

ENOS ENABLING ONSHORE CO₂ GEOLOGICAL STORAGE IN EUROPE

The Newsletter

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Research institutes across Europe join forces through a new scientific project

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A new project, named ENOS (ENabling Onshore CO₂ Storage in Europe), that unites research institutes from 17 countries, was launched in September 2016 (Figure 1). The main objectives of this European Horizon 2020 project are to increase field experience relevant to geological storage of CO₂, refine techniques and tools used for site selection and monitoring and to advance communication between science and society on the geological storage of CO₂. ENOS is an initiative of CO₂GeoNet, the European Network of Excellence on the geological storage of CO₂ (www.co2geonet.com).

The ENOS project is coordinated by BRGM (France) and unites 19 partners, one of which, CO₂GeoNet, comprises 10 of its members as third parties. The ENOS project is financed by the European Union's Horizon 2020 programme with a budget of 12.5 M€ as well as partners' own and national funds. The project will run until August 2020.

ENOS strives to advance the development of CO₂ storage onshore. Several field sites in various geological settings will be studied in detail and best practices that stakeholders can rely on will be produced. In this way, ENOS will help demonstrate that CO₂ storage is safe and environmentally sound in order to help increase the confidence of stakeholders and the public in CCS as a viable mitigation option.

The project will benefit from access to several onshore research sites (Figure 1). At the storage pilot of Hontomin in Spain, 10,000 tonnes of CO₂ will be injected into a limestone rock layer at a depth of 1,500 m. Key parameters will be studied in order to monitor the evolution of the geological reservoir and to demonstrate that the storage operations have no negative impact on the environment. Innovative injection strategies, designed to optimise storage whilst guaranteeing site safety in the short and long term, will also be tested.

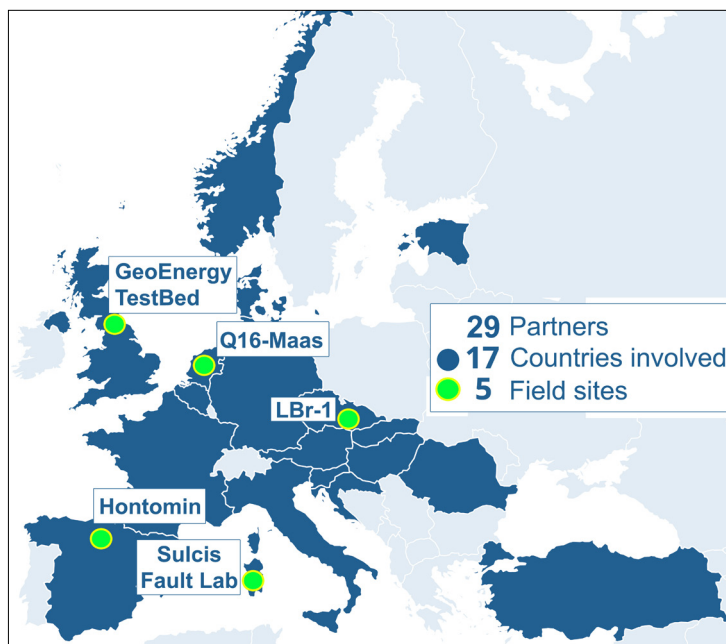


Figure 1. Map showing the countries and field sites involved in the ENOS project.

Tests at two other sites will allow project partners to improve techniques to detect CO₂ in the subsurface so that, in the unlikely case that CO₂ leakage was to occur, smaller amounts of CO₂ could be identified more quickly. Such in-situ experiments will also help provide ground truthing for leakage simulations in two different geological settings, one in a shallow aquifer and the other along a fault plane. The first site, an initiative of the University of Nottingham and the British Geological Survey, is a field laboratory near Nottingham, UK, called the 'GeoEnergy Testbed', and the second is the 'Sulcis Fault Lab', located in Sardinia, Italy. An additional two proposed pilot storage sites, LBr-1 in the Czech Republic and Q16-Maas in the Netherlands, complete the ENOS test site portfolio.



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HONTOMIN, SPAIN

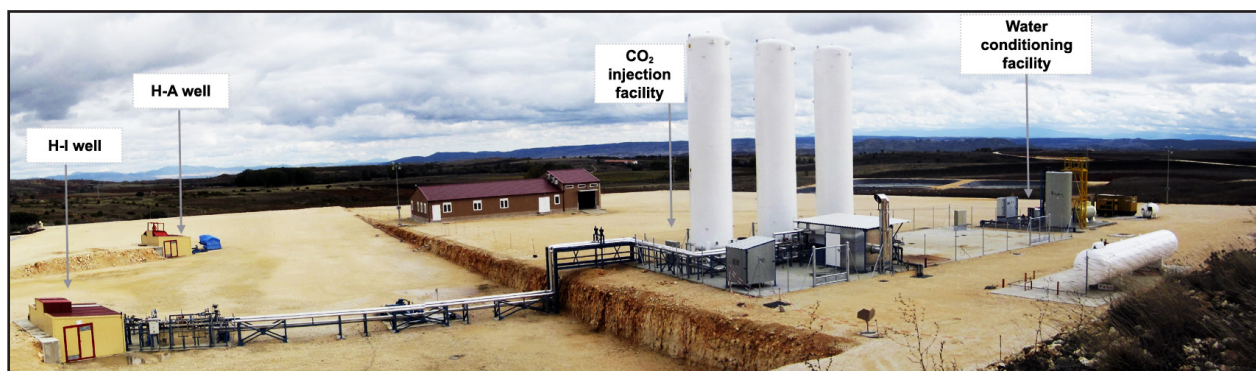


Figure 2. Hontomin Technology Development Plant.

The Hontomin Technology Development Plant (TDP) for CO₂ geological storage, located close to the city of Burgos (Spain), is currently the only active onshore injection site in the European Union. It is managed by Fundacion Ciudad de la Energia (CIUDEN) and it has been recognised by the European Parliament as a key test facility.

The principal reservoir/seal pair is formed by Lower Jurassic carbonate rocks (limestones and dolostones) sealed by marls and black shales. The rocks at around 1,500 m depth take the form of a structural dome, where the main seal is the Marly Lias and Pozazal Formations and the reservoir is the Sopena Formation. The reservoir has a high level of fracturing and it is compartmentalised into geological blocks, but this does not affect the seal integrity.

One injection well (HI) and one observation well (HA) form part of the TDP, with the facilities for CO₂ injection and water conditioning connected to HI (Figure 2). The vertical wells have been drilled to depths of up to 1,600 m on the flank of the domed reservoir, with a distance of 50 m between them at surface. Both wells have been equipped for deep monitoring (pressure/temperature sensors, reservoir water sampler, electrical resistivity tomography, distributed temperature system, distributed acoustic sensor and hydrophone array).

Thirty one passive seismic stations comprise a monitoring network covering an area of 18 km². Eight wells form part of the hydrogeological monitoring network, three of which have been specifically drilled for the project into the Utrillas Formation overlying the top seal, where freshwater aquifers are located (wells drilled to depths of 150 - 400 m). These wells are equipped with instrumentation to remotely check groundwater chemistry and level to confirm that CO₂ has not migrated out of the storage reservoir into shallow formations.

Different monitoring campaigns were conducted on and around the TDP in order to characterise the reservoir/seal pair (e.g. 2D-3D reflection seismic survey, vertical seismic

profile in the injection well, controlled source electromagnetic, microgravimetry, soil gas monitoring and hydrogeological studies).

The challenge at Hontomin was to manage the low injectivity of the reservoir. Laboratory and field tests were designed and performed to overcome this issue. Finally, a CO₂ injection strategy, utilising liquid phase CO₂ was implemented, and the operational efficiency and the effects of impurities in the CO₂ stream were analysed. The injection strategy (Figure 3) has been patented under Spanish regulations (Spanish Patent 201500151).

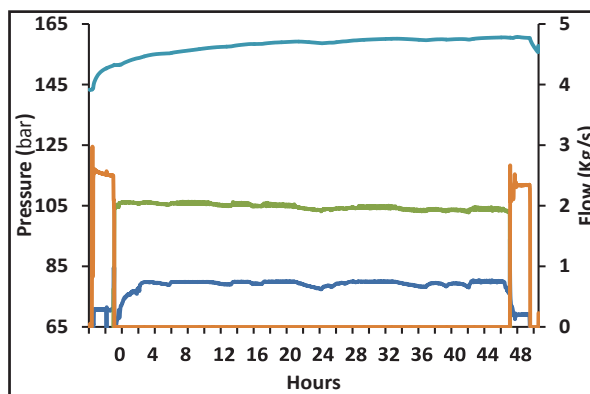


Figure 3. CO₂ injection in liquid phase. Operational monitoring: CO₂ Well Head Pressure (dark blue line), CO₂ flow (green line), Bottom Hole Pressure (light blue line) and brine flow (brown line).

Hontomin TDP is now ready for larger scale injection (10, 000 t) and will host field activities planned in ENOS work package 1 "Ensuring safe storage operations". Research will include injecting CO₂ at larger scale, updating the dynamic model, passive seismic monitoring, geochemical/geophysical monitoring and risk management.

Coordinator: CIUDEN	<p>Work package 1. Ensuring safe storage operations</p> <p>The following activities have been performed at Hontomin pilot site: 3D geological and dynamic modelling, first deep sampling campaign (reservoir water samples), sparker tests at 500 m depth and intelligent distributed acoustic sensor system logging, start of CO₂ injection campaign and installation of soil gas monitoring stations. The first injection campaign is currently ongoing. The second deep sampling campaign and the first 3D vertical seismic profiling campaign will be performed in the summer of 2017.</p>	Coordinator: BRGM
Coordinator: BGS	<p>Work package 3. Managing leakage risks for protection of the environment and groundwater</p> <p>The first tranche of research will focus on natural analogue sites: fieldwork to study sites where CO₂ is naturally seeping to the surface will take place in Italy during June. Data from these sites will be used to examine the surface expression of leakage through geological faults in order to support improvement of monitoring techniques. This fieldwork is being aligned with work carried out through ECCSEL project. Site characterisation is ongoing at the Sulcis field laboratory and GeoEnergy Test Bed which will support upcoming ENOS activities.</p>	Coordinator: TNO
Coordinator: UniRoma1	<p>Work package 5. Coordination with local communities</p> <p>Researchers have been busy preparing to work with local communities: a workshop took place in The Hague in February 2017 during which the methodologies of the four country teams were shared and harmonised. Illustrative material to explain the research that will be performed through ENOS is also being developed. In November 2016, a workshop in Rome united all researchers, to identify the topics to be communicated. We will meet again in May 2017 to define end-user friendly formulations for describing the research that will be carried out through ENOS.</p>	Coordinator: CGS
Coordinator: IRIS	<p>Work package 7. Spreading innovation</p> <p>Work package 7 got off to a flying start with delivery of the ENOS website and templates for presentations and deliverables. The Plan for Exploitation and Dissemination of Results (PEDR) was updated by all partners. The next task is establishment of the End-User Committee – a group of stakeholders from R&D sector, industry, NGOs and governments, to help us shape one of the ENOS key-deliverables: Best practices for onshore storage in Europe. Please contact rbe@iris.no for more information. Finally, you are now reading the first ENOS newsletter - one of the work package 7 dissemination activities!</p>	Coordinator: GEUS
	<p>Work package 2. Ensuring storage capacities and cost-effective site characterisation</p> <p>Using the lessons learned from the research sites of the ENOS project, work package 2 will develop methodologies for uncertainty management of numerical predictions of storage capacity in highly heterogeneous media (Hontomin), CO₂ plume migration in storage site overburden (GeoEnergy Test Bed) and smart characterization data compilation (Sulcis Lab). A cost effective drilling technique will be tested. Discussions held in Hontomin in March allowed definition of the modeling scenarios planned for 2017.</p>	
	<p>Work package 4. Integration of CO₂ storage with local economic activities</p> <p>Work package 4 is studying socio-economic benefits of using CO₂ streams to buffer supplies for greenhouses in the Netherlands and for enhancement of oil production (CO₂-EOR) in the Czech Republic. For the buffer site, screening of purification costs of re-produced CO₂ is being performed. Modelling to improve the history match of oil production will support later research on CO₂-EOR optimisation. Schemes for the economic models, to assess revenues from CO₂ utilisation, are under development for both case studies.</p>	
	<p>Work package 6. Sharing experience worldwide and seeding storage projects in Europe</p> <p>Since the start of ENOS, WP6 has focused on establishing international partnerships with CO₂ storage pilots and test sites outside Europe for the ENOS Storage site twinning programme, the Leakage simulation alliance and Experience sharing Focus groups. This has been successful and research partners from the USA, Australia, Canada, South Africa and South Korea will soon be engaged in ENOS exchange and liaison activities. ENOS partners also began the assessment of new storage pilot opportunities in Europe and future research priorities in the area of CO₂ storage.</p>	
	<p>Work package 8. Promoting CCS through education and training</p> <p>At the first E-learning workshop (March 2017) agreement was reached for the content of all 10 ENOS e-lectures, including final design and functionality of the PowerPoint template (text slides, tables, figures, reference style) developed by BGR.</p> <p>The first meeting (March 2017) of the educational programme group prepared input for the construction of a Professional Master course on CCS, to be developed by ENOS university partners. Practical sessions of the Master course will be organised at the ENOS field sites and supervised by ENOS research partners.</p>	
	<p>Work package 9. Project management</p> <p>The ENOS kick-off meeting was organised in Brussels on 17-19th October 2016 at the Royal Belgian Institute of Natural Sciences. The next project meeting will take place in autumn 2017 at one of the partner institutions.</p>	

Coordinator: BRGM



ENOS website

The ENOS website is accessible at web address www.enos-project.eu and provides general information about the ENOS consortium and test sites as well as general project information, latest news, ENOS publications and international meetings partners are planning to attend. Please subscribe to the project newsletter via our website and we will keep you updated with the latest ENOS news.



ENOS presentations

The ENOS management board have presented general information about the ENOS project at several flagship CCUS events:

- 13th Conference on Greenhouse Gas Control Technologies (GHGT-13), November 2016, Lausanne, Switzerland:

Gastine M., Berenblyum R., Czernichowski-Lauriol I., de Dios J.C., Audigane P., Hladik V., Poulsen N., Vercelli S., Vincent C., Wildenborg T. Enabling Onshore CO₂ Storage in Europe: Fostering international cooperation around pilot and test sites. Poster presentation.

Materials are available on the ENOS website in the highlights section www.enos-project.eu/highlights/

List of ENOS partners (*= Members of CO₂GeoNet)

Europe: CO ₂ GeoNet	Estonia: TTUGI*	Slovakia: SGUDS
Austria: GBA*	France: BRGM* (Coordinator), Flo-dim, Geogreen, IDIL	Slovenia: GEOINZ*
Belgium: GSB-RBINS*	Germany: BGR*	Spain: CIEMAT, CIUDEN*, IGME*
Croatia: UNIZG-RGNF*	Italy: NHAZCA, OGS*, Sapienza University of Rome*, Sotacarbo	The Netherlands: TNO*
Czech Republic: Czech Geological Survey*	Norway: IRIS*	Turkey: METU-PAL*
Denmark: GEUS*	Romania: GeoEcoMar*	UK: BGS*, Heriot Watt University*, Silixa, University of Nottingham

- CLIMIT Summit March 2017, Oslo, Norway:

Hladik V., Gastine M., Berenblyum R., Czernichowski-Lauriol I., de Dios J.C., Audigane P., Poulsen N., Vercelli S., Vincent C., Wildenborg T. Enabling Onshore CO₂ Storage in Europe: Fostering European and international cooperation around pilot and test sites. Poster presentation.

Development of the ENOS educational program was presented by the ENOS coordinator Marie Gastine and Task 8.3 leader Sabina Bigi at:

- 4th UNI-SET Energy Clustering Event. Universities in the Energy Transition: Focus on Sustainable Transport and Carbon Capture, Storage & Use, Imperial College London, UK, 27-28 March 2017:

Gastine M., Poulsen N., Bigi S., Saftic B., Shogenova A., Pickup G., Hall T. and Sinayuc C. The educational programme within the ENOS Project: the development of an international master course on CO₂ geological storage. Oral presentation.

Come and talk to us at upcoming events

- 12th CO₂GeoNet Open Forum (Driving CCS Towards Implementation) and ENOS workshops, 8-11 May, 2017, San-Servolo Island, Venice, Italy

- 11th IEAGHG Monitoring Network Meeting, 13–15 June, 2017, Traverse City, Michigan, USA. (*David Jones, presentation on shallow monitoring, work package 3*).

ENOS publications

Gastine M., Berenblyum R., Czernichowski-Lauriol I., de Dios J.C., Audigane P., Hladik V., Poulsen N., Vercelli S., Vincent C., Wildenborg T. 2017. Enabling Onshore CO₂ Storage in Europe: Fostering international cooperation around pilot and test sites. Proceedings of GHGT-13, Energy Procedia, in press.

ENOS partners

