



Natural Hydrogen in France

July 13th, 2026



A LEADING PLATFORM FOR LOW-CARBON ENERGIES IN EUROPE



**Using low-carbon
fuels** (biogas/RNG,
abandoned mine
methane, hydrogen)



**Carbon capture and
utilization/storage**

**PROVIDING VARIOUS
SOLUTIONS**



ELECTRICITY



HEAT



GAS

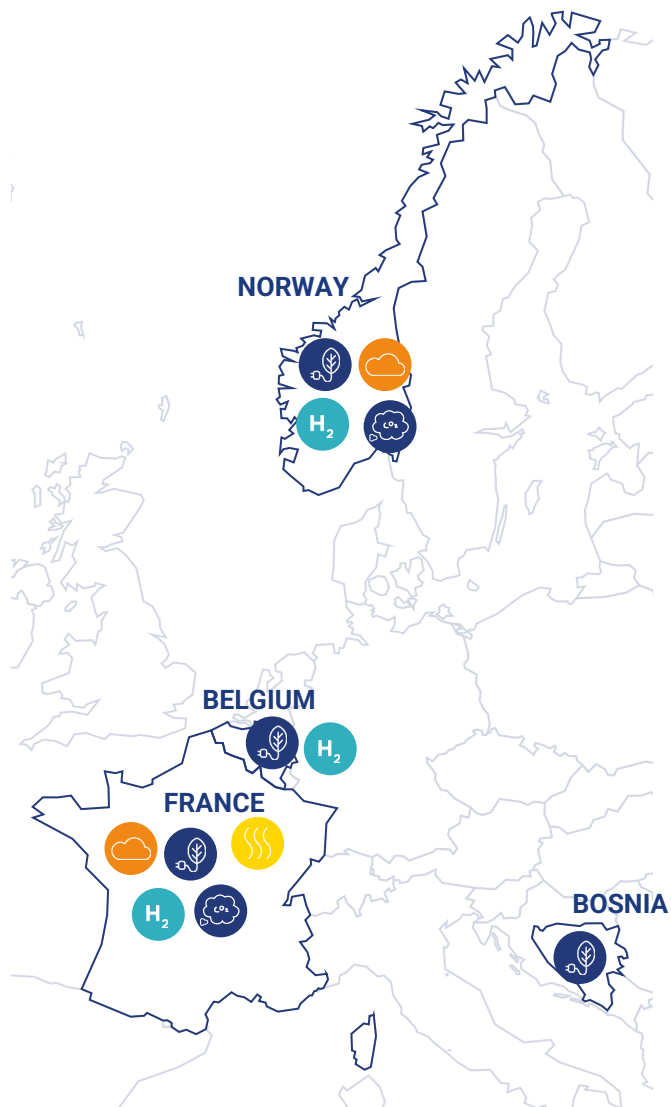


HYDROGEN



CO2

FDE: A DIVERSIFIED ASSET OPERATIONS BASE IN EUROPE



ELECTRICITY

FRANCE, BELGIUM & BOSNIA
NORWAY UNDER DEVELOPEMENT



HEAT

FRANCE



GAS (incl. RNG)

FRANCE
NORWAY UNDER DEVELOPEMENT



HYDROGEN

FRANCE & BELGIUM
NORWAY UNDER DEVELOPEMENT



CO2

FRANCE & NORWAY UNDER
DEVELOPEMENT

22,5 MW

installed
cogenerations
+

65 MW

installed PV

8 MW

installed

c. 220

GWH

gas annual
production

STRONG FOCUS ON RESEARCH, INNOVATION & DEVELOPMENT

Method and system for extracting Carbon Dioxide by anti-sublimation for storage thereof

1

Refrigeration process and system for recovering cold from methane by refrigerants

3

Method for frosting carbon dioxide contained in liquid methane

5

Process for solid-phase extraction of substances from gas mixtures

7

2

System for cooling a psychrometric mixture by coupling a condenser and an evaporator

4

Process for refrigerant subcooling

6

Method and device for coupling cooling and heating effects

8

Cryogenic process for the separation of CO₂ and H₂S

8 International patents in our portfolio

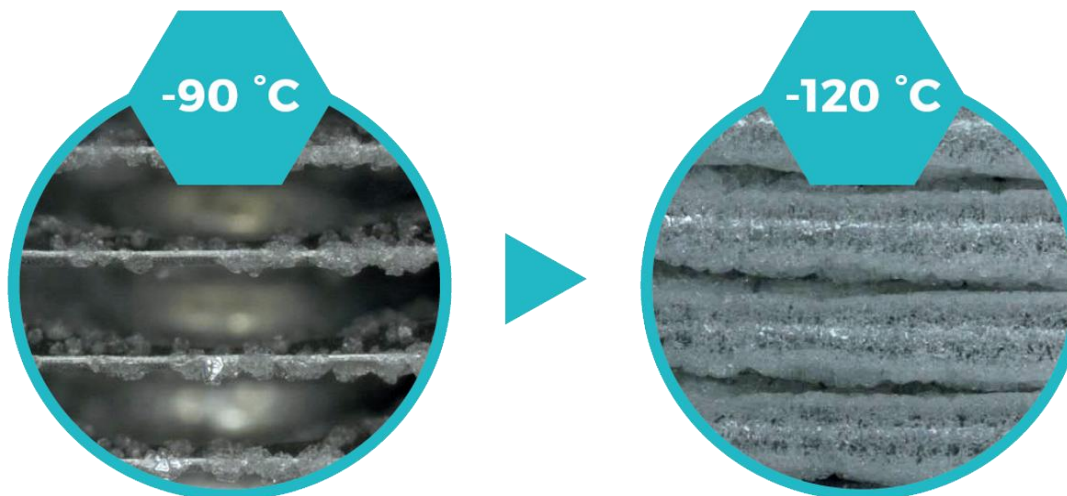


To go further:

- **The process of freezing a volume of CO2 at 5% concentration begins at -109°C.** To further reduce the concentration, the temperature is lowered to -125°C.
- **Thawing starts when the HTF (Heat Transfer Fluid) reaches a temperature of -5°C.** The CO2 sublimates, the pressure rises to the triple point and the CO2 thaws and is recovered in liquid phase (draining of the exchanger by pressurization).
- **Continuous freeze/thaw process, with two units operating in parallel.**

• A unique antisublimation capture process

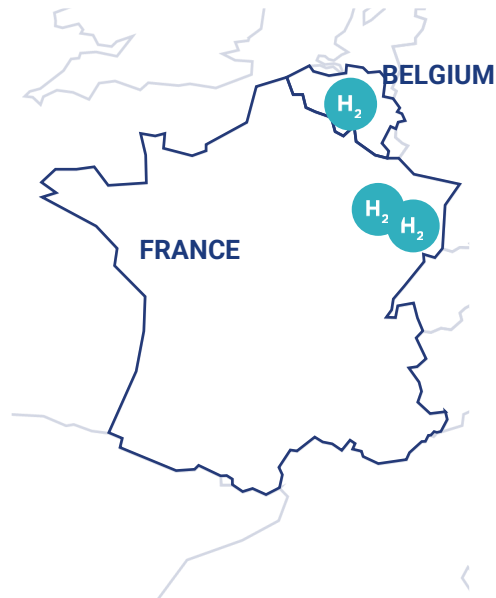
- Condensation unit (160°C to 2°C) to reduce concentration of water (< 0.7% Vol).
- The condensation unit also reduces SOx (1 ppm), HCl and HF. NOx depends on detailed composition (NO, N2O and NO2)
- Water freezing to reduce water content to 1 ppm (-40°C to -90°C)
- CO2 freezing (down to -125°C) with integrated cascades and chiller to reduce residual CO2 content below 0.5% Vol.



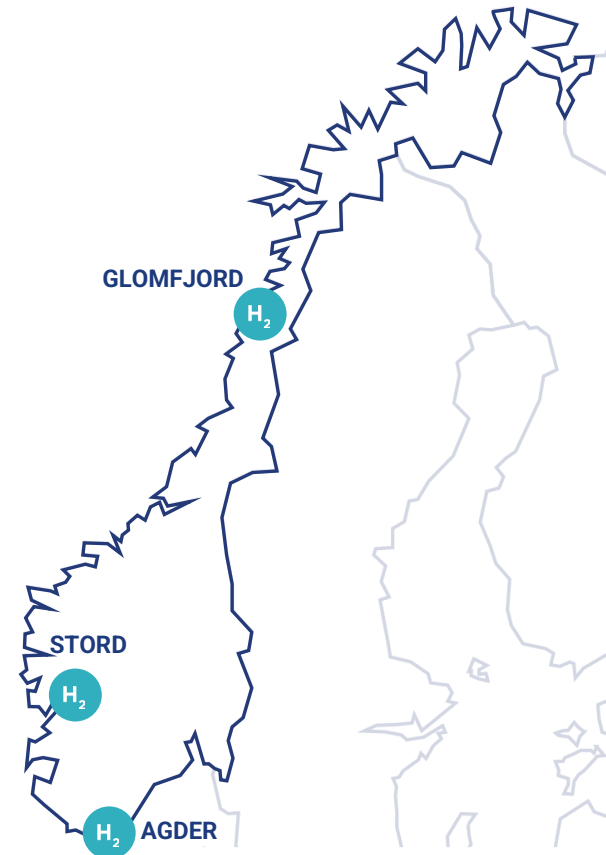
- Technology of cryogenic capture by freezing (**antisublimation**) of CO₂ at atmospheric pressure (fully automated system)
- 100% powered with green electricity => 40% reduction of energy consumption vs competition
- **CO₂ recovery rate up to 98%** (TRL 9 for biogas application)
- **CO₂ purity 99,7% to 99,9%** (TRL 9 for biogas application) – **Northern Light Standards**
- **TRL 6-7 for CO₂ capture on fumes exhaust**
- **Flexibility:** compatible with CO₂ fumes concentration from **1 to 100%**.
- Exhaust fumes flowrate (25 to 100% of nominal).
- **Fumes flowrate from 10 000 to +3 millions Nm³/h**



HYDROGEN

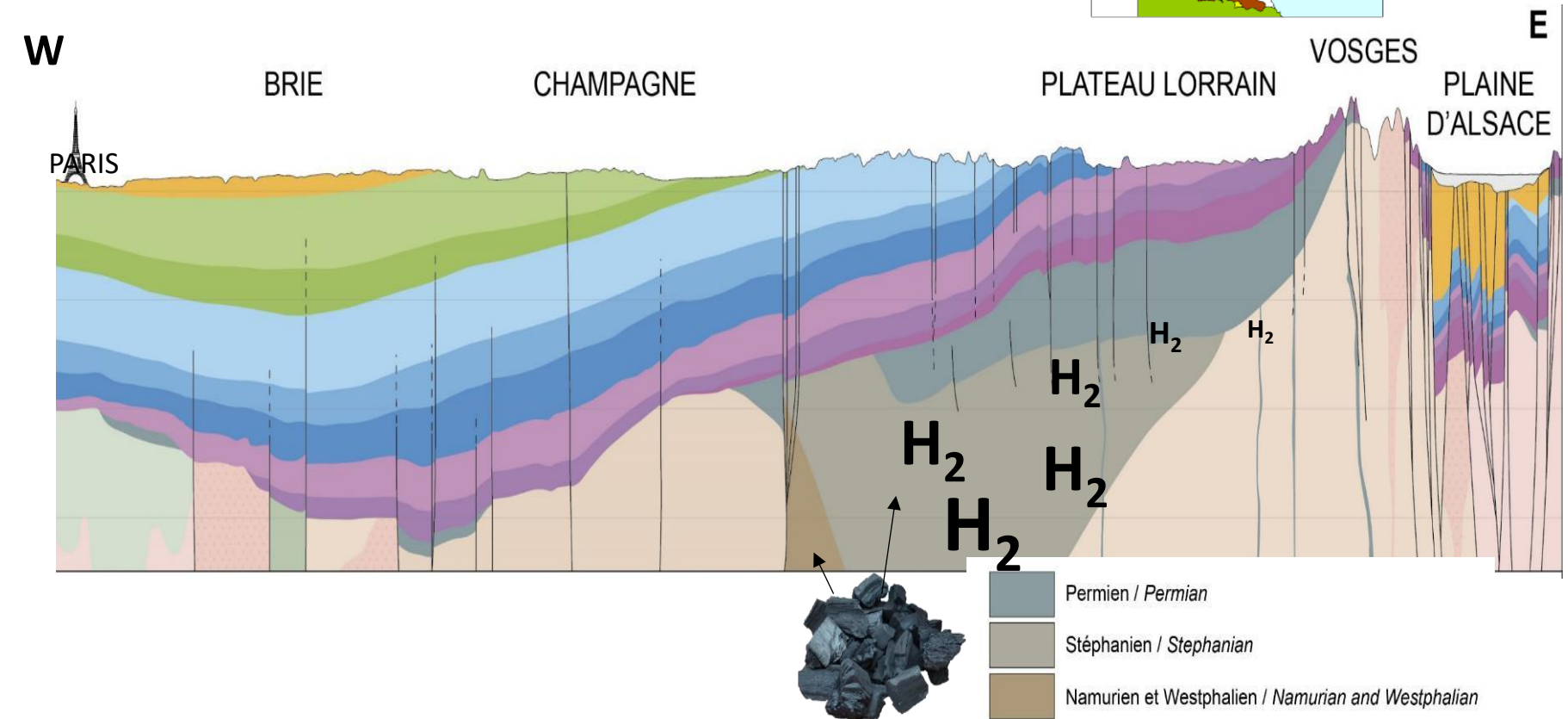
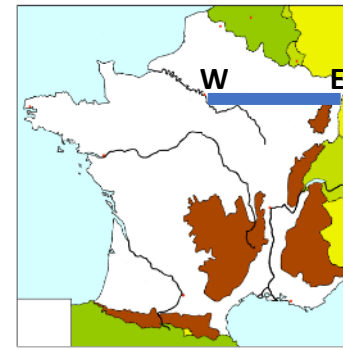


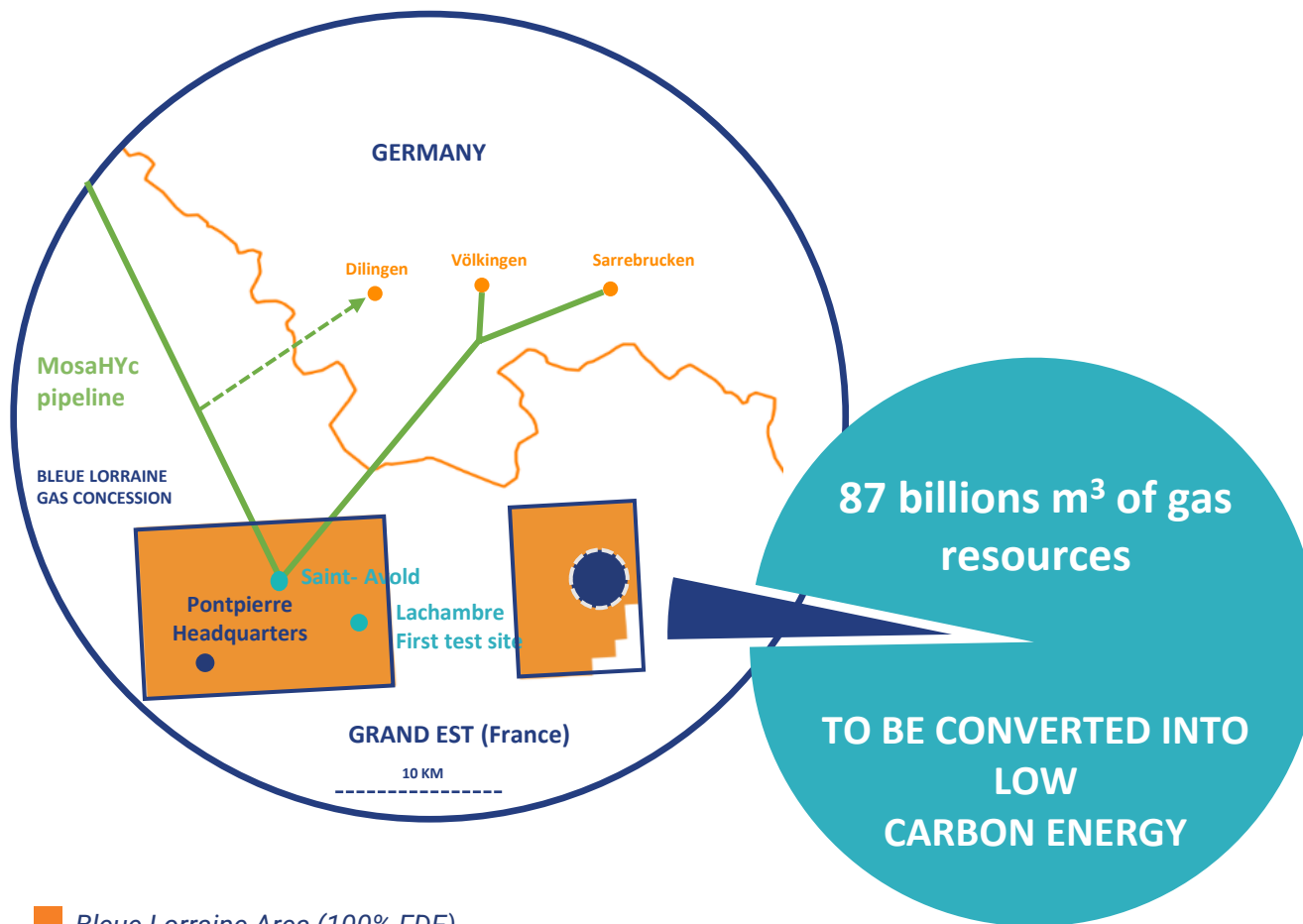
- ▶ 1 low carbon **H2 Project under development** in **France**, converting gas reserves into Blue H2 associated with CCUS
- ▶ 1 natural **H2** appraisal site in France - A larger portfolio under construction
- ▶ 1 low carbon **H2 Pilot site** in **Belgium** as part of EDF and Materia Nova consortium



- ▶ 1 renewable **H2** site in production in Norway
- ▶ 3 other renewable H2 Projects **under development**

WHY LORRAINE?





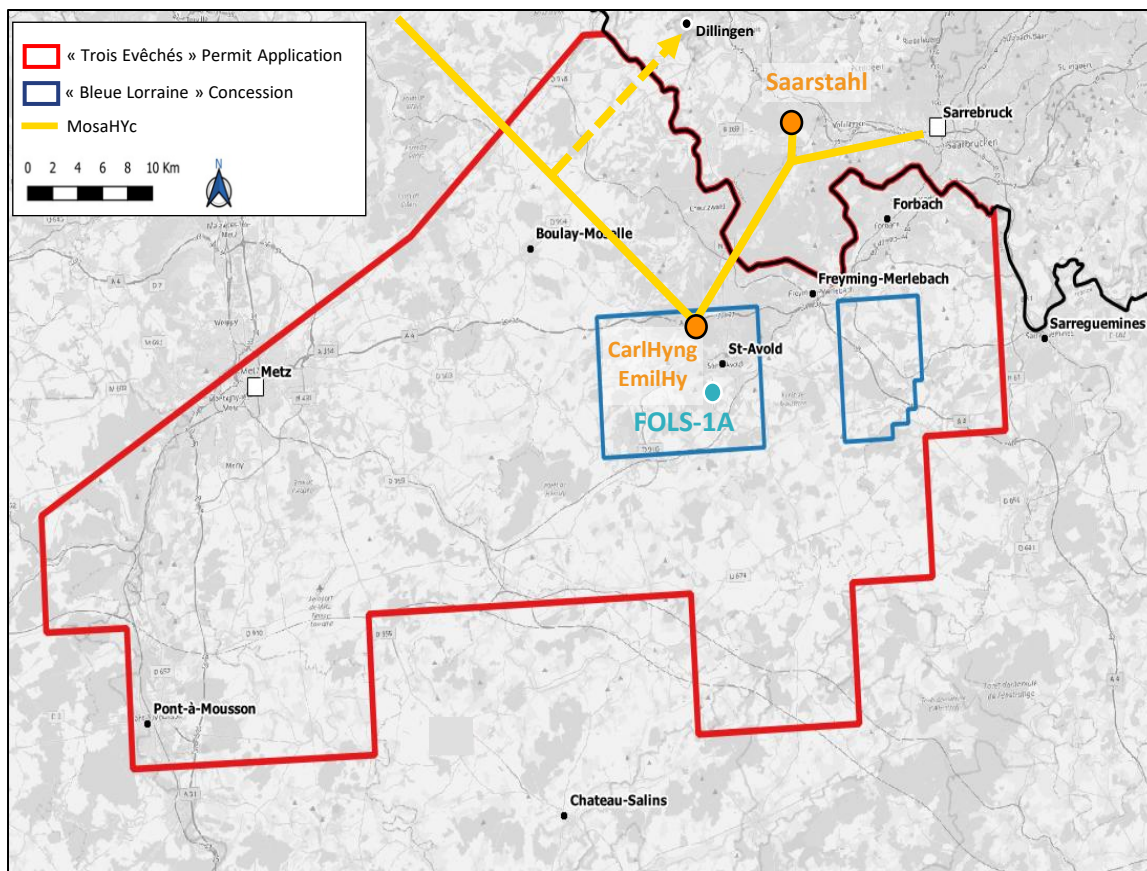
Valorisation options

-  **Power**
-  **Gas**
-  **Heat**
-  **Hydrogen**
-  **CO₂ Storage**

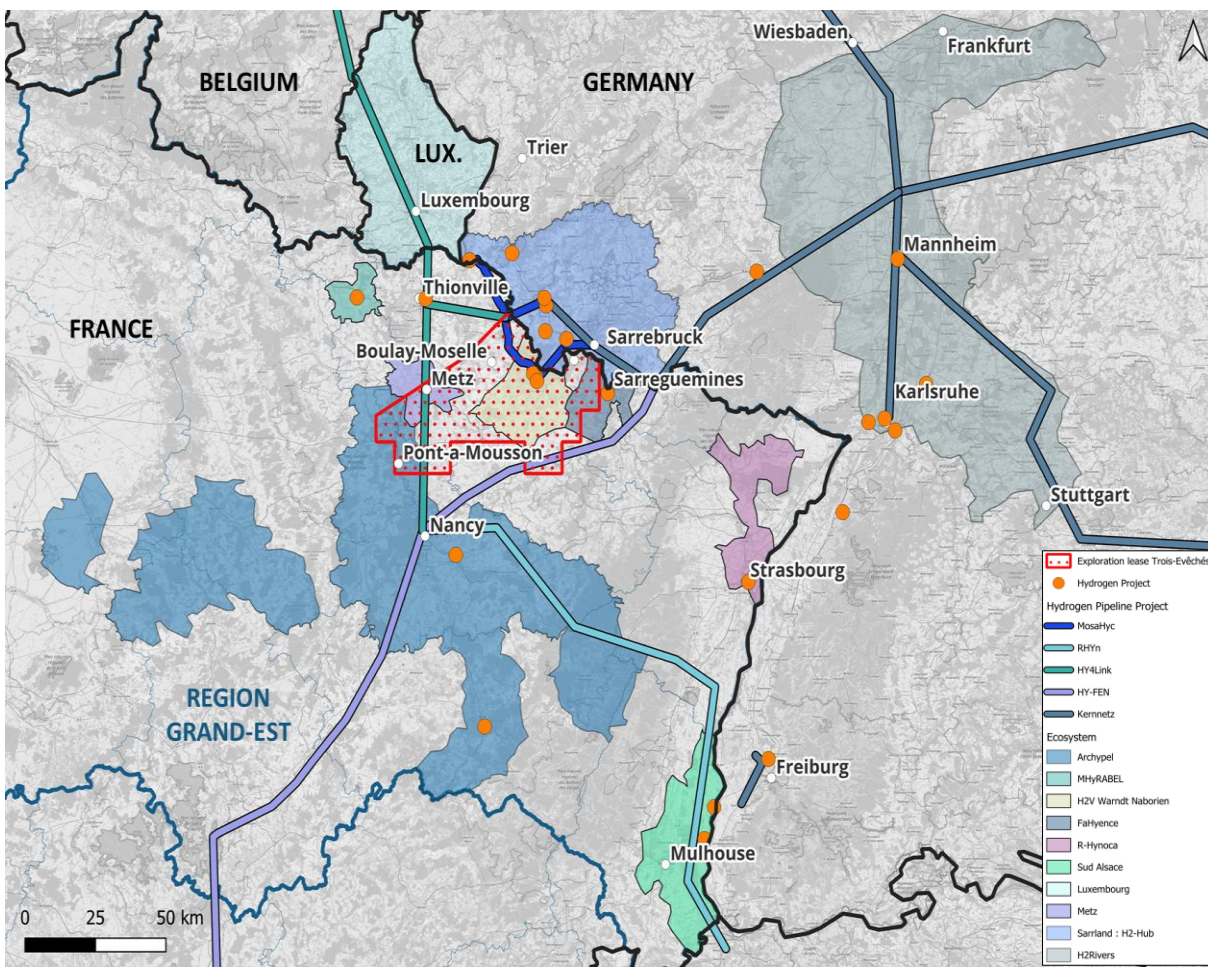
 **Bleue Lorraine Area (100% FDE)**



Certified Contingent Ressources (2C) Bleue Lorraine, and surrounding areas (MHA, 2018)



- ◆ **Significant discovery made in Folschviller (FOLS-1A)**
- ◆ **New consortium REGALOR II with planned appraisal program (2025-2028)**
 - FDE
 - Academic partners (universities, research labs)
 - Institutional partners (national surveys, research centers)
 - Industrial partners (listed companies, SME)
- ◆ **Exploration permit « Trois Evêchés » permit (2254 km²) granted for 5 years with 10 years extension**
 - Evaluation of potential
 - Pilot well, 1 to 2 appraisal wells
 - 3D seismic
 - Production test and certification



STRATEGIC POSITIONING



1. Extraction

Located at the France/Germany border. Direct production from Folschviller and Pontpierre sites.



2. Infrastructure

Direct connection to MOSAHYC pipeline, the first European cross-border H2 transport network (under construction).



3. Consumers

High-demand industrial cluster within 100km radius. Multi-country delivery capability (FR, DE, LU).



Offtake Pipeline

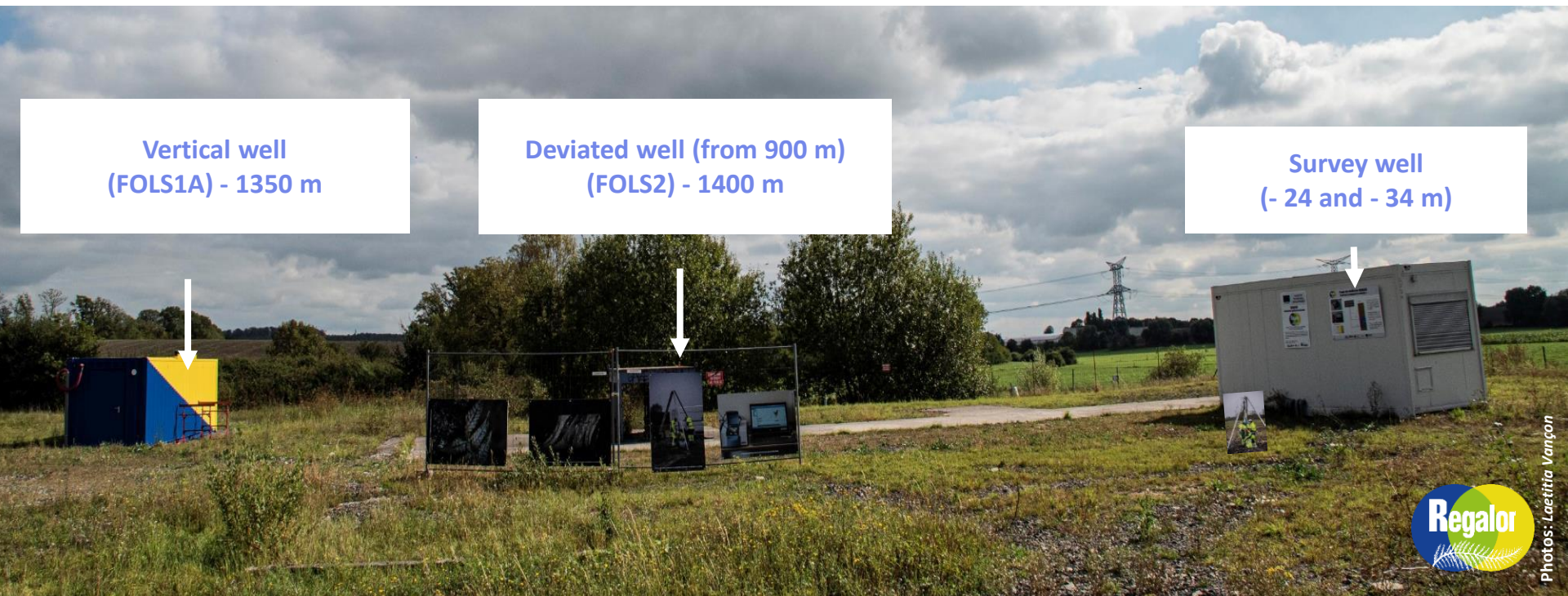
Offtakers

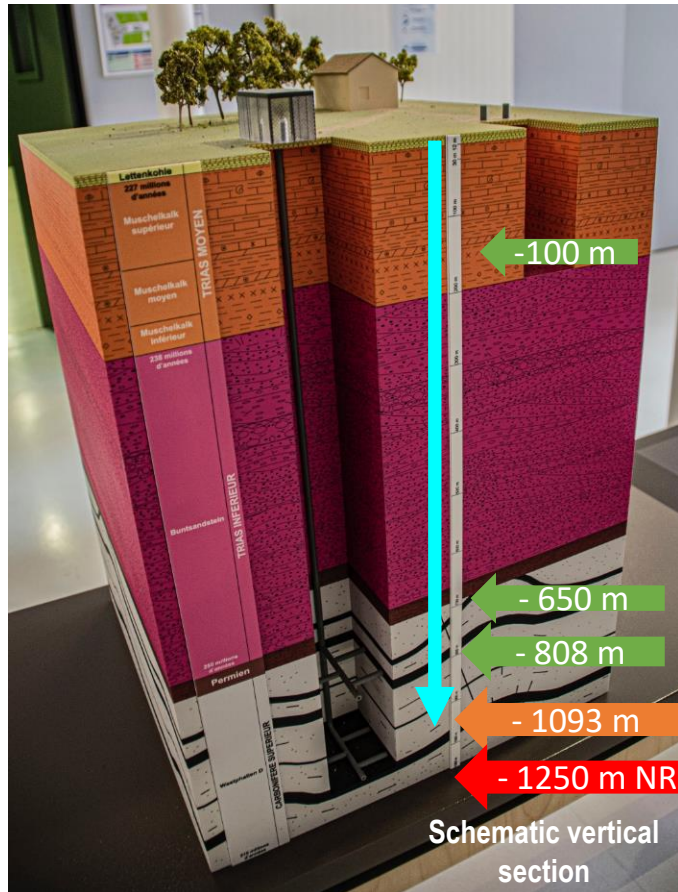
15+ identified

MOSAHYC Capacity

€100M/yr

1. Degassing of deep hydrogen via the Earth's crust and mantle
2. Reaction of water with iron silicates in the Earth's mantle (serpentinization) or with rocks carrying iron carbonates or iron sulphides in the Earth's crust
3. Decomposition of hydroxyl in mineral structure
4. Natural radiolysis of water in contact with uranium minerals
5. Decomposition of coal into anthracite then graphite
6. Bacterial activity
7. Interaction between steel and water in boreholes or mine galleries
8. Friction in fault zones





Specifications

Continuous measurement
by U-Tube or gas sampling

Semi permeable membrane

Resistant to 200 bars

P-T sensors

Measurement when P_{gas} is
stabilized

Sampling of gas under high
pressure

Allow gas concentration
estimate and measurement
of rare gases and isotopes

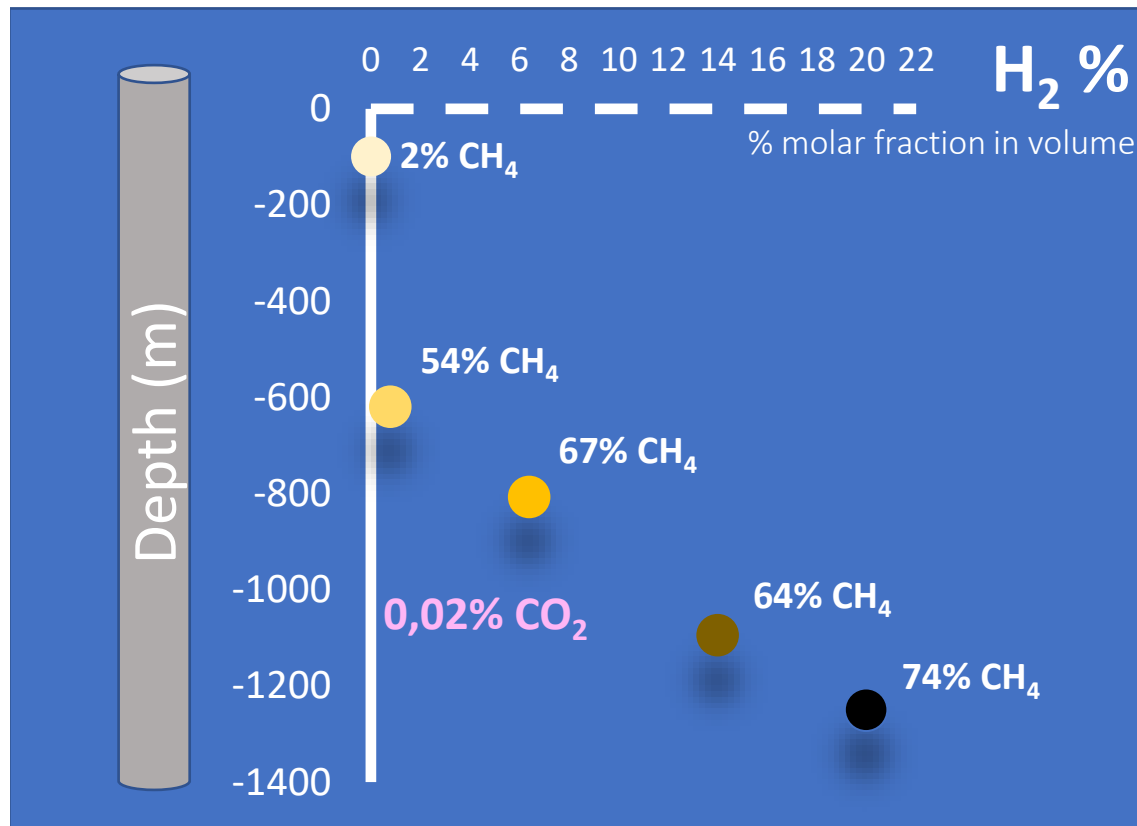
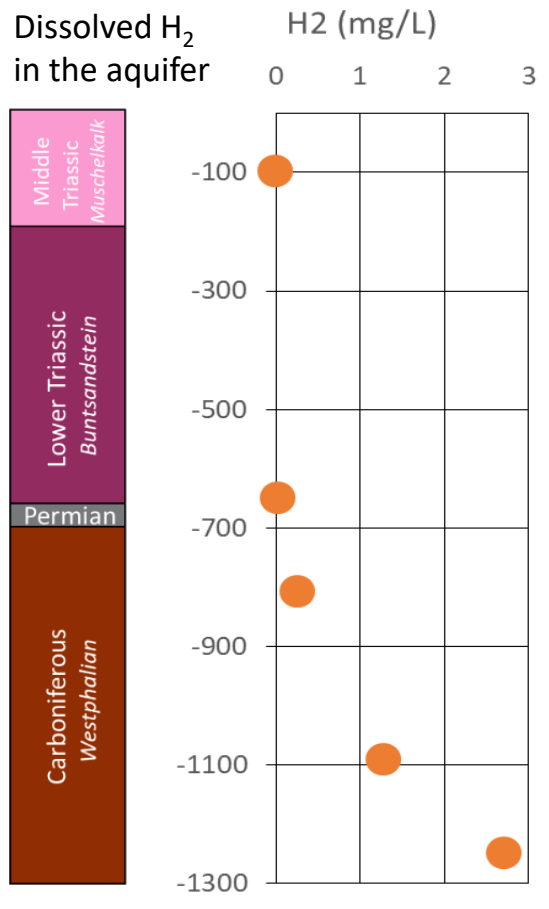
SysMoG™ probe



European patent
shared between
Solexperts and
University



FIRST SUCH MEASUREMENTS IN THE WORLD

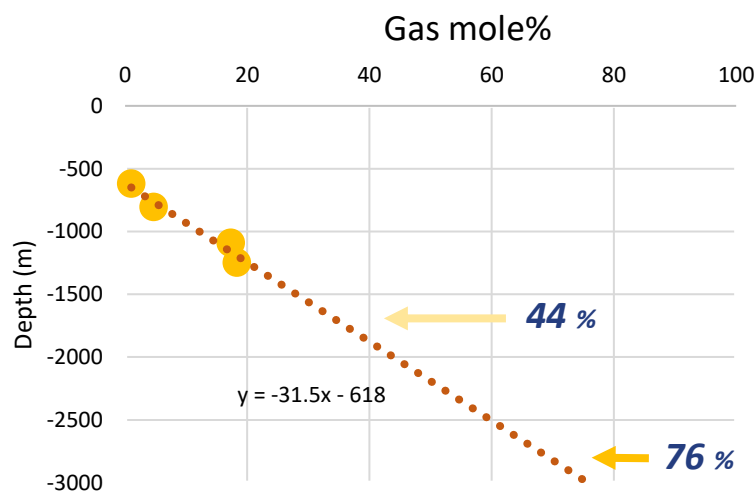


A hydrogen (H₂) concentration that increases with depth!

- Volume of sediments in the Sarro-Lorrain Basin
16,000 km² x 3 km
- Average porosity of the Carboniferous
7 vol%
- Linear extrapolation of the evolution profile of the gas concentration of H₂ (mole%) (-900 to -3000m)
Dissolved hydrogen at -3 km: 30.8 mg/L

$$[H_2] = 7.8 \times 10^{-4} \exp \left(543 \left(\frac{1}{T} - \frac{1}{298.15} \right) \right) x_{H_2}(g) P$$

[H₂] is the concentration of the dissolved hydrogen in g/L,
T_(K) is the measured temperature at the corresponding depth,
P is the measured aquifer pressure at the corresponding depth,
χ_{H₂} is the hydrogen molar fraction of the corresponding depth.



Horizon 2030 : 20 Mtonnes/year

**H₂ in Lorraine: 34 millions of tonnes
calculated in place (409 Bcm)**

Two main hypotheses are proposed:

- **Siderite and iron-ankerite** (Fe(II)), which are widespread, can **reduce water to hydrogen** in the deepest Carboniferous sediments of the Lorraine Basin:



- Additionally, **H₂ thermogenesis from coal** is not ruled out:



and coal plays the role of **Eh buffer**, maintaining a very low Eh allowing the preservation of the H₂ resource

Both reactions are temperature-dependent, requiring over 150°C, corresponding to a depth of 5 km, for initiation

The consequences of H₂ generation models:

Siderite and iron-ankerite (Fe(II)) oxidation:



the reaction kinetics are fast

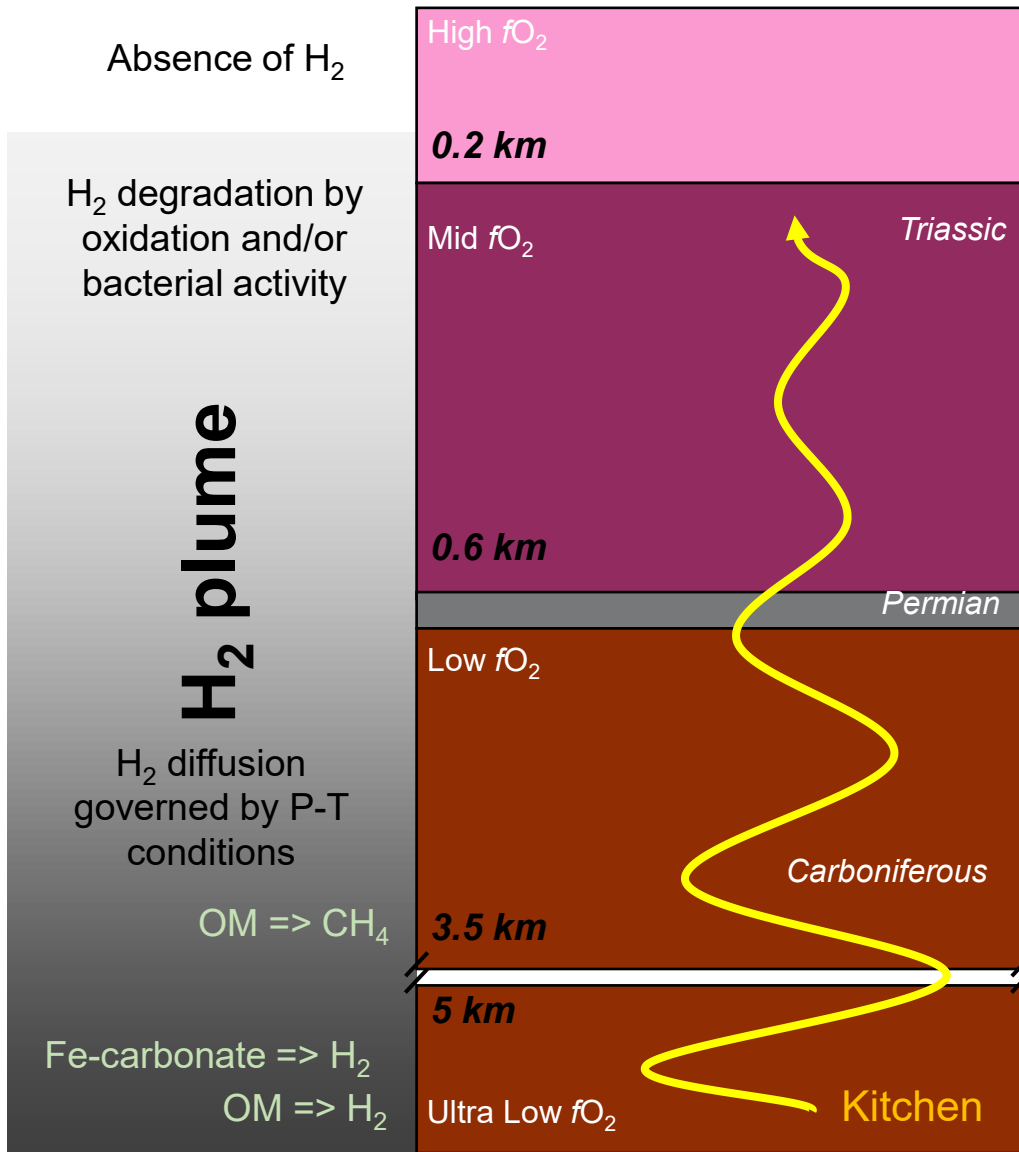
H₂ is renewable

H₂ thermogenesis from coal :



the reaction kinetics are slow

H₂ is not renewable



- ◆ Detectors located at -24 m and -1 m depth away from FOLS1A do not detect hydrogen, indicating that **natural hydrogen exploration** cannot rely solely on surface measurements and **requires drilling**
- ◆ The H₂ plume is governed by P-T conditions and **H₂ consumption through oxidation or bacterial activity** in Mesozoic sediments or soil
- ◆ The hydrogen concentration profile suggests a **hydrogen diffusion** with a source likely deeper than 5 km
- ◆ Furthermore, H₂ resources in the form of **dissolved gas** should not be overlooked to estimate the resources

- **Establish the Viability of Natural Hydrogen:** Showcase the potential for commercial extraction and utilization of natural hydrogen resources.
- **Transform the Gas Industry Model:** Revolutionize the industry by demonstrating the feasibility of producing gas from dissolved sources within aquifers.
- **Enhance Resource Accessibility:** Position the resource closer to consumers, improving availability and reducing transportation costs.
- **Prioritize Sustainability:** Emphasize the importance of renewability while redefining the traditional concept of gas reservoirs.
- **Leverage SysMoG™ for Innovation:** Position SysMoG™ as the cutting-edge solution to advance underground exploration technologies.
- **Develop an “In-Situ” Gas Separation Facility:** Create a facility capable of extracting and separating various gas types directly from underground sources.
- **Pioneer a New Era in Underground Exploration:** Reinvent underground prospecting and production to establish a green, sustainable industry focused on responsible resource management.



- ◆ How is H2 produced?
- ◆ Confirmation of H2 concentration with depth
- ◆ Confirmation of kinetics
- ◆ Test measuring probe and production tools
- ◆ Certification of H2 reserves

- ◆ Duration: 3 years

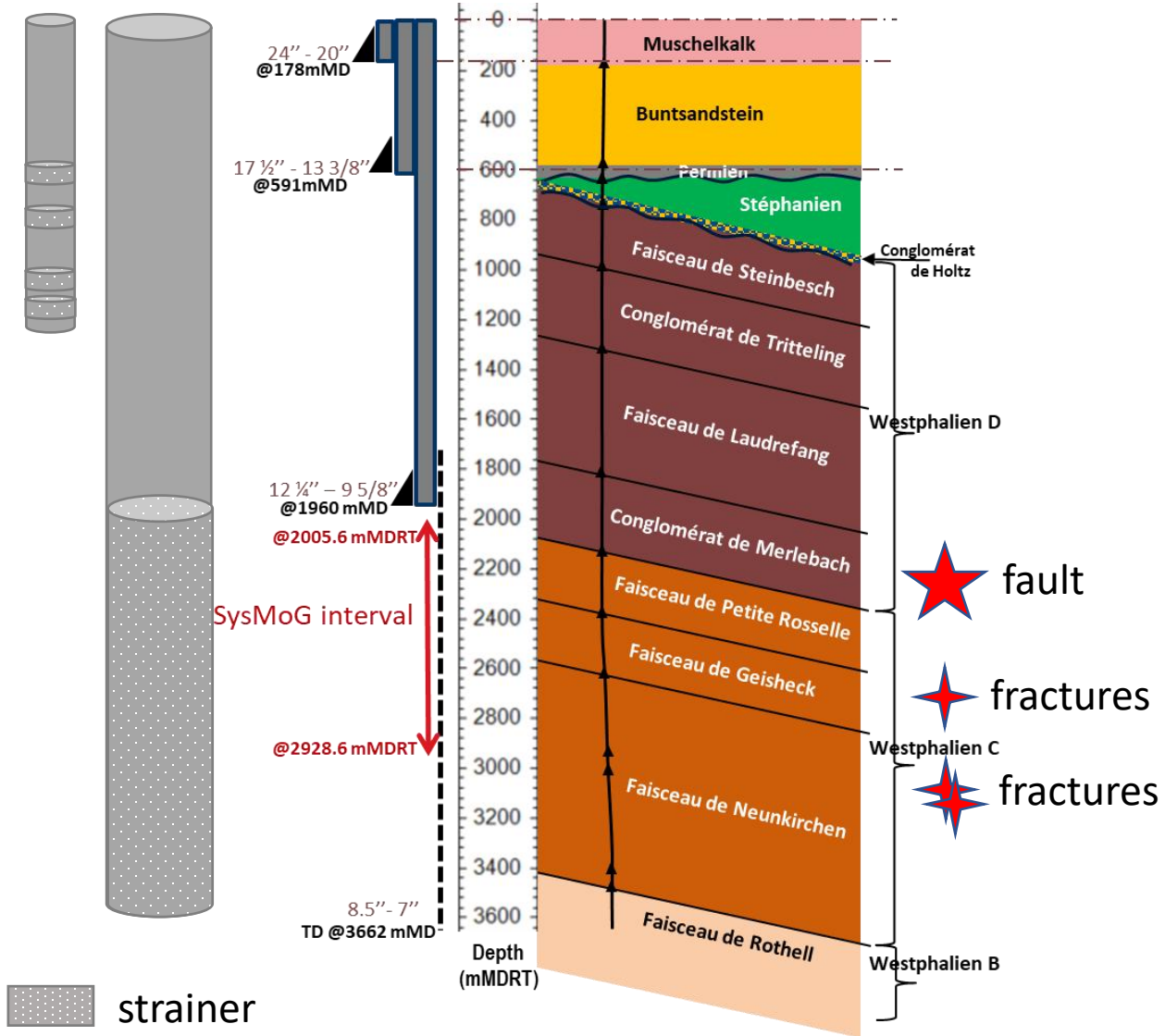
- ◆ Budget: 14 M€
- ◆ 8 M€ from FTJ funds
(Europe/Région
Grand Est)





FOLS-1A PTH-2

- ◆ **New SysMoG™** probe was designed and tested in lab by Solexperts to be adapted to deep conditions. Then, tests on PTH-2 well **validated** the **new version of the SysMoG™** probe
- ◆ **Gas sampling** started in May, just one week after the end of the drilling operation
 - ✓ **36.1% mol H₂** @ 2242 m
 - ✓ **49.6% mol H₂** @ 2426 m
- ◆ **Water in the borehole was not at equilibrium with the rock formation**
 - ✓ Presence of residues of drilling (mineral and organic materials),
 - ✓ O₂ detected between 0.2 and 0.8 bar in the water column



-3.655m

Hydrogen Discovery

*Pontpierre | France
Natural Hydrogen*



- ◆ Second hydrogen discovery in Lorraine
- ◆ Hydrogen measurements and numerous samples being taken during drilling
- ◆ SysMoG™ measurements completed down to 2928 mRT, confirming very high H₂ concentrations increasing with depth
- ◆ SysProG™ tests to be carried out, in parallel with all the analyses of the data collected during the drilling phase, which are currently underway.



To be continued...

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FDE
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positive impact