The GRHYD project

Grid Management by Hydrogen Injection for Reducing Carbonaceous Energies

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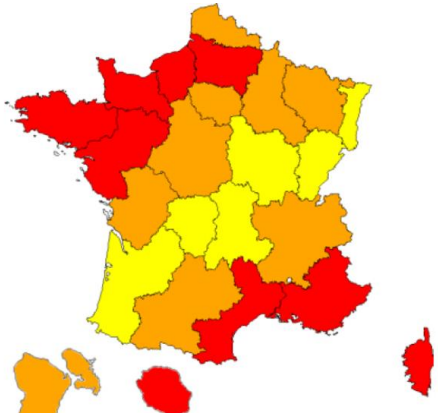
Power-to-Gas

Renewable Energy growth in the French energy mix : Geographical shift between the electricity consumption places and the RE production sites

In 2020, wind power will provide 10% of the total electricity production

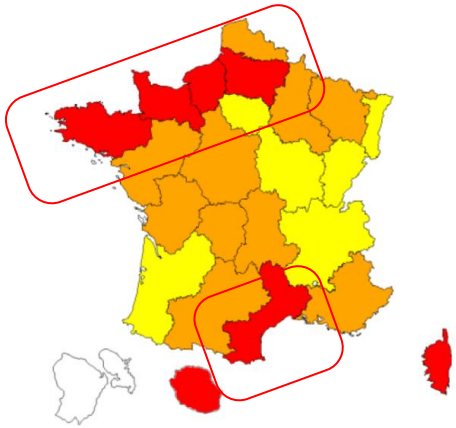
Wind farms are mainly in North and West of France, most of the solar farms are in South of France:



RES installed capacity in 2020

- Red: $Cap_{RE} > 1500$ MW
- Orange: $500 \leq Cap_{RE} \leq 1500$ MW
- Yellow: $Cap_{RE} < 500$ MW

=> Local needs for storage of Renewable Energy in 2050



Ratio between RES installed capacity (MW) and electricity consumption (MW) in 2020

- Red: ratio > 100%
- Orange: 50% ≤ ratio ≤ 100%
- Yellow: ratio < 50 %

The transformation of energy mix requires to develop new flexibilities

Renewables are growing but they are intermittent

- Wind onshore & offshore (7.5 TW in France in 2012), photovoltaïcs (3.5 GW), hydro power, etc.
- Renewable energy will provide 1/3 of electricity production in 2020

The balance between supply and demand, more and more difficult to ensure, threatens the stability of the power system and degrades the quality of electricity supply

- Intermittent RE production, more or less predictable, rarely programmable
- “Peak deficit” vs overproduction "off peak"
- Points of congestion, difficulty in extending the grids

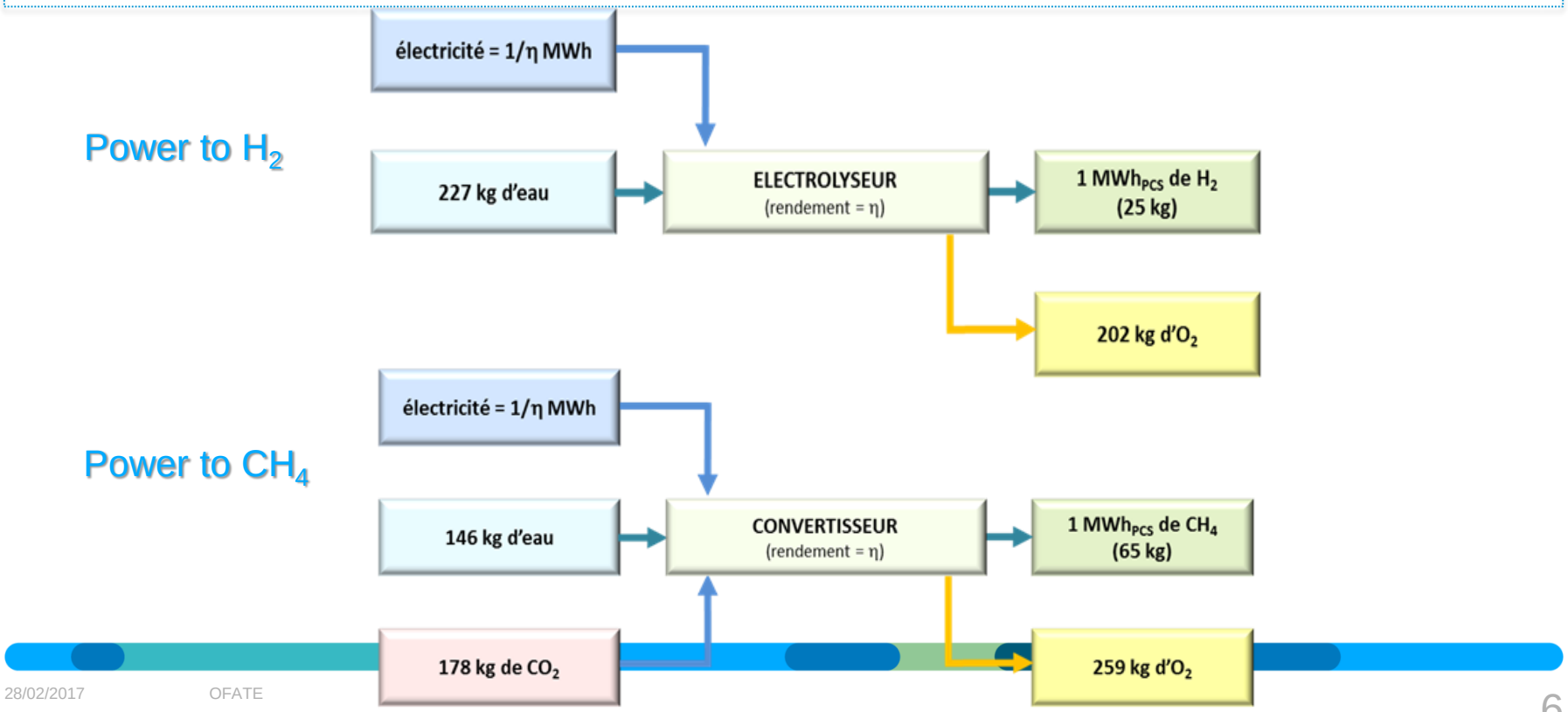
The creation of new vectors of flexibility has become a necessity

- Flexibility in consumption => new flexible uses and "smart grids"
- Flexibility in production => more flexibility on "conventional" plants

with respect for the environment and with the reduction of greenhouse gas emissions as a guideline

Power to Gas concept:
Power to H2 … to CH4 … to Gas

"Power to Gas" is expected to become a reality in the market over a period of 5 to 10 years, benefiting from the structural evolution of the intermittent generation of electricity from renewable energies and the mature new electrolyser technologies.

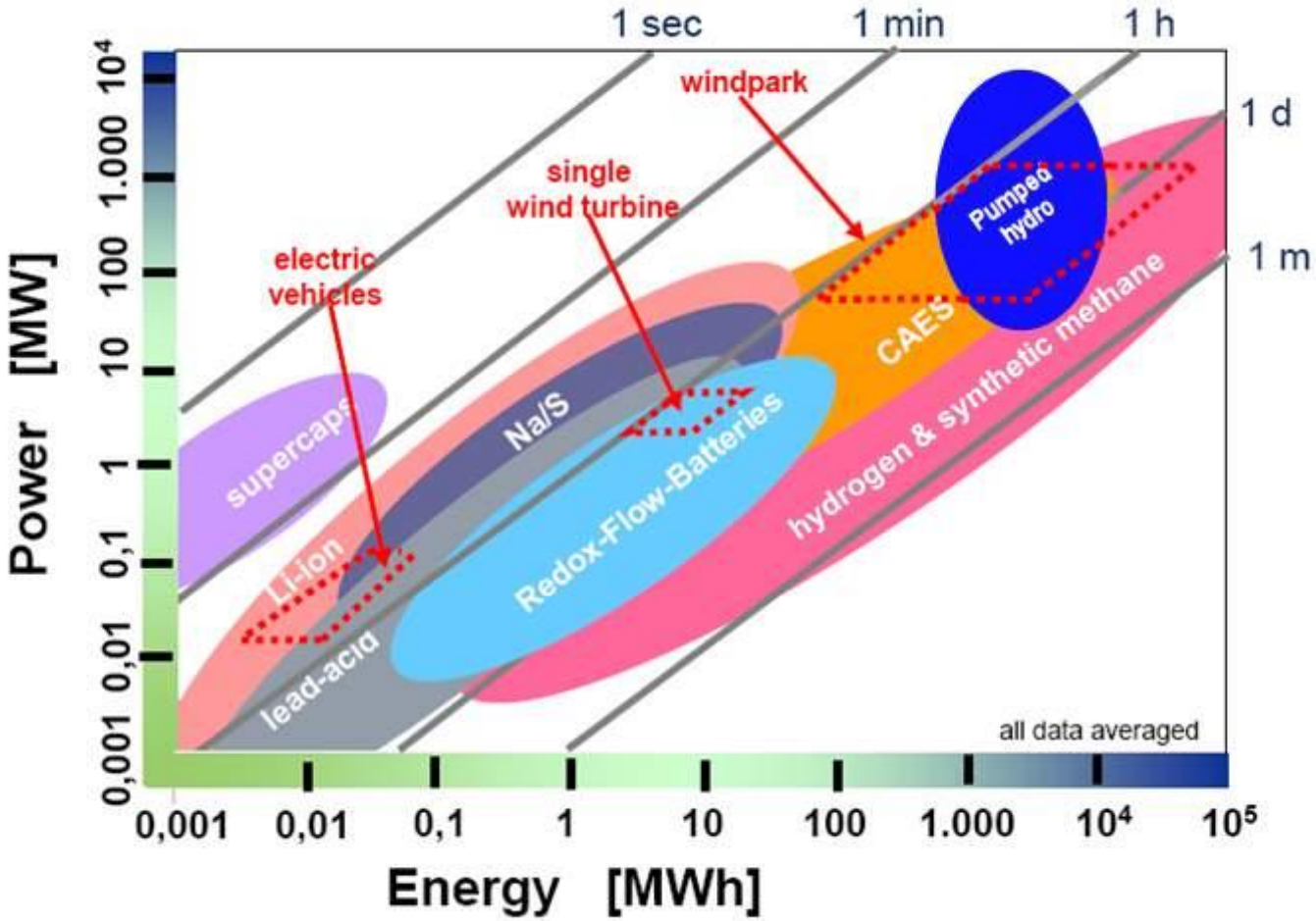


Power to Gas: technico-eco advantages

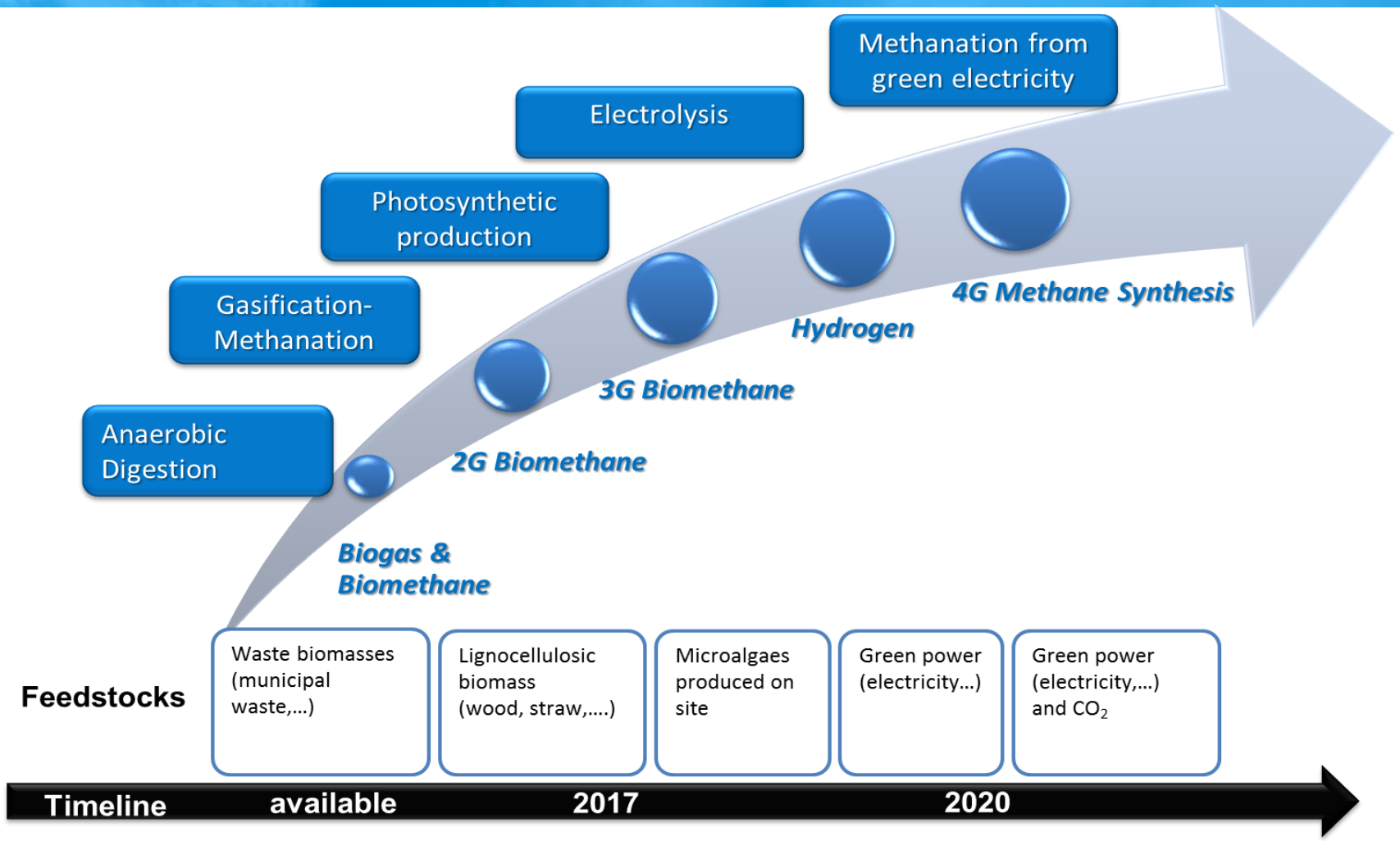
Taking advantage of low market electricity prices, generated by intermittent low-cost marginal electricity production, to produce combustible gases (hydrogen or synthetic methane) that can be easily stored and transported in existing natural gas infrastructures

- 4 differentiating assets:
  1. Storing very large amounts of energy over very long periods (up to several months)
  2. Transporting energy using GN networks
  3. Arbitrate markets between electricity generation and other uses of gas = "Power to Gas" ... "not to Power" (option)
  4. Strong capacity of the gas system to absorb, to dampen intermittent and variable productions
- Power to Gas: an activity at the crossroads of ENGIE's businesses
  - Electricity production, transmission, storage, distribution and marketing of gas, arbitrage on gas and electricity markets, CO2 valuation (services)

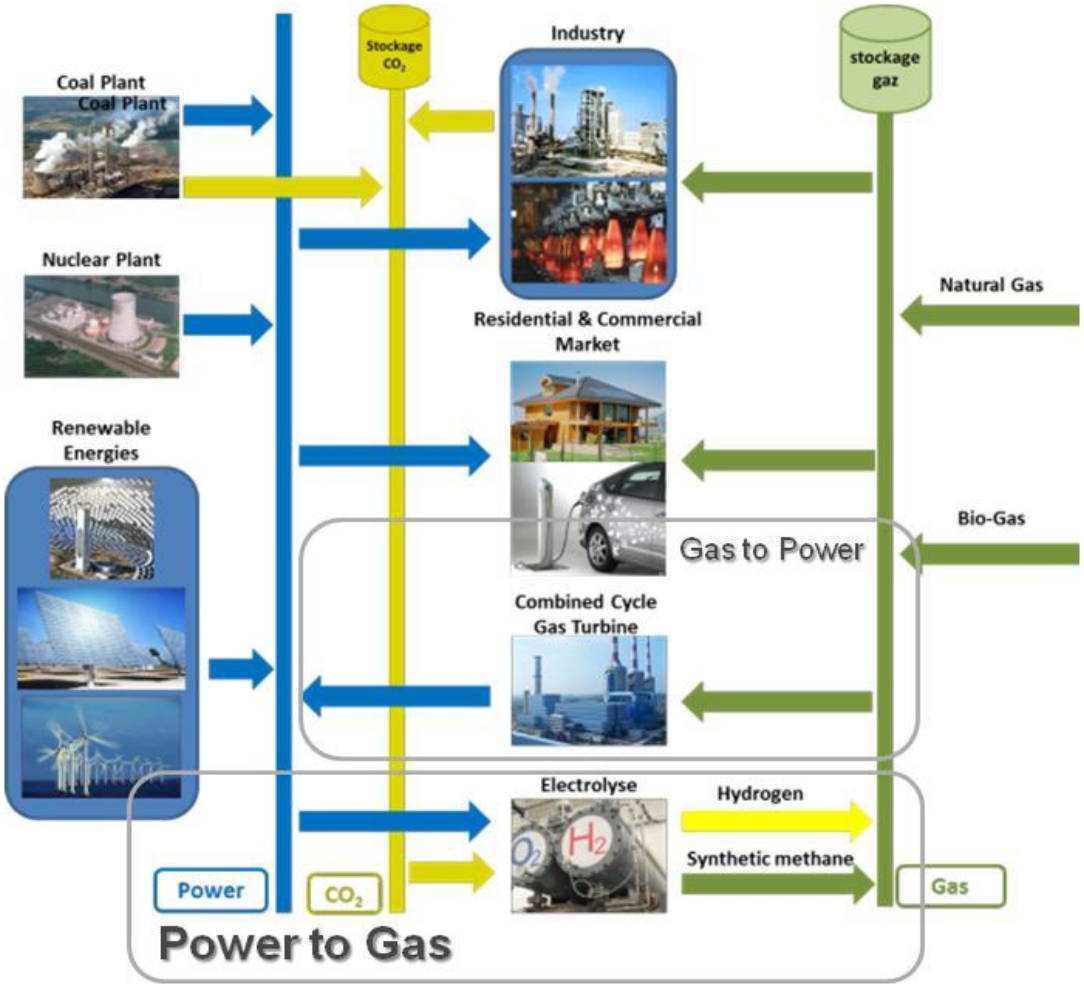
"Power to Gas“: a form of storage with an extended scope



The "Power to Gas" is part along the development path for "green gases"



Power to Gas generates synergies between electric grids and gas networks



By 2050, in a scenario of strong penetration of intermittent Renewable Energy, coupled with ambitious energy efficiency targets, modeling of the electricity system shows that **production surpluses could approach 75 TWh/year, ie nearly 15% of French production.**

On the basis of these modellings, **the production of hydrogen or methane synthesis could reach 20 TWh/year, ie nearly 7% of the consumption of natural gas in France.**

02

Background and Overview of GRHYD

Investment for the Future: 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.*

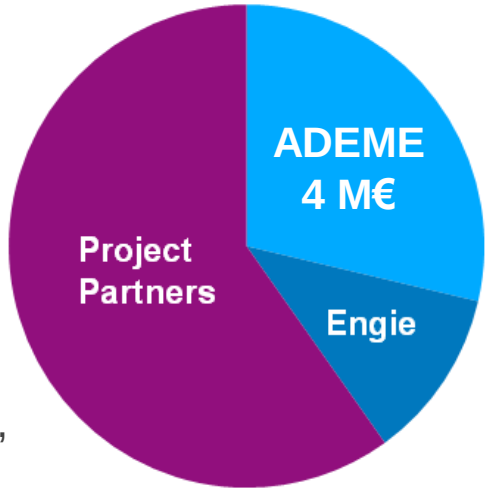
- France's first ever 'Power-to-Gas-to-Grid' project in France **and a significant step** towards the development of hydrogen at urban level.

- The GRHYD project also addresses the theme of "**Hydrogen for a Sustainable City" as this energy is Green.**

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

- **Dunkirk municipality**
- **The area's public bus company,** DK'BUS Marine.
- **Leading energy company** ENGIE plus 3 subsidiaries:
  – **ENGIE Ineo** (energy management for the H2 production&storage station,
  – with **GRDF** (GN-H2 mix injection and distribution in the gas grid),
  – and **GNVERT** (CNG) for the Hythane® refueling station for buses.
- **OEMs**: AREVA H2Gen and McPhy Energy, for H2 production and storage
- **R&D and technical centers**, CEA, INERIS, CETIAT

Budget: 15.3 M€



GRHYD = Two pilots based on Hydrogen to assess the relevance of underlying Power to Gas supply chain

GRHYD Objective : Produce H2 from renewable electricity, supply it to customers as an NG-H2 mixture by means of the gas distribution grid, and consume it locally

Residential use, heating, cooking, hot water, CHP, and mobility (fuel for buses)

A NEW TYPE OF GAS FOR GRID

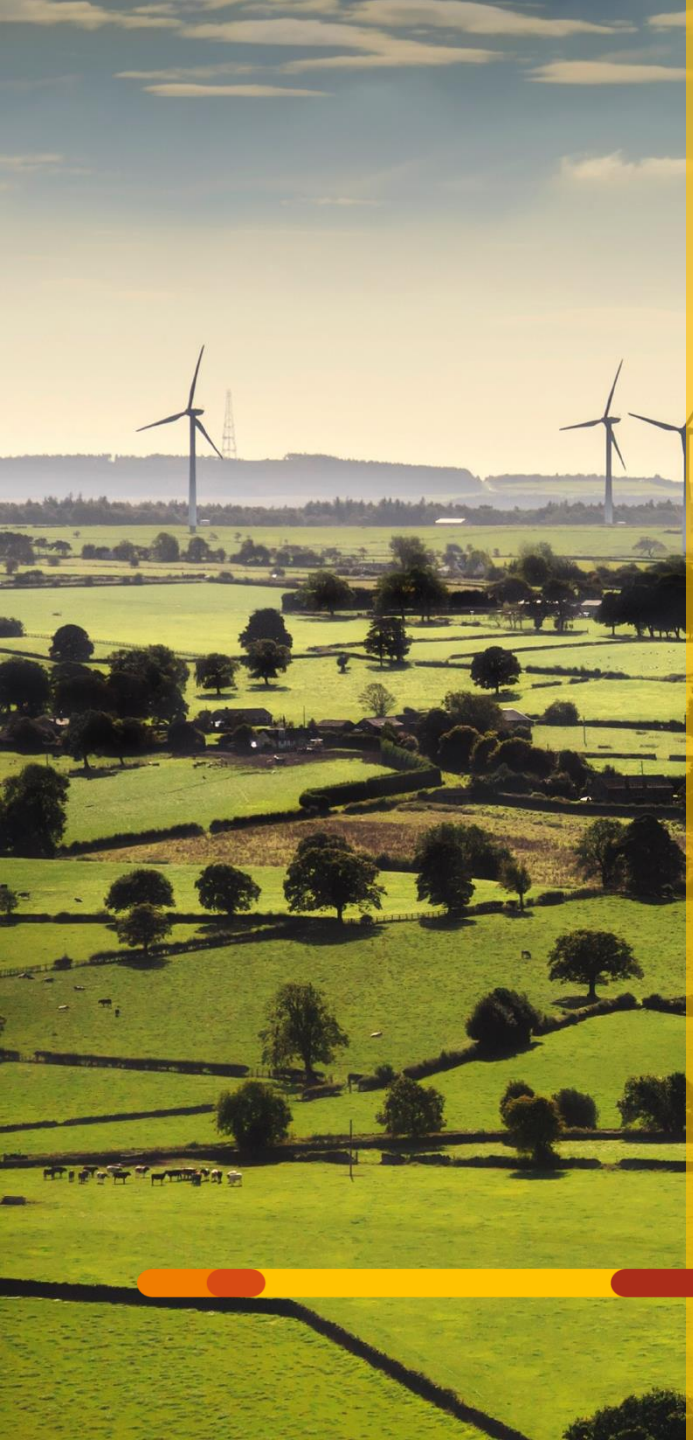
A new kind of gas for homes

A new 200-home estate will be supplied with NG-H2 blends.
The H2 content may fluctuate but will never exceed 20% vol.

SUSTAINABLE MOBILITY

A new fuel for urban buses

By piloting Hythane® fuel on a commercial level.
The NGV station and dozens of urban buses will be adapted to Hythane® (20% vol. H2)



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Environmental and economic matters addressed via the pilots

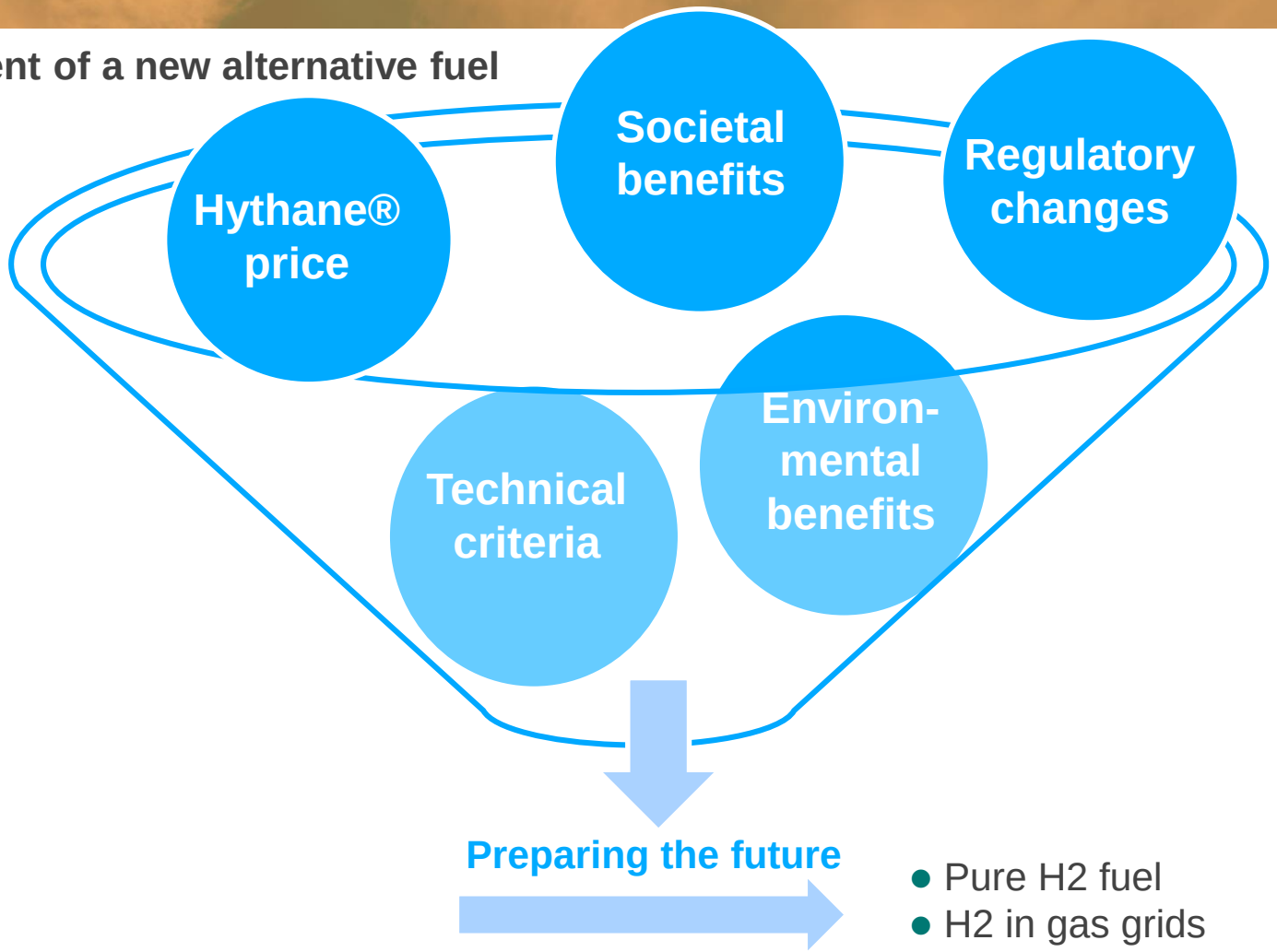
Power to Gas has major environmental benefits

- **Unlocks markets for renewable and low carbon energy sources**, through their conversion into hydrogen gas.

- **It opens up several options, including H2 injection into the natural gas grid and utilization of the H2/NG blend as a vehicle fuel** (Hythane®, 'H2 enriched NG'):
  - **Higher engine efficiency** (+7% vs CNG)
  - **Lower emissions of local pollutants** (-10% vs CNG)
  - **Lower consumption of primary energy** (fossil energy replaced by renewable H2 energy).

GRHYD Project to explore the conditions for expanding the Hythane® fuel market

Deployment of a new alternative fuel



- Pure H2 fuel
- H2 in gas grids

R&D Pilot : « new gas for residential uses » Hythane® to be supplied to 200 houses

Electricity supply + H2 production & storage → NG supply + Hythane® injection → New distribution grid (low pressure) → Gas appliances (boilers, radiators, cookers etc.)

Objectives	Progress	
Technical feasibility study	▪ **Design optimization of the H2 chain vs energy needs (heating, hot water, cooking) and availability of 'green' electricity**	✓
Safety (regulations)	▪ **French Ministry gave in June 2016 its approval for injecting H2 in gas grid, for GRHYD experimentation**	✓
Performance assessment of 'green' H2 production & storage	▪ Technology innovation for electrolysis (PEM) and H2 storage (at low pressure on metallic hydrides)	
Social acceptance	▪ No objection for this new 'gas' at home, but clear and complete information needed	✓
Assessment of economic and environmental results.	▪ **Support mechanism to valorize the renewable value of this green gas, to be designed (guarantee of origin,…)**	

R&D Pilot : « new gas for residential uses »

Industrial Pilot "Hythane® fuel for bus fleet"
Deployment of a new vehicle fuel on a commercial scale

Electricity supply + H2 production & storage → CNG supply + Hythane® injection → Inner pipe network (automatics, monitoring) → NGV buses (Hythane® adaptation)

Objectives	Progress
Technical and economic analysis of Hythane®	▪ **Design optimization of the H2 station** vs fuel needs and 'green' electricity
Safety (regulations)	▪ Ongoing risk assessment & management for permitting issue
Deployment of Hythane®	▪ Bus, engine and depot adaptation ▪ Regulation for vehicle "homologation" to be adapted (IVECO) ▪ **Hythane® fuel station start planned for 2018**
Social acceptance	▪ **Introduction of the new fuel to passengers: no objection noticed trough first sociological studies**
Development of a sustainable economic model	▪ Early Life Cycle Analysis (LCA) ▪ Ongoing negotiation between Hythane® supplier (ENGIE GNVERT) and Dunkirk municipality for a 15 years contract

Industrial Pilot “Hythane® fuel for bus fleet”

Hythane® refuelling station:
To be opened soon

GRHYD
Renouvelons nos énergies

Thank you !

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Power to Gas

Back up

Power to Gas : First economic elements

- Objective: To produce competitive hydrogen or synthetic methane compared to fossil natural gas at the point of injection, including externalities (CO2 tax, for example)
- Example: Conditions gathered during 2600 hours in 2012
  - The competitiveness of P2G does not require access to abnormally low electricity prices (zero or negative)
  - Assuming a gas sale price of € 40/MWhPCS, oxygen co-produced at € 40/t and a yield of 75%, **the competitive limit of P2G is reached for an electricity price of € 37/MWh.**
  - Powernext served a price below this value for 2600 hours in 2012 for an average price over this period of 27.2 €/MWh.
- **"Power to Gas“ is a solution of flexibility at least as interesting as the storage of electricity**

Main Opportunities and Threats on the development of Power to Gas

O

- Development of Intermittent Renewable Energies
- Increased flexibility requirements on the electrical system
- Possibility of arbitrage on gas and electricity markets
- Difficult development of power grids

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- Fall at a very low level of natural gas prices in Europe (shale gas effect)
- Competition of other flexible consumers in access to electricity
- Reform of the electricity market in its price formation mechanism