GRHYD : a successfull demonstration for the new gas H2NG

Isabelle ALLIAT (ENGIE Lab CRIGEN)

8th HIPS-Net workshop, June 17, 2021

GRHYD

Let's renew our energies

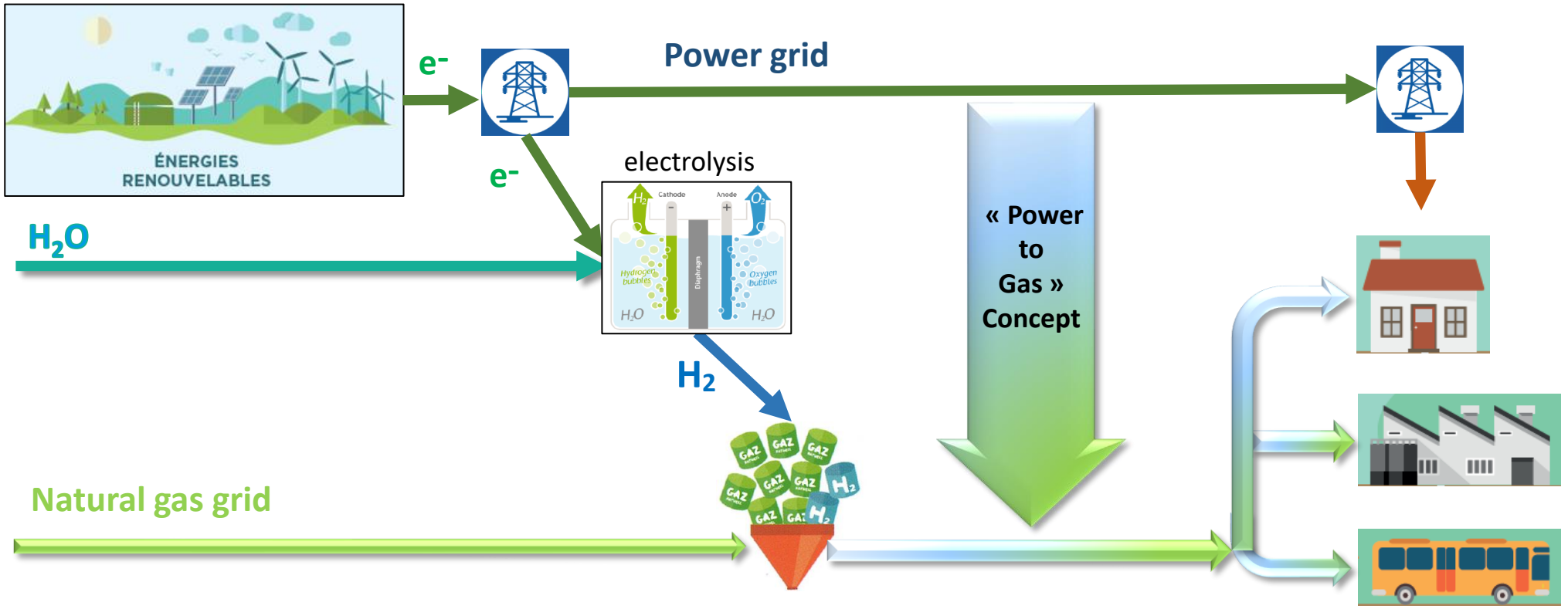
The GRHYD project
Grid management by Hydrogen injection for Decarbonizing the energies

Context and aim

GRHYD
Renouvelons nos énergies

The aim: store and valorize renewable energies in existing gas networks thanks to hydrogen vector

- Power-to-gas is a **solution of flexibility and arbitration** for the coupling between **power** grid and **gas** grid thanks to the **hydrogen** energy vector



French Investment for the Future Program: The GRHYD 'Power-to-Gas-to Grid' project

- Selected mid-2011 by the French Government, as part of the **'Investment for the Future'** *pilot and technology platform for renewable and low carbon energy: hydrogen and fuel cells*
- **French first** ever "Power-to-Gas-to-Grid" project in France and **a significant step** towards the development of hydrogen at urban level
- The GRHYD project also addresses the theme of **"Hydrogen for a Sustainable City"** bringing more renewables in urban energy uses

MINISTÈRE DE LA TRANSITION ÉCOLOGIQUE
Liberté Égalité Fraternité

INVESTIR L'AVENIR

ADEME
AGENCE DE LA TRANSITION ÉCOLOGIQUE

tenerrdis

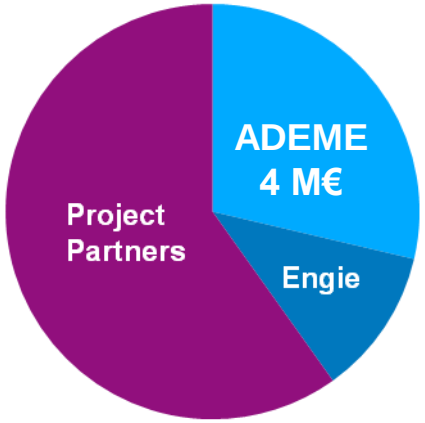
Région Hauts-de-France

GRHYD
Renouvelons nos énergies

An Experts Partnership to build a new supply chain based on Hydrogen-enriched natural gas

- **Dunkirk municipality**
- **Local operator of urban buses,** DK'BUS Marine
- **Leading energy company ENGIE** and 3 subsidiaries:
  - **ENGIE Solutions (Ineo Normandie)** (energy management for the H2 production & storage station),
  - with **GRDF** (GN-H2 mix injection and distribution in the gas grid),
  - and **ENGIE Solutions** (NG fuels) for the Hythane® refueling station for buses.
- **OEMs**: AREVA H2Gen for H2 production, and McPhy Energy for H2 storage
- **R&D and technical centers:** CEA, INERIS, CETIAT

Budget: 15.3 M€



The gas uses staged and evaluated by means of operational demonstration

Two pilots based on Hydrogen to assess the relevance of H2NG chain for sustainable cities

- **GRHYD objective : produce H2 from renewable electricity, inject this H2 into the gas distribution grid and consume the new H2-NG gas locally** (heating, cooking, hot water, CHP, and mobility)

A NEW GAS : H2NG

A new kind of gas for homes

A new 100-home district and the boiler of a health center, are supplied with a new type of gas H2-NG.
The H2 content fluctuates but doesn't exceed 20% vol.

From feasibility demonstration to commercialisation

SUSTAINABLE MOBILITY

A new fuel for urban buses

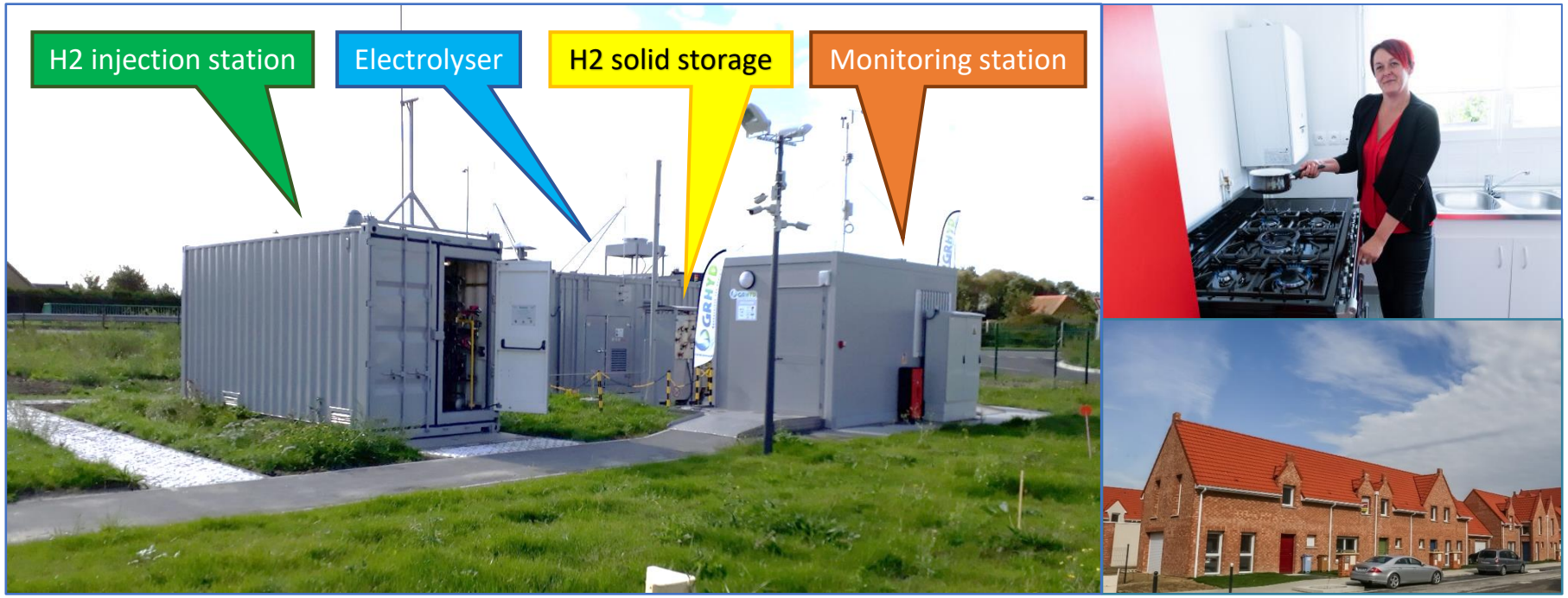
Through a **pre-commercial** demonstration, NGV station and 30 urban buses will be adapted to Hythane® fuel (5% and 20% H2 vol)

GRHYD
Renouvelons nos énergies

The main results of the new gas H2NG demonstration

1st Power-to-Gas H2 demonstror in France : Mission accomplished !

- **Successfull operation of the R&D pilot :**



✓ **Evaluate in actual conditions : the technical, environmental, regulatory and societal aspects of a sector using new H2NG energy for usual gas uses at home**

Good social acceptability among user residents

- A priori favorable experimentation area: a population accustomed to an industrial environment
- An information system combining public meetings with future residents, targeted communications, posters in housing buildings

Feedback from sociological studies carried out with residents (focus group, interviews):

- ➢ Confidence in the project partners to manage the industrial safety issue
- ➢ Their main concern: impact on the energy bill (neutral in the context of the project)

Pilot operation and H2NG delivery

ENGIE Solutions

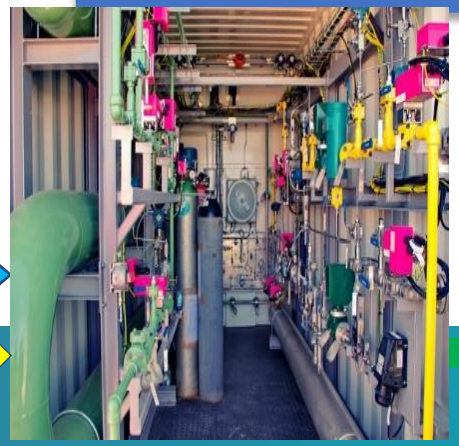
GRHYD
Renouvelons nos énergies

A complex technical chain successfully implemented

Electrolyser

Storage

Injection skid (from 6% to 20% H_2)



NG

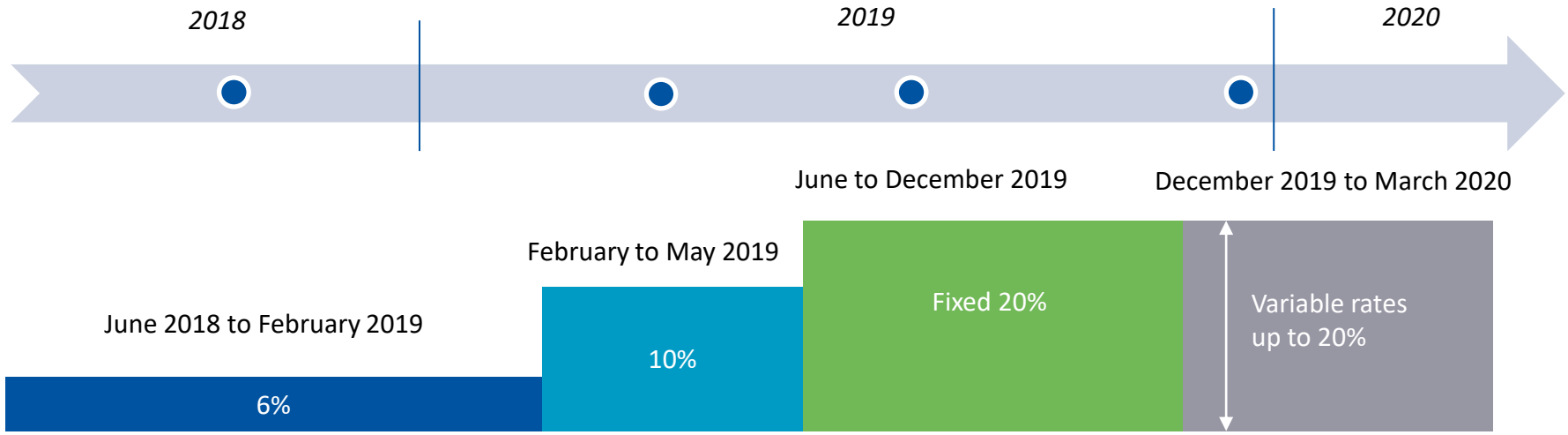
- Gas consumption (average flow) : ~8 $m^3(n)/h$ in summer and 40 $m^3(n)/h$ in winter
- Production capacity: 12 $m^3(n)/h$ H_2
- Storage capacity: 50 $m^3(n)$ H_2
- H2 production: ~ 13 000 $m^3(n)$ H_2 (consumption of 112 GWh renewable electricity and 14,4 m^3 pure water)
- Production of ~ 6 500 $m^3(n)$ O_2, released in the atmosphere

Supplying a new district :

- 103 households (76 collectives, 27 individual houses): individual condensing boilers (standard), gas cookers
- 1 care facility (EPSM) (4300 m^2): 3 tertiary boilers

GRHYD
Renouvelons nos énergies

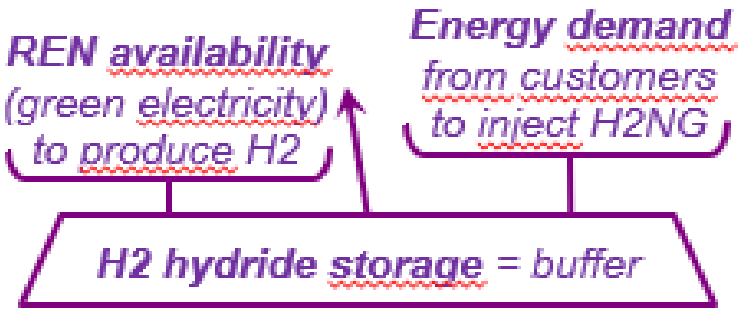
The demonstration lasted 22 months, and applied the fluctuating H_2 content in gas during the winter 2019-2020



Checking process:

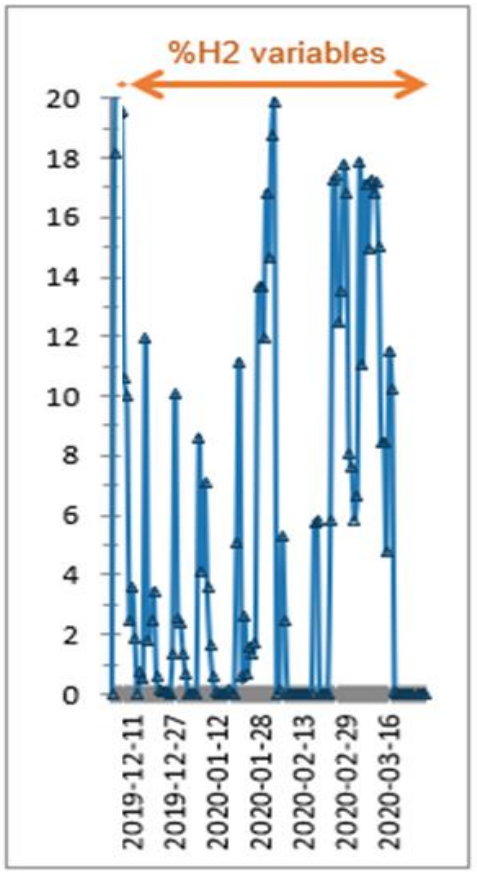
- Grid exploitation & safety procedures
- H2 electrolyser, storage, injection: exploitation
- Societal acceptance: habitants enquiries
- Domestic boilers, cookers: efficiency, combustion
- Central heating boilers: efficiency, combustion

Strategy for driving H2 equipments:

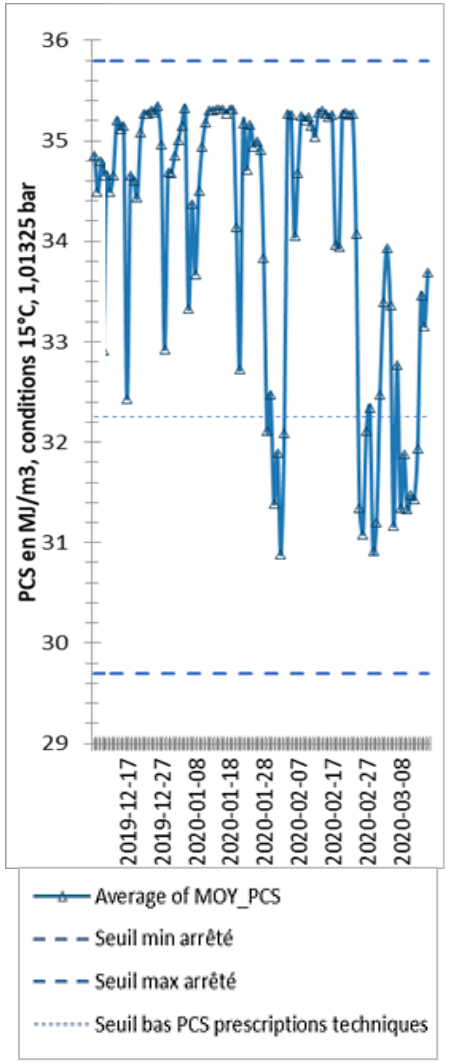


GRHYD
Renouvelons nos énergies

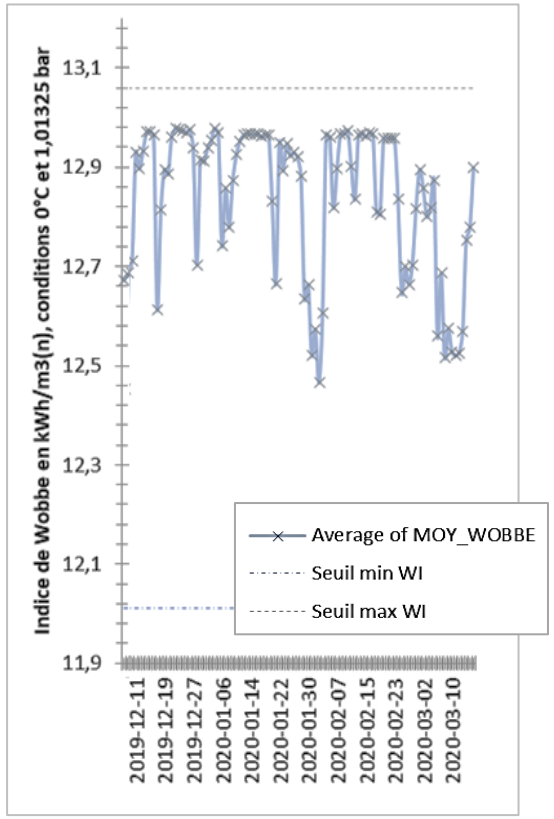
H2NG gas quality



- The fluctuating H2 % run during the winter times (Dec-March)



- The delivered H2NG fulfilled the DSO requirements in France (L-gas), except:
  - Content of H2 in NG
  - Calorific value:
    - GCV is out of the legal range above 12% H2 in L-gas
    - Large fluctuations will lead to development of Smart Gas Grid (billing purpose)
- The Wobbe index shows rapid instantaneous variations which may impact some sensitive end-uses, other than domestic gas appliances



GRHYD
Renouvelons nos énergies

The distribution gas infrastructures

GRDF
GAZ RÉSEAU DISTRIBUTION FRANCE

GRHYD
Renouvelons nos énergies

Confirmed adaptability of equipment, network and downstream meter facilities (gas appliances) to hydrogen/natural gas mixtures

Complex technical chain successfully implemented

Laboratory testing confirmed by field experimentation:

- Fragilization of materials ✓
- Tightness of equipment ✓
- Permeation / leaks ✓
- Odorization ✓
- Meters compatibility ✓
- Non-stratification (no over-concentration of H2) ✓

Tests of innovative equipment :

- New injection skid with H2/NG mixer
- Gas analyser

Indoor installations

Laboratory testing confirmed by field experimentation:

- Fragilization of materials (copper) ✓
- Tightness of the equipment ✓

Gas appliances

Laboratory testing confirmed by field experimentation:

- Individual new condensing boilers (Saunier-Duval) ✓
- New and existing boilers from the boiler room of the care center ✓

Laboratory tests only :

- Existing individual boilers and gas cookers ✓
- New gas cookers ✓

The technical feedback makes it possible to validate the feasibility of the injection of 20% vol. H2 in a new gas distribution network, supplying new homes

MAIN ELEMENTS OF REX ON THE DISTRIBUTION NETWORK:

- ✓ **No security incident** including during the adjustment periods of the demonstrator equipment
- ✓ **No incident recorded during operations to operate the network** at increased frequency (systematic search for leaks, inspection of valves, inspection of interior pipes and risers)
- ✓ **Very good quality of the hydrogen produced:** <5 ppm H2O and <5 ppm O2 => compliance with technical requirements for the gas distributed
- ✓ **Derogations** from regulatory thresholds have been given for H2 content, PCS and Wobbe index

DOWNSTREAM THE GAS METER:

- Campaigns on domestic gas appliances (volunteer residents) and on the tertiary boilers

Test results on domestic boilers

CETIAT
ensemble, innover et valider

GRHYD
Renouvelons nos énergies

Tested domestic gas appliances

	Labo (CETIAT)	Site (residents)
Domestic boilers	2 new boilers *(Saunier, Chappée)* 3 old boilers*(Frisquet, Chaffoteaux, Saunier)* 0, 10, 15, 20, 25 and 30 %vol. H2	3 new boilers *(Saunier)* 6, 10 and 20 %vol. H2
Cookers and ovens	1 new 1 old 0, 10, 15 and 25 %vol. H2	1 old (6 and 10 %vol. H2) 1 new (6 and 10 %vol. H2) 1 new at 20 %vol. H2

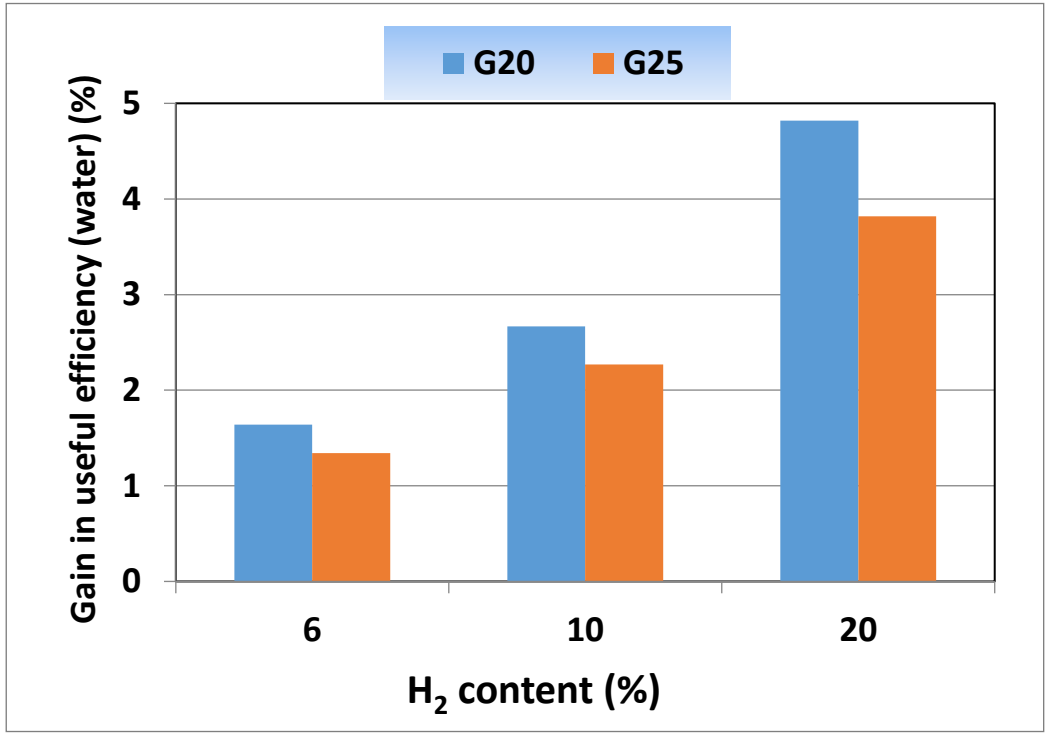
Tests in laboratory

Measures on site

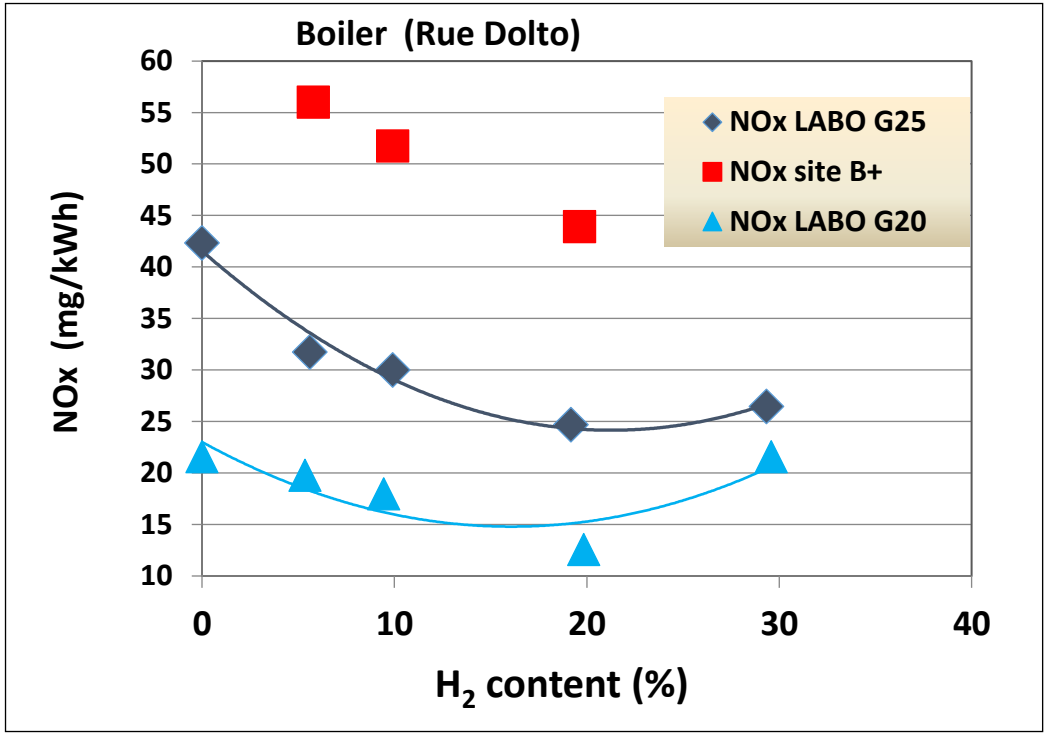
GRHYD
Renouvelons nos énergies

Results in lab and on-site (Saunier boiler)

- ✓ Useful efficiency (water) increases with the H2 content
  - ✓ Higher values with G20 reference gas



- ✓ Reduction of NO_X emissions (labo and site) with H2 content
  - ✓ Higher values with L-gas (GN-B+) on site



Conclusions of tests on domestic boilers

- ✓ **<u>These results are specific to the boilers tested, they confirm the literature, but they cannot be directly extrapolated to other boiler models</u>**
  - ✓ Reduction of the useful power and the heat output
  - ✓ Maintain of combustion efficiency and **increase of useful efficiency**
  - ✓ **Reduction of emissions : CO_2, CO and NO_x**
  - ✓ No problems relating to safety, noise, shutdown, securing, declared during technical inspections on site

For future deployment

- **Long-term impact of hydrogen (aging, endurance)** is to be verified in future projects
- There is a need for large-scale test campaigns **to adapt the standards to the new H2NG gas**

Conclusion of the new gas H2NG demonstration

A success of the injection demonstration plant that reinforces the technical feasibility of the new sector

Technical success in setting up a complex Power-to-Gas chain (hydrogen production by electrolysis - H2 storage - injection of H2 in mixture up to 20% (vol.) with variable rates): 22 months of field demonstration, design & testing of innovative equipment (PEM electrolyser, solid H2 storage, injection station, gas analyzer)

A new gas distribution network and residential-tertiary natural gas uses that work well with the H2/natural gas mixture, under industrial safety conditions equivalent to the natural gas ones

Constructive technical dialogue with the French administration

Good social acceptability among users, their main concern being the management of the energy bill

A confirmed environmental benefit of hydrogen injection: -6% CO2eq vs natural gas or 20 tons of CO2eq avoided on the neighborhood per year, **reduction in CO emissions** (-63%) and **NOx** (-42%) at the stack (exhaust system) of domestic boilers

A demonstrator that guides future work

Continue to optimize the Power-to-Gas chain by relying on improved solutions for operation and monitoring of the equipment

Work on European regulations, standardization & certification with consideration of hydrogen in gas infrastructures and gas uses to prepare for industrial deployment (network equipment, gas analyzer and meter, equipment and installations downstream meters, gas appliances, etc.)

Develop equipment and operation-maintenance procedures adapted to the new composition of the gas supplied (inspection method and frequency, leak detectors adapted to the mixture, etc.)

Extend the compatibility analysis of the natural gas chain by carrying out tests **on the existing devices** (distribution network, indoor installations, downstream meter equipment in the residential, tertiary and industrial sectors)

Continue R&D work on **protection solutions for sensitive network installations or customers** (e.g. membranes separating H2 from natural gas)

As a conclusion

- **In France, Territorial Communities have an interest in this new green gas**
- **The GRHYD project is preparing the ground for the pre-industrialization and deployment of the new H2NG gas: the next project will increase in size!**

Hythane®
as fuel
for urban buses

A pre-commercial demonstration

ENGIE Solutions

GRHYD
Renouvelons nos énergies

The Hythane® pre-commercial demonstration: goals and challenges

The aim:

- **Starting from the R&D project ALTHYTUDE, GRHYD project was aiming to achieve a pre-industrial and commercial demonstrator**
- **On the fleet of busses in Dunkirk city by retrofitting the current NGV installation enabling a 15 years commercial fuel supply contract**

The challenges down the road:

- **Different positions between vehicle manufacturers and refueling station developers**
- **Developing a new market**
- **Lack of regulation (vehicles), that was needed for a pre-industrial scale project**

Conclusion on Hythane® demonstration

Results synthesis:

- **An interest of local communities and fleet operators in Hythane® fuel, as H2-CNG and H2-bio-CNG blend, if environmental results are demonstrated with the new Eurocodes**
- **An overall cost analysis (TCO) showing the competitivity of the Hythane® fuel vs CNG and FC**
- **Vehicle regulation is in between : NGV = R110 and H2 = R134, with a French limitation to 2% H2 in CNG fuel (décret 2017)**

Where we are as GRHYD close out:

- **A parallel rise of the H2 mobility market during the GRHYD project lifetime, that might step up on the potential of Hythane®**
- **Questions raised by the GRHYD project are current hot topics induced by development of Power-to-Gas H2 projects**
  - Adaptation of the European or International regulation to Hythane® fuel & vehicles
  - Potential interesting synergies between H2 and Hythane® due to the development of Power-to-Gas projects on the French grid, assuming environmental and economical performance of Hythane® are confirmed

OPÉRATION RÉALISÉE AVEC LE CONCOURS
DES INVESTISSEMENTS D'AVENIR
ET DE L'ÉTAT CONFIÉS À L'ADEME

ADEME
AGENCE DE LA TRANSITION ÉCOLOGIQUE

INVESTIR L'AVENIR

En partenariat avec :

Région Hauts-de-France

reu3

Dunkerque Grand Littoral

tenerrdis

ENGIE

ENGIE Solutions

GRDF

cea

CETIAT

AREVA H_2Gen

INERIS

McPhy
Driving clean energy forward

DK'BUS

Ville pilote :

Ville pilote
Cappelle

THANKS FOR YOUR ATTENTION

Isabelle.Alliat@engie.com
Helene.Pierre@engie.com

GRHYD
Let's renew our energies