Patagonia Wind - Hydrogen Project: Underground Storage and Methanation

A. Pérez[1*], E. Pérez[1], S. Dupraz[2] and J. Bolcich[1]

[1]*Hychico S.A. Av. Córdoba 950, Piso 5C (C1054AAV) Buenos Aires – Argentina*
[2]*BRGM (French Geological Survey), 3 Av. C. Guillemin, 45060 Orléans - France*

(*) rperez@capex.com.ar

Introduction

The estimated 2,000 GW wind power potential of Argentine Patagonia, its natural resources and infrastructure are the best combination for a Large Scale Wind-Hydrogen production in Hychico´s vision. A Hydrogen Plant producing 120 Nm^3/h (99,998 % purity), and a Wind Park (6.3 MW), with an average annual capacity factor of 50% constitute the first stage of Hychico's program. This "Green" or zero emission hydrogen will supply developing markets such as fuel cell, and or internal combustions engines for vehicles and stationary applications.

The decarbonisation of the energy system faces the challenge of how to integrate an increasing share of intermittent renewable energies such as wind or solar power. Underground Hydrogen Storage is one of the options that may facilitate this integration and it may become a viable option for large-scale electricity storage especially in places with suitable geology and electricity generation from renewables and surplus in the order of tens of TWhs over extended periods [1].

In 2010 Hychico began geological studies to start an Underground Hydrogen Storage in a depleted gas reservoir located near its hydrogen facilities. An Environmental Impact Assessment and a Public Hearing process were passed and then it was started a program involving multiple stages with different hydrogen and natural gas injection-withdrawal cycles.

In association with the BRGM, Hychico is currently developing another pilot project that focus on the potential of depleted gas reservoirs to accomplish methane production by biological processes. As this resulting synthetic natural gas fulfils all requirements of conventional natural gas, it can be used in any natural gas applications and direct combustion technologies.

The goal is to find out the key factors involved in the processes, including the characterization of microorganisms, and optimization of processes.

First results show good behavior of the selected depleted gas reservoirs as well as some favorable conditions for methanation processes inside it.

Underground Hydrogen Storage

As Hychico's facilities are located in an oil and gas field, the well "F-160" was selected for the pilot project taking into account its distance from the hydrogen plant, size, depth, original pressure, geological and mechanical conditions among others. The main characteristics of the reservoir are described in table 1.

The selected reservoir belongs to the glauconitic type, a deposit of marine origin in the developed Golfo de San Jorge Basin in Argentine Patagonia.

The Environmental Impact Assessment as well as a Public Hearing process was approved by governmental entities and after that, Hychico was allowed to build a 2.3 Km hydrogen pipeline connecting the Hydrogen plant and the F-160 well head. A special pipe developed for hydrogen applications and based on multilayer polymeric materials has been used and tested.

The project involves three stages with the following goals:

Stage I: to confirm properties and seals of the reservoir by injecting natural gas and withdrawing it until reaching original pressure of 26.5 bar-a. Small amount of hydrogen were injected to use it as a tracer and several monitoring points were set.

Stage II: to study the behavior of the reservoir with hydrogen by injecting until reaching an intermediate pressure and composition

Reservoir properties	
Reservoir type	Glauconitic. Sandstone covered by clays.
Depth [mbhw]	815
Original pressure [bar-a]	26.5
Gas Original in Situ [Nm^3]	~ 750,000
Average thickness [m]	2.5
Porosity [%]	25
Permeability (abs) [mD]	500
Water saturation [%]	55
Ground temperature [°C]	55

Table 1. Main characteristics of the well "F-160"

(about 10% @10 bar). Changes in reservoir properties as well as in gas composition are being analyzed.

Stage III: to check the hydrogen tightness of the reservoir at the original pressure by injecting natural gas again to raise the pressure.

Results to be developed in the paper will include flows and pressure evolution, amount of injected and cushion gases, simulations using a well known software to check reservoir properties as is shown in figure 1.

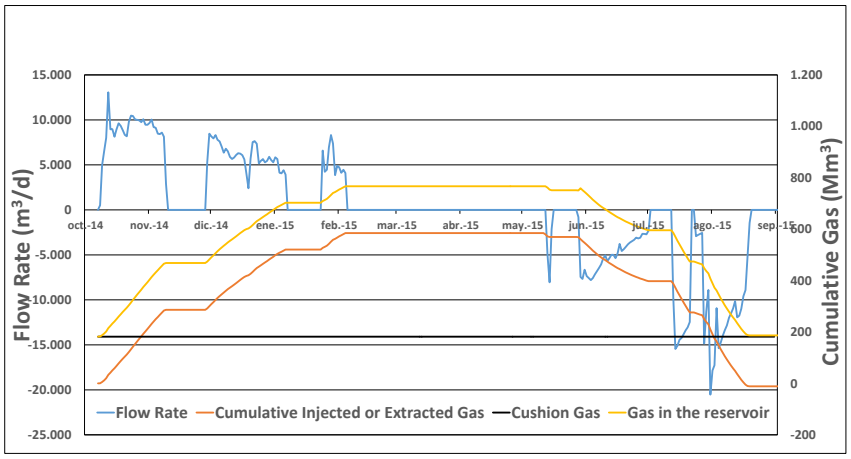

Figure 1. Flow and volumes evolution during injection and withdrawal cycles.

For the reservoir itself, hydrogen specific issues can involve chemical and bacteriological reactions as well as alterations in the mechanical and permeability properties due to their interaction with hydrogen. Samples of rocks, fluids and biological material were taken to characterize the reservoir and these possible interactions.

On the other hand, hydrogen embrittlement is probably the strongest technical constraint, which needs to be addressed by proper choice of materials and monitoring and control of pressure and temperature. One of the objective is the investigation of interactions between the equipment of depleted gas reservoirs and the hydrogen that could be stored in this kind of systems such as pipes, tubing, casing, packers, concrete, seals.

Methanation pilot project

Methanogenesis is the biological generation of methane. In some conditions, this generation can be achieved by archeal metabolisms using hydrogen and carbon from inorganic sources. Namely, these metabolisms may induce biologically methane production from hydrogen gas and CO_2 (i.e. contained in the natural gas):

$$4H_2 + CO_2 = CH_4 + 2H_2O$$

Methane from such processes has usually a high purity, it is easy to store and to transport and its combustion emits few pollutants compared to oil and coal combustion [2]. This behavior of hydrogen in underground storage has been observed in storages of town gas during injection–extraction cycles [3].

The Hychico-BRGM Pilot Project focus on the potential of depleted gas reservoirs to accomplish methane production by biological processes. It involves several phases including biological characterization, laboratory and field tests and modeling. The tasks aim at the monitoring and optimization of the reservoir parameters concerning the site as well as at the understanding of "in situ" geo-microbial reactivity. The goal is to find out the factors that could lead to the production of methane by means of hydrogen and CO_2, including the identification of different types of microorganisms that can be involved in such metabolic reactions.

Physical and chemical parameters that allow the existence (i.e. growth) of microbes and more precisely methanogens (i.e. temperature, pH, Redox conditions, salinity, specific metals and organic substances presence), as well as biomass limitation and biological consortia composition were investigated in samples of formation water and rock "plugs" obtained from drillings in the same geological horizon of well "F-160". The first results indicate that the reservoir conditions are favorable to perform methanation.

The paper will show the main results, issues and outlook of the above mentioned projects, Underground hydrogen storage and Methanation, until the date of publication of this work.

References

[1] "Assessment of the Potential, the Actors and Relevant Business Cases for Large Scale and Long Term Storage of Renewable Electricity by Hydrogen Underground Storage in Europe". HyUnder Project. Executive Summary (2014).

[2] Burkhardt, M., Busch, G., (2013). Methanation of hydrogen and carbon dioxide. Applied Energy 111, 74-79.

[3] Smigai P. Greksak M., Kosankova J., Buzek F., Onderka V., and Wolf I. (1990) Methanogenic bacteria as a key factor involved in changes of town gas in an underground reservoir. FEMS Microbiol. Ecol., 73: 221 – 224.