Power to Gas

A new way to valorize electricity overproduction

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The structure of the energy mix is changing

An energy mix in mutation/transition

- **Strong development of intermittent renewable energy sources at low marginal cost: Wind, Solar, Ocean energy**
- 20% of renewable energies in Europe within 2020
- Strong development of decentralized RES productions sites
- New usages of electricity

Flexible solutions are required to manage this significant increase of renewable and intermittent electricity in the network

- Constrains on the supply/demand balance
- Risks on the stability of the electric system
- Deficit “peak” vs. overproduction “off peak”
- Demand on network development

Reduction of CO_2 emissions

- Many solution has been proposed for CO_2 emissions reduction:
  - Increase energy efficiency of equipments,
  - biofuels, etc…
- Exchange “stored” carbon by “avoided” fossil carbon can be an interesting solution

« Power to Gas – one flexible solution

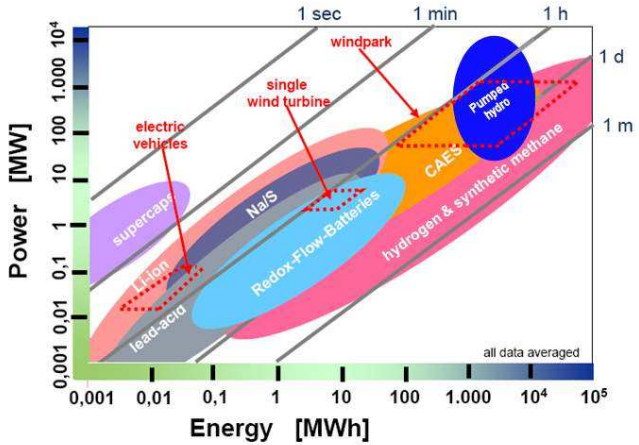
Take advantage of low price of electricity on the markets, **caused by overproduction of intermittent electricity at low marginal cost**, to produce add value gas fuels (hydrogen or methane synthesis) which can be easily stored and transported in the existing natural gas infrastructures.

4 advantages

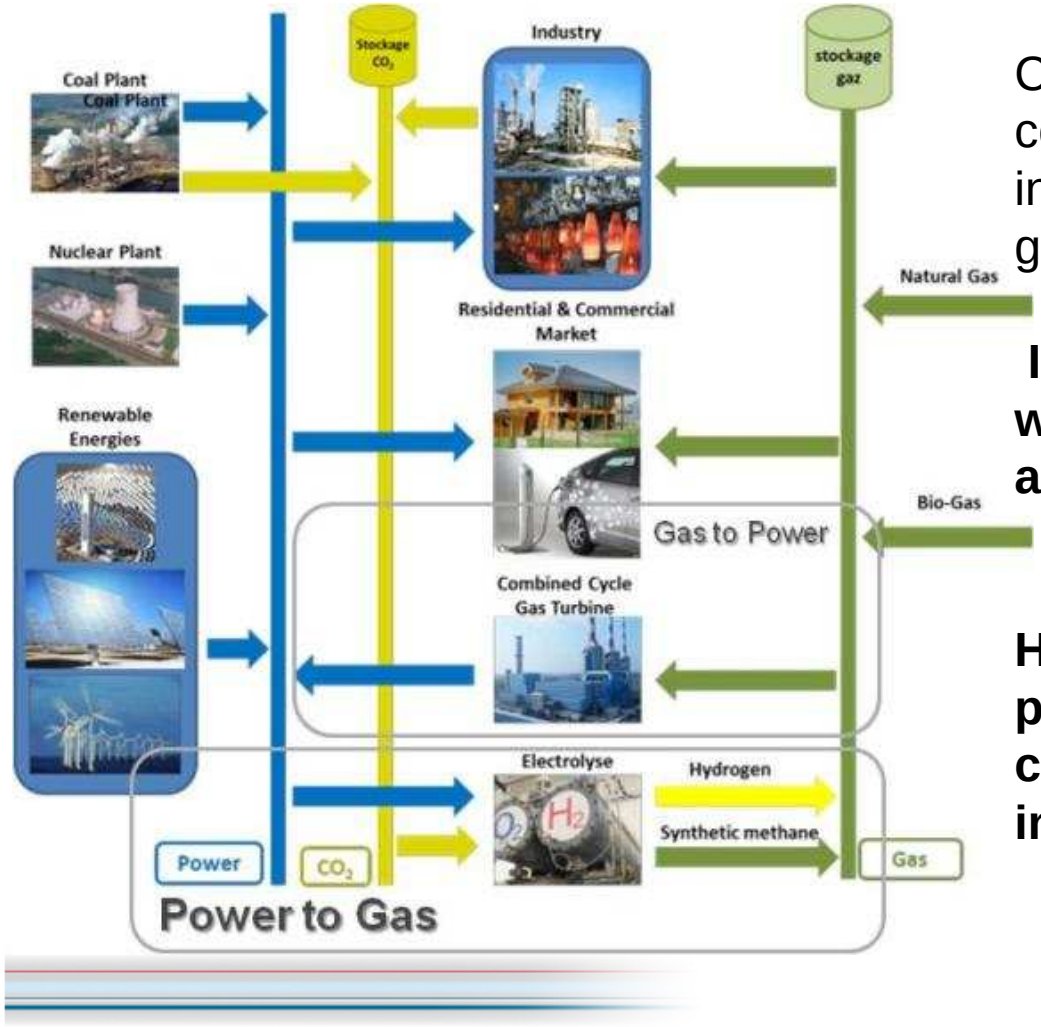
- Ability to store large quantities of electricity over very long periods (several months).
- Possibility of transporting energy using natural gas grids.
- Possibility of arbitrage between markets power generation and other uses of gas.
- High ability of gas grids to absorb / cushion variable and intermittent productions

The "Power to Gas", at the crossroads of the activities of GDF SUEZ

- Electricity production, transport, storage, distribution and marketing of natural gas, arbitrage between gas and electricity markets



« Power to Gas » : creating synergies between gas and electricity systems



Considering a scenario taking into consideration a strong integration of intermittent RES, coupled with ambitious goals of energy efficiency :

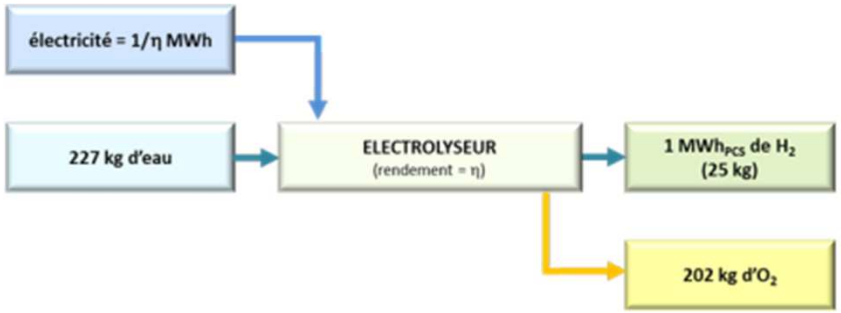
In 2050 the electricity overproduction will reach 75 TWh/year i.e., **15 % of the actual electricity production in France.**

Hydrogen and synthetic methane production of 20 TWh/year which corresponds to 7% of NG consumption in France

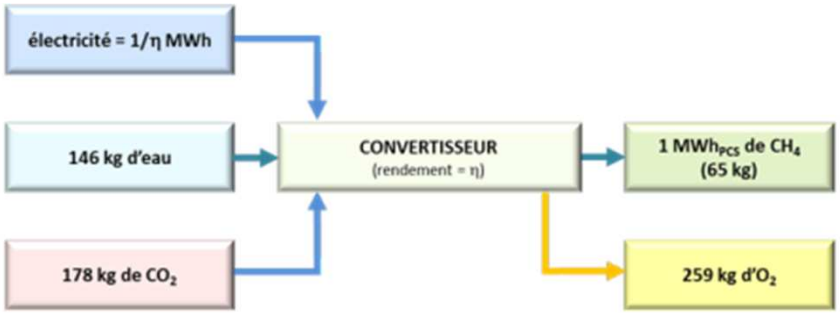
« Power to Gas »: a reality over the next 5 to 10 years

The "Power to Gas" will become a reality on the market over the next 5 to 10 years with the evolution of the structure of the production of electricity, mainly with the development of renewable energy, and the maturity of new technology for electrolyzer

Power to Hydrogen



Power to methane



Business concept of “Power to Gas”
First economic elements

- **goal**
  - Produce hydrogen or methane synthesis competitive against fossil natural gas at the injection point, externalities included (CO2 tax, for example)

- **Conditions met during 2600 hours in 2012**
  - Competitiveness of P2G does not require to access at an abnormally low prices of electricity (zero or negative)
  - By assuming a sale price of gas at 40 € / MWhPCS, of oxygen at 40 € / t and a efficiency of 75%, the competitivness of P2G is reached for a price for electricity lower than € 37 / MWh**.**
  - Powernext served a lower price than this value during 2600 hours in 2012 with an average price during this period of 27.2 € / MWh

- **"Power to Gas", a flexible solution at least as interesting as the electricity storage**

Over 50 projects on Power to Gas all over the world are in progress

GDF SUEZ projects on Power to Gas

- **Project GHRYD (France) (Invest. d'Avenir)**
  - Project managed by GDF SUEZ which main goal is to inject H2 in a NG network of an eco- neighborhood of 200 homes and the utilization of Hythane® as a fuel for 50 buses in Dunkirk
- **Projects Minerve, Demeter (France)(ANR, KIC)**
  - R&D project on the development of a flexible technology for Power to Gas, in particular Power to methane concept
- **Etc.**

Projects in Europe

- **Project Ameland (Netherlands)**
  - H2 injection in a specific NG network supplying 14 homes
- **Project Eon (Germany)**
  - H2 injection in the distribution NG network. This H2 is produced by electrolysis (360 Nm3/h, 2 MW) from the overproduction of electricity of a wind farm (Falkenhagen)
- **Project Audi (Germany)**
  - Synthetic methane production from renewable H2 for fuels and for injection in the NG network .
- **Project Enertrag (France)**
  - H2 production from water electrolysis coupled with a PV farm of 40 MW in Cambrai region

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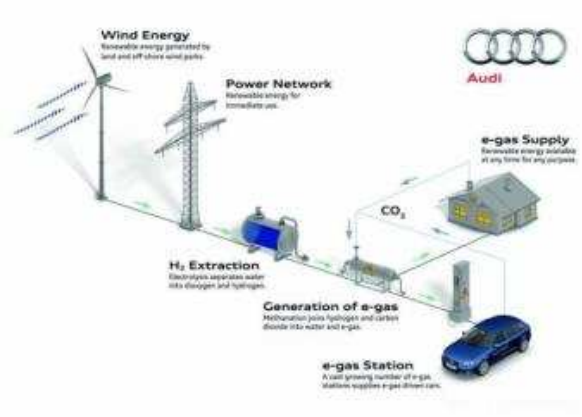

Grid Management by Hydrogen Injection for Reducing Carbon Energies

GRHYD « Power to Gas » project introduces hydrogen as a flexible solution to store, transport and valorise intermittent renewable energies through « green » natural gas

- ❑ Sustainable Hydrogen production and injection into the gas grid
- ❑ Use of the mixture in final appliances (stationnary and Hythane® fuel)

French Program for future Investments

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

Ministère de l'Écologie, du Développement durable et de l'Énergie

ADEME
Agence de l'Environnement et de la Maîtrise de l'Energie

INVESTISSEMENTS D'AVENIR

12 Partners representing the value chain

GDF SUEZ

Dunkerque Grand Littoral
COMMUNAUTÉ URBAINE

GNVERT GDF SUEZ

GrDF
GAZ RÉSEAU DISTRIBUTION FRANCE

INEO GDF SUEZ

DK'BUS Marine

AREVA

CETH2

McPhy energy

DE LA RECHERCHE À L'INDUSTRIE
cea

INERIS
maîtriser le risque pour un développement durable

CETIAT
ensemble, innover et valider

GRHYD : « Power to H2 for sustainable city»

2 pilots for production, distribution and local use of renewable H2 mixed with natural gas in DUNKIRK

Sources of Renewable or low carbon power

Injection into the power grid

Excess of Power = Production of H2 by electrolysis, storage and fuel distribution

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Different types of valorization

Hythane® (6% and 20%) in vehicles (bus, garbage trucks, etc)

Pre-industrial Pilot

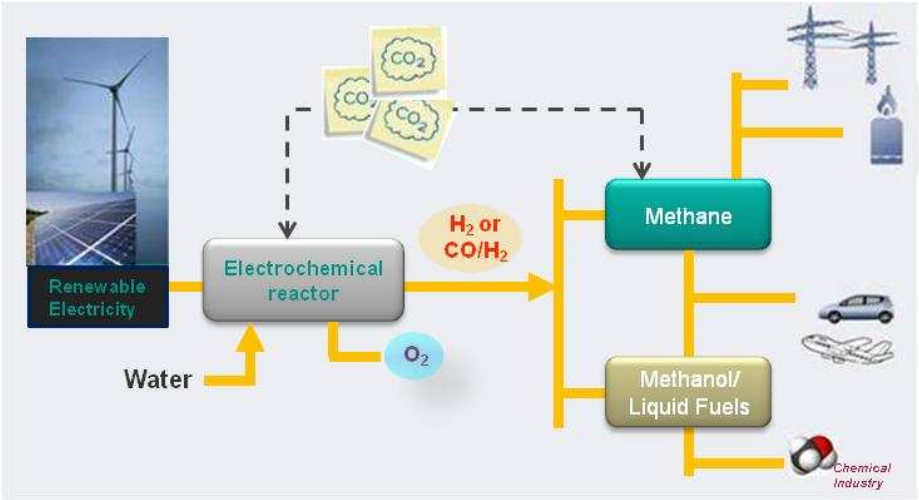
From 6% to 20% H2 injected into distribution gas grid and NG uses in a new district

Research pilot *distribution grid*

- Complete assessment (technology, economy, environment, society)
- Preparation of the deployment and construction of global economic models

MINERVE Project

- **Flexible storage of excess CO_2-free electricity (from renewables or nuclear) by converting CO_2 into storable high added value products: CH_4, synthetic fuels, chemicals**



-Project funded by KIC InnoENergy
- Managed by GDF SUEZ
- Partners : CEA, KIT, AGH, Solvay

Low T Electrolysis + methanation (H_2, CO_2)

- **Alkaline electrolyzer coupled with a CO_2 methanation reactor**
- Equipments already developed at industrial scale
- Industrial prototype developed by Solar Fuel (ETOGAS)
- Non-optimized global process efficiency
- Cost of synthetic methane?

MINERVE Concept
HT Co-electrolysis + methanation (H_2, CO)

- **HT Co-electrolyzer coupled with a CO methanation reactor**
- Heat recovery from methanation reactor to produce steam
- High efficiency of co-electrolyzer (~90%)
- CAPEX reduction due to the double function of co-electrolyzer: steam electrolysis + RWGS function to produce syngas
- CO methanation more developed than CO_2 methanation
- **Higher global efficiency of the process**

- **Thank you for your attention**