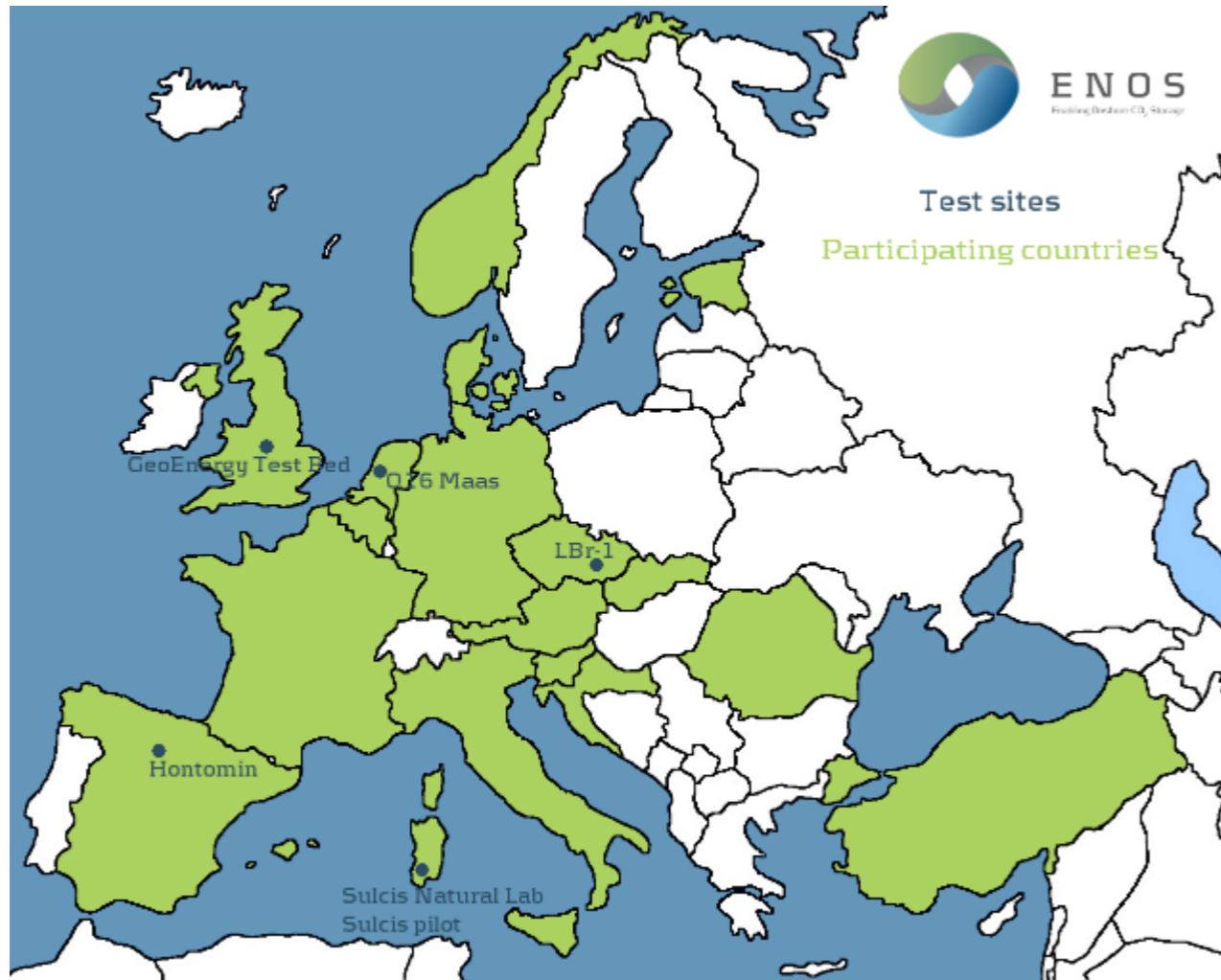


ENOS

Enabling Onshore Storage in Europe

BASRECCS ENOS workshop

# Europe-wide collaborative effort



The project is a  initiative,

endorsed by  EERA  
European Energy Research Alliance  
CCS - Carbon Capture and Storage

Visit our website:

[www.enos-project.eu](http://www.enos-project.eu)

Or contact us for information

[enos@brgm.fr](mailto:enos@brgm.fr)

# Develop CO<sub>2</sub> storage onshore in Europe

**Develop and field test** key technologies adapted to onshore applications;

**Integrate** CO<sub>2</sub> geological storage into the socio-economical fabric by involving local population;

**Create favourable environment** for onshore storage across Europe by:

**support** knowledge sharing to maximise the benefits of site demonstrations,

**integrate** research results and creating best practices from real-life experiments,

**support** preparation of new pilot projects and upscaling to demonstration,

**bring** innovation to society through dialogue and communication,

**promote** CCS through training and education.

# Project structure



Marie Gastine,  
BRGM  
Project  
coordinator



Lionel  
Loubeau,  
CIUDEN  
WP1 leader



Ceri Vincent,  
BGS  
WP3 leader



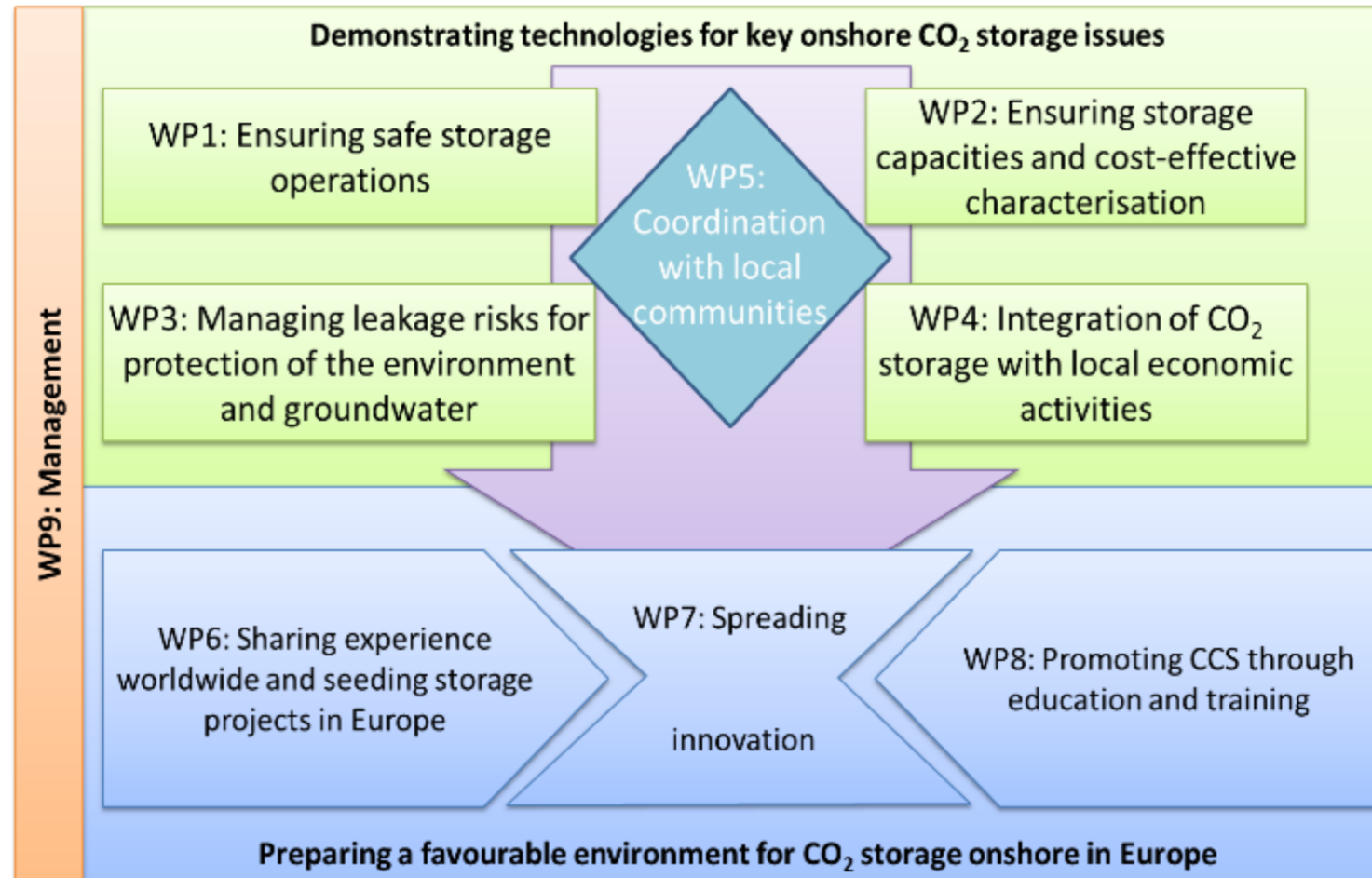
Vit Hladik,  
CGS  
WP6 leader



Roman Berenblyum,  
IRIS  
WP7 leader



Niels Poulsen,  
GEUS  
WP8 leader



Pascal  
Audigane,  
BRGM  
WP2 leader

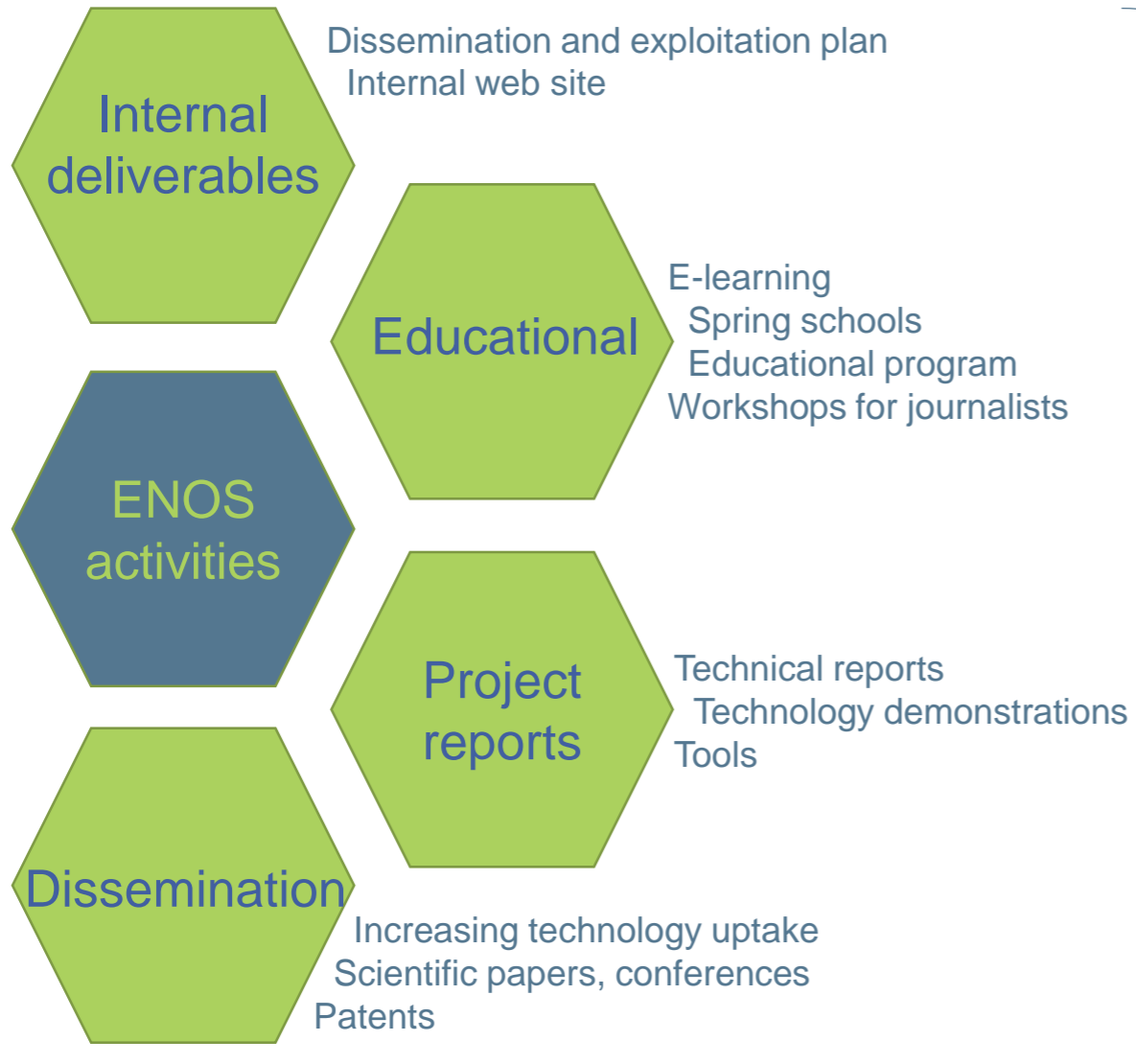


Samuela  
Vercelli,  
UniRoma1  
WP5 leader



Ton  
Wildenborg,  
TNO  
WP4 leader

# Project deliverables



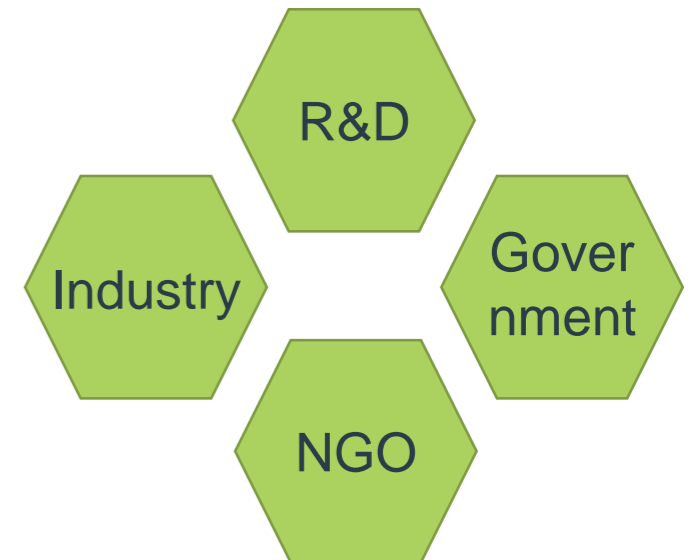
Specific deliverables  
Lots of technical information  
Lots of details  
Not necessarily easy to understand, use and comprehend by those outside the research and engineering community

## Best-practice documents

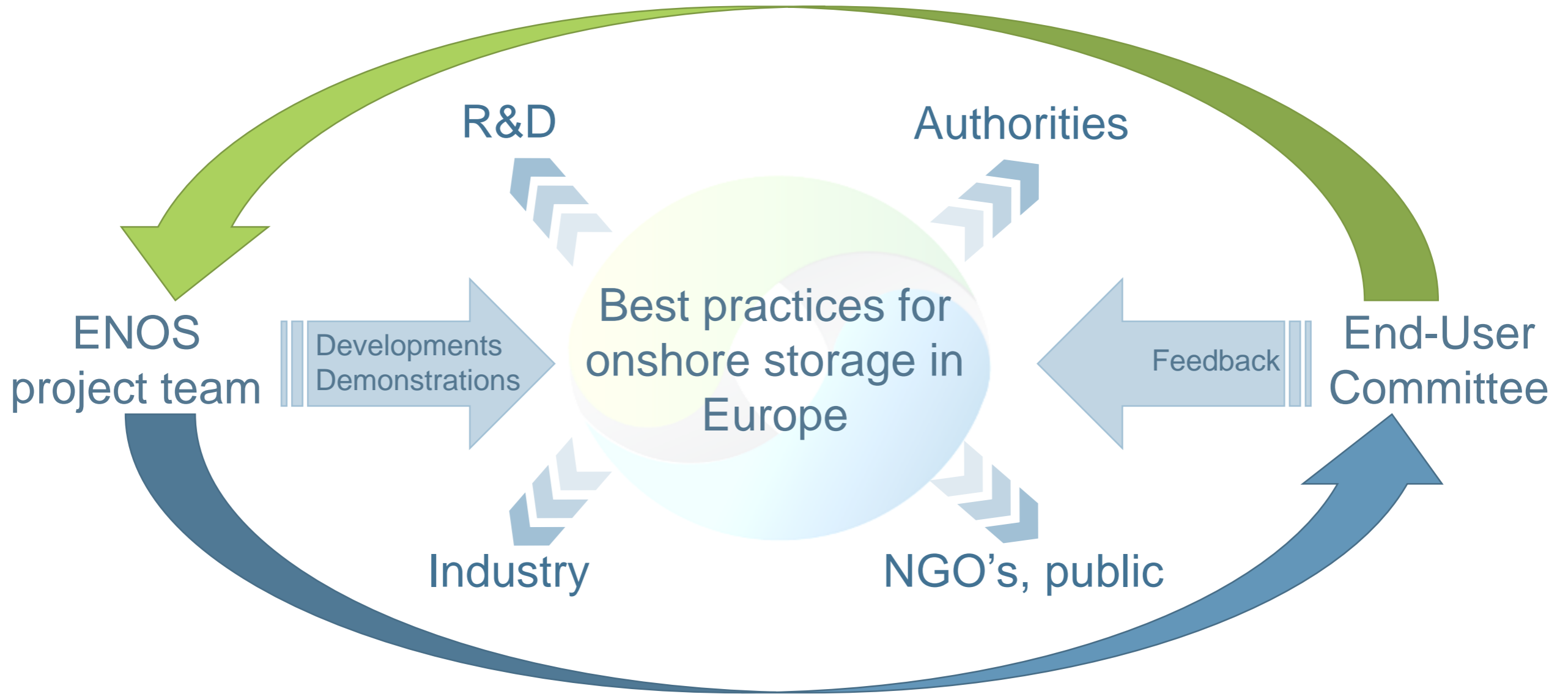
Fit-for-purpose

Address particular audience  
Short summary of key findings

Key element in exploitation of ENOS results



# Interactive tailoring of project outcomes for target audiences



# ENOS

Work packages and research areas covered

# WP1 Ensuring safe storage operation

**Demonstrate** innovative injection strategies and history matching approaches for increased confidence of operators in managing sites safely;

**Validate** methodologies using microseismic monitoring network data to manage induced seismicity risk;

**Validate** tools and methodologies for monitoring the CO<sub>2</sub> plume in the reservoir and for acquiring data on reservoir properties for improved understanding on reservoir behaviour;

**Develop** smart integration of the different monitoring data acquired during operation;

**Develop** an integrated risk management workflow for reliable and safe CO<sub>2</sub> storage operation encompassing monitoring activities, potential risk mitigation and corrective measures;

**Define** technical guidelines for CO<sub>2</sub> storage operation, through cooperation in R&I of research institutions, industry and service providers;

## Sites involved:

 Hontomin, Spain





# WP2 Ensuring storage capacities and cost-effective characterization

**Further investigate** potentialities of next-generation 'high resolution' reservoir modelling to assess impact of heterogeneities on CO<sub>2</sub> storage capacities; (BRGM, HWU, BGS, UNOTT, CIUDEN)

**Quantify** the reliability of storage capacities estimates; (HWU, BGS)

**Lower characterisation costs** through (i) the validation of methodology to optimise exploration program, and (ii) the development of front-end engineering study for low cost drilling. (CIUDEN, SOTACARBO)

**Sites** involved:



Hontomin, Spain;



GeoEnergy Test Bed, UK



Sulcis Fault Lab, Italy



**Key outcome:** Technical guidelines on storage capacities estimates and cost-effective site characterization

# WP3 Managing leakage risks for protection of environment and groundwater

**Advance and validate** surface and downhole monitoring technologies relevant to onshore storage, including for groundwater protection

**Improve understanding** on the impacts of leakage and of potential leakage pathways (geological faults and boreholes) to enable a more effective monitoring strategy

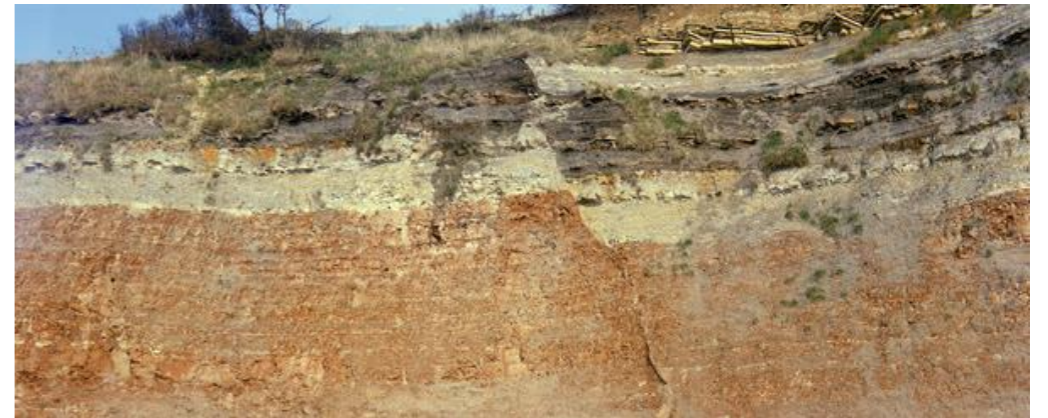
**Produce best-practice guidelines** for a monitoring programme that integrates the newly advanced ENOS technologies and techniques with state-of-the-art commercially available tools

**Real-life experience** from field laboratories and sites where CO<sub>2</sub> is naturally seeping to the surface utilised to realise these aims

**Sites** involved:

 GeoEnergy Test Bed, UK

 Sulcis Fault Lab, Italy






# WP4 Integration of CO<sub>2</sub> storage with local economic activities

Creating **incentives** for CCS and **new jobs** by integrating storage technology with other activities



Sites involved:

-  LBr-1: abandoned oil field to demonstrate integration with **Enhanced Oil Recovery**;
-  Q16-Maas: gas-condensate field to demonstrate **buffering** for utilisation and shipping.
-  K12 B: offshore gas field to **provide data** on the composition of the back produced CO<sub>2</sub>.

# WP5 Coordination with local communities

**Finding solutions together:** direct input of the population in making sense of the technology

**Systematic exploration** of technical challenges together with members of the public to identify the “good conditions” for onshore storage

**Listening to all points of view:** collaboration with citizens and stakeholders for producing socially sensitive best practices

**Public info tool:** a communication infrastructure for storage pilots



# WP6 Sharing experience worldwide and seeding storage projects in Europe

**Establish partnerships** and share experience and knowledge with groups and entities executing onshore CO<sub>2</sub> storage pilots, demonstration projects and leakage simulation tests **in Europe and worldwide**

Identify **success criteria** that can be applied to create a catalogue of potential situations where new storage sites might be successful

Pave the way for **pilot sites** in the ENOS project portfolio to **further develop** beyond the end of the project through planning of follow-up stages of their development and/or upscaling to a larger amount of stored CO<sub>2</sub>

Prepare a **Roadmap for upscaling** identified synergies of CO<sub>2</sub> storage with CO<sub>2</sub> utilisation

# WP7 Spreading innovation



\* Plan for Exploitation and Dissemination of Results

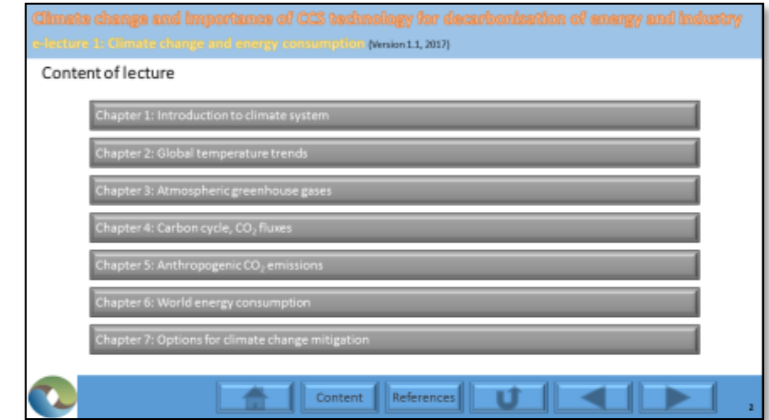
# WP8 Promoting CCS through education and training

**Educational**

CCS joint master programme  
E-learning  
“Spring Schools”  
Workshops



E-learning



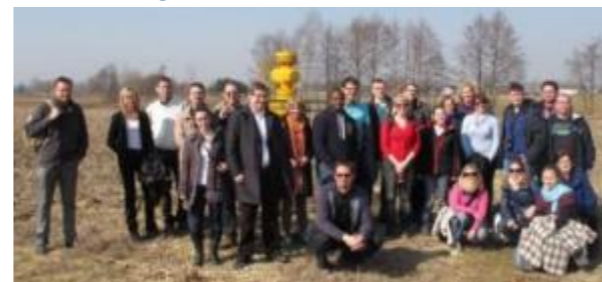
Near the pilot sites



Workshops for journalists and stakeholders



3 “Spring Schools”- intensive training courses for researchers



# ENOS

Test and pilot sites



# LBr-1, Czech Republic

**Depleted hydrocarbon field** in the Czech part of the Vienna Basin, produced mainly in the 1960s

Tertiary **sandstones** at ca. 1100 m depth

Planned **ENOS activities:**

Assessment of leakage risks through abandoned wells and faults, including possible shallow groundwater contamination

Scenarios for CO<sub>2</sub>-driven Enhanced Oil Recovery (**CO<sub>2</sub>-EOR**) and its integration with CO<sub>2</sub> storage

Study on regional CO<sub>2</sub>-EOR potential of the Vienna Basin



# The UK GeoEnergy Test Bed (GTB)

The **GTB** is a **research facility** initiated by the British Geological Survey and the University of Nottingham comprising an instrumented borehole array

The **GTB** site represents a £6M investment **to support new and emergent geo-energy sectors critical for a sustainable energy future** (including £2.5M UK government-funding through the ERA project)

## The **GTB** will

**Provide a national facility** for future researchers, technology developers and industrial operators

**Catalyse collaboration** with UK and overseas institutions

Enable development and testing of **innovative monitoring technologies**

**Improve understanding** of impacts and processes in the shallow subsurface

**Provide ground truthing** for advanced simulation software



For **ENOS**, the GTB will be used to **advance innovative monitoring technologies** and techniques for **detection of fluid migration** in the shallow subsurface **and leakage**

# Hontomín Technology Development Plant, Spain

Unique onshore injection site in the EU, **recognized by the European Parliament as a key test facility** (*E.P. Resolution 2014*)



**Deep saline aquifer** comprised of **fractured carbonates** with low porous matrix permeability

**Injection** well (HI) and **observation** well (HA) reaching the depth of 1600 m

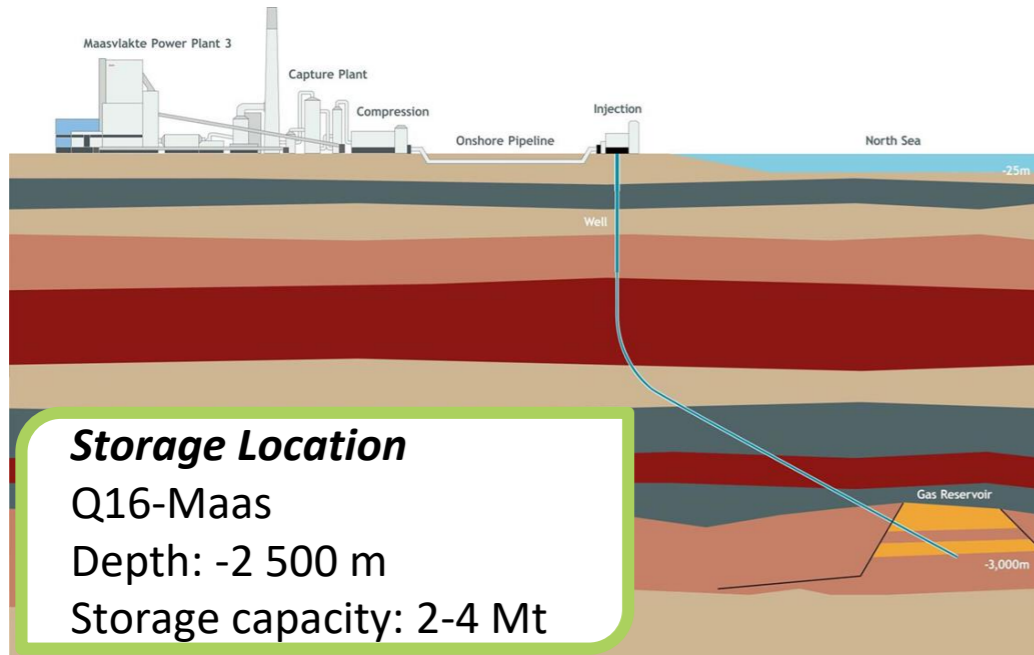
**Well monitoring** (P/T sensors, deep sampling, DTS, DAS, ERT and hydrophone array)

CO<sub>2</sub> **injection facility**      **Water conditioning** facility      **Hydrogeological monitoring** network

**Seismic monitoring** network      **Control** room



# Q16-Maas, the Netherlands



Support **CO<sub>2</sub> buffering concept**

Focus on **technical and economic feasibility**

Strict **CO<sub>2</sub> specifications for greenhouses** (high purity)

Injection/production in a **buffer** site case

**Economic** uncertainties

**Connect to ongoing stakeholder dialogues** and public perception

**Condensate-rich gas** field in Triassic sandstone reservoir

**Production** started in April 2014

**Enhanced recovery and storage:** 2019 - 2022 (studied in ROAD project)

Optional **seasonal buffering** from 2022 onwards (addressed in ENOS)



# Sulcis fault lab (SFL), Italy

SFL will study gas migration processes in faults to better understand outcomes in an unlikely case of CO<sub>2</sub> leakage.

SFL will test the sensitivity and effectiveness of monitoring tools and technologies designed and developed by ENOS partners.

Key focus is better understanding of the potential changes of groundwater quality after unlikely leakage event.

The aim is to study impacts and to develop a robust groundwater monitoring strategy.

SFL infrastructure is funded by national funds – Ricerca di Sistema.



## SFL Infrastructure

One observation well and one inclined injection well

9 groundwater monitoring wells

CO<sub>2</sub> storage system and gas injection control system

50 CO<sub>2</sub> monitoring probes

Baseline data available:

Seismic survey and baseline

Geochemical survey and baseline

2D/3D seismic reflection

Geochemical and geophysical monitoring

Soil gas monitoring

Stratigraphic reconstruction

Planned experiment

Small amount of CO<sub>2</sub> injected at 250m, near a fault reproducing unlikely CO<sub>2</sub> leakage.

Different monitoring tools: seismic and down-hole, to study the CO<sub>2</sub> migration, changes of the injection and rock / fault parameters.

Computer modelling to analyse and predict leakage behaviour.

For information please contact [enos@brgm.fr](mailto:enos@brgm.fr) or visit [www.enos-project.eu](http://www.enos-project.eu)



**E N O S**  
Enabling Onshore CO<sub>2</sub> Storage



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653718