The 11th NEDO-CDTI Joint Workshop

"Technologies for Hydrogen Valley in Spain and Japan – Regional H2 Value Chain"

UNDERGY (UNDERground EnerGY): Underground Storage of Green Hydrogen in a depleted field.

Cristina Yuste

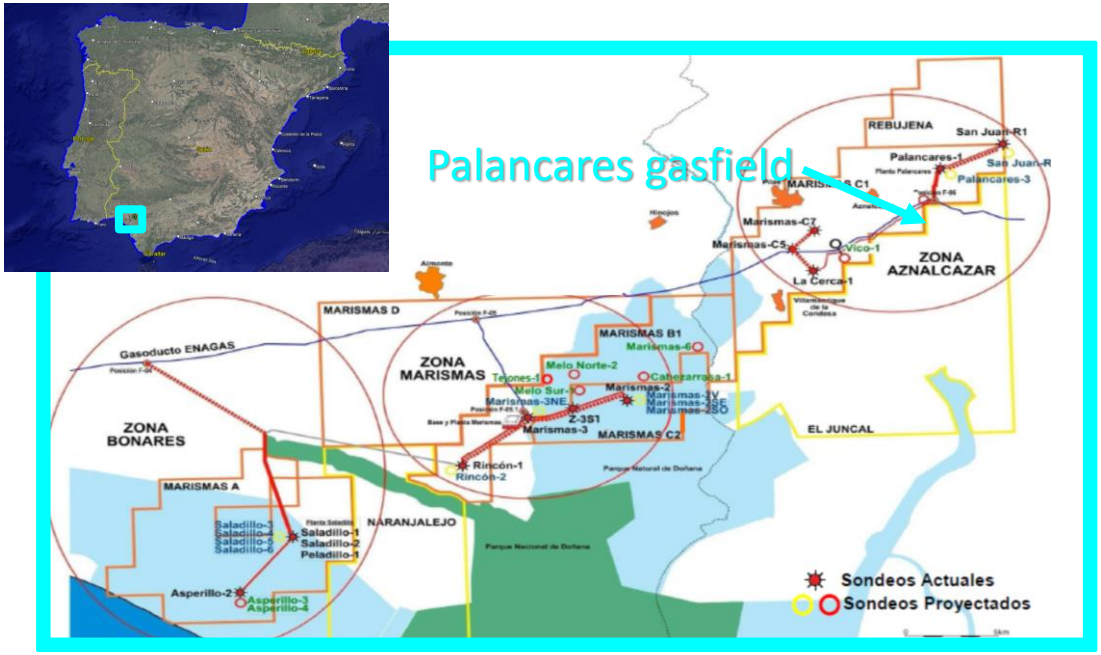
Project Development Manager

Trinity Capital SLU

Trinity Capital, assets in southwest Spain

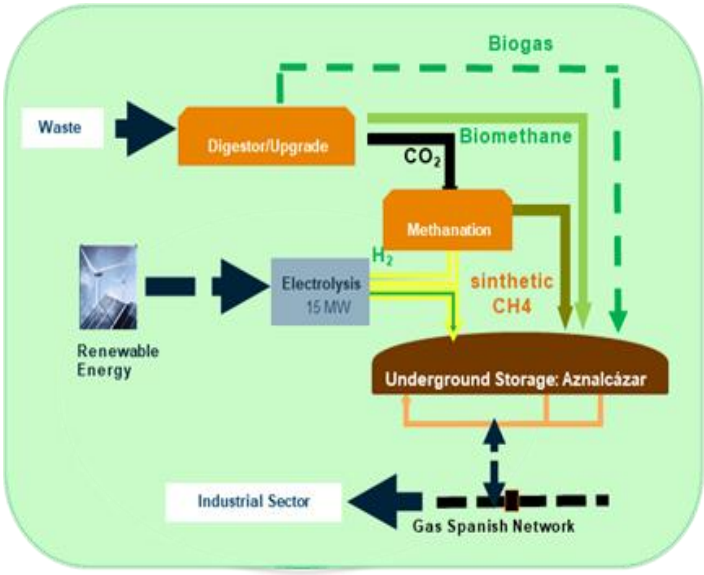
- ✓ Trinity Energy Storage owns several Exploitation Concessions in the Guadalquivir basin, in Southwestern Spain, operated by highly experience technical staff with over 25 years experience.
- ✓ Exploration on this area commenced in ’80, starting gas production in 1990. So far, over 1 bcm has been produced and over 2 bcm resources potential identified.

- ✓ Trinity main assets include 2 UGS in depleted natural gas fields (integrated in the Spanish gas system).
- ✓ Another 3 UGS of our property have been tested as excellent gas storages, which include Palancares gas field (pending of authorization).



Trinity Energy Storage Strategy: ACES

- ✓ Trinity is focused on the use of its depleted gas fields as underground renewable gas storage through ACES project as main target (Andalusian Conversion Energy Storage).
- ✓ Usege of existing Palancares underground structure to store renewable gases (green H2, biogas, and synthetic methane) by three means:
  - 15 MW electrolyzer fed by a PV plant-built ad-hoc
  - Generation and upgrading of biogas
  - Pilot of synthetic CH4 generation with CO2 from biogas.



- ✓ ACES in figures:
  - 620 ton/yr of green H2, as first step
  - 5,000Nm3/d of biogas recovering 2,800 Nm3d of CO2
  - 300 Nm3/d of synthetic methane
  - Underground Capacity: 150 MMm3, WG: 65 MMm3 (200 GWh).
- ✓ Final objective is to extend results to all depleted reservoirs of the area of our property

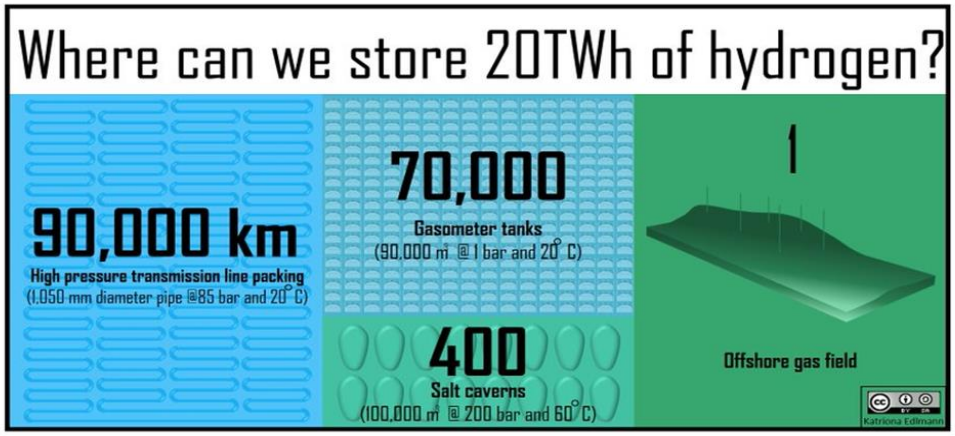
UNDERGY (UNDERground EnerGY): Objectives

UNDERGY

- ✓ UNDERGY project arises from the commitment for year 2050 of having 100% generation of renewable energy and zero emissions.
- ✓ No country will meet climate targets without long-duration energy storage. Spanish energy storage road map foresees 20 GW of storage capacity by 2030 and 30 GW by 2050.
- ✓ 25 TWh surpluses expected in Spain by 2030. Out of all energy storage technologies investigated, only underground storage seems to be the most appropriate for seasonal storage.
- ✓ UNDERGY will assess the viability of the underground storage of energy in the form of green hydrogen in Spain. This information will be used to build and integrated into an efficient energy management system using a Geographic Information System.

Europe needs 600GW of energy storage by 2050, says trade body EASE

By Cameron Murray



Modified from Katriona Edlmann, May 2021

UNDERGY (UNDERground EnerGY):
Budget and Duration

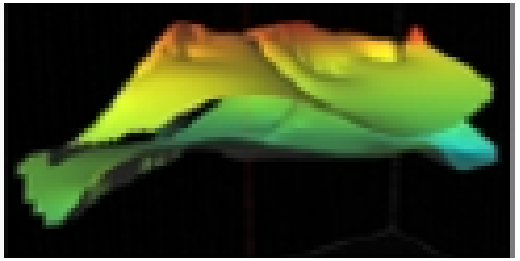
- ✓ Undergy is undertaken by a consortium of six Spanish companies and the collaboration of six benchmark research organisations.
  - It commenced in October 2021, and plan to finish by December 2024.
  - It has a total budget of € 5,599,227.00 and a grant of € 3,490,674.75

- ✓ The Project is subsidized by the Centre for Technological Development and Innovation (CDTI) under the 2021 call for proposals of the Science and Innovation Missions Program supported by the Spanish Ministry of Science and Innovation. The grant given to the project is being funded by the European Union through the Next Generation EU Fund.

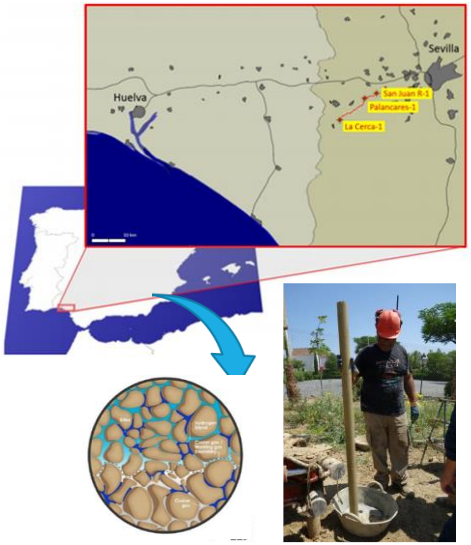
Naturgy
PETROLEUM
ayterra
Instituto Geológico y Minero de España
Centro Nacional del Hidrógeno
TECNICAS REUNIDAS
H2B2
UNIVERSIDAD POLITÉCNICA DE MADRID
Gessal
LOYOLA
VNIVERSIDAD D SALAMANCA
tecnalia
Financiado por la Unión Europea
NextGenerationEU

UNDERGY: Activities 1 and 2

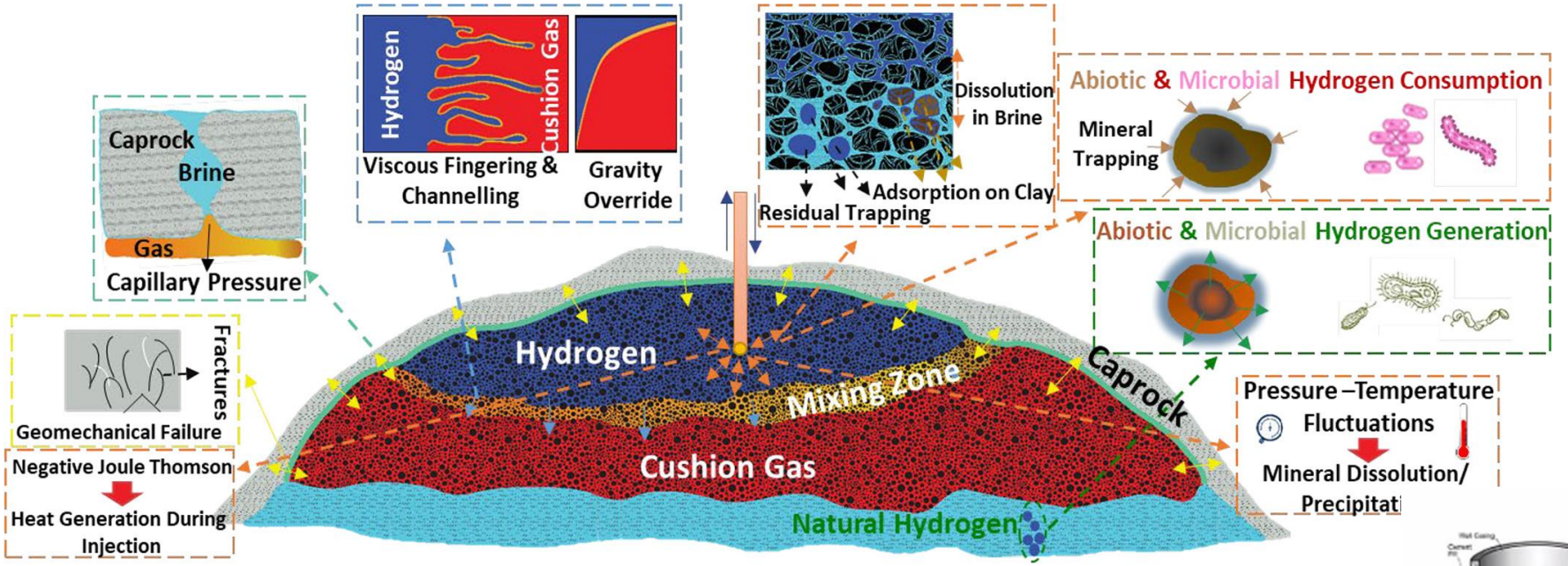
- ✓ The project is divided in six activities, led by one partner, related to different objectives:
  - **Activity 1**: Estimation of Green H2 seasonal storage capacity in Spain.
    - Lead by GESSAL, identification of potential structures to store H2 in the Spanish underground.



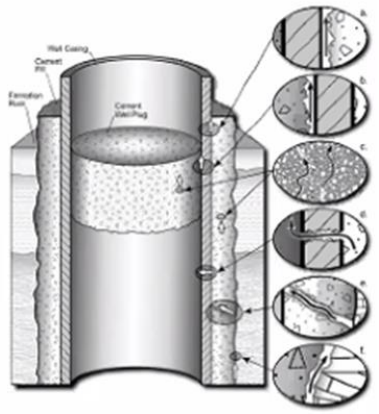
  - **Activity 2**: Assessment of Palancares, depleted gas field, as Underground Hydrogen Storage.
    - Lead by Petroleum (through Trinity), will investigate, on a laboratory scale, the liability of the conversion.
    - Laboratory work will focus on reactivity of fluids (CH4, H2, CO2, and brine) among them and rocks (Reservoir and seal) at reservoir P and T.
    - Possible downhole methanitation due to bacteria activity
    - Construction of static and dynamic models of Palancares.
    - Estimation of H2 storage capacity for defined operational scenarios and possible upscaling of the results to other depleted deposits with similar characteristics.



UNDERGY. Activities 1 and 2:
Challenges of Storing Hydrogen in Porous Media



Offshore Geological Storage of Hydrogen: Is This Our Best Option to Achieve Net-Zero? *ACS Energy Lett.* 2021, 6, 6, 2181-2186



Gasda et al. *Env. Geol.* 2004

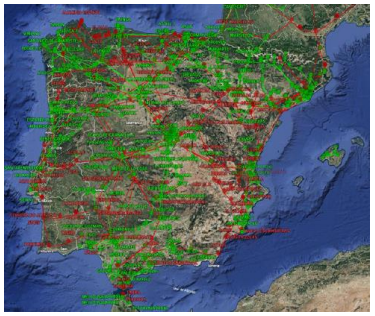
UNDERGY: Activities 3, 4, and 5

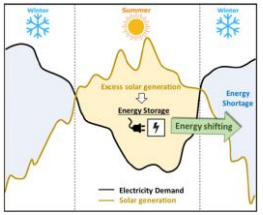
- **Activity 3**: Electrolysis Process
  - Lead by H2B2, working on a conceptual design of a new 20 MW electrolyzer suitable for UHS.
  - Substantial technical improvement of overall process: water treatments that minimize rejection, power adequacy and better option of the stacks.
- **Activity 4**: Surface facility research
  - Lead by Técnicas Reunidas will investigate into the possibility of converting the existing facilities for future use for H2, prioritizing the potential use of existing equipment.
  - Two scenarios: 20% H2/80% CH4 blend, and 100% H2. They will also investigate options of injecting CO2 to account for future synthetic methane generation.
- **Activity 5**: Risk analysis.
  - Lead by Ayterra, will address the potential risks associated to the underground storage of hydrogen, at some levels:
    - Hydrology and hydrogeology
    - Seismicity, geotechnical and geomorphological
    - Electrolysis and gas handing
  - Location of potential regional sources of CO2: technical and economical aspects. Reduction of emissions analysis

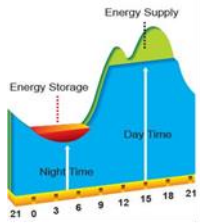
UNDERGY: Activity 6, Efficient Energy Management System

- **Activity 6**: Integration into an Efficient Energy Management System
  - Lead by GNCOM, will focus on the definition of an energy integrated management system to achieve a 100% renewable target prioritizing security of supply.
  - Model built on a Geographical Information System (GIS), including several maps:
    - Renewable resources (based on weather forecast)
    - Underground storage sites (suitable for green H2)
    - Gas and electricity networks (existing and planned)
    - Existing and expected demand and Hydrogen consumption

Electricity (green) and Gas (red) Spanish network







SPAIN: Monthly Solar Irradiation Estimates and PV Geographical Information

Existing facilities at Palancares depleted gas field

1. Well head

2. Separation Filter

3. DPC-2802 Compresor

7. Well site

4. Fuel Gas Unit

5. Dehidration Unit

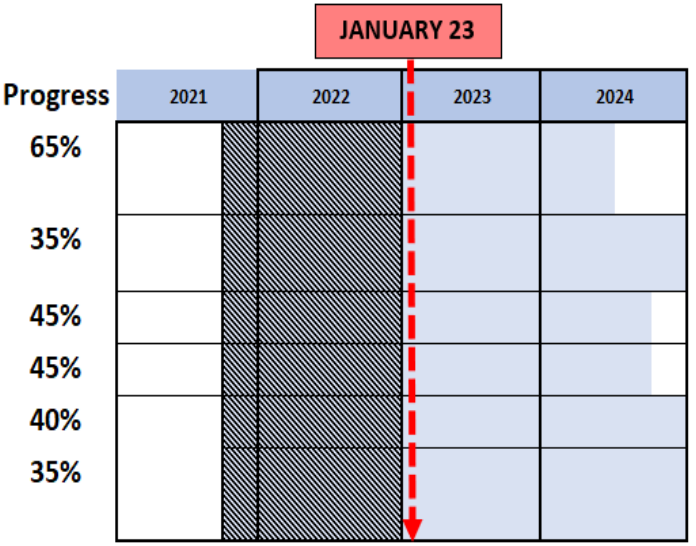
6. Water Tank

8. Control Room

UNDERGY: Progress Status

- ✓ Progress description of activities at Jan 2023:
  - Inventory of UG structures finished
  - Pilot reservoir selected, Palancares.
  - Rock samples acquisition and selection
  - Lab analysis on going: First samples introduced in reactors last Monday
  - PEM bench installed in lab.
  - Collection of surface data. Revision of existing facilities done and selection of critical points.
  - Identification of potential sources of CO2. Environmental and risk analysis aspects on going. Seismic risk analysis finished.
  - Compilation and analysis of documentation, maps, national plans, market information and provisions. Developed proof of concept of the model in Google Earth format

	Progress
1. SEASONAL STORAGE CAPACITY OF H2 IN SPAIN	65%
2. GREEN H2 STORAGE PILOT STRUCTURE	35%
3. ELECTROLYSIS PROCESS	45%
4. INVESTIGATION OF FACILITIES	45%
5. RISKS AND CO2 ANALYSIS	40%
6. INTEGRATED EFFICIENT MANAGEMENT ENERGY SYSTEM	35%



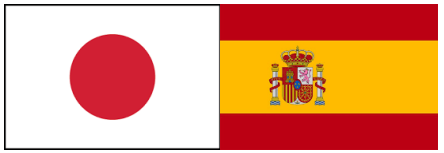
UNDERGY: Other Challenges Identified

- ✓ Besides technical challenge of storing H2 in the underground, other unexpected challenges found for the time being:
  - Compilation of the Spanish energy network database
  - Rock samples and laboratory (contact established with European Universities):
    - Subsurface rock samples availability and quality
    - Conditioning of samples prior to analysis using reservoir brine.
    - Timing of lab experiments
    - Lack of experience of traditional laboratories in handling H2.
  - Electrolyzer fed directly from non-manageable renewable plants

All individual aspects involved in the production, handling and storing of green H_2 are indeed a challenge:

Lack of lab procedures, electrolysis from renewable sources, personnel skills, H_2 material specs, risk assessment…

Japan and Spain closer than expected a priori



- ✓ Japan is highly dependent on natural gas imports (as it is Spain),
  - 4,5 Tcf consumption of natural gas per year 5th in the world and 0,74 Tcf of proven gas reserves. Two UGS on operation.
- ✓ Japan is also committed to renewable generation:
  - In 2022, Japan renewable generation has exceeded 20% for the first time ever: Solar power accounted for 8.3%, wind power 0.9% and hydropower 7.5%.

- ✓ **Japan and Spain are heading a promising future** of **energy independence** based on renewable potential.
- ✓ H2 as an energy vector makes necessary the development of underground hydrogen storage. **Both countries have potential sites for underground h2 storage**

Ideas for a Japan – How could Japan benefit from Undergy project?

- ✓ Japan and Spain have both interest on developing in-house H_2 to displace the foreign natural gas.
- ✓ Combination of increase of renewable sources in the Generation mix, together with the support to H_2 as an energy vector makes necessary creation of underground hydrogen storage.
    - ✓ Common goal:
        - Domestic green H_2 production to decrease our energy dependency
        - Validation of UHS, in a 100% renewable future.
- ✓ Trinity is creating value out of our depleted gas fields, and willing to export its knowledge to another fields.
- ✓ Collaboration will lead us to success: Trinity will share its experience on underground gas storage, and specifically green H_2 through Undergy and welcome to learn for you.

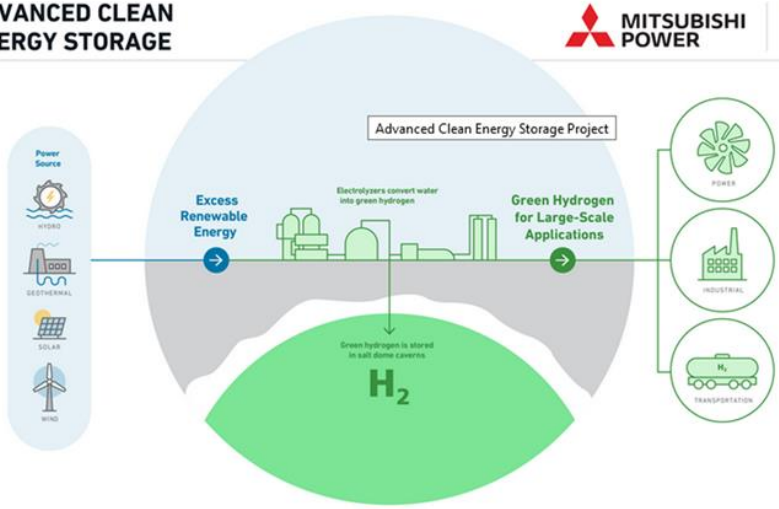
Examples of Existing Projects for possible collaborations

ACES DELTA

ADVANCED CLEAN ENERGY STORAGE

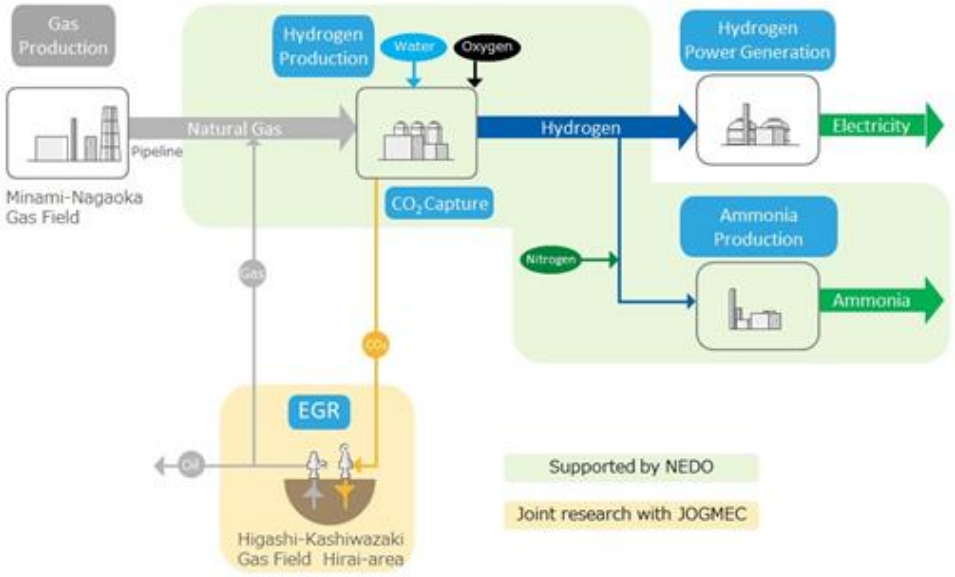
MITSUBISHI POWER

MAGNUM



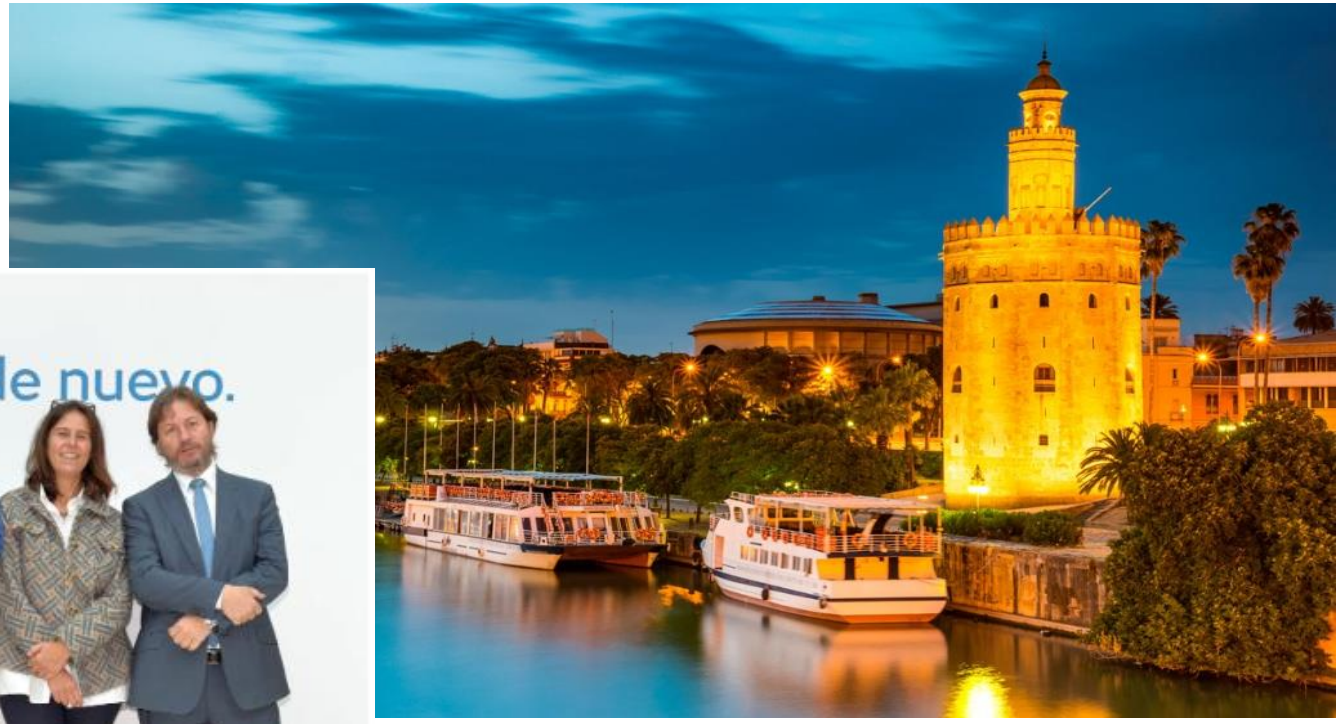
OIL & GAS

Inpex gives investment nod for Japan's first clean hydrogen and ammonia CCUS project 21/11/2022, 3:27 am



- ✓ Trinity Energy Storage has experience in both salt caverns and CO2 storage projects

Underground Storage of Green Hydrogen in a depleted field



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