RENOVAGAS Project: Power to Methane

Western Region Workshop – 28 & 29 Sept 2017 – Lisbon, Portugal

Gas Natural Fenosa

Renovagas Project, Num. RTC-2014-2675-3 funded by Spanish Ministry of Economy, Industry and Competitiveness (MEIC)

GAS NATURAL FENOSA

gasNatural fenosa

Renovagas

Natural gas supply

Natural Gas transportation

Power generation

Gas y Elec. Distribution

Marketing

Trading

More than **30** countries

More than **23M** customers in the world

19,939 employes[1]

EBITDA € 5,264 M[1]

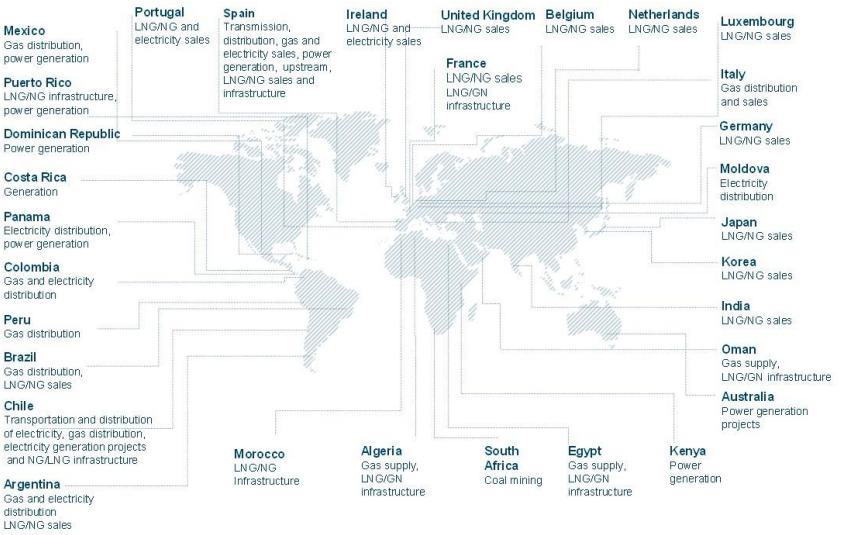
Total assets € 48,132 M[1]

Installed capacity 15,471 MW[1]

Innovation vs sales 0,26 %

Innovation FTE 150

Innovation expenditure € 59 M



The largest integrated gas and electricity company in Spain and Latin America

A multinational company, leader in the sector of gas and electricity committed to Innovation

We are the principal supplier of LNG in the Atlantic and Mediterranean basins (30 bcm).

1. All figures at close of 2015 , except those referred to Innovation, which refer at close of 2016.

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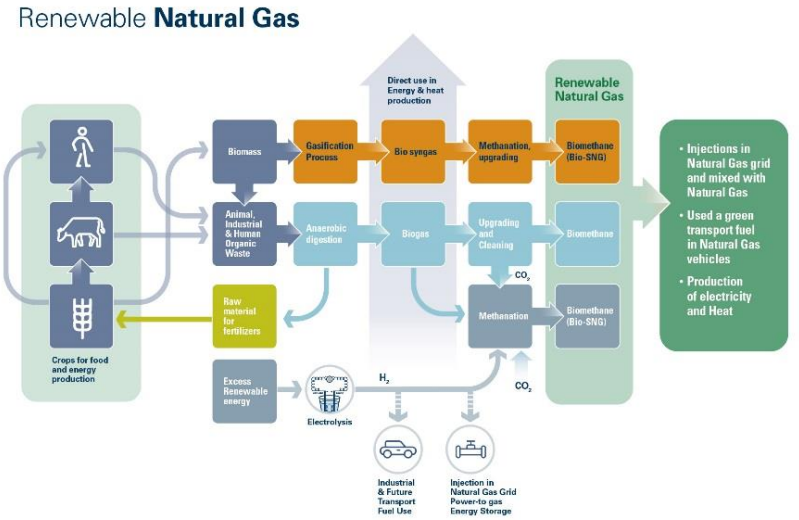
Why Power to Gas

What it is *Power to Gas*:

- An energy storage solution to produce hydrogen (or SNG) from electrical power (preferably renewable).

Why we need *Power to Gas*:

- Rapid growth of worldwide renewable power generation.
- Peak power production will lead to generation curtailments of Renewable Energy.
- Renewable power is intermittent.
- *Need for power storage.*



SNG: Synthetic Natural Gas

- ✓ Esentially methane produced from H_2 and CO_2
- ✓ Can use CO_2 from biogas

ETIP SNET

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Spanish Joint Industrial Project

- The **aim** is to develop a **technology for production of Synthetic Natural Gas**, SNG, from **renewable sources**.
- Funded by Spanish Ministry of Economy, Industry and Competitiveness (MEIC) within the framework of the National Programme for Research Aimed at the Challenges of Society.
- Budget 2.16 M€ (1.19 funded by MEIC).
- Duration: 30 months, September 2014 to June 2017.
- Led by Enagás.

It is foreseen a future escalation of the technology in two subsequent phases.

ETIP SNET

GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

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The consortium

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Objectives

- To develop and construct a 15kWe Power to Gas plant (SNG), using H_2 produced from water with electrolysis and CO_2 sourced from a biogas stream. Direct use of CO_2 from biogas
- To optimise H_2 production from renewable energy sources.
- To develop a new catalyst.
- To develop a new reactor.
- To test the pilot plant in real condition.
- Detailed engineering for a larger plant: 250kWe.
- To estimate future renewable power and biogas availability in Spain
- Economical study to show the feasibility of this technology.
- The SNG should have a quality fulfilling Spanish specifications.

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Catalyst and Methanation Reactor

$$CO_{2(g)} + 4\,H_{2(g)} \rightarrow CH_{4(g)} + 2\,H_2O_{(g)}$$
$$\Delta H_R^0 = -165\,kJ\,/\,mol$$

Catalyst

- Based on ruthenium.
- Allows direct conversion of biogas to SNG.
- Biogas: 65 % CH4 + 35 % CO2.
- High selectivity to methane formation.
- High carbon dioxide conversion.
- Higher than the nickel based commercial catalyst at the same high spatial velocity of gas in the reactor.

Electrolyser

- Alkaline electrolyser, based on anionic exchange membranes (AMWE).
- Maximum H_2 production: 2 Nm^3/h
- H_2 Purity: 99,94 %
- Efficiency at nominal point: 4,8 kWh/m^3

Methanation Reactor

- Multi channel technology
- Temperature: 275-325 ºC
- Pressure: ≥ 25 bar
- Ratio H_2/CO_2 ≥ 4 mol/mol

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Plant Integration and Installation in WWTP

- All equipment installed in a 6m container
- Installation in WWTP. Jerez de la Frontera.
- Connected to a biogas plant. Biogas cleaning needed

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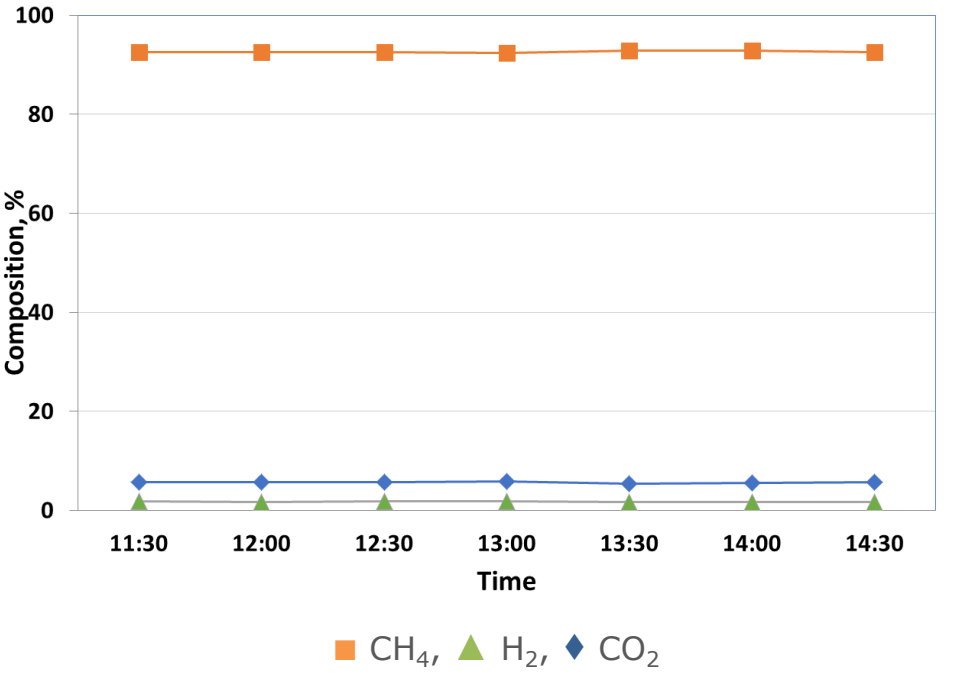
Methanation Results

- Good CO_2 conversion.
- High selectivity to CH_4.
- Stability of reaction.



Nº	Test	CH_4 %-mol	N_2 ppm	CO_2 %-mol	H_2 %-mol
1	80-100% nominal load	95,5	280	1,68	2,75
2	60% nominal load	95,5	690	2,96	1,41
3	100% nominal load	95,9	600	0,085	3,88

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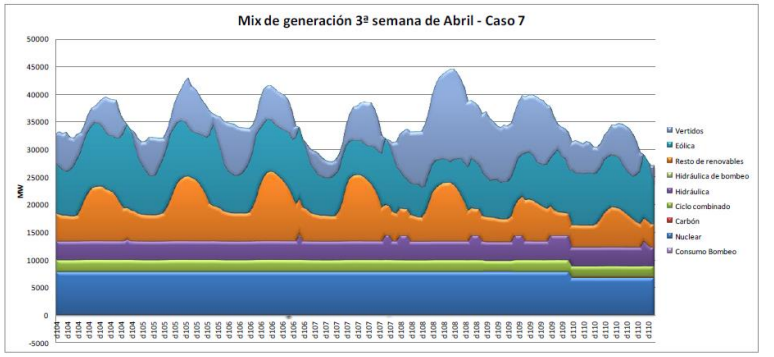
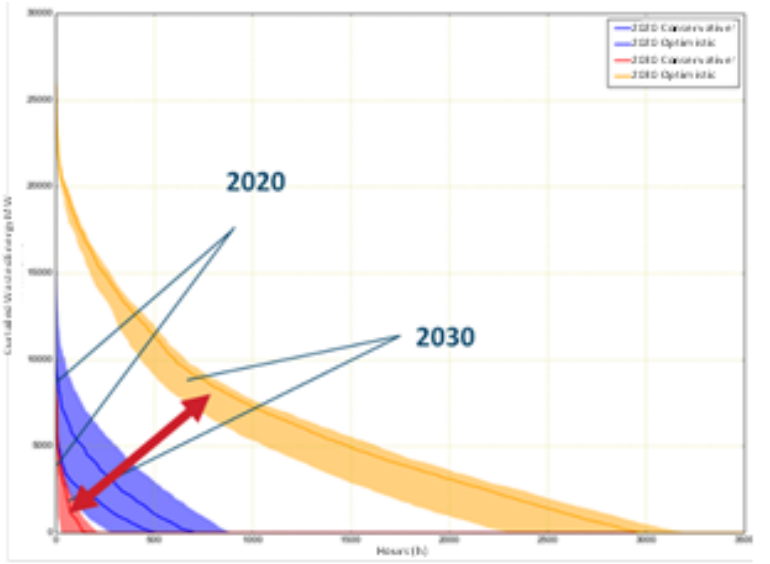
Potential in Spain

- Predicted future surplus of RES for different future generation scenarios considering:
  - ✓ Electricity Demand
  - ✓ Hydraulic Production
  - ✓ Wind Generation Profile
  - ✓ Increasing Renewable Capacity



- Projection to 2020 and to 2030, but there is a large uncertainty on 2030 figures.

- Principal findings: For an optimistic scenario in 2030, it will be possible to store about 10,000-12,000 GWh of power as SNG.
  - ✓3,5% 2016 gas demand



This study was carried out in 2015-2016.

RES capacity increase in Spain in 2019 will change the figures

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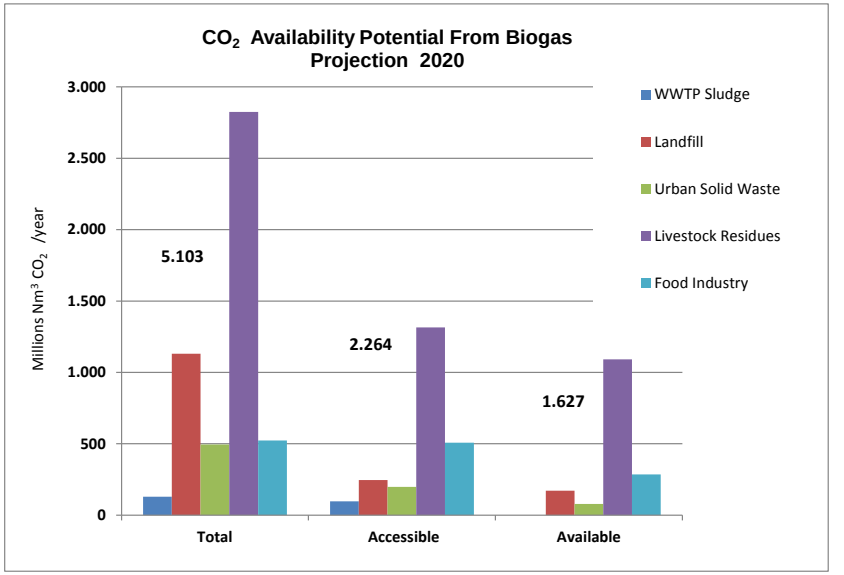
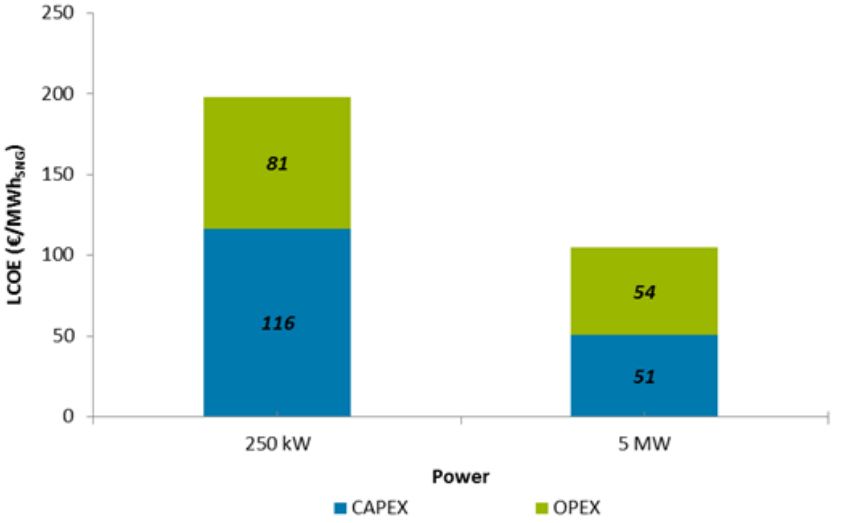
Potential in Spain

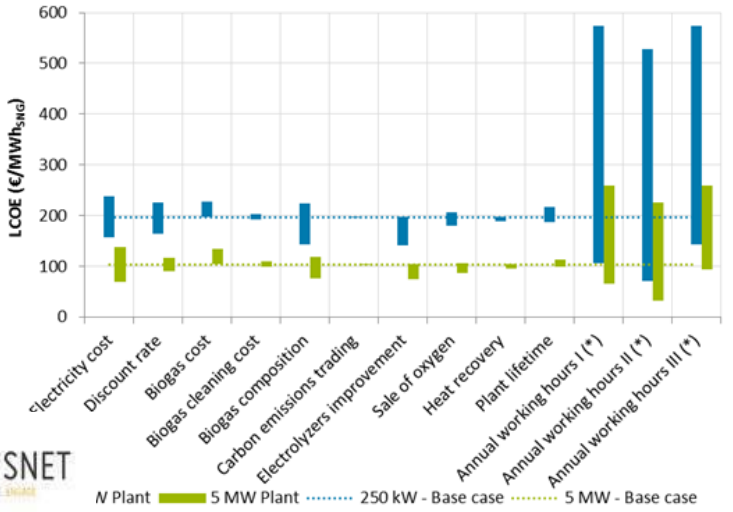
- CO_2 availability from biogas for future developments analysed.
- Biogas plant location according to electricity and gas grid: key aspect in the project feasibility



Economical Study

- Based on a LCOE indicator.
- Main inputs:
  - Two plant sizes: 250kWe & 5000kWe.
  - 3000 hour/year operation.
- Sensitivity study of main inputs.
- Main finding:
  - Influence of working hours/year.
  - Size: intensive in capital expenditure.
  - Electricity price, main operational cost.





Sensitivity study of main inputs / Comparison

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Lessons Learnt

Methanation Process

- Very Good performance and stability of the developed catalyst
- Composition and prior treatment of the contaminants in the biogas is crucial for the methanation process.

P2G Potential

- Plant siting has to take into consideration the gas and electricity grids as well as the CO_2 source that could limit potential.
- Costs of H_2 and CH_4 production are heavily dependent on the operating hours of the electrolyser and methanation plants.

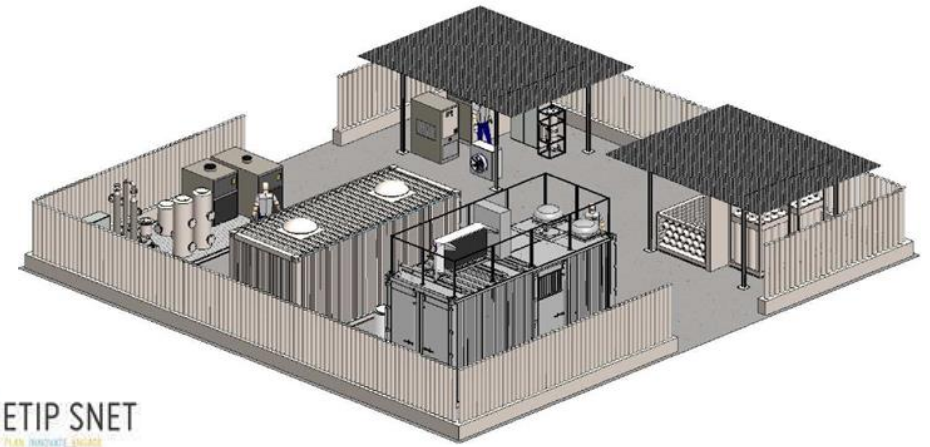
Barriers to innovation deployments

- Requirement to validate the long-term performance and design of the plant at a demonstration level resulting in the need for significant investment.
- P2G is currently expensive and it's future depends on achieving predicted future significant electrolyser cost reductions and finding further improvements in the costs of the methanation process.

Next Steps

Following the successful demonstration of the first phase, the partners are currently discussing a follow-up project:

- To scale up the technology to the next scale.
- To update the P2G Potential Study within Spain taking into consideration the recent two RES auctions in Spain and future scenarios.
- Update of the Economical Study according to new scaled up plant and future scenarios in Spain.



Detailed engineering for a scaled up 250kW plant

Thank you