Italian National Agency for New Technologies, Energy and Sustainable Economic Development

LCS-R Net

Power to Gas Technologies and Innovative Use of Existing Energy Infrastructures to meet long term CO_2 Neutrality Goal

LCS-Rnet 11° Annual Meeting

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Outline

- Introduction
- Energy Storage Technologies and Power to Gas
- Assessment of technologies
- Hydrogen production and CO_2 methanation
- Background activities at ENEA
- Conclusions and perspectives

Introduction

"ENEA is the National Agency for New Technologies, Energy and Sustainable Economic Development, a public body aimed at research, technological innovation and the provision of advanced services to enterprises, public administration and citizens in the sectors of energy, the environment and sustainable economic development"

9 Research Centers
5 Research Labs
16 Regional Offices
1 Office in Bruxelles

Its focus sectors are:

energy technologies (renewable sources, energy storage, smart grids…), nuclear fusion and nuclear safety, energy efficiency, technologies for cultural heritage, seismic protection, food safety, pollution, life sciences, strategic raw materials, climate change…

Other institutional tasks are:

National Agency for Energy Efficiency
The National Institute of Ionizing Radiation Metrology
Integrated Service for the management of non-electronuclear radioactive waste

Background

- Today electricity sector is moving to higher RES penetration but… storage issues & balancing

- On the other hand 240 000 km of meshed gas network all over EU w/ 118 millions of end-users (45%)

- Today gas sector in EU covers 20-25% final energy demand but is traditionally oriented to fossil→NG

- Moreover in 2050 EU forsee a 80% reduction of GHGE on 1990 basis Climate Neutrality of Energy Sector

CLIMATE MITIGATION… ENERGY 75% EMISSIONS BUT SUSTAINABLE, SECURE & COMPETITIVE…

HOW TO MANAGE ALL ?

Avoiding emissions replacing fossil fuels with renewables alternatives

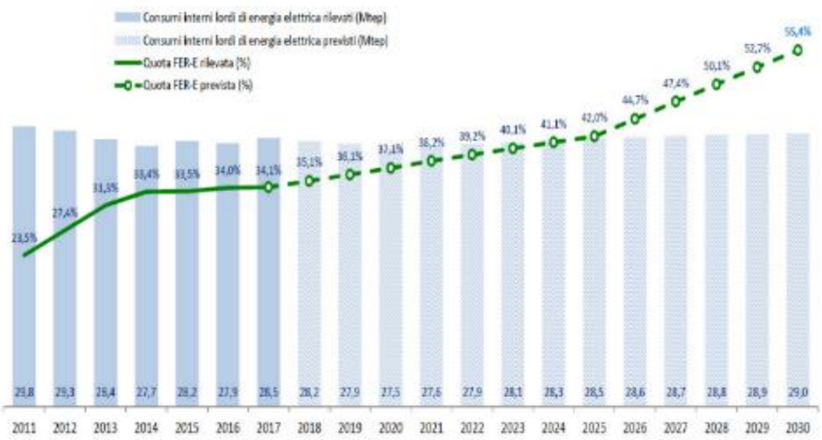
Utilizing carbon dioxide in closed loops in industrial activities

Sequestering carbon dioxide in geological permanent storage

Renewable Energy Sources & Energy storage

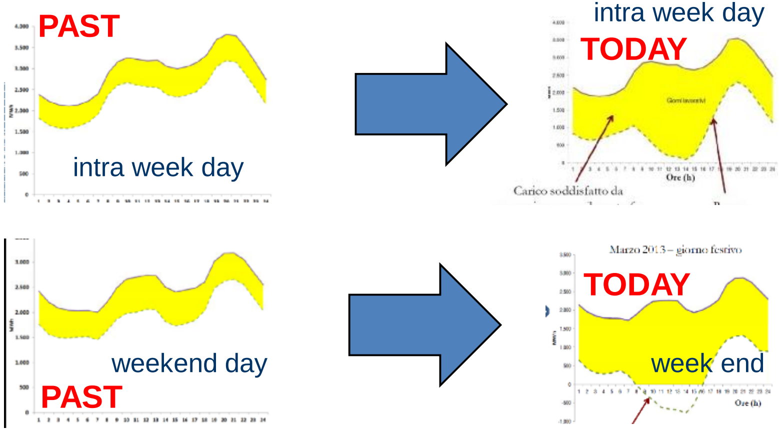
Broad consensus on scenarios with 60% maximum electrification

2019 PNIEC 55% share of Electricity from RES at 2030 - 34%2017



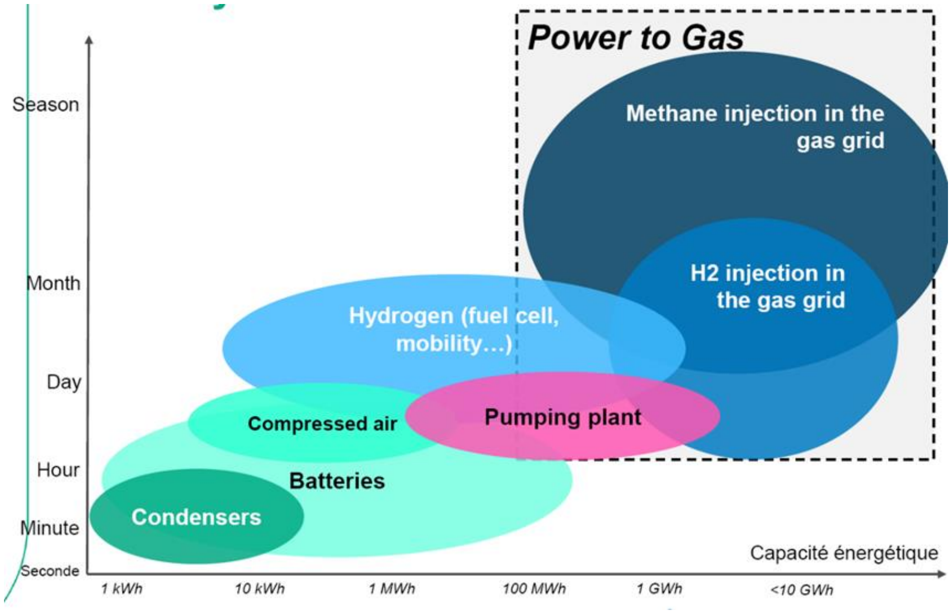
Energy storage can contribute to peak shaving of vRES (wind & sun) avoiding surplus or deficit in power supply.

Daily production South Italy



Higher penetration of RES in electricity market leads to the needed developing of daily and seasonal energy storage systems.

Energy Storage Technologies



Fonte: GRTgaz | Jupiter1000 for the ADEME – NEDO seminar

1) **Differ in capacity:**

- ✓ Condensers, flywheel, batteries… compressed air energy storage, pumped hydro energy storage systems (BAU) can offer relatively limited capacity (40TWh in EU 5d)
- ✓ Power-to-Gas systems have potentially higher capacity with the actual gas storage capacity (1131 TWh not considering available linepack that has to be added)

2) **Differ in time scale:**

- ✓ Short, Medium, Long
- ✓ Seasonal

Existing Gas Grid & long term CO2 Neutrality Goal

- Renewable Gas can serve as a seasonal storage of renewable energy

BUT MORE!

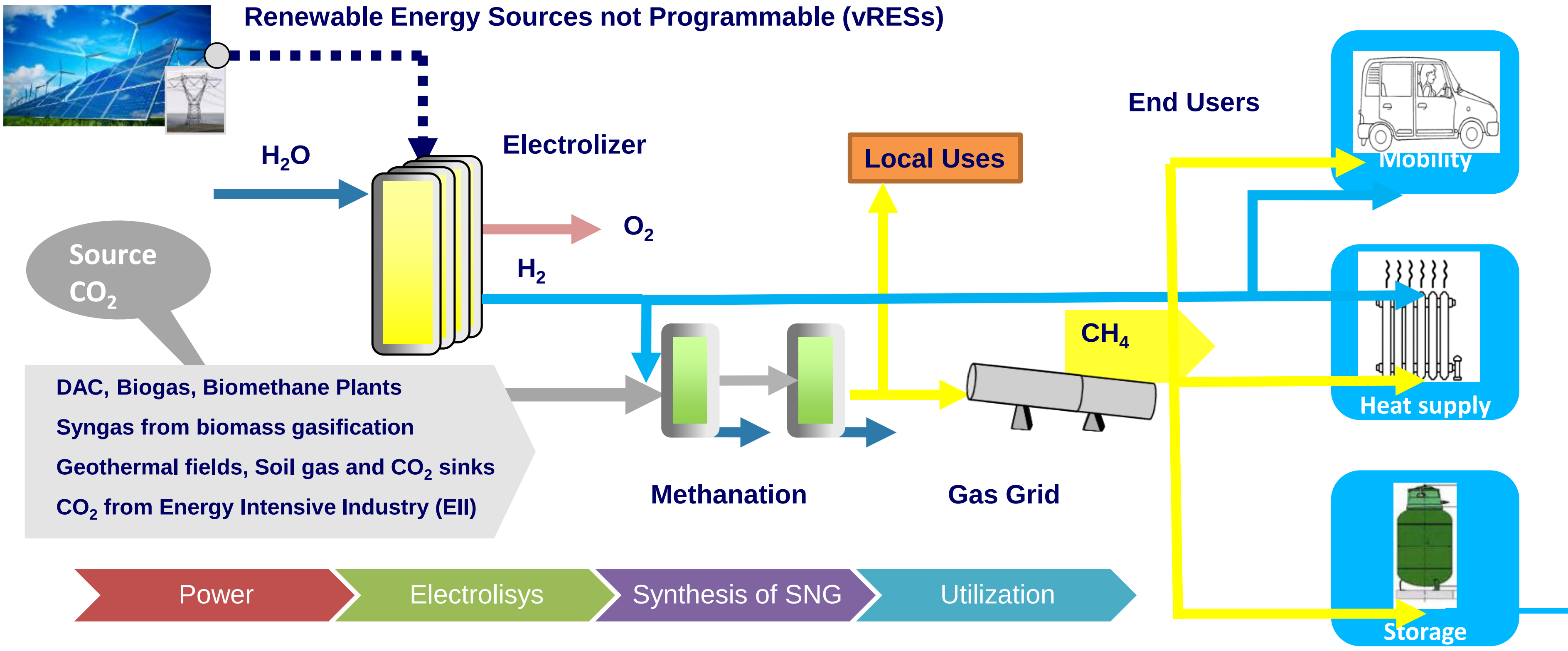
- Gas networks can reduce the need for electricity network espansion
- Replacing NG by **Renewable Gas enables climate-neutral energy end use!**

- RG → Biomethane, Hydrogen, Synthetic Methane

all coming from RES and biogenic sources - in the transition also blue hydrogen could be used

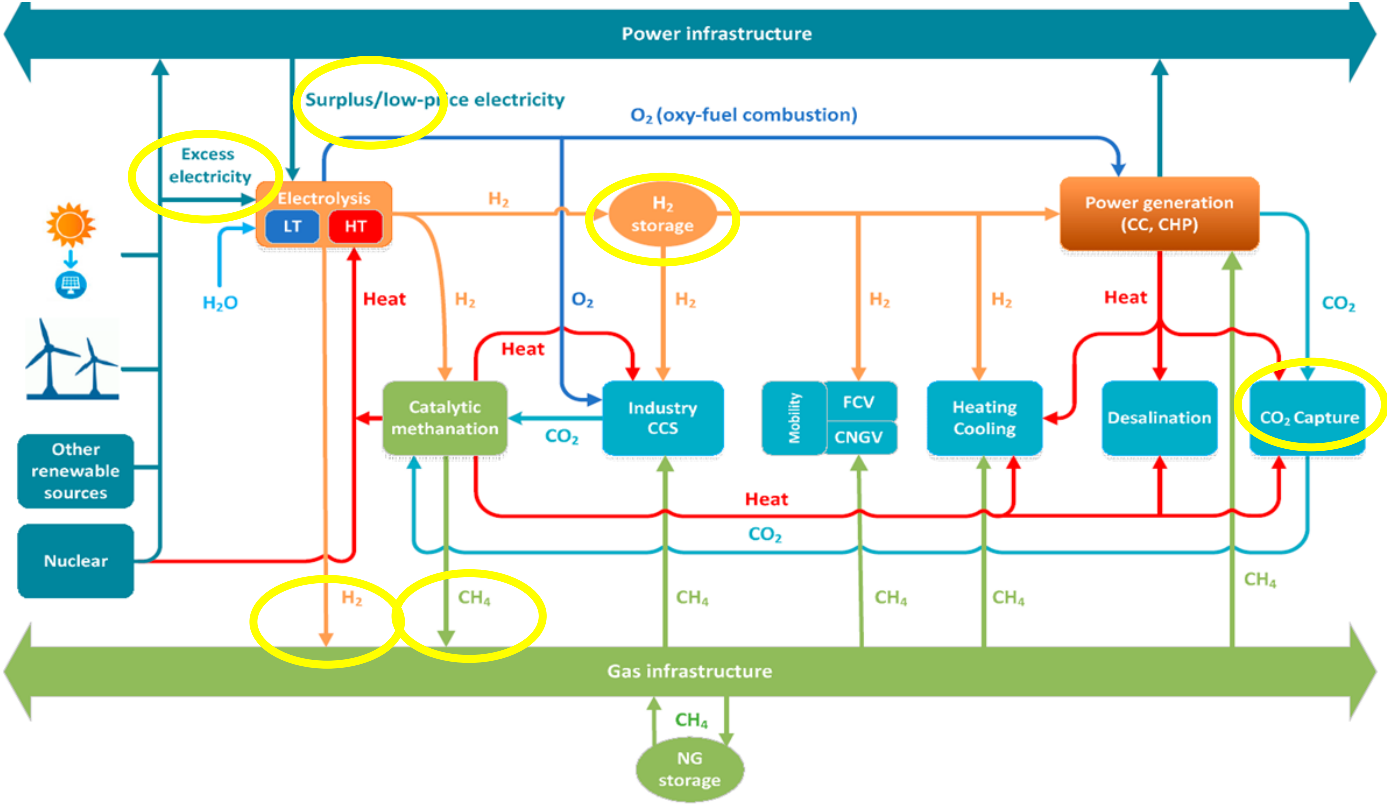
- Utilization of readily available gas infrastructure requires less investments
- Can speed up the transition to a future energy system also fostering security of supply
- Can ensure cost effectiveness from a societal perspective

Power to Gas Technologies P2H2 & P2M

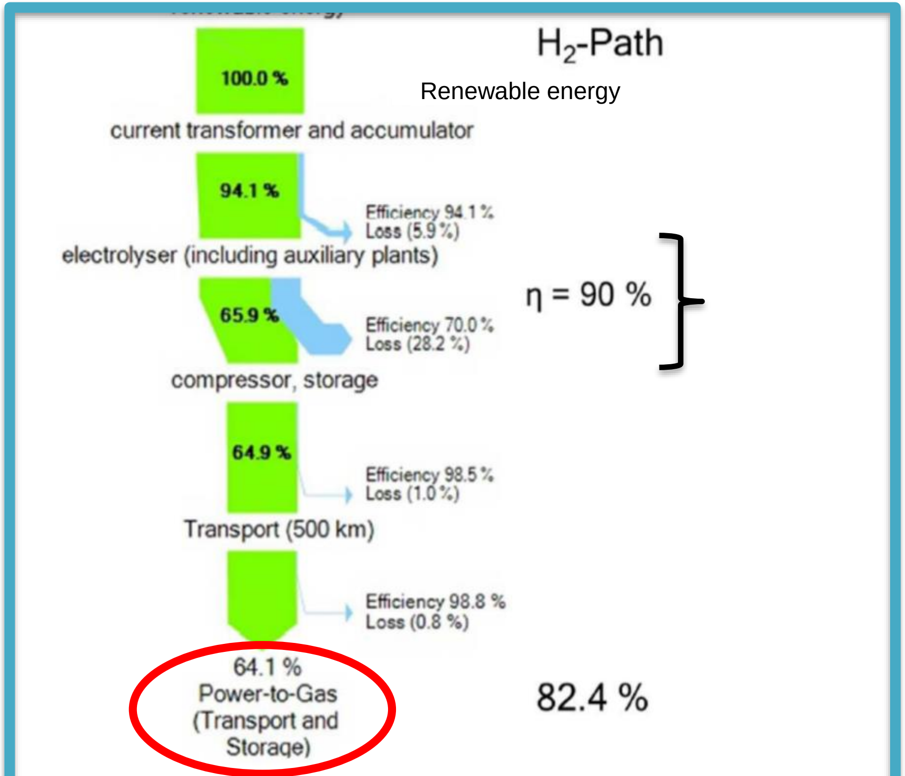


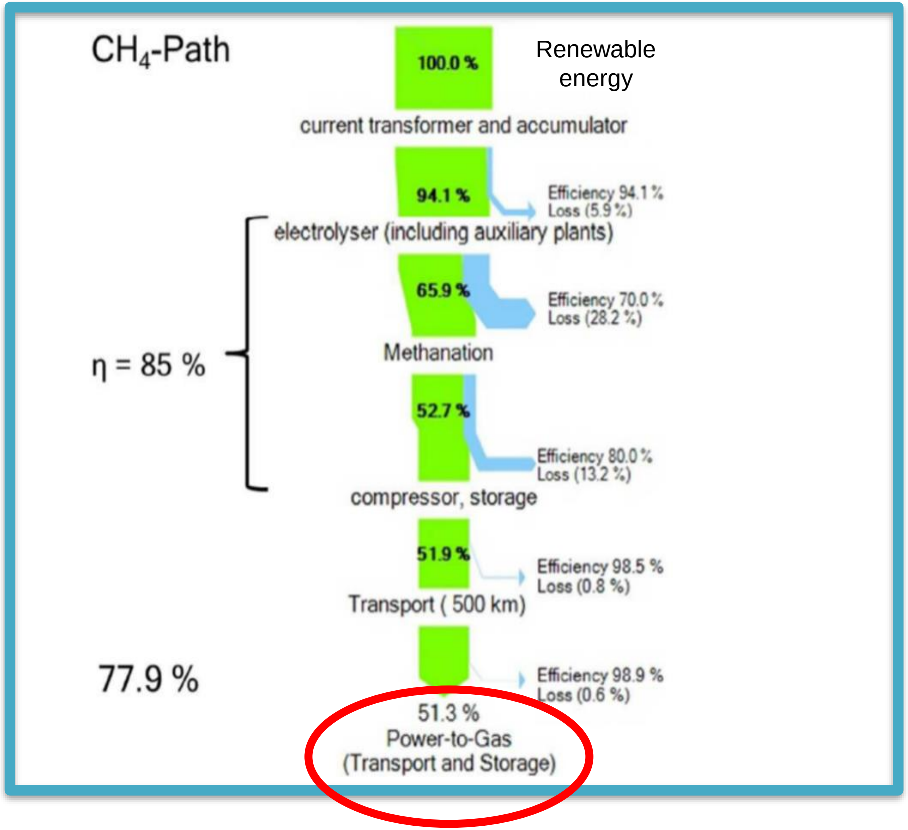
Sector Coupling and Innovative Use of Grids

Power & Gas Grids:
A new Paradigma…



Efficiency of P2H2 and P2M processes





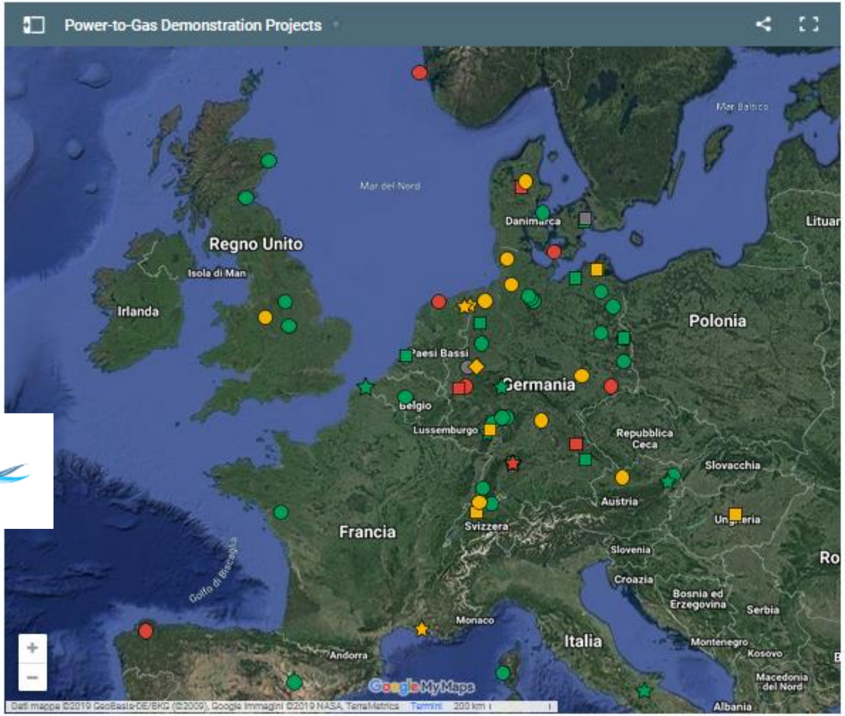
Source DVGW Research Center at Engler-Bunte-Institut of Karlsruhe Institute of Technology (KIT) Marco Gaz

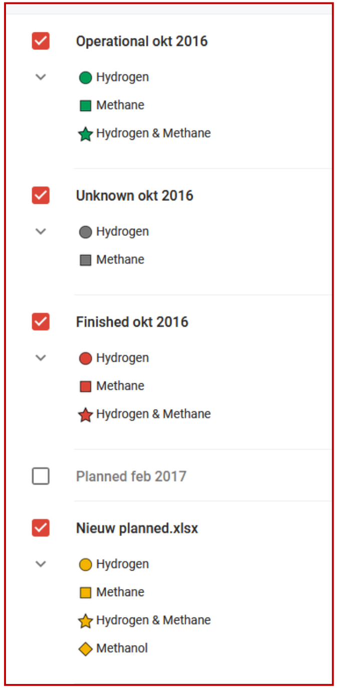
P2G Demo Projects in Europe

Demostration

Projects and

Plants in EU





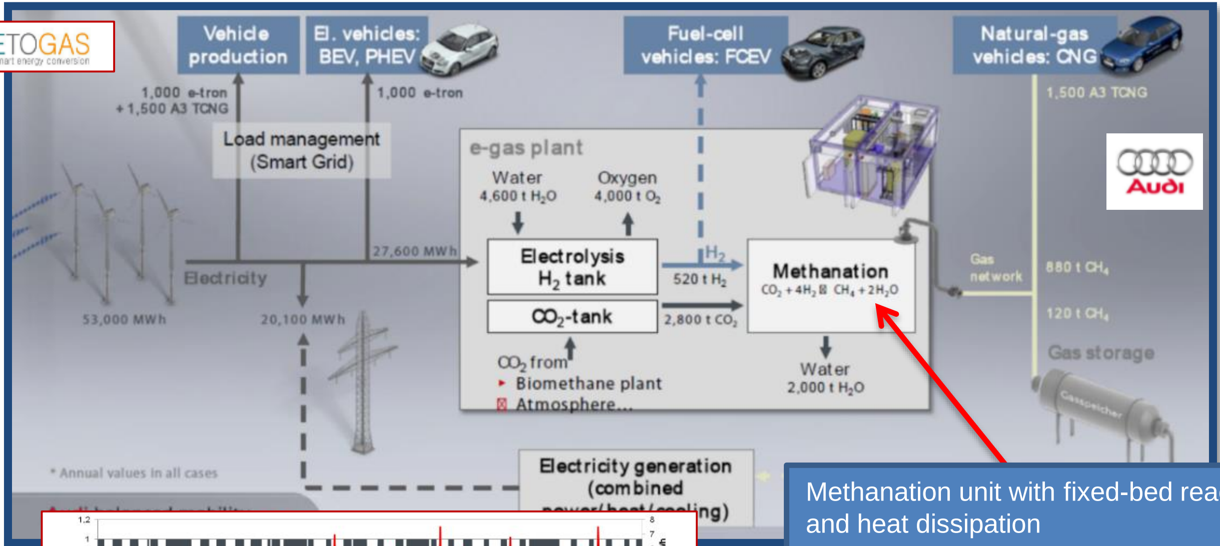
Source: http://www.europeanpowertogas.com/demonstrations

Examples of P2G Plants

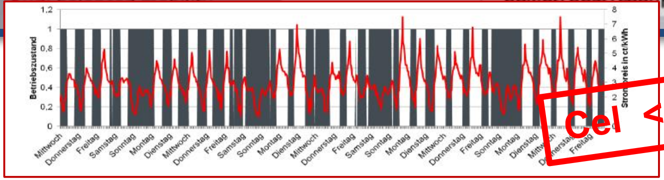
HZI/Etogas

Audi Pilot Project with 6 MWe plant in Northern Germany (2015)

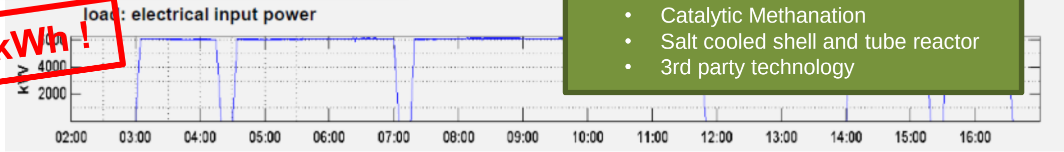
ETOGAS smart energy conversion



Methanation unit with fixed-bed reactor and heat dissipation



Cel < 3 c€/kWh !



Power $_{input}$ elect 3 x 2 MW$_e$

Eff.PtG: (w/heat) 54% - 70%

Max. H_2 out 1300 Nm³/h

Max. H_2 storage time 60min

Max. CH_4 output 325 Nm³/h

Operation time 4.000 h/a

Delivery: 2013/Q4

BoP and EPC: ETOGAS

Electrolysis

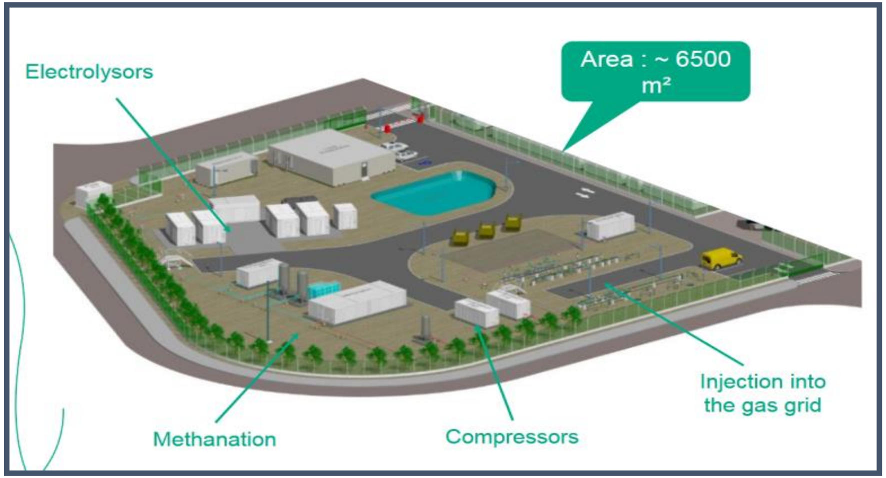
- Alkaline Electrolyzer
- Atmospheric operation with downstream compressor
- 3rd party technology

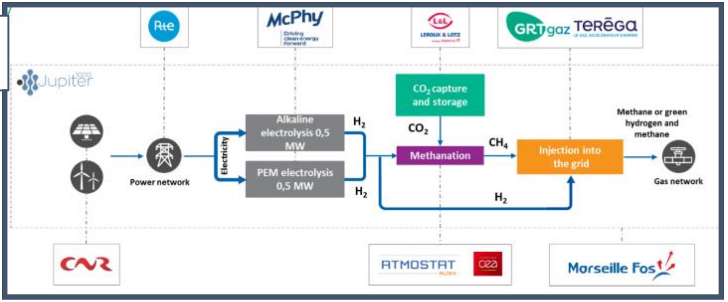
Methanation

- Catalytic Methanation
- Salt cooled shell and tube reactor
- 3rd party technology

Examples of P2G Plants

Jupiter1000





Coordinator GRTgaz French TSO

Site: Fos sur Mer France (2018)

Demostrate practical application of P2G technology

2 technologies for electroliser: PEM and Alcaline

CO_2 delivered from industrial plant

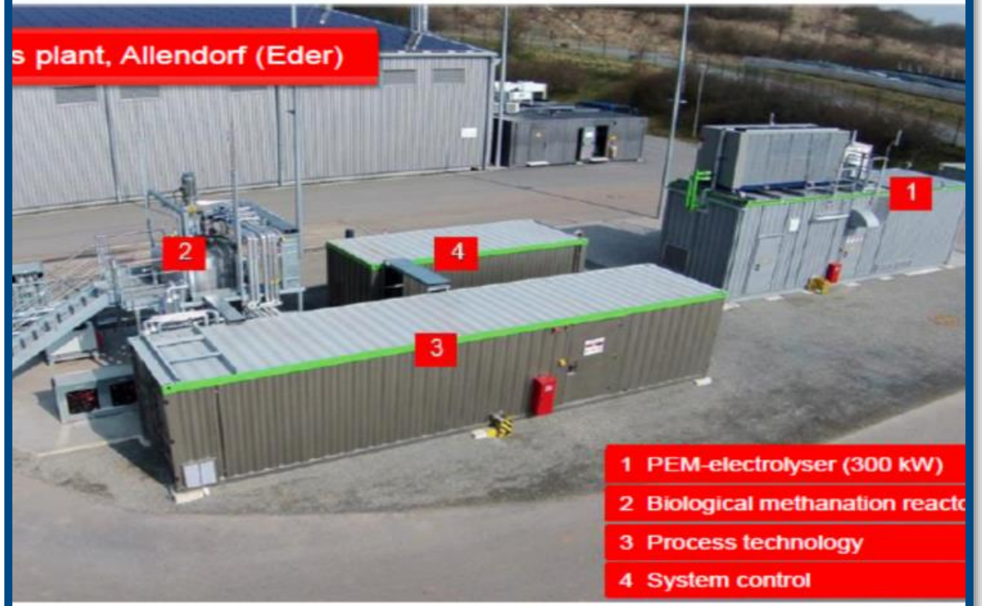
Injection tests of H_2 mixed with CH_4 w/ H_2 <6 % vol

Power $_{input}$ elect 1 MW_e	(0.5 Alcaline & 0.5 PEM)
Max. H_2 output	200 Nm^3/h
Max. CH_4 output	30 Nm^3/h

Fundings: 30 M€
40% da GRTgaz (Commission de Régulation de l'Energie)
30% da UE (FEDER), Etat Francaise (Program ADEME)
and Autoritè Regional Provence-Alps-Coute Azur

Examples of P2G Plants

MicroBioEnergy

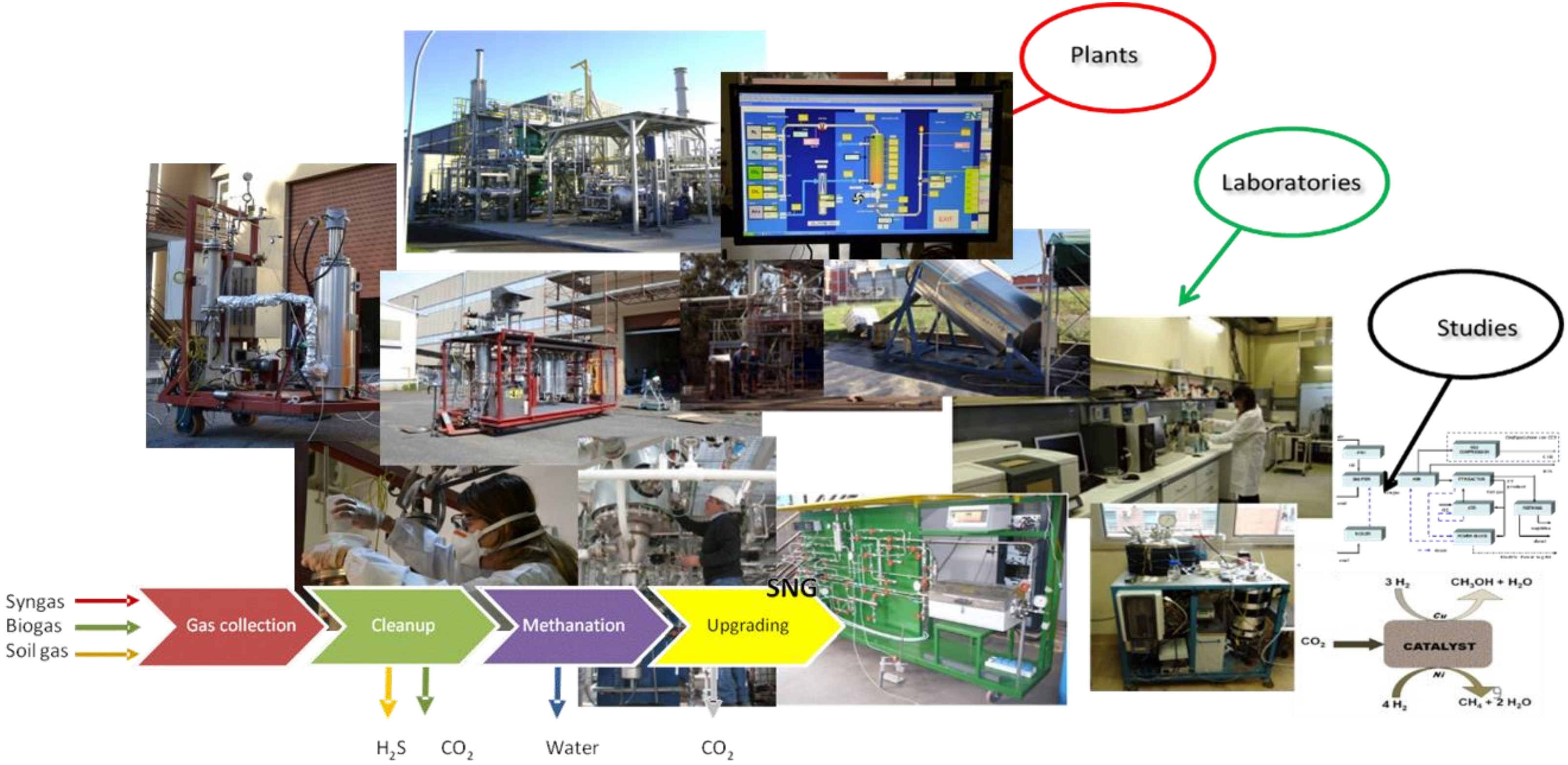


Power to Gas with biological methanation applications in biogas upgrading
Injection into gas grid since March 2015: Operation time: > 8.000 h / Performance: CH_4> 8%, H_2< 2%

Research trends and needs in P2G

H_2 Production Electrolysis	Test e developing of different processes in P2G application (Alcaline, PEM, SOEC… Flexibility in terms of variable power supply Fast load variations keeping high efficiencies, rangeability, stand by Benchmarking of technologies High temperature, high pressure
Methanation	Adaptability to various carbon sources (dac, biogas, syngas, effluents from EII…) Catalysts: different basis Ni, Ru…, different concepts (bulk, monolite, foams, structured…) New concepts for reactors: compactness, flexibility, rangeability Methanation “in situ” and “ex situ” for biological reactors
CH_4 as a fuel	Injection into national gas grids Refuelling stations for mobility LNG as a fuel for heavy duty transport and shipping
Heating	Buildings, process, power generation…

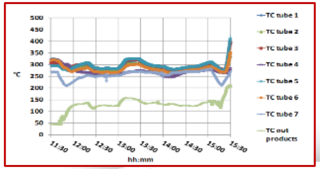
ENEA's approach

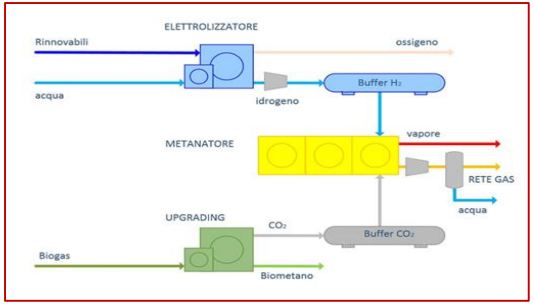


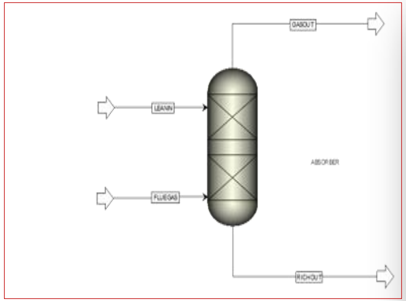
Background on P2G

- Systems and component testing at pilot scale (electrolysis, methanation…)
- Commercial and Adhoc Catalyst test on lab and pilot plants
- Modelling, system and economic analisys
- Coordination of R&I activities, collaboration w/ Industries and Univercities
- Technology transfer, patents, support to P.A. and Policy Makers



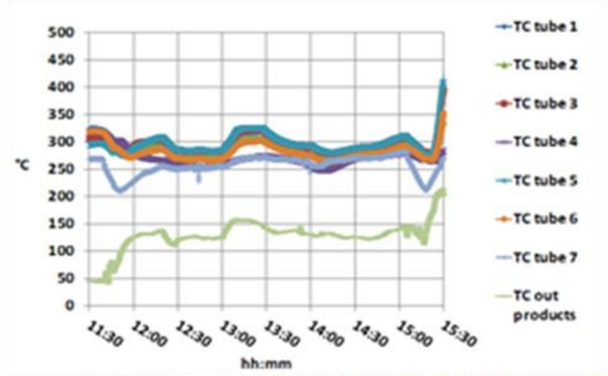


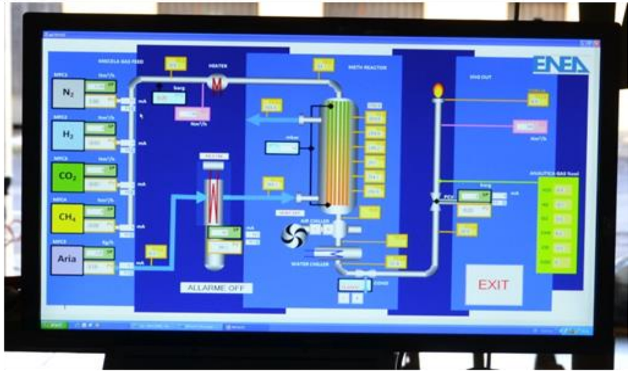



Experimental activities

Source: ENEA





Conclusions

- Power-to-Gas (both P2H e P2M) is a promising technology and a possible measure to improve Renewable Gases Use and energy storage (seasonal) w/ injection into Gas Grid based on Coupling of Power and Gas Transmission Infrastructures
- Process integration has to be done taking into account flexibility, costs, efficiencies and environmental advantages
- Different activities/projects are ongoing on different scales (MW) new uses of existing gas grid will be possible
- Production, storage and use/injection of RES gas (H_2 from Electrolyzer, SNG, biomethane…)
- Injection into the grid and heavy duty transport sector can be important drivers
- CO_2 can come from natural sources and/or from industrial processes (biogenic or fossil is NOT the same)
- Development of technologies, industrial applications, business real cases, financial support, rules… are NEEDED!

The role of gas need not to be limited to balancing vRES but it could enable climate neutral energy

w/ existing infrastructure and on end-user side with relatively cost efficient way

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