrumentation adapted to massive hydrogen consumption »

Oil refining is the industrial process that has historically consumed the most hydrogen worldwide (46% of global consumption). Decarbonizing refineries represents one of the identified levers for scaling up renewable hydrogen production. We're talking about tens to hundreds of thousands of tonnes of hydrogen consumed per year, **equivalent to the installation of electrolyzers with a total output of over 400MW.**

## Simplified oil refining diagram



### LEGEND

- P Pressure measurement
- G Gas analysis
- F Flow measurement
- T Temperature measurement
- Ld Liquid analysis
- Lv Level measurement

There are two processes using hydrogen:

- **Hydrocracking:** a catalytic cracking process in which added hydrogen breaks down long-chain hydrocarbon molecules into lighter, highly valuable fractions.
- **Hydrotreating:** a key stage in oil refining at 170 bar, aimed at removing certain elements present in oil cuts (elimination of sulfur by hydrodesulfurization and nitrogen by hydrodenitration/hydrodenitration), which are poisons for the catalysts used in refining.

## Challenges for oil refining



### Reliability/Durability

The specificity of this mature and massive sector is the challenge of large volumes consumed, leading to large reactor, pipe (>25 DIN) and tank dimensions. This is an equipment replacement market, where **durability and predictive maintenance are key issues.**



### Control/Performance

The challenge of process control in a high-volume, low-margin sector requires **metrological performance and increasing digitalization** of flow, level, volume, temperature and pressure measurements.



### Safety/Environment

The growing challenge of **reducing leaks** for environmental reasons calls for instrumentation dedicated to detecting small leaks on large installations.

### Induced requirements

**H2 requirement:** 99.9% pure (grade B), gas measurement of 4 critical impurities  
Low pressures (<30 bar) and high pressures for certain processes.

**Sensor material issues:** high-temperature resistance, H<sub>2</sub>, H<sub>2</sub>S, H<sub>2</sub>O, mechanical wear and corrosion, hydrogen embrittlement.

**Certifications :** ATEX, ESP, Oil & Gas safety and standards

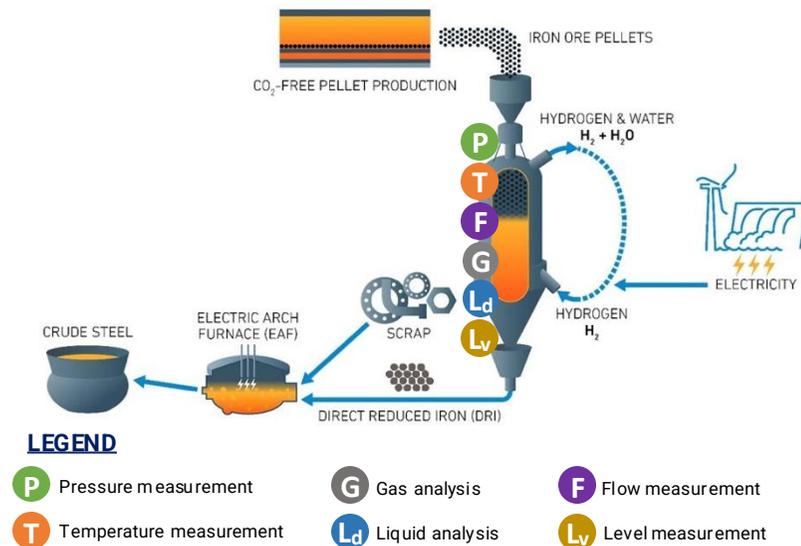
# Steel industry (direct hydrogen reduction)



« Instrumentation for continuous, intensive use »

Hydrogen is a means of eliminating CO2 emissions in the iron ore reduction stage of steel production, **replacing coke or natural gas**. ArcelorMittal has announced plans to replace 3 blast furnaces with DRI<sup>1)</sup> installations from 2027. These sites alone would account for **25% of industrial greenhouse gas emissions in France**.

## Diagram of direct reduction of iron ore with hydrogen



There are two processes for transforming iron ore into steel: Blast Furnace-Basic Oxygen Furnace (BF-BOF) and Direct Reduced Iron-Electric Arc Furnace (DRI-EAF). The former largely dominates the European market, but the latter is being developed in certain gas-rich countries (Algeria). The DRI process using renewable or low-carbon hydrogen is developed to decarbonize primary steel production. Steel is also massively recycled in EAF in Europe.

## Challenges for direct hydrogen reduction



### Control/Performance

DRI-H2 is a process that is developing with new large-scale projects (100 - 1000 MW electrolysis) supported by steel industry players who have mastered DRI process instrumentation. The supply of hydrogen must therefore be integrated with modern, digitalized control of high-volume processes. The size of these projects calls for **massive, integrated digital measurement solutions**.



### Reliability/Durability

The major challenge is the cost and reliability of supply, which means that the instruments have to be long-lasting, reliable throughout the year and capable of predictive maintenance.

### Induced requirements

**H2 requirement:** 99.9% pure (grade B), low pressures (<30 bar)

**Sensor materials issues:** corrosion resistance (H2O), hydrogen embrittlement, mechanical wear and durability.

**Certifications :** ATEX, ESP

*Nota: 1) DRI = Direct Reduced Iron*

# Industrial chemistry applications



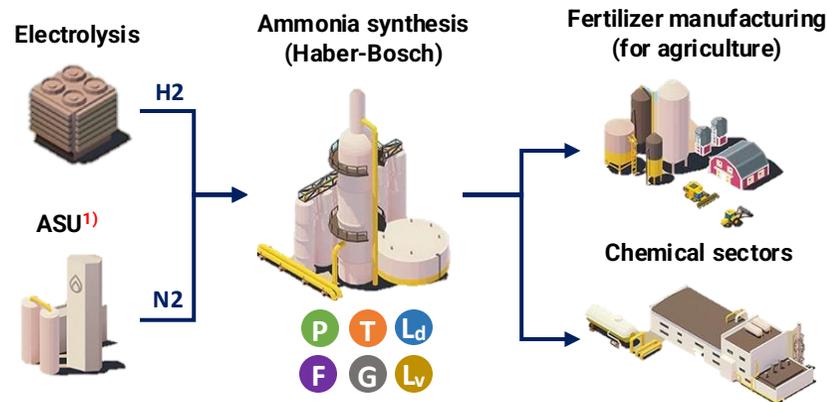
« Instrumentation adapted to massive hydrogen consumption »

Hydrogen is an important industrial raw material for :

- **Ammonia synthesis**, used in fertilizer manufacture.
- **Methanol synthesis**, used in several chemical sectors.
- **Food industry**, for the hydrogenation of fats.

Hydrogen is also used in other sectors such as perfumery, cosmetics and pharmaceuticals...

## Production and uses of ammonia decarbonized by hydrogen



### LEGEND

- |                                  |                                      |  |
|----------------------------------|--------------------------------------|--|
| <b>P</b> Pressure measurement    | <b>G</b> Gas analysis                | <b>F</b> Flow measurement              |
| <b>T</b> Temperature measurement | <b>L<sub>d</sub></b> Liquid analysis | <b>L<sub>v</sub></b> Level measurement |

Image credits : YARA, Nutrien  
Nota : 1) ASU = Air Separation Unit

After petrochemicals, ammonia synthesis and methanol synthesis are the two most important industrial uses of hydrogen. They will therefore play a **key role in the industrialization of the hydrogen sector**.

- Once ammonia has been obtained, most of it (at least 75%) is used in the fertilizer industry. The remainder is used in the pharmaceutical, textile, fine chemicals and plastics industries.
- Methanol is used as antifreeze (coolant), solvent, fuel, as a denaturant for ethyl alcohol and to produce biodiesel.

**Instrumentation for these two applications is already in place and well known.**

## Challenges for industrial chemistry



### Control/Performance

Ammonia and methanol production projects involve very large volumes and flows of hydrogen. A critical issue is therefore the optimization of large-scale chemical engineering by implementing control with **massive, integrated digitalized measurement solutions**. Hydrogen supply instrumentation therefore needs to be integrated into the process, with a wide range of sensors for different chemicals and under the **high temperature and pressure conditions required by the process**.



### Safety

Chemical products are a major safety issue, with the specific dangers of nitrogenous (AZF) and toxic (methanol) products requiring chemical engineering standards.

### Induced requirements

**H<sub>2</sub> requirement:** 99.9% pure (grade B), gas measurement of 4 critical impurities  
**Sensor material challenges:** corrosion resistance, hydrogen embrittlement, hydrogen permeation, high-temperature resistance.

**Certifications :** ATEX, ISO 14687, ISO 19880-8, Chemical and petroleum engineering standards, Legal metrology

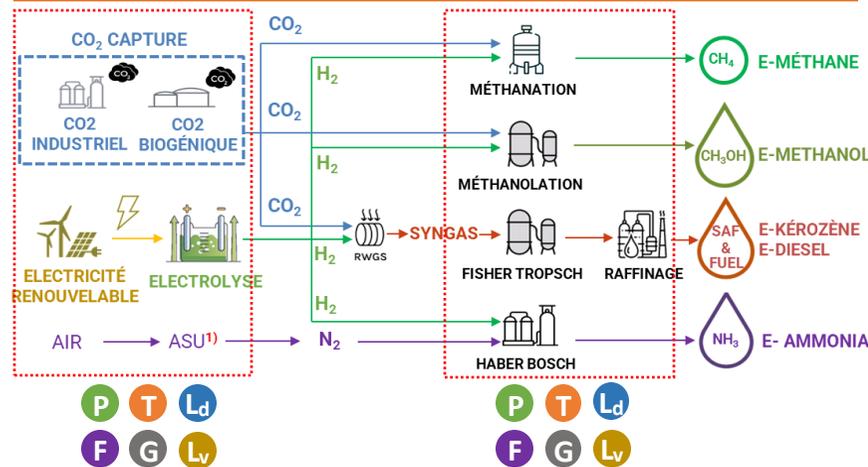
# E-fuels



« Instrumentation adapted to massive hydrogen consumption »

E-fuels, like e-methane, e-kerosene and e-methanol, are gaseous or liquid fuels produced from CO<sub>2</sub> and hydrogen derived from renewable or decarbonized electricity. **The electrolytic raw material used (electricity) differentiates them from biofuels**, which are mainly produced from biomass.

## E-fuels



### LEGEND

-  Pressure measurement
-  Gas analysis
-  Flow measurement
-  Temperature measurement
-  Liquid analysis
-  Level measurement

Each electrofuel has its own advantages:

- **E-methane:** use in its liquid form LNG (liquefied natural gas) or in its gaseous form in maritime or road transport.
- **E-methanol:** use as a feedstock by the chemical industry or as a fuel for the maritime sector (dual-fuel solutions already deployed).
- **E-ammonia:** used as a raw material in fertilizer production, as a fuel in the maritime sector or as a hydrogen transport vector.
- **E-kerosene:** e-kerosene is used in air transport. It is one of the Sustainable Aviation Fuels (SAF).

## Challenges for electrofuels



### Control/Performance

The e-fuels production projects are new and of massive scale (50-500 MW electrolysis), which implies large dimensions. A critical challenge is to optimize large-scale chemical engineering by implementing control with **massive, integrated digitalized measurement solutions**. Hydrogen supply instrumentation therefore needs to be integrated into the process, with a wide range of sensors for different chemical products, and in conditions of high temperature and pressure, depending on the process.



### Safety

Chemical products represent a major safety issue, with the specific dangers of nitrogenous (AZF) and toxic (methanol) products imposing standards close to those of refining and chemical engineering.

### Induced requirements

**H2 requirement:** 99.97%, and gas measurement of 14 critical impurities, high pressure depending on the process.

**Sensor material challenges:** corrosion resistance, hydrogen embrittlement, hydrogen permeation, high pressure, high temperature.

**Certifications :** ATEX, ISO 14687, ISO 19880-8, Chemical and petroleum engineering standards, Legal metrology

# Industrial hydrogen combustion



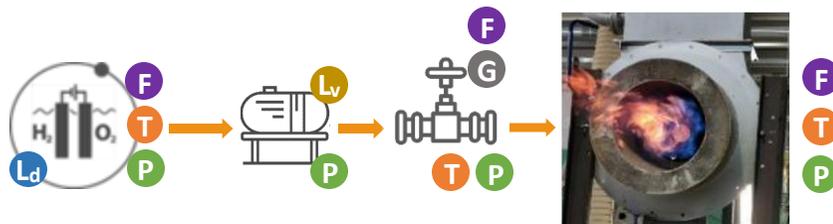
## « Instrumentation for industrial and high-power sites »

Rapidly diffusible solution for decarbonization by retrofitting fossil gas combustions for thermal processes:

- **Metals:** steels, aluminum, copper, foundry, forging, rolling ...
- **Minerals:** Glass smelting, asphalt, corundum, minerals and salts, etc.
- **Organics:** Paper, Malt, Brewing, Whisky, Cooking and Food...

Switching to H2 modifies combustion and heat transfer properties, as well as the composition of the furnace atmosphere. A major challenge is the technical validation of the impact on furnaces and products in the many sectors concerned. The volumes involved are immense, and on-site production by electrolysis **from 2 to 30 MW is the main supply route.**

## Hydrogen Combustion



### LEGEND

- |   |   |   |
|---|---|---|
|  Pressure measurement    |  Gas analysis    |  Flow measurement  |
|  Temperature measurement |  Liquid analysis |  Level measurement |

According to the Alice Alliance, of the 240 TWh of non-electric process heat in France, a maximum of 29% could be electrified. The market for H2 combustion would be mainly in the 147 TWh used for high-temperature, high-power retrofit furnaces. The actual market will be determined by the technical, site integration and regulatory limits of other decarbonation options.

## Challenges for industrial combustion



### Control/Performance

Operating the **feed flows of gas burners** is critical for performance, combustion efficiency, control of the furnace atmosphere and respect of emissions standards (especially NOx). It concerns air and hydrogen, but also conventional fuels (LPG or NG) and oxygen in case of oxycombustion. In addition, **legal metrology** of purchased gases implies temperature and pressure measurement to normalize the flow.



### Regulatory

Pollution concentration (NOx) is a ratio of flue gas volume after condensation. But H2 oxycombustion essentially generates water vapor, and therefore zero volume after condensation, which makes the current standard inapplicable and calls for its evolution.

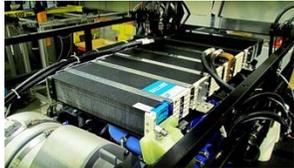
### Induced requirements

**H2 requirement:** 99.9% pure (grade B), gas measurement of 4 critical impurities, Pressure <30 bar

**Sensor material challenges:** High-temperature resistance, H2 and H2O.

**Certifications :** ATEX, ESP, Legal metrology, NOx pollution standards

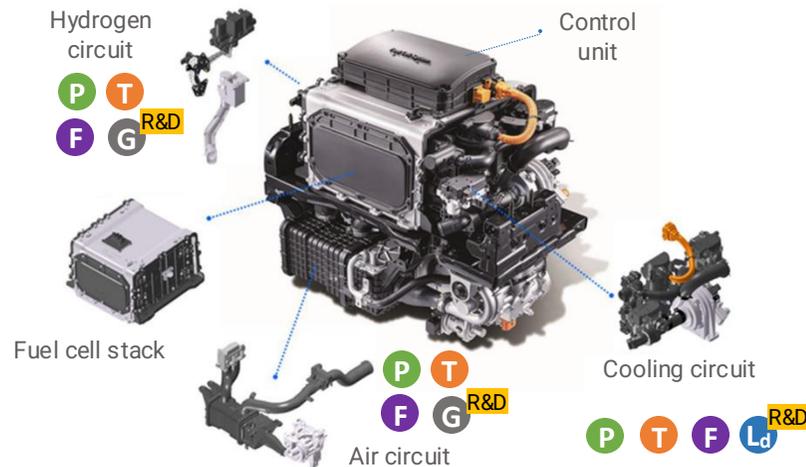
# Fuel cell applications



« Instrumentation adapted to multi-fluid and multi-physics environments »

Fuel cells convert the chemical energy contained in hydrogen into electrical energy. The more mature PEM fuel cell system is used for two types of application: hydrogen mobility and stationary applications (gensets, residential cogeneration, back-up units).

## Fuel cell system diagram (on-board)



### LEGEND

-  Pressure measurement
-  Temperature measurement
-  Gas analysis
-  Liquid analysis
-  Flow measurement

- **Air circuit:** at the cathode, ambient air is first compressed, then humidified before being fed to the fuel cell.
- **Hydrogen circuit:** at the anode, hydrogen is supplied by a hydrogen blower, which controls the efficiency of the entire system.
- **Cooling circuit:** the cooling circuit ensures heat dissipation and is necessary for cold-start capability.
- **Electrical circuit:** a control unit controls the entire system.

## Challenges for fuel cells



### Control/Performance

Simultaneous control of pressure, temperature and flow ensures performance (efficiency, durability) and **reduces energy & maintenance costs.**



### Hydrogen and water quality

The extreme sensitivity of PEM fuel cells requires not only H<sub>2</sub> purity, but also non-contamination of the fluids involved (dust, residues of material degradation, zero water conductivity), which may necessitate the use of several analytical instruments.



### Safety

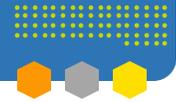
Appropriate instrumentation prevents the build-up of high concentrations of O<sub>2</sub> in the H<sub>2</sub> stream (and vice versa), over-pressurization and overheating of the fuel cell.

### Induced requirements

**H<sub>2</sub> requirement:** 99.97% (mobility), gas measurement of 14 critical impurities  
**Sensor materials issues:** corrosion, hydriding, H<sub>2</sub> embrittlement, H<sub>2</sub> permeation, high-pressure, vibration resistance, temperature cycling, mechanical strength and fatigue in an on-board environment.  
**Certifications :** ATEX, MID-002, OIML r139, ISO 14687 (R&D)



# Main European regulations



## Mobility



## Other regulations

European Directives	Texts common to all EU countries, but each member state is free to develop its own tests based on the European text.
<b>OIML r139</b> (replaces EC79)	[International recommendation] Compressed gaseous fuel measuring systems for vehicles
<b>ISO 23273</b>	Fuel Cell Road Vehicle ; Safety Specification
<b>EC79 and associated regulation rules</b> (Expiring in July 2023)	Commission Regulation (EU) No 406/2010 of 26 April 2010 implementing Regulation (EC) No 79/2009 of the European Parliament and of the Council on type-approval of hydrogen-powered motor vehicles
<b>SAE J2601</b>	Protocol and process limits for hydrogen fueling of vehicles
<b>SAE J2578</b>	Recommended Practice for General Fuel Cell Vehicle Safety
<b>ISO 14687</b>	Hydrogen fuel quality (off-line H2 quality measurement)
<b>ISO 19880-8</b>	Hydrogen fuel quality control (on-line H2 quality measurement)

Voluntary, non-mandatory: public authorities can make all or part of a standard mandatory, by issuing a specific regulatory text to this effect.

Directives Européennes	Texts common to all EU countries, but each member state is free to develop its own tests based on the European text.
<b>Seveso - 2012/18/UE</b>	Industrial accidents
<b>IED - 2010/75/UE</b>	Industrial emissions
<b>ATEX 2014/34/UE</b>	Explosive Atmospheres
<b>MID-002 2014/32/UE</b>	Governs the marketing of legal metrology measuring instruments.
<b>MD - 2006/42/EC</b>	Machinery
<b>PED-2014/68/UE</b> <b>TPED-1999/36/EC</b>	Stationary pressure equipment Transportable pressure equipment
<b>LVD - 2014/35/UE</b>	Low voltage
<b>EMC - 2014/30/UE</b>	Electromagnetic compatibility
<b>EIHP</b>	Safety - Work Package 5

The CE mark attests to the station's compliance with European safety requirements (PED/TPED, ATEX, LV, EMC, RoHS-Reach).

## Companies providing Instrumentation Solutions

This white paper presents the instrumentation challenges in the hydrogen value chain for six families of equipment:

→ Discover the solutions offered by **GIMELEC members** to meet these needs: 14 of our experts present their offers for the six families opposite. This directory also allows you to find out more about the GIMELEC companies active in hydrogen instrumentation.

[Click here](#) to access the GIMELEC directory

<p><b>Mesure de pression</b></p> <p>ABB EMERSON Endress+Hauser Fuji Electric GEORGIN JUMO Schneider Electric SIEMENS VEGA WIKAI</p> <p>PAGES 7-10</p>	<p><b>Mesure de température</b></p> <p>ABB EMERSON Endress+Hauser Fuji Electric GEORGIN JUMO Schneider Electric SIEMENS VEGA WIKAI</p> <p>PAGES 11-13</p>	<p><b>Mesure de débit</b></p> <p>ABB EMERSON Endress+Hauser Fuji Electric JUMO Schneider Electric SICK SIEMENS WIKAI</p> <p>PAGES 14-16</p>
<p><b>Analyse liquide</b></p> <p>EMERSON Endress+Hauser JUMO METTLER TOLEDO Schneider Electric</p> <p>PAGES 17-18</p>	<p><b>Analyse gaz</b></p> <p>ABB DURAG GROUP EMERSON Endress+Hauser envea Fuji Electric SICK SIEMENS</p> <p>PAGES 19-20</p>	<p><b>Mesure de niveau</b></p> <p>ABB EMERSON Endress+Hauser Fuji Electric JUMO SIEMENS VEGA WIKAI</p> <p>PAGES 22-24</p>

→ For solution providers covering the entire hydrogen value chain (production - storage - transport - distribution - applications), find the [Panorama of H<sub>2</sub> Solutions](#) proposed by France Hydrogène online.

→ On the [Vig'hy](#) hydrogen observatory, you will also find the online directory of **France Hydrogène members**: 450 French hydrogen industry players covering the entire value chain: major industrial groups, SMEs, start-ups, laboratories and research centres, associations, competitiveness clusters and local authorities.