Overview of Power-to-Gas processes
Few illustrations of demo sites

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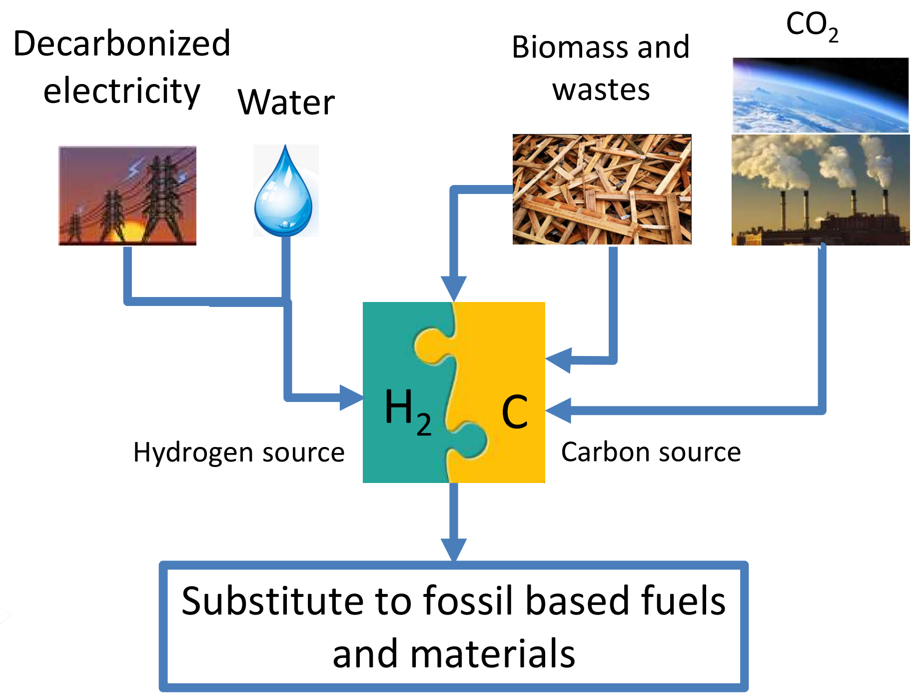
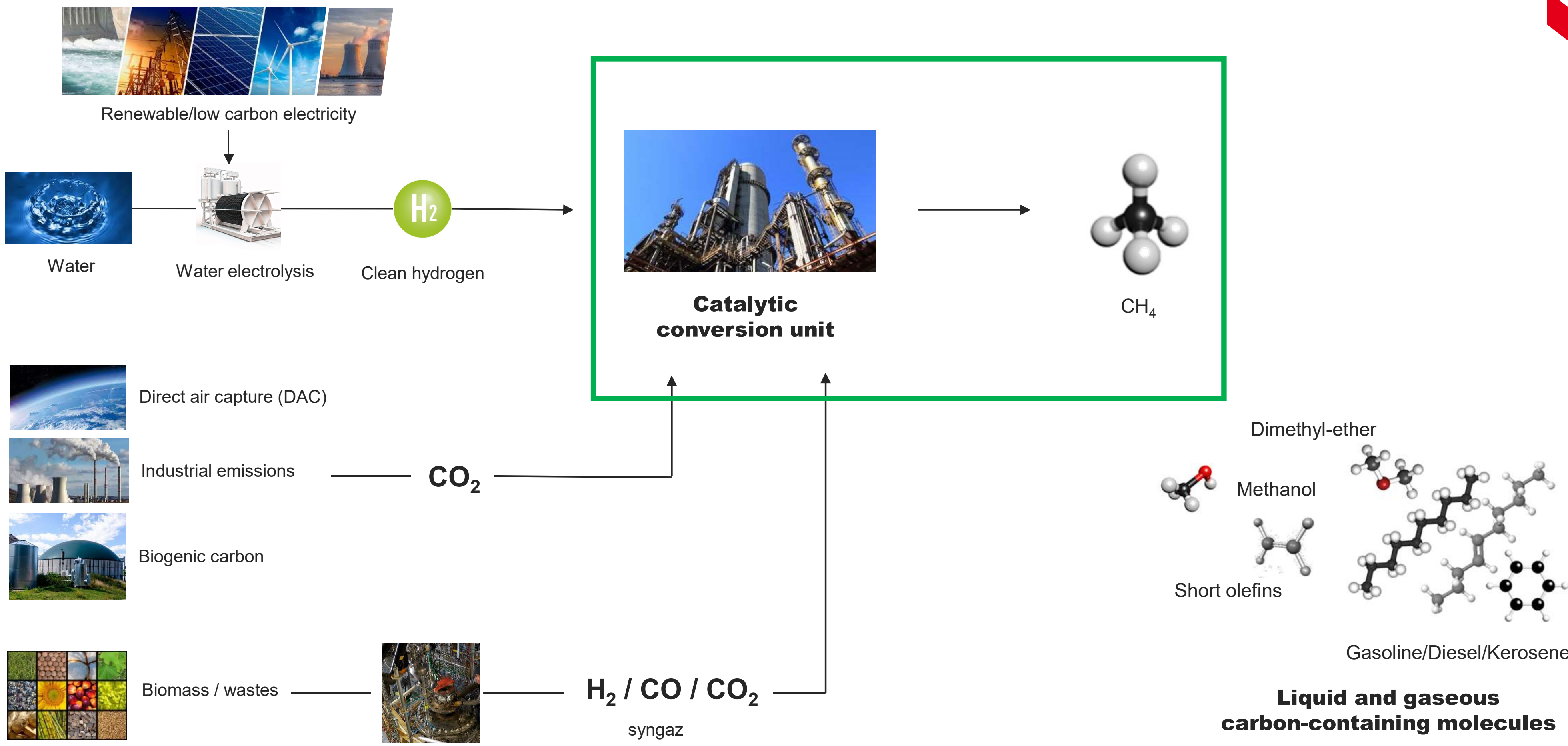
Carbon Capture and Usage



Catalytic conversion technologies

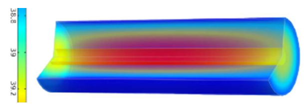


From idea to industrialization

Illustration : Milli-structured reactor industrialised for methanation reaction

Experimental benches
& Analytical platform

Reactor modelling
& simulation tools



Idea
R&D and tech. survey

Technology selection

Millistructured reactor

Proof of Concept labscale

Demonstration

Demonstration projects

Jupiter 1000
GRTgaz
STORE&GO
European Commission
MÉTHYCENTRE
storengy

Industrialization

KHIMOD
ALCEN

Context of a P2G process

Constraints

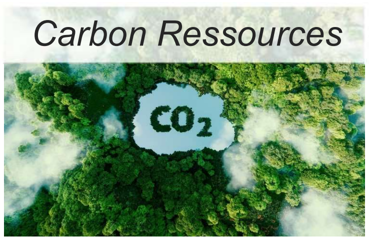
Energy availability

Quantity (power scale)
Electrical Sources
(on/off grid, intermittency)
Heat availability

Hydrogen Ressources

Water availability
Water quality (purification

Carbon Ressources



Quantity
Quality (Purification)
Stoichiometry

Land take
Regulation
Social-acceptance
Industrial landscape

Localization

Catalytic process

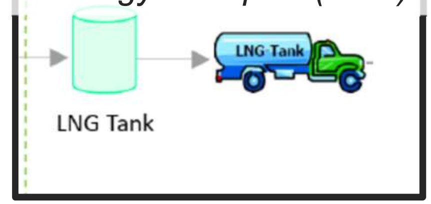
For each technologies :
Adaptability,
Flexibility

& process optimization

Applications

Mobility (CNG)

Energy transport (LNG)



Grid injection

cea

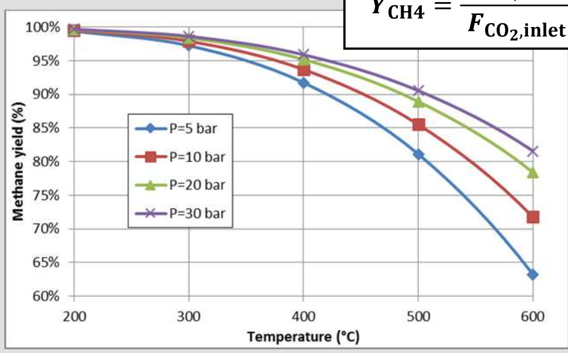
Intrinsic methanation limitations

Sabatier reaction : $CO_2 + 4H_2 \Leftrightarrow 2H_2O + CH_4 \quad (\Delta_r H_{298} = -165 KJ/mol)$

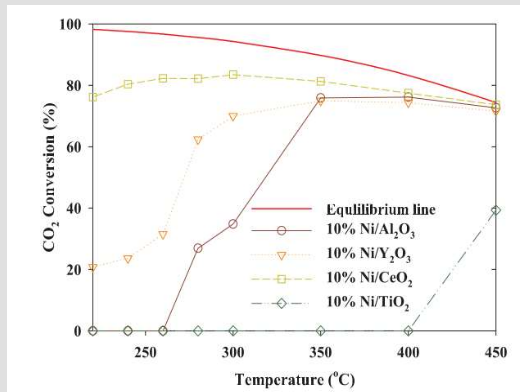
Paul Sabatier
Nobel Prize 1912

Thermodynamics

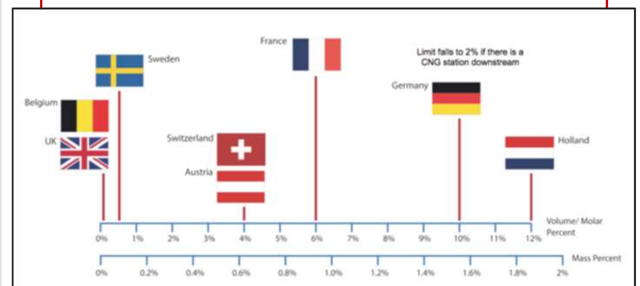
$$Y_{CH4} = \frac{F_{CH4,outlet}}{F_{CO_2,inlet}}$$



Kinetics



Product specifications



Gas grid H_2 tolerance
In France : H_2 < 6 vol.% (now ~ 0 %),
< 2.5 vol.% CO < 2 vol.%

Trade-off between Thermodynamics and Kinetics
+ catalyst lifetime
+ costs
+ specs …

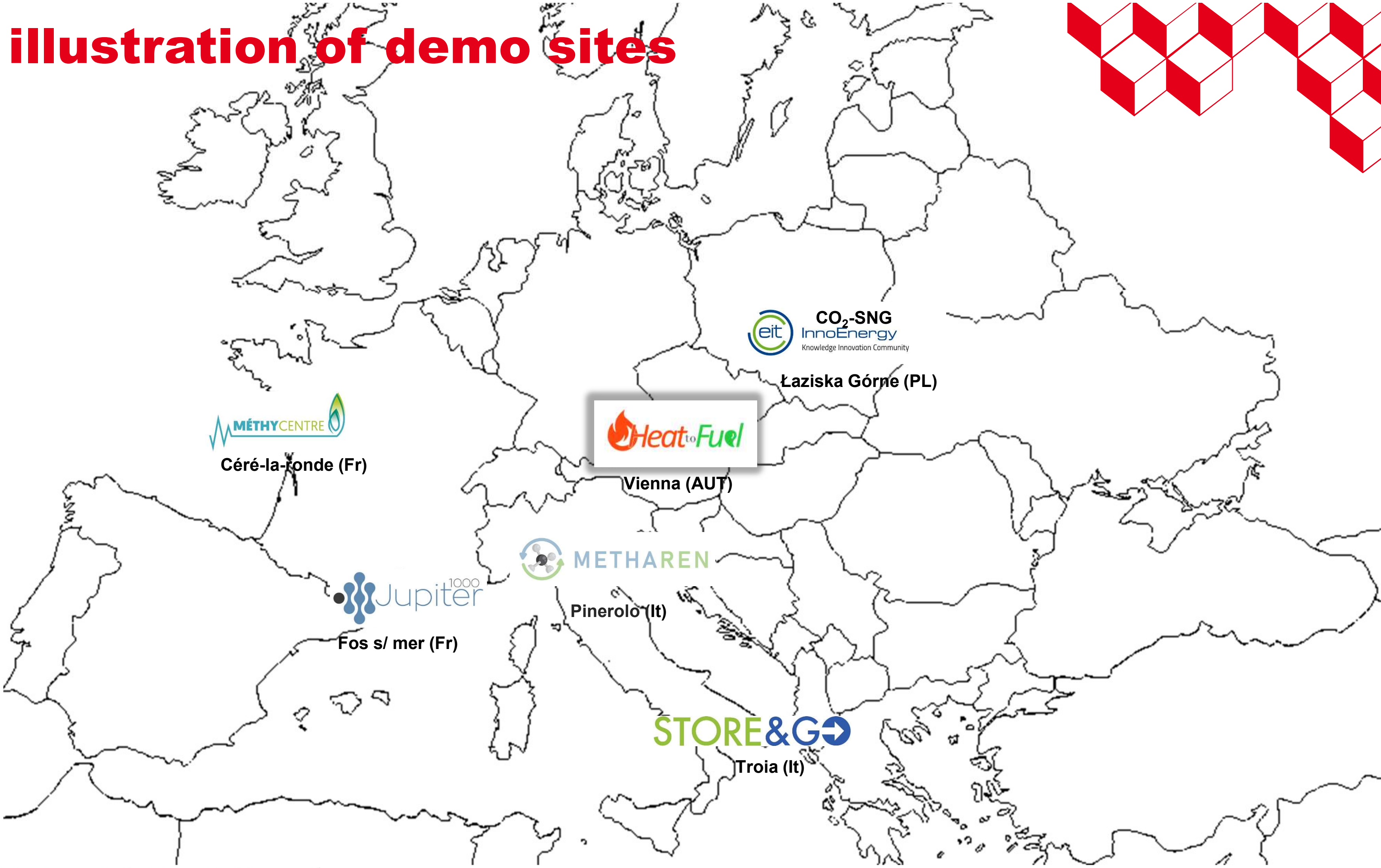
Exoth

Yield > 97% for **T<300°C**

→ minimum activation temperature

Active catalyst → Hard to reach in one reactor pass

Few illustration of demo sites



CO2_SNG Kick-Inno Energy project (CNG)

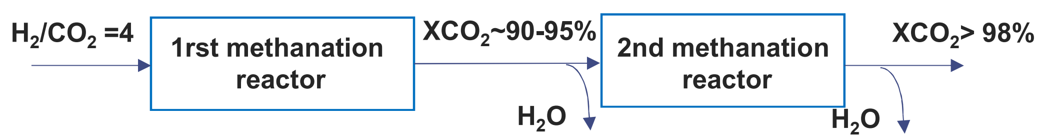
CO_2-SNG is a pilot plant located at Laziska in Poland
The produced SNG could be used as a fuel for internal combustion engines (CNG)

Sources available:

- **CO_2** captured from **flue gas** (using **amine** absorption)
- **H_2** obtained from **water electrolysis** (100kWe)

Outlet quality target = CO_2 **conversion > 98%**

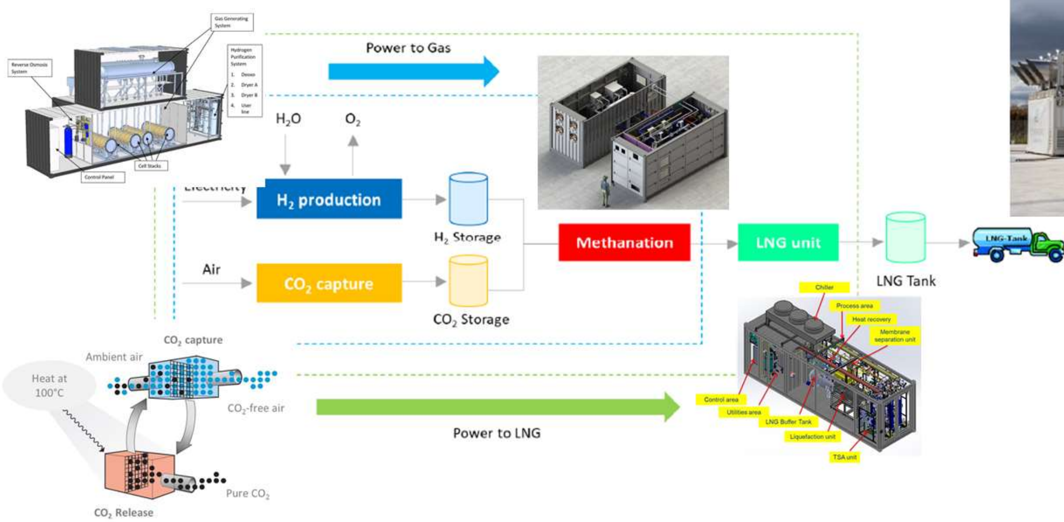
Selected process : **two-stage** methanation reactor



2014-2019

STORE &GO Project – Troia (LNG)

STORE&GO gathers 3 demos in Europe, one in TROIA, Italy
The produced methane is liquefied for island supply

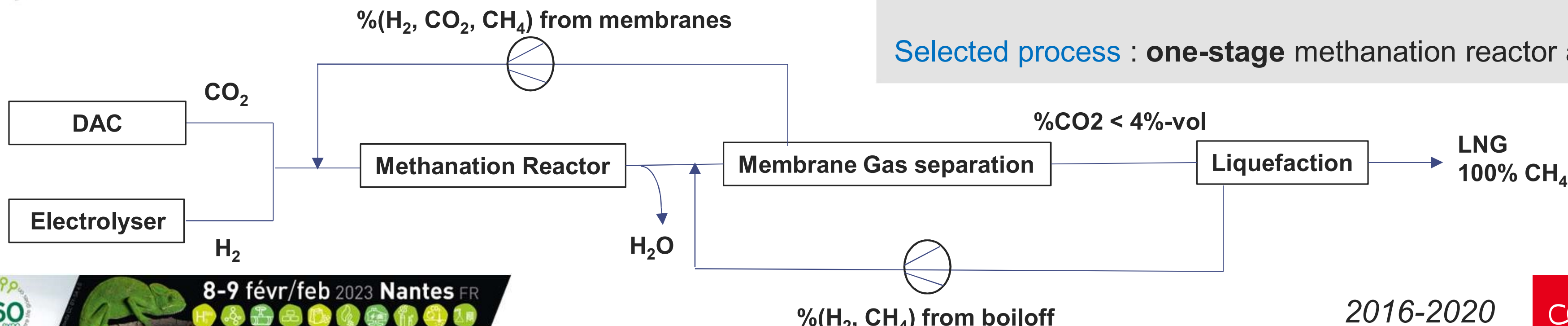


Sources available:

- **CO_2** captured from air (**Direct Air Capture**).
- **H_2** obtained from **water electrolysis** (200kWe)

Outlet quality target = CO_2 **conversion > 95%** & **xCO_2<4%vol**

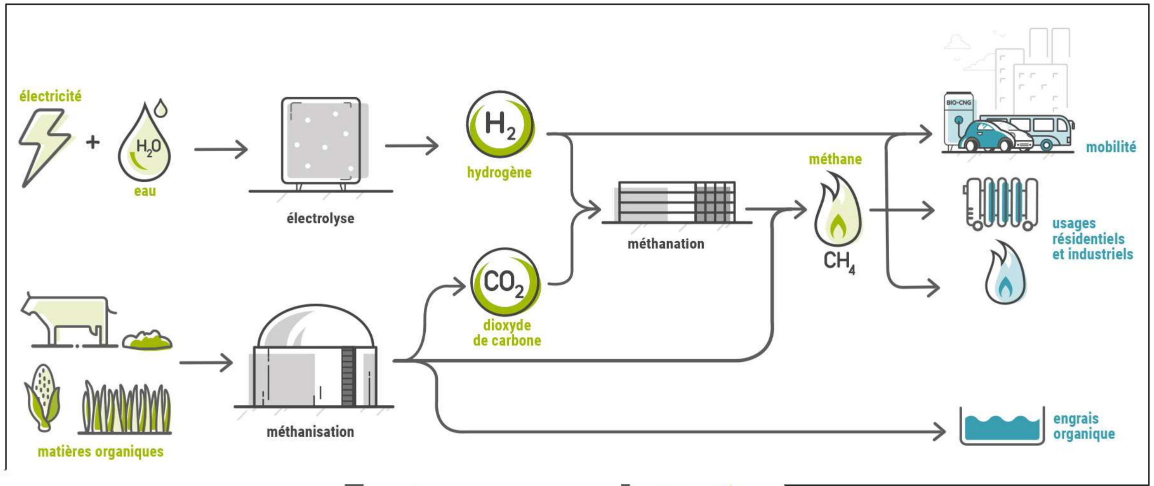
Selected process : **one-stage** methanation reactor and **recycling**



2016-2020

Methycentre: Biogas methanation

Methycentre is a pilot plant located at Céré-la-Ronde, France
Produced CH_4 will be injected into the local gas network (domestic & industrial needs) + mobility

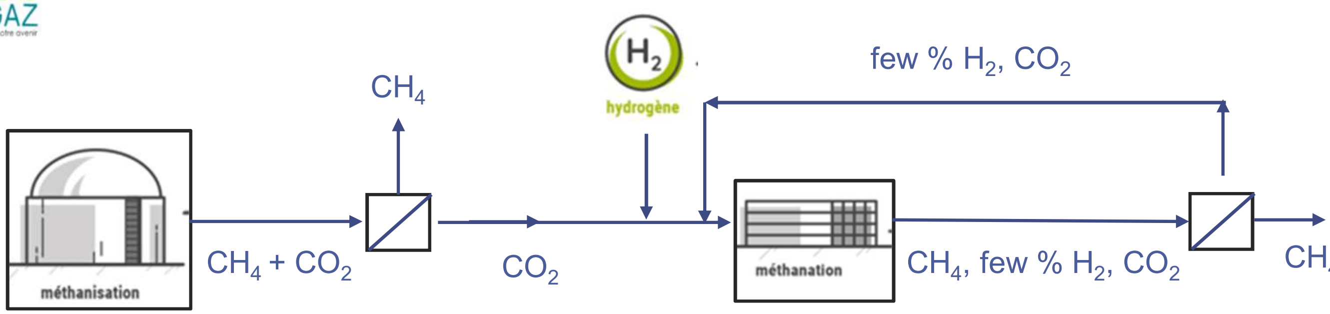


Sources available:

- Biogas $\mathbf{CO_2}$ **+**$\mathbf{CH_4}$
- $\mathbf{H_2}$ obtained from **water electrolysis** (250kWe)

Outlet quality target = CO_2 conversion **> 98%**

Selected process : **one-stage** methanation reactor and **recycling**



Under progress

Jupiter 1000 – CO_2 methanation

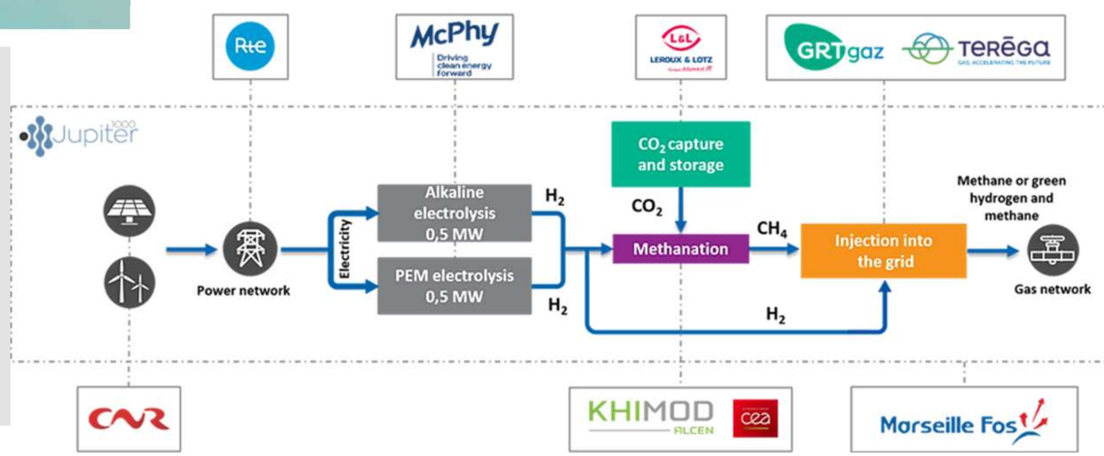
Jupiter is an industrial demonstrator located at Fos-sur-Mer, France
Produced H_2 & CH_4 will be injected in the gas network

Sources available:

- **CO_2** captured from **flue gas** (using **amine** absorption)
- **H_2** obtained from **water electrolysis** (500kWe for methanation & 500kWe for H_2)

Outlet quality target = CO_2 **conversion > 90%**

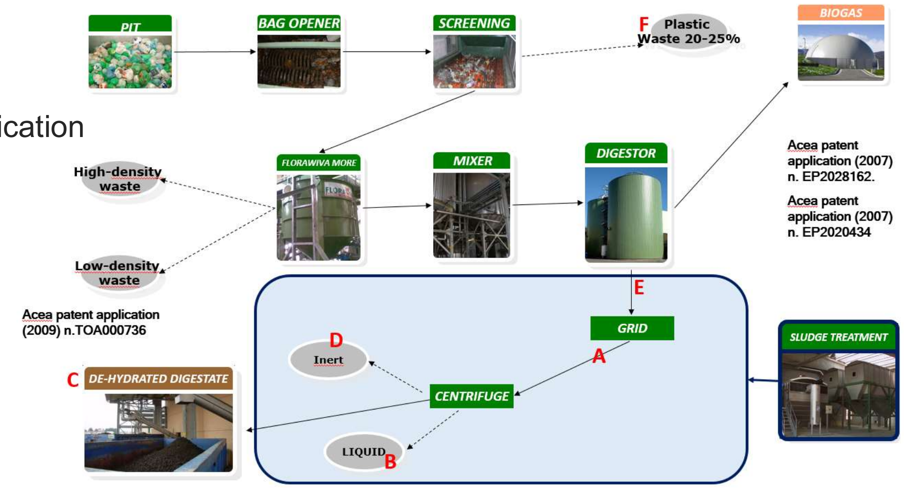
Selected process : **one-stage** methanation reactor + **dilution** by the grid

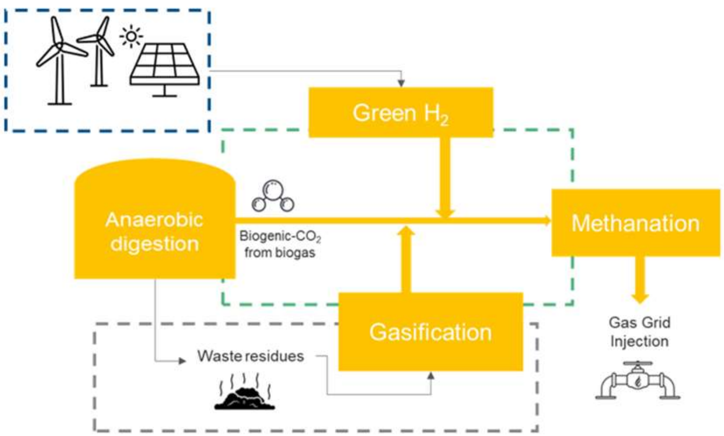


H_2 injection in 2020
CH_4 injection in 2023

Metharen – Biogas methanation

METHAREN demo will be held by ACEA, Pinerolo, Italy
The process will produce biomethane compliant with the Italian natural gas grid specification





- REN storage thanks to methane production
- Intermittency management with effluent valorisation
- Efficient system thanks to smart integration and best state of the art bricks
- Water & Carbon circularity

Methanation reactions:
$CO + 3 H_2 \rightarrow CH_4 + H_2O$; ΔH = -206 kJ/mol
$CO_2 + 4 H_2 \rightarrow CH_4 + 2 H_2O$; ΔH = -165 kJ/mol

METHAREN

(17 partners, 7 countries)

Co-funded by the European Union

Sources available:

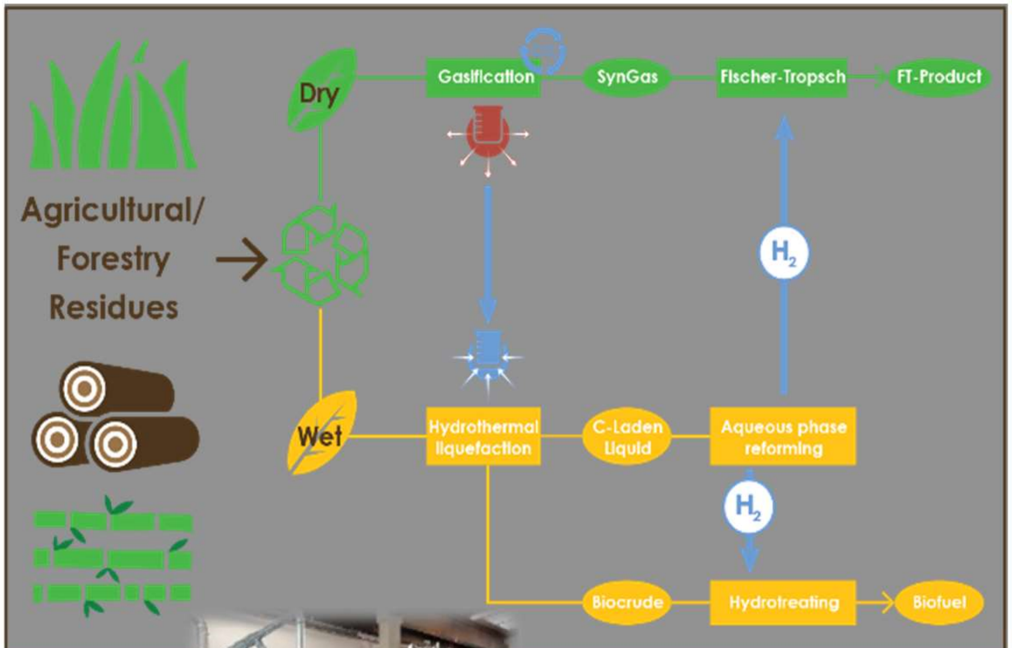
- Biogas (**CO_2 + CH_4**) + syngas from gazification (**CO + H_2**)
- **H_2** obtained from **water electrolysis** + **syngas**

Outlet quality target = Italian grid specification

Selected process: under reflexion

Start Nov.2022

Heat-To-Fuel: Towards hydrocarbons



FT

APR

APR + FT Unit

HTL unit

Sources available:

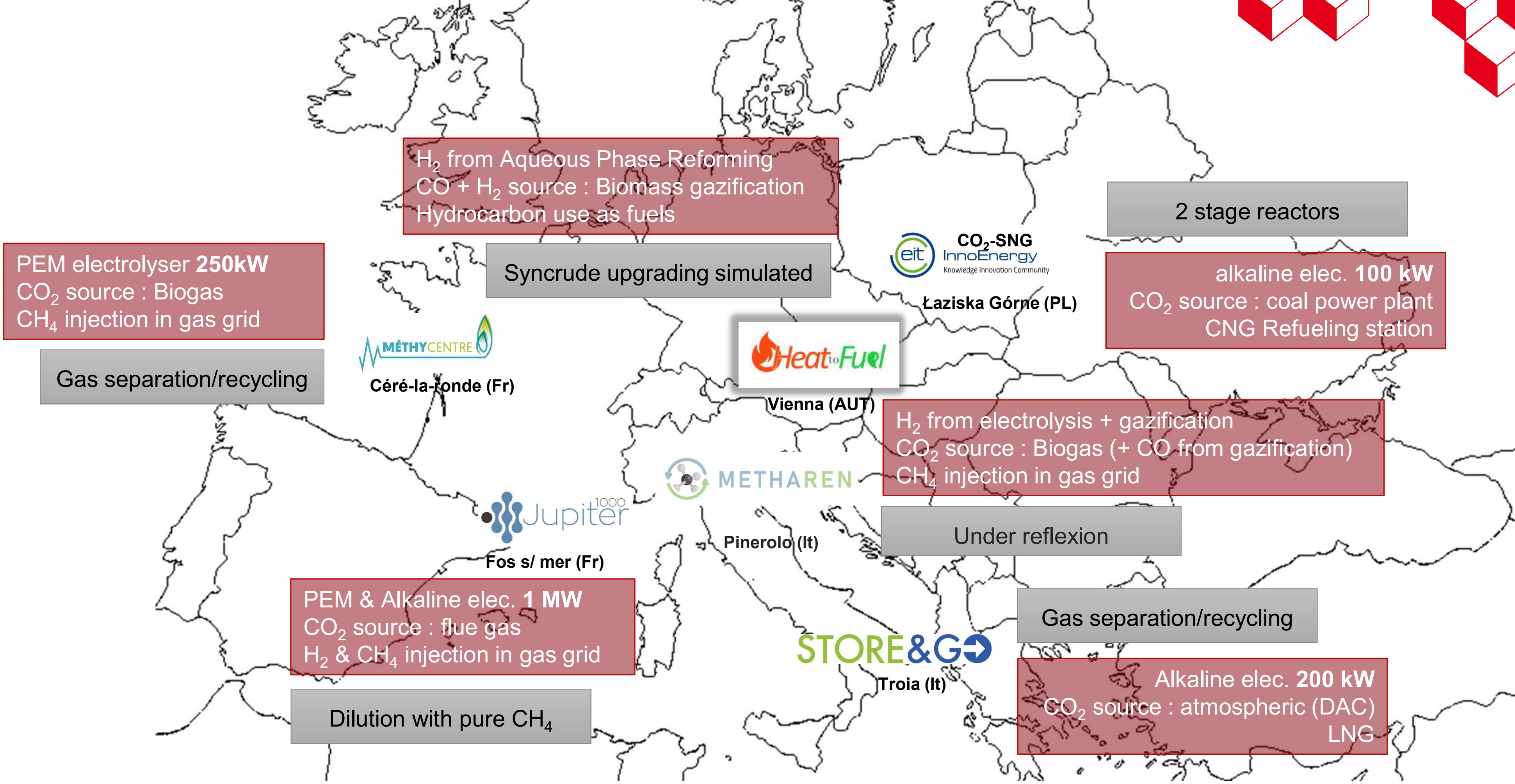
- Syngas from gazification (**CO + H_2**)
- **H_2** complement from **APR** + **syngas**

Outlet quality target : Mainly kerosene among liquid products

Selected process : **one-stage** FT reactor + **APR** coupling

2017-2022

Few illustration of demo sites - conclusion



The Team

Thank you for your kind attention

Meet us stand E 24