the energy house

Snam: Monitoring Plan

A quick outlook based on UGS experience

Outline

- **Snam** & **Snam Stoccaggio** Overview
- Monitoring in Snam experience
- Monitoring in CCS projects
- Conclusions

The largest European gas infrastructure player

Italian & International Assets[1]

Data as of FY 25

~ 31 Bn€[3]	~ 37,600 km	~ 21 Bcm capacity	~ 22 Bcm/y capacity
RAB[2]	Transport	Storage	LNG Regasification

Italian Assets

Data as of FY 25

~ 26 Bn€	~ 33,100 km[4]	~ 18 Bcm capacity	~ 19 Bcm/y capacity
RAB[2]	Transport	Storage	LNG Regasification

1) Including pro-quota of International assets
2) 2025 Tariff RAB (Regulatory Asset Base)
3) Including TAG, GCA, Desfa, Teréga, Italgas and OLT pro-quota 2025 Tariff RAB
4) o/w 10,000 national and 23,100 regional network

Snam is the most integrated European TSO, leader in transport and storage

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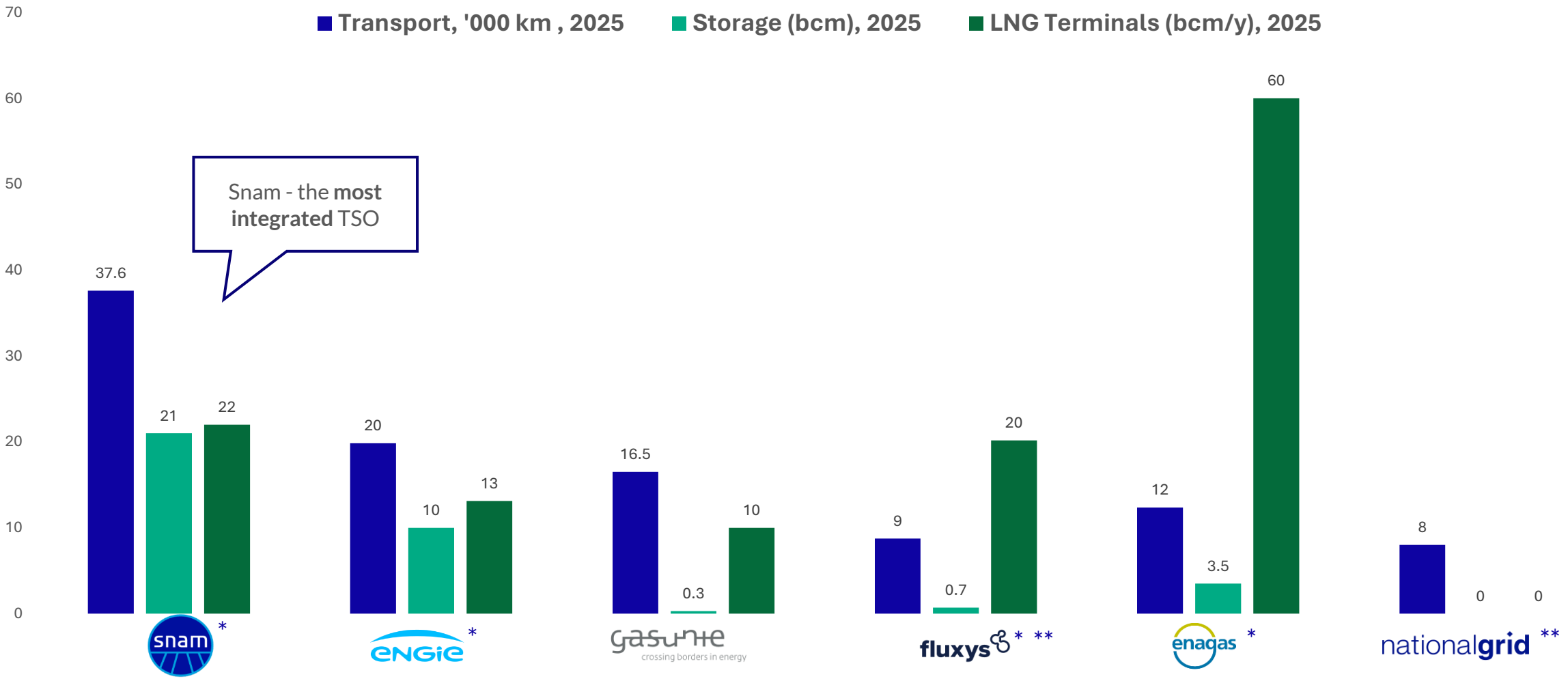


*Data are recomputed pro-quota to the investment owned
**Data do not consider equity investments in USA, , Mexico and Peru

Snam Assets - Underground Gas Storages

ITALY: Main figures

Headquarters
Milano (registered office)
Crema (operating office)

Storage concessions
12, of which 5 in Lombardy, 4 in Emilia-Romagna, 1 in Veneto and 2 in Abruzzo

Clients
~ 90

Natural gas storage capacity
19 bcm

UGS volumes injected/withdrawn: ~21 bcm

12 depleted gas fields
18 reservoirs
~500 wells

FRANCE: Main figures

Headquarters
Pau (registered office)

Storage concessions
2 (Lussagnet and Izaute)

Clients
~ 20 (shippers)

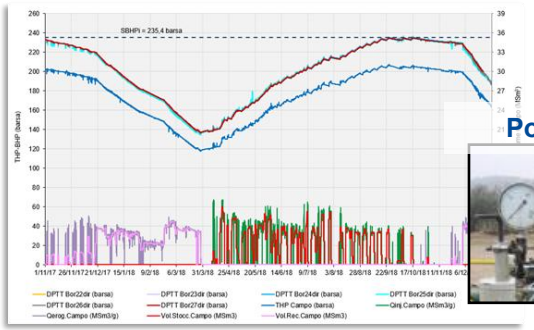
Gas moved
~ 6 bcm

Natural gas storage capacity
6,5 bcm

25% of French capacity

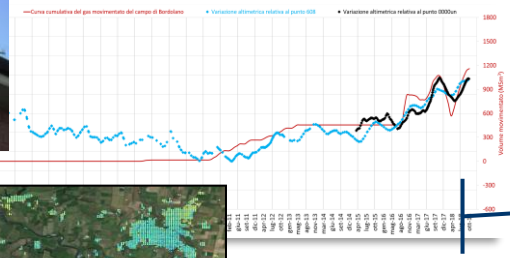
Reservoir Geo-Monitoring

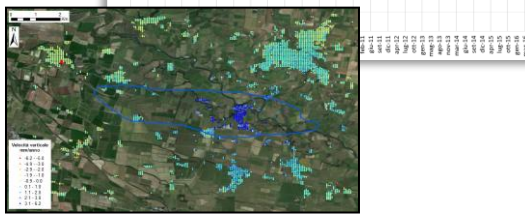
A multidisciplinary and advanced approach tailored to UGS



Pore pressure

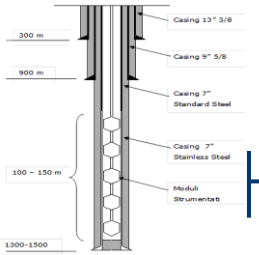
CGPS stations & SAR





Surface network

Deep borehole



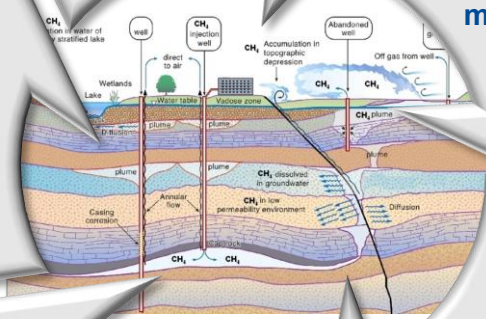
Reservoir monitoring and pore pressure analysis

Gas-water contact monitoring

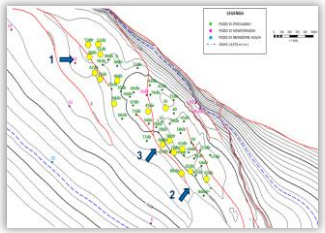
Subsidence

Geochemical

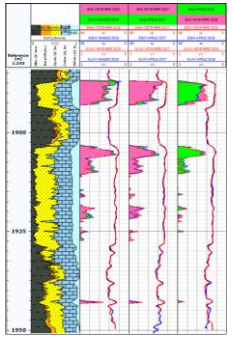
Microseismicity



Water production



Gas saturation logs

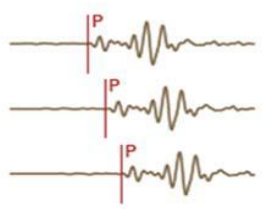


Geochemical stations

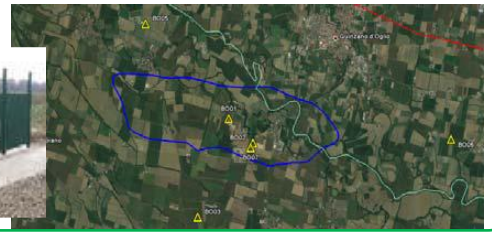
Unique competences for safe operations

Monitoring Components in details

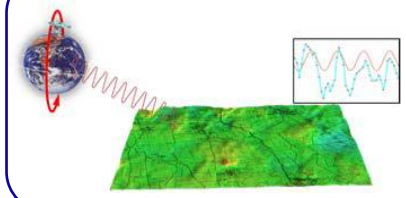
Microseismic



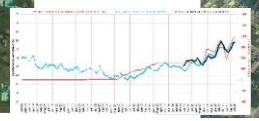
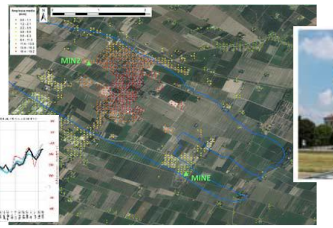
- Surface & borehole stations



Ground Deformation

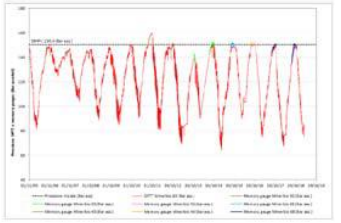


- SAR interferometry
- Continuous GPS monitoring

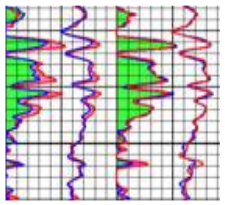





Pore pressure

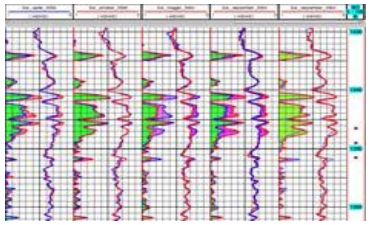
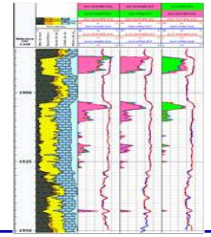
- Continuous pressure data acquisition
- Static pressure profiles




Gas-Water Saturation



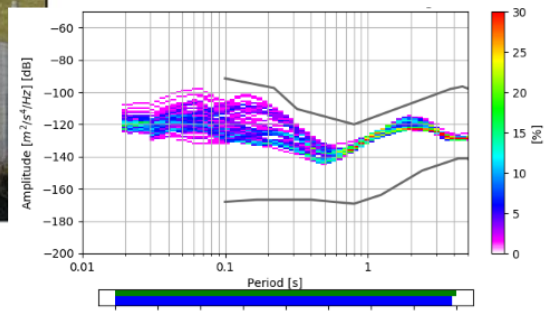
- Reservoir saturation logs in monitoring wells

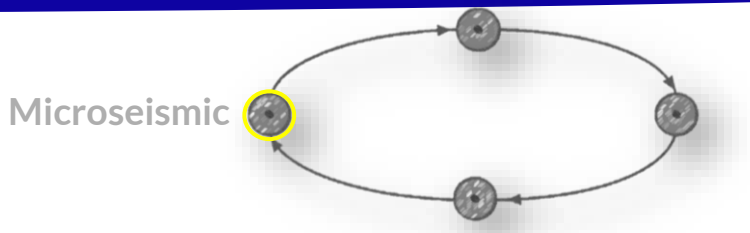



Microseismic Monitoring

The network design

- Analysis of the background seismicity
- Analysis of the background noise to select the suitable sensors
- Seismic network design is tailored according to the site, to maximise the spatial accuracy and minimise the number of employed stations
- Update and network QC is also performed during the network utilisation
- The seismic network can be composed of surface, shallow or deep borehole stations

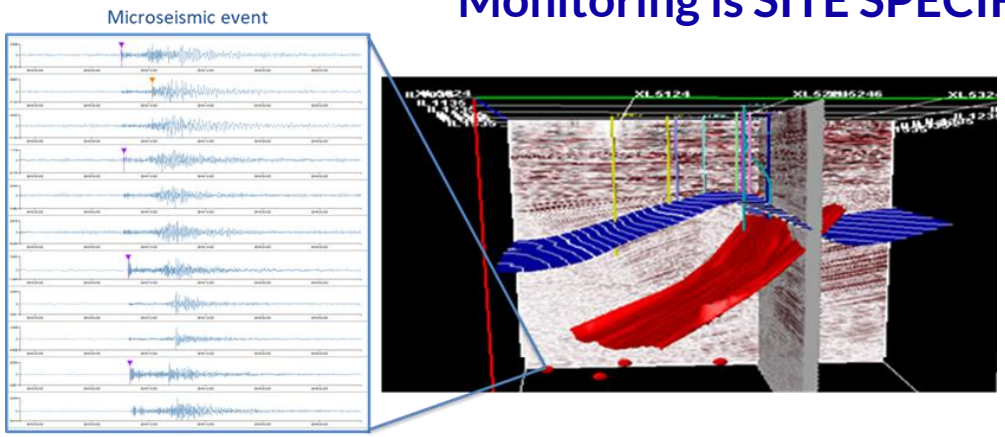




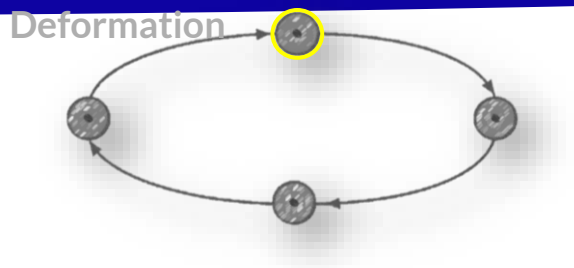
The final network is designed to be able to correctly detect and locate the events

- Network geometry shall minimise the error in location as much as possible.
- The network sensitivity is assessed through continuous monitoring.
- The collected data are used to improve the geological model, for faults interpretation and data analysis.

Monitoring is SITE SPECIFIC



Deformation Monitoring

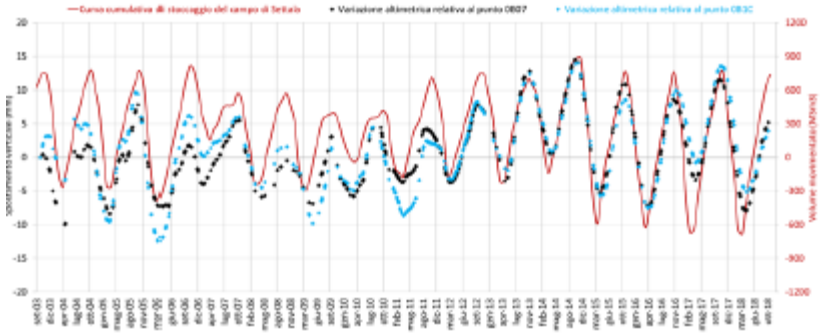


The final network understand spatially and temporally deformation

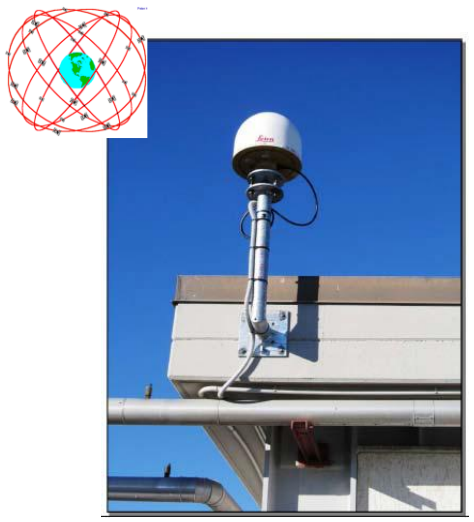
The purpose of the ground deformation UGS monitoring is the measurement of the **surface oscillation during injection and withdrawal phases,** in terms of amplitude and areal extension.

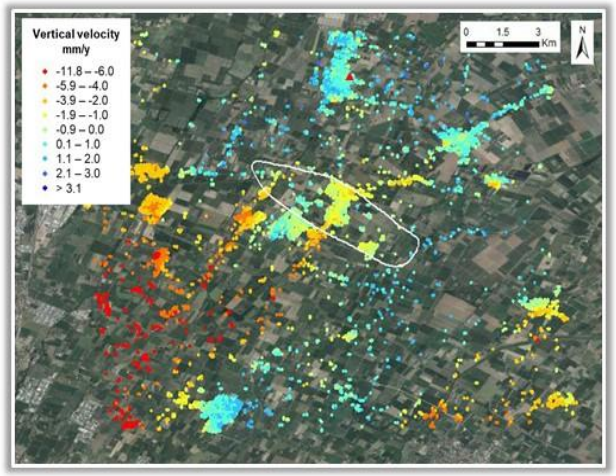
The measured amplitude are expected larger at the center of the reservoir and to rapidly decrease towards the boundary.

Those information are then used for the geomechanical model building and its update



Monitoring is SITE SPECIFIC

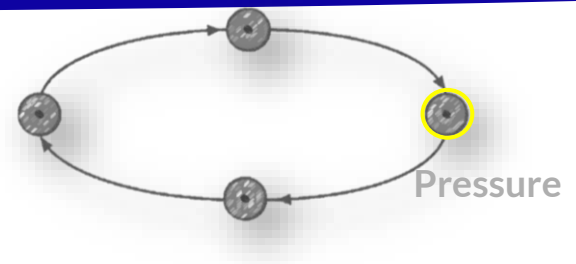




Snam utilizes both:

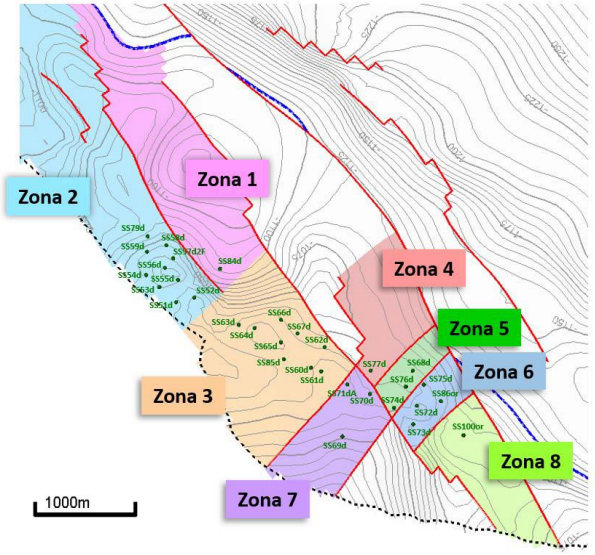
- **InSAR:** interferometry high precision measurements from satellite extended outside the UGS area, used to calibrate the geomechanical model
- **CGPS:** continuous and real-time GPS measurement, allowing a high degree of accuracy and a measurement in absolute value

Pressure monitoring

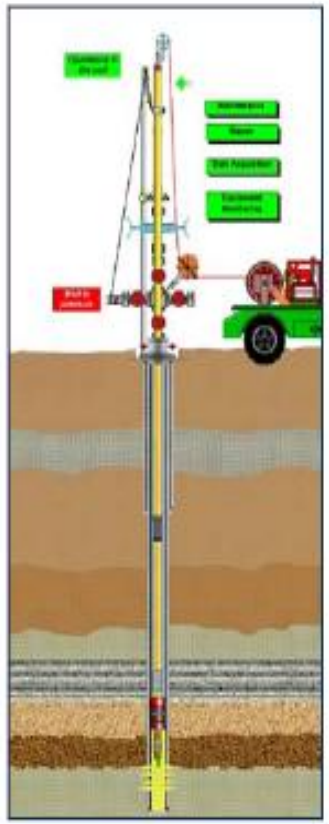


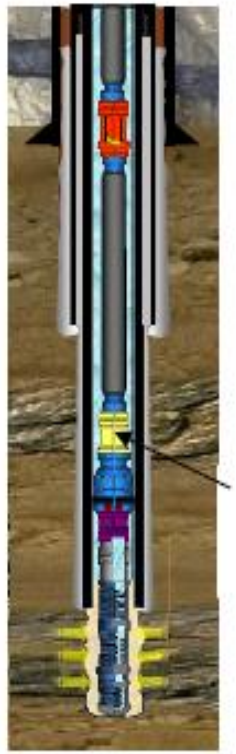
Pressure measurements include:

- Permanent monitoring through dedicated tools (DPTT)
- Temporary sensors installation (memory-gauges) – timing plans and chosen wells are carefully selected
- Milestones measurement plan, for static and dynamic characterization



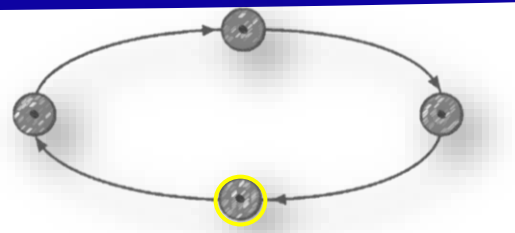
Evaluation of the UGS performance and characterization through the analysis and measurement of the pressure for the whole cycle + pressure check for the compartmented reservoirs





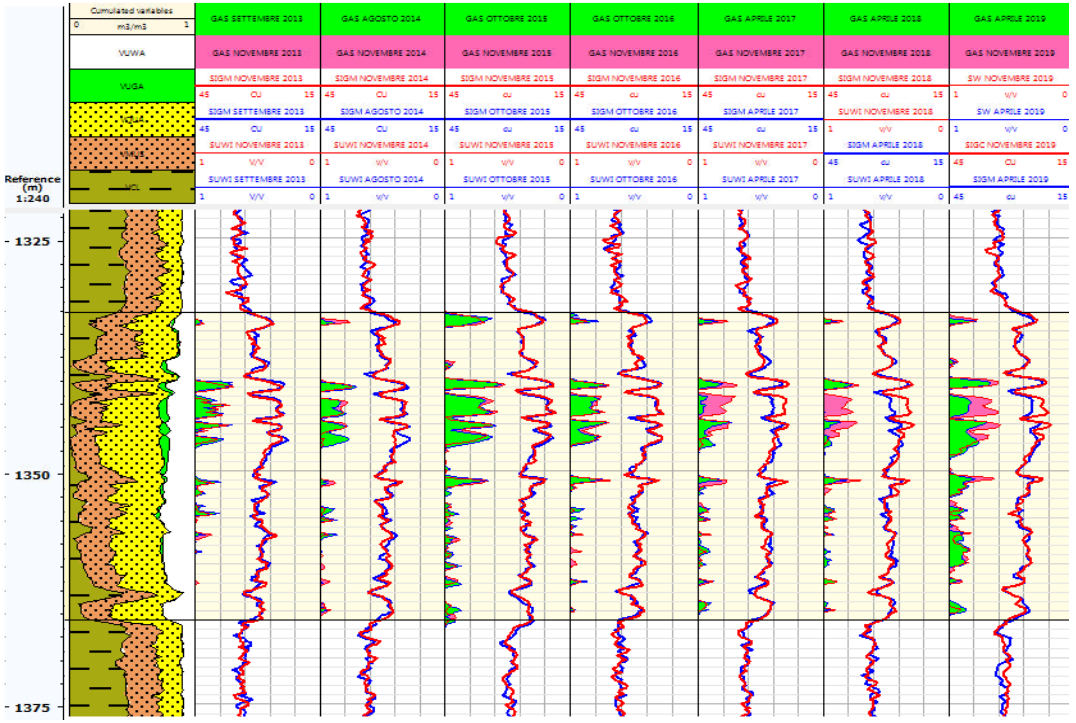
Permanent monitoring gauges

Water-Gas saturation Monitoring

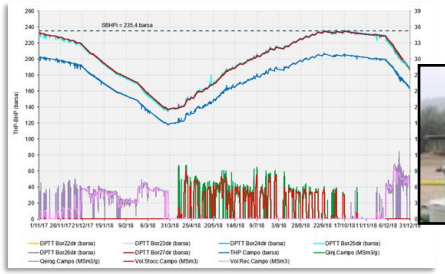


The gas-water saturation measurement allows to verify the reservoir gas saturation and eventual variation of the GWC and/or verify the spill point through periodical logs acquisition

The reservoir saturation is monitored at key time intervals, mandatory at the beginning of a cycle and also eventually at more stages during the industrial activity

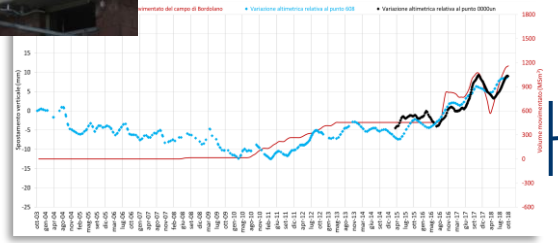


CCS monitoring plan

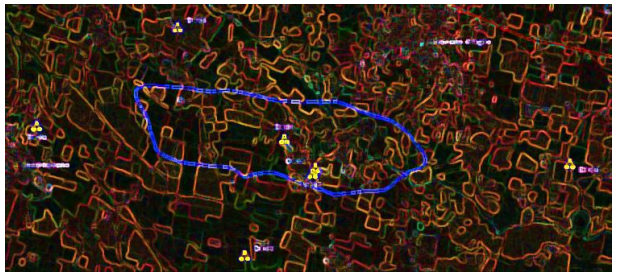


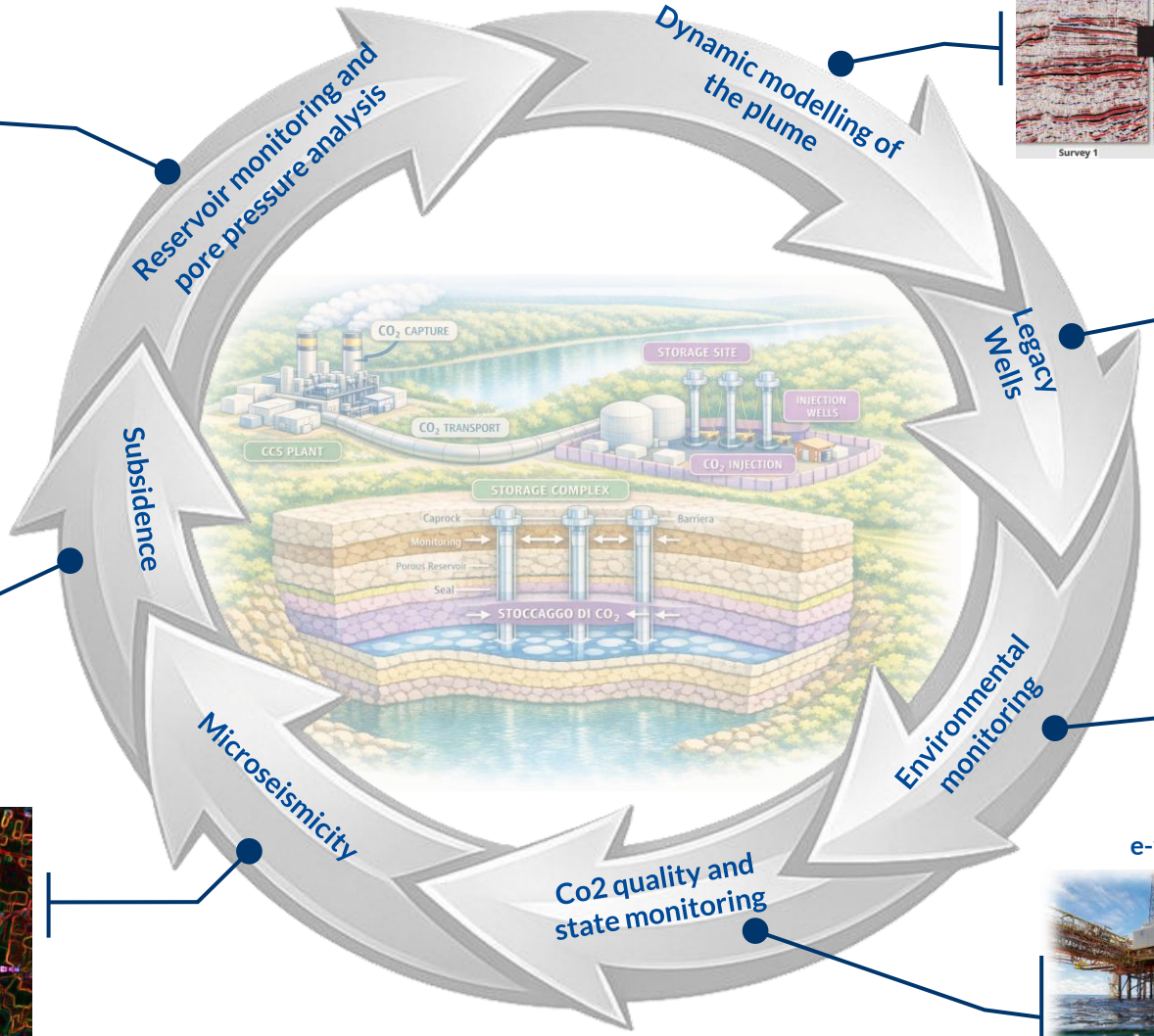
Pore pressure

CGPS stations & SAR

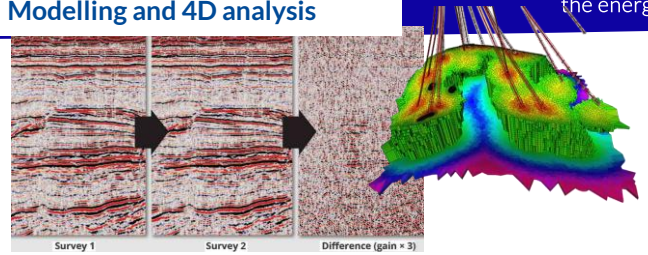


Microseismic network



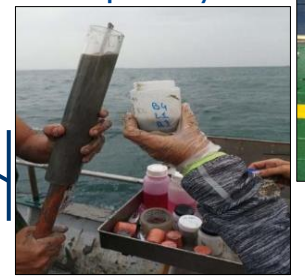


Modelling and 4D analysis



Visual inspection

Bentic/Water sample analysis



e-vpms

CCS Monitoring plan

Monitoring is a crucial component for risk mitigation and one of the key activities required to ensure the safety of geological storage

- To compare **actual and modelled** CO2 plume behaviour
- To detect significant irregularities, i.e., differences between expected and measured behaviour of the storage complex
- To detect **CO2 migration**, i.e., out of the storage reservoir
- To detect **CO2 leakage**, i.e., outside the storage complex
- To assess the **effectiveness** of corrective measures
- To update the assessment of **safety and integrity** of the storage complex in short and long term, including the assessment of CO2 confinement

Snam CCS Monitoring Plan Elements

Operational	Plume	Pathways	Environmental (Leakage)
• Injection Well control • Pressure & Temperature • Composition • Quantification	• Calibrate models • Migration • Kinetics • Trapping mechanism • Trapping efficiency • Pressure	• Caprocks • Faults & Fractures • Wells • Aquifers	• Leak detection • Leak quantification • Emissions • Safety & Environmental aspects

Conclusions

UGS

Main target: **Storage site**

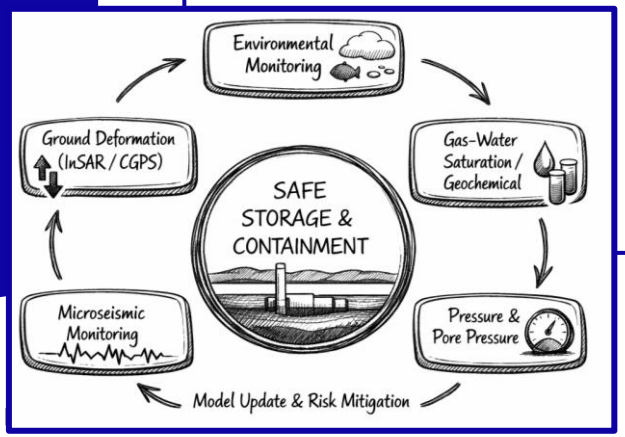
Activity: **Injection AND Withdrawal**

Goal: **Ability to retrieve the injected gas**

-> Withdrawal volume = Injected volume

Monitoring

- Reservoir: Logs/ Fluid contact/Dynamic models
- Environmental: sampling analysis around the area/ water
- Containment: Deformation/Microseismic/Geomechanics
- Wells: withdrawal for the whole area of the reservoir



CCS

Main target: **Storage complex & storage site**

Activity: **Injection**

Goal: **Containment for years to come**

Monitoring

- Reservoir: Logs/ Fluid contact/Dynamic models
- Environmental: sampling around the area/water/at legacy wells
- Containment: Deformation/Microseismic/Geomechanics/Geochemical/ Legacy wells
- Wells: optimized for injection only
- Long Term Containment : Evolution of geochemical possible interaction at reservoir and caprock over long time period / plume migration
- Capture and pipeline monitoring

Proven UGS monitoring capabilities provide a robust and reliable foundation for safe and effective CCS operations