

Project no.:
271495

Project acronym:
ECO-BASE

Project title:
**Establishing CO₂ enhanced oil recovery Business advantages
in South Eastern Europe**

Collaborative Project under the ERA-NET ACT programme

Start date of project: 2017-08-01
Duration: 3 years

Final report

Revision: 2

Project Consortia

Organisation	
NORCE	
TNO	
METU PAL	
GeoEcoMar	
CO2Club Romania	
PicOil Info Consult	

INTRODUCTION

The Paris Agreement calls for greenhouse gas emission regulations consistent with keeping the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the increase to 1.5 °C. Storing CO₂ is becoming an essential part of reaching this target, and commercial utilization of CO₂ is one of the mechanisms to create a business case for the storage process.

The objective of the ECO-BASE project was to support deployment of carbon capture utilisation and storage (CCUS) by screening data, developing CCUS roadmaps and exploring for potential CO₂ Enhanced Oil Recovery (CO₂-EOR) pilots in South-East Europe (SEE).

ECO-BASE has assessed the potential for CCUS through CO₂-EOR via a number of activities:

- Created an inventory of CO₂ sources (potential capture projects) and sinks (potential sites for CCUS through CO₂-EOR) in Romania and Turkey;
- Identified possible clusters and performed case studies evaluating potential of CO₂-EOR + Storages business cases;
- Set up regional CCUS development plans through CO₂-EOR roadmaps;
- Organized knowledge transfer workshops for local CCUS stakeholders.

ECO-BASE aimed to provide insight into prospective revenue streams and business models for CCUS through CO₂-EOR in SEE and thereby to support large-scale CCUS deployment in the region. The project was carried out by organisations in Turkey, Romania, the Netherlands and Norway.

Sub-project 1. Mapping potential.

Work under Sub-Project 1 comprised the following activities.

Inventory of source and sink capacities

The work started by investigating the pilots and feasibility studies that have already been performed in the SEE region. These projects as well as other national and regional studies in SEE region gave valuable information and data to be included in the database. Carbon capture and storage (CCS) has a high potential of reducing CO₂ emissions, but it is still a slow-moving technology. At present, the only industry scale CO₂ storage projects actually storing CO₂ in Europe are the Sleipner and Snøhvit projects in Norway. Nevertheless, new initiatives are being developed in Norway, in the UK and The Netherlands. Storage potential has been mapped at varying levels of detail in the North Sea and the potential for CO₂-EOR has been the subject of research for several decades.

TURKEY

In Turkey CO₂-EOR is a well-known process applied by the state petroleum company since 1986, the sole aim has been the increase of oil recovery. CCS is not taken into consideration in any national policy document. Therefore, there is also no law regulating CCS.

ROMANIA

Romania has the potential to become CO₂ negative. This is the conclusion of a report, "Our future is carbon negative – A CCS Roadmap for Romania", published by Bellona Foundation¹. The report models the Romanian electricity system until 2050 by considering current energy plans, with CCS added. Apparently, the large availability of sustainable biomass in Romania gives the country the unique potential for CO₂ negative electricity.

GREECE

Studies have pointed to opportunities for CCUS, in the form of CO₂-EOR, but so far, no initiatives have been undertaken to develop these to real projects. CCS currently has no clear role in government plans for energy system reform or emission reduction. CO₂-EOR seems relevant for all three countries. It is being deployed in Turkey, using CO₂ from a natural source, but only with the goal of EOR. The process has been studied in Greece but is not currently deployed. Data on the subsurface may not be readily available. There is potential in supporting the inclusion of CCS in national policies.

Environmental impact assessment

The anticipated effects of the CO₂-EOR on the environment have been assessed. The work has been reported in deliverable D1.7. The results have been split up in two parts:

1. Guidance based on a literature review on environmental impact assessment for CO₂-EOR including mitigation actions when CO₂-leakage would occur;
2. A practical description of the possible environmental impacts of the CO₂-EOR part of the regional CCUS cluster case based on this guidance.

DATABASE DEVELOPMENT

Based on knowledge gained in a review of other projects a database was setup. The database was to be used later in the project.

Database framework

ECO-BASE adopted the database structure as used in and developed by the CO₂STOP project, which aimed to produce an up-to-date and publicly available database of CO₂ storage options in the EU.

Inventory of available data.

Within ECO-BASE additional data on sources and sinks was gathered, technical risks were assessed, environmental aspects and regulatory and legal aspects were analysed.

¹ A. D. Erena, G.-R. Filip, E. Fjøsna, J. Helseth, E. Hoff, C. Perez-Garcia, F.-P. Filip, D. Taylor, G. Tjetland, C. Sava and K. Whiriskey, "Our future is carbon negative: A CCS roadmap for Romania," The Bellona Foundation, Oslo, Norway, 2012.

Mapping of sources and sinks.

GIS-based maps were created based on the gathered data. This was done in such a way that it is easily visible where sources and sinks are located, what amounts of CO₂ were involved, timing of sources and sinks was included and the reliability/uncertainty level of the data was accessed

CO₂-EOR roadmaps

Objectives were to identify and match industrial clusters and CO₂ sources, like from industrial, energy production or even natural sources. To create inventories of legislation and incentives and identify potential legal and technological bottle necks. To identify storage and EOR potentials and to create roadmaps for the development of CCUS in specific clusters. The activity was transferred to SP2 in order to provide more detailed and concrete plans for clusters selected.

Source and sink clustering and matching.

Using the maps developed in the earlier stages of the project, source and sink clustering was performed. The matching was based on capacities as well as timing of availability, but also, the uncertainty and reliability of the data was taken into account.

Roadmap framework development.

In order for CO₂-EOR to move beyond research, business cases are required which consider other aspects than the source and sink capacities. Roadmaps will support the development of business cases by taking into account aspects other than the technical ones. In ECO-BASE we developed a framework which can be used to create cluster-specific roadmaps in an organised way. The framework covers aspects concerning infrastructure, economics, environment, regulations, risks, politics, public awareness and perception and the development of storage capacity. Any resulting roadmaps should in general be regionally oriented and dedicated to explore CO₂-EOR business cases and their purpose is to clarify and illustrate which steps need to be taken to realise those business cases.

Decision tree for ranking CO₂-EOR potential

For CO₂-EOR to happen, all actors in the value chain from must commit to the project, that is from the emitter capturing CO₂, transport operator that operate pipeline/ship/trucks facilities, and to the reservoir operator where CO₂ is utilized and stored. All actors need to have acceptable and positive business cases before a commitment is made. The business cases are typically based on defining key performance indicators, and then quantitative estimate for how the activity led to positive future cash flows (FCF) and discounting rate for net present value (NPV). The basic premise of a rational decision process is that the internal rate of return needs to exceed the weighted cost of credit, plus a safety margin. Within SP1 we illustrated the creation of the decision tree from the field operator's perspective. Decision trees represent a structured way of providing insights into the process and parameter uncertainty that affects the outcome of a series of decisions. The trees are used for decision support, where the structured way of displaying conditional probabilities are shown in an instructive way.

After the framing process the decision tree analyses was performed. Many possible scenarios and main uncertainties emerge because of the alternative decisions that can be made during the development of a CO₂-EOR project.

Selecting clusters for further studies.

The Bradestiy structure in Oltenia West, Romania was selected together with Işalnița powerplant. The cluster is located in the region producing over 30% of nation energy and responsible for significant share of national emissions. The business case of capturing CO₂ at the powerplant, transporting by a pipeline to the Bradesti field where it would be used for CO₂EOR and later storage. The business case would be evaluated from the perspective of the field site operator.

The ‘Turkish case’ consisted of analysing if one can prolong the on-going CO₂EOR operation in Bati Raman oil field by paying the costs of using anthropogenic CO₂ rather than CO₂ from the depleting natural gas deposit in Dodan. Dodan is connected to Bati Raman field with 82 km long pipeline. Bati Raman is a well-documented case, it is the largest oil-deposit in Turkey and the oil production has been going through phases of pressure decline, water injection, and, since 1986, combination of in-fill drilling and continuous CO₂ injection. In our study two CO₂ sources were considered for the case: the oil refinery in Batman and cement factory in Kurtalan both located in close vicinity of existing CO₂ transport infrastructure.

The findings of this SP laid the basis for confirming that initial idea of CCUS through CO₂-EOR being economically viable. SP2 has taken this forward by conducting more detailed evaluations of Bradesti, Romania and Bati Raman, Turkey using the ECCO tool provided by TNO.

The SP2 activities will aim towards bringing the two clusters closer to positive DN1 decision by providing first CCUS through CO₂-EOR evaluations for the future stakeholders.

Deviations from proposed work plan

During the project meeting in 2018 the ECO-BASE team discussed and later proposed to ACT consortium to move the roadmapping exercise to the SP2 in order to make the roadmaps more specific for selected clusters. The suggestion was accepted by ACT consortia.

Sub-project 2. Optimisation of EORStore: creating a business case

The objective of Sub-Project 2 (SP2, “Optimising EORStore”) of the ECO-BASE project was to initiate discussions between key local stakeholders and provide concepts and initial techno-economic analysis (TEA) for the first CCUS (carbon capture utilisation and storage) projects in Turkey and Romania. Unlike the USA, where an extensive infrastructure related to CO₂-EOR (enhancing oil recovery by injecting CO₂ into oil reservoirs) has been built up over several decades², CCUS facilities in Europe³ are largely local in scale. ECO-BASE has worked on two “first of a kind” (FOAK) case studies selected in SP1 to investigate the business potential for CO₂-EOR projects with associated permanent CO₂ storage (EORstore). The main goal of this SP is to achieve a first steppingstone towards answering the question at the first decision gate: Is there a business case?

SP2 looked first at the modelling approach to fit the data and knowledge available. An important aspect of the EORStore case studies is the ability to evaluate efficacy and costs / profits along the

² R. J. Edwards and M. A. Celia, “Infrastructure to enable deployment of carbon capture,utilization, and storage in the United States,” *PNAS*, vol. 115, no. 38, p. E8815–E8824, 2018.

³ “The potential for CCS and CCU in Europ,” 32nd meeting of the European gas regulatory forum, 5-6. JUNE 2019. Coordinated by IOGP, https://ec.europa.eu/info/sites/info/files/iogp_-_report_-_ccs_ccu.pdf, 2019

whole value chain. During the early stages of the evaluation process verified data may be scarce and estimates are commonly based on simplified modelling approaches or on comparisons with analogue cases. To build the complete picture of the EORStore business case the project relied on the ECCO tool⁴ developed during ECCO project⁵ and made available to project partners by TNO. For both Romanian and Turkish case an oil-field operator decision process was simulated. I.e. the costs of CO₂ at the wellhead was calculated and EOR potential was estimated based on it. In order to estimate the EOR performance analogue data and correlations^{6 7}[XXX] were combined with mechanistic reservoir simulation modelling. Resulting EOR type curves were used in estimation of EOR efficiency by ECCO tool. Total field storage capacity was estimated using combination of material balance and mechanistic reservoir models. Finally, uncertainty analysis was carried out using Crystall Ball to assess the impact of physical (permeability, STOIP, type curves) and financial uncertainties (CAPEX, OPEX, revenues) on NPV/IRR. A set of global parameters from “Blue hydrogen as accelerator and pioneer for energy transition in the industry” openly available report from July 2019 through the H-vision programme⁸ was used.

Having decided on modelling approach a decision trees for potential business models were set up for Romanian (Figure 1) and Turkish (Figure 2) clusters in order to guide the modelling process.

⁴ Petter E. Røkke, Jana P. Jakobsen, Grethe Tangen, Mona J. MølInvik, “ECCO – European value chain for CO₂,” *Energy Procedia*, p. 3893–3899, 2009.

⁵ Løvseth, S.G., Wahl, P.E., Bos, C., Coussy, P., Eickhoff C., “D3.1.4 Documentation for the new version of the ECCOtool V2,” 2011.

⁶ N. A. Azzolina, D. V. Nakles, C. D. Gorecki, W. D. Peck, S. C. Ayash, L. S. Melzer and S. Chatterjee, “CO₂ storage associated with CO₂ enhanced oil recovery,” *International Journal of Greenhouse Gas Control*, vol. 37, pp. 384 - 397, 2015.

⁷ M. K. Verma, “Three Approaches for Estimating Recovery Factors in Carbon Dioxide Enhanced Oil Recovery: U.S. Geological Survey Scientific Investigations Report 2017–5062,” 2017. [Online]. Available: <https://pubs.usgs.gov/of/2015/1071/pdf/ofr2015-1071.pdf>.

⁸ www.h-vision.nl, www.deltalings.nl/h-vision

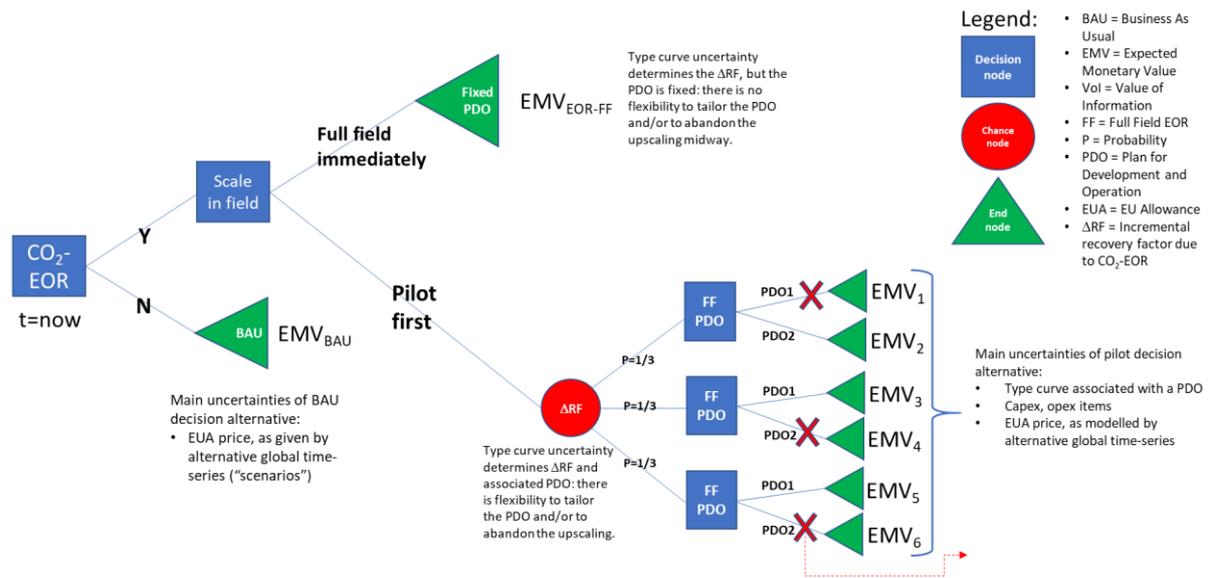


Figure 1. Decision tree for Romanian case with several scenarios defined: Business as usual, direct full field implementation of EORStore and application of EORStore after pilot test.

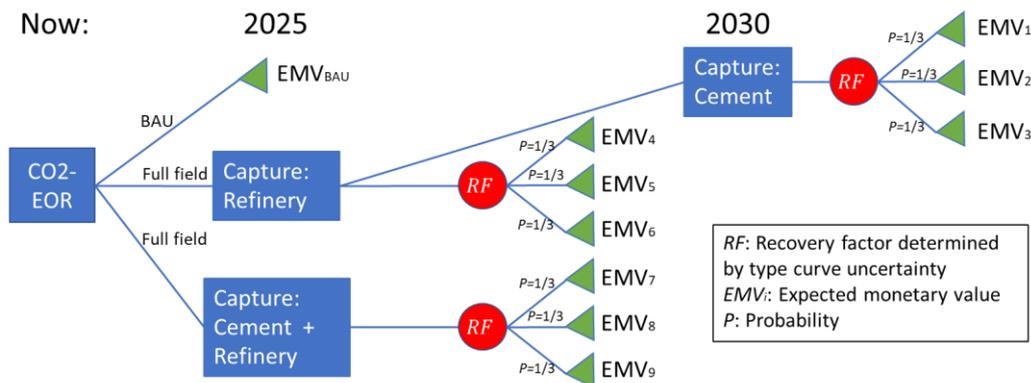


Figure 2. Decision tree for Turkish case with business as usual and two capture scenarios: from cement and refinery starting at 2025 and from refinery in 2025 and cement later on in 2030.

The work then proceeded to identify key goals and constraints for main actors in Turkish and Romanian ECO-BASE clusters. Main opportunities were found to be linked to emission reductions and business advantages by selling CO₂ for additional oil recovery as well as supporting local economy and allowing for just transition to green energy. At the same time, a number of regulatory, contractual, risk and market constrain have been identified and summarized.

SP2 looked into the expected progress towards the first decision gate “Approval of project initiation (idea2project)” after ECO-BASE project completion and concluded that while a good progress towards DGR #1 was made, direct involvement of the industrial actors is needed to fulfil all DGR#1 criteria.

We have identified FOAK project issues and looked on several examples from Norway, the Netherlands, USA and Canada of how these issues may be resolved. De-risking the EORStore opportunities and required stakeholder interactions were discussed. It was concluded that technology readiness, cost and cost reduction, financing and legal / regulatory aspects are key in de-

risking the FOAK projects, while long-term planning, governance, proper contractual setting and good financial frameworks together with government support of FOAK projects are key in ensuring stable and long-term stakeholder interactions.

The work proceeded to compute the decision paths and carry out the uncertainty analysis. When choosing for how to continue with CO₂ for EOR in the Bati Raman field, there are four decision paths that were simulated, namely business as usual (i.e. deplete Dodan), buy CO₂ from the refinery in Bati Raman from 2025 with an option to procure CO₂ from the Kurtalan cement factory in 2030, or from both CO₂ sources already from 2025. For the base oil price scenario, the outcomes are almost the same, while when the oil price follows the high trend, the refinery capture from 2025 and simultaneous capture from the refinery and cement factory from 2025 are most profitable with the lowest financial risk. Overview of the KPIs for Turkish cases is presented in Table 1 with NPV and other parameters reported for the last year of production with 10% discount rate. The total storage capacity at the field was estimated to be up to 16 Mtons CO₂.

Table 1. Overview of the key performance indicators for Turkish cluster.

	BAU	Refinery 2025	Refinery 2025, cement 2030	Refinery and cement 2025
Last year of production	2026	2037	2040	2036
NPV, M€	116.6	197.7	287.0	410.4
Tot oil sales, M€	322.8	663.8	930.3	1165.7
Tot Gov take, M€	-74.1	-132.6	-189.0	-249.4
Avg oil prod cost, €/bbl	23.6	31.2	29.4	26.5
Tot. Cost of CO ₂ , M€	-6.0	-57.5	-112.8	-151.1
Tot. Stored CO ₂ , Mt	0.6	2.1	5.5	5.38
Oil produced by CO ₂ , Mbbl	6.83	20.32	37.09	36.87
Total additional recovery	0.37 %	1.10 %	2.00 %	1.99 %

Looking on the oil field operator perspective in Romania three options were identified: to continue with business as usual (continue water injection), to deploy CO₂-EOR full field from start, assuming all risks deriving from this decision (mainly the uncertainties related to performance and behaviour of the reservoir) or to start with a 5-year pilot prior to full field deployment. Our simulations showed that deploying CO₂-EOR is more profitable than doing business as usual. But the NPV is very much dependent on the oil price and on the characteristics of the reservoir, since these are major uncertainties. Reservoir characteristics are uncertain because public data was used in the project. KPIs for Romanian case are reported for the last year of production with 10% discount rate in Table 2.

Table 2. Overview of end results from the reference case simulations from section 2.2.3-6, for BAU, pilot, full field EOR after pilot and full field EOR from start, respectively. These point estimates represent key performance indicators for the cases modeled with ECCO tool.

	BAU	EOR full field from 2025	EOR full field after pilot 2030			Pilot 2025-2029 (10% of the field)		
	Water inj.	Med TC	Low TC*	Med TC	High TC	Med TC	Low TC	High TC

Last year of production	2044	2041	2042	2046	2051	2029	2029	2029
NPV, M€	67.8	269.0	-41.6	207.3	365.7	-3.9	-23.4	0.4
Tot oil&gas sales (discounted), M€	258.3	846.8	411.5	714.1	941.3	51.3	29.1	56.2
Tot Gov take (discounted), M€	-44.0	-173.2	-81.3	-164.2	-213.0	-7.9	-3.5	-9.1
Avg oil prod cost of proj. period, €/bbl	-29.7	-34.4	-78.3	-33.0	-28.0	-44.6	-65.3	-36.4
Tot cost of CO2 (bought + recycled), M€	n.a.	-372.4	-286.9	-361.5	-474.9	-25.6	-28.5	-24.5
Tot CO2 bought from Isalnita, Mt	n.a.	-113.7	-87.4	-138.5	-181.7	-22.0	-22.0	-22.0
Oil produced by CO2, M bbl	n.a.	36.3	16.5	34.6	53.2	1.38	0.77	1.55
Additional recovery by CO2, %	n.a.	12.37 %	5.82 %	12.24 %	18.81 %	9.5 %	5.3 %	10.7 %
Tot recovery, %	34 %	44.13 %	39.5 %	47.3 %	54.2 %	40.5 %	35.8 %	41.5 %

* TC stands for type curve

The lowest risk corresponds to BAU case, however, BAU also means low expected monetary value (low risk, low reward). Though it may appear that implementing CO₂-EOR as soon as possible is profitable, this comes with a greater risk. Starting with a pilot is essential to reduce the uncertainties and the risks related to reservoir behaviour.

Based on the work carried out in SP1 and SP2 roadmaps for both cases were developed. The principle difference between Romanian and Turkish clusters lies in:

- Lack of technological experience along CCUS value chain in Romania in contrast to ongoing CO₂EOR in Turkey
- Availability of EOR and storage regulations in Romania in contrast to lack of appropriate legal framework to effectively regulate storage of CO₂ in Turkey.

This difference effectively defines some critical issues for the execution of plans laid out in countries roadmaps. In Romania, the critical aspect is engaging the stakeholders to prepare the scalabel EOR pilot with anthropogenic CO₂. In Turkey, it is engaging stakeholders and establishing the dialog with the state to legally enable CO₂ storage. Without this cluster will be reduced to conventional EOR case with anthropogenic CO₂ entering EOR market but without added value of permanent CO₂ storage.

Due to the COVID crisis the stakeholder dialog was delayed till Autumn 2020 and carried out in a series of online meeting and local consultations. Finally, ECO-BASE consortium got a confirmed interest from several industry partners in Romania (Dacian Petroleum and Heidelberg Cement) and Turkey (TUPRAS). A dialogue with Turkish Petroleum corporation, OMV Petrom, and Işalnița power station was still ongoing at the moment of writing this report.

Partners from Greece who were not able to actively participate in ECO-BASE due to lack of funding has joint the ACT III discussion together with CERTH. The plan was to streamline developments in Greece and bring it up to speed using ECO-BASE developments.

Preliminary conversation was also held with Danish Technical University. DTU showed interest to contribute with fluid flow and capture research experience.

An ACT III proposal structure and outline were prepared and discussed. After several meetings of the extended consortia it was decided not to pursue ACT III opportunity mainly due to the two main factors:

1. Financing structure (limited budgets are available in Turkey and Romania where the main work would have to be done) and focus of countries involved in potential proposal.
2. More maturation is needed in aligning ideas with industrial stakeholders.

EU green fund and horizon Europe possibilities are currently being studied by the consortia.

Deviations from proposed work plan

During the ECO-BASE project meeting in 2019 the team together with ACT representatives discussed need to restructure SP2 deliverables to better reflect project developments and data availability. The focus of the SP2 shifted from being deeply focused on the subsurface aspects to evaluating techno-economic performance of the whole value chain on the field's operator business case perspective. The new deliverable plan also was subject to delays mainly due to challenges posed by Corona crisis.

Sub-project 3. Knowledge transfer

The sub-project is aiming at knowledge sharing between North-West Europe (NWE) and South-East Europe (SEE).

Meetings organised by ECO-BASE

The Kick-off meeting was held on 11 October 2017 in Athens. Several topics including the status of the data for the first report, database framework, CO₂-EOR workshop in the upcoming Sardinia summer school, and templates, logos, website, publication rules were discussed. The next internal project meeting was held in Utrecht, the Netherland in 2018. The results of the Sub-project 1 has been shared and the potential clusters for Turkey and Romania were presented during the meeting. The roadmap framework was discussed as well, so that the future work has been planned. The meeting was beneficial for programming the work for other subprojects. It was also decided to establish a video meeting every second Tuesday of each month in order to track all project activities. Besides, a weekly Friday status update meeting was held throughout 2019 to coordinate SP2 studies. On 20 June and 19 September 2019, two meeting were held in Bucharest, Romania. The first meeting was about the Romanian case study and the search for a methodology we need to overcome the data scarcity. The next meeting was the annual project meeting and current project status was shared. A new structure for the SP2 deliverables has been constructed during the meeting. The progress on the SP3 and SP4 are also discussed. In order to accelerate the SP2 studies, a two days long meeting was held in Utrecht, the Netherland on 19 and 20 November 2019. The workshop was very helpful on speeding up the simulation cases and aligning the activities in Turkey and Romania. Although the final internal meeting had to be done as an online meeting on 26 November 2020 because of the Covid-19 conditions, it allowed more participation of scientists from each partner. The results of the project have been shared. Project finalization activities were planned.

Dissemination and outreach

The website has been created after the selection of the logo and the colours in the Kick-off meeting (<https://ECO-BASE-project.eu/>). The website presents the project, the consortium, highlights and newsletters. The Highlights section presented the important events throughout the project. The registrations for the upcoming events were taken and the survey links are also published using the website.

The Newsletters' were prepared to present the latest results and developments of the ECO-BASE project to the broader audience. The first Newsletter presented the ECO-BASE project and the ERA-NET ACT Scheme. The Sulcis Summer School and Dr Sava's interview were included as well. The second Newsletter gave information about the SP-1 cases for both Romania and Turkey. The established framework for Regional EORStore Roadmaps was the second main topic in that newsletter. There were announcements for the upcoming CCUS related events as well. The third Newsletter shared the workshop activities of the ECO-BASE team during the Sulcis Summer School. The Methodology to optimize for CO₂-EOR combined with permanent storage was also presented. The third newsletter included an announcement for the ECO-BASE Seminar on Legal and Regulatory Framework of CO₂ Utilization and Geological Storage. The fourth newsletter showed the results of that seminar and some announcements about the upcoming events. The fifth and last Newsletter published the results of the ECO-BASE project.

Several key dissemination events were held already during the first project year. Dr Constantin-Stefan Sava (GeoEcoMar) has been interviewed by the Energy Industry Review Magazine. The ECO-BASE project has been presented during the Business opportunities for CCUS in the Baltics (BASRECCS) conference by Roman Berenblyum (NORCE). An extended abstract was submitted and presented as a poster during 14th International Conference on Greenhouse Gas Control Technologies conference. Filip Neele (TNO) presented a paper during the International Energy Agency (IEA) and the King Abdullah Petroleum Studies and Research Center (KAPSARC) workshop on January 2018. Dr Constantin Sava (GeoEcoMar) presented the ECO-BASE project during the 2018 South Eastern Europe Upstream annual conference and exhibition. The dissemination actions for the year 2019 included the open Seminar on Legal and Regulatory Framework of CO₂ Utilization and Geological Storage which was held in Romania on September. The project poster presented at CO₂GeoNet Open Forum on May 2019. ECO-BASE project was presented to Turkish stakeholders by Dr Caglar Sinayuc (METU-PAL) during the events held due to the "Technical Assistance for Developed Analytical Basis for Formulating Strategies and Actions toward Low Carbon Development" project activities. ECO-BASE team was involved with the workshop in Sotacarbo summer school and presented ECO-BASE project status and findings. ECO-BASE project was represented by Christian Bos (TNO) during the EU CCS Storage Research Projects Science-Policy Showcase in Brussels. Dr Alexandra Dudu (GeoEcoMar) presented the ECO-BASE project at the World Petroleum Congress in Bucharest. ECO-BASE was represented by Roman Berenblyum (NORCE) both in the ACT knowledge sharing workshop in Athens and the Zero Emission Platform Advisory Council Meeting in Brussels in 2019. In 2020 very few dissemination events were carried out due to COVID-19 crisis. The key being CO₂-EOR online summer school by METU and project presentation during Bergen winter seminar. The 15th of the Green House Gas Control Conference was decided to be held as a full virtual event and ECO-BASE project outcomes will be presented in March 2021.

Courses

During the Sixth Annual International Sulcis CCUS Summer School (2018), ECO-BASE team has given several lectures to the students about the CO₂-EOR in combination with storage (Roman Berenblyum, NORCE), CO₂-EOR in Turkey (Caglar Sinayuc, METU-PAL) and Romania (Constantin Sava, GeoEcoMar). Then, the students were given a map of Romania and asked for matching emitters and potential sinks by considering the available conditions. Outcomes of the clustering exercise and key factors considered were presented and discussed by the groups.

The Seventh Sulcis Summer School was focused on the CCUS and Low Carbon Technologies in 2019. Around 20 PhD students attended the school. Roman Berenblyum (NORCE), Alexandra Dudu (GeoEcoMar), Caglar Sinayuc (METU-PAL) and Christian Bos (TNO) gave lectures about CO₂-EOR and status of the ECO-BASE project. The students were divided into groups and asked to represent different stakeholders (public, emissions, transport and storage operators) in early dialog on establishing regional business cases.

For the 2020, two courses were planned: the CO₂-EOR Summer School in Turkey and Sulcis Summer School in Italy. Due to the Covid-19, the Sulcis Summer School was cancelled. The CO₂-EOR Summer School on the other hand, was held as an online workshop in September 2020. The students were asked to register via the ECO-BASE website. A total of 121 people mostly students from METU Ankara and North Cyprus Campuses registered the event. The summer school topics included the Enhanced Oil Recovery (Dr Doruk Alp, METU), CO₂-EOR Project in Bati Raman (Turgay Inceisci, Turkish Petroleum), CO₂ Capture and Utilization Technologies (Dr Selcen Basar, Turkish Refineries), CO₂ Pricing and Carbon Policy (Dr Volkan Orhan Tekin, Turkish Refineries) and What is CCUS? Creating a Business Case (Roman Berenblyum, NORCE).

Sub-project 4. Public awareness and acceptance

Public acceptance analysis

In a well-functioning society, decisions are made to solve problems and in order to do so a common understanding is required. SP4 looked at the questions of like: When shaping the public opinion, what role do the editorial and social media play in shaping public perception and opinion? What are the new ways of our time and do trust and mistrust affect democratic developments and the capability to solve common problems? How can we measure developments over time, and how can we evaluate how e.g. ECO-BASE can contribute to media – and thereby public opinion?

Public awareness study

In the spring – summer of 2020 a questionnaire dedicated to the public opinion in Romania and Turkey was launched on the project website. The aim of the research was to understand the level of knowledge and information of the general public about the devastating aspects generated by climate change and the importance of implementing CCUS technology. With 98 people answered, majority were at least informed on the climate change issues, see Figure 3.

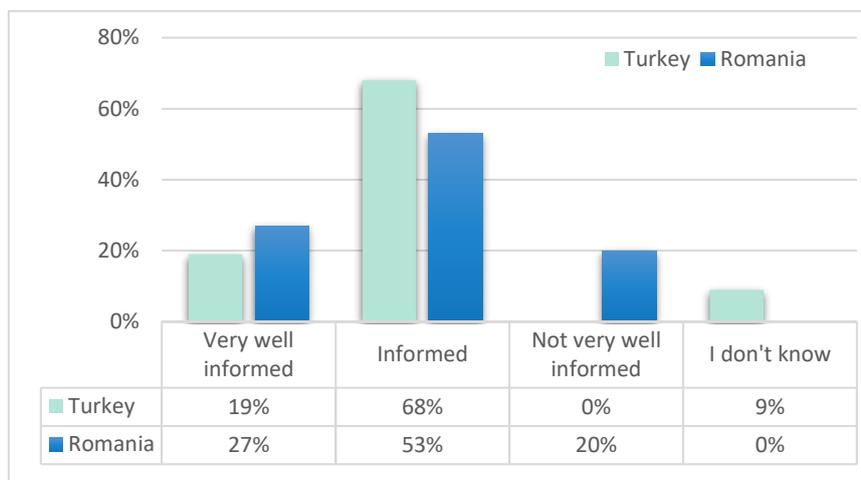


Figure 3. Responses to “How well are you informed about the various cases of climate change?”

Reduction of CO₂ emissions were mentioned as the priority by majority in Romania (80% of answers) and about a half of responders in Turkey (48% of answers). 38% of people know what CCUS is, and an additional 22% have at least heard about it. As an outcome of the study we see the need for additional education campaign as a part of further cluster developments, however we do not expect significant resistance to establishing the clusters as they are in the areas generally familiar with industrial operations. In Turkey the cluster would be built on top of existing CO₂ infrastructure and operations.

Liasing with other projects

The projects representatives have been participating at the joint telcons with social scientist from ENOS, ALIGN CCUS, ACORN, ELEGANGY, STRATEGY CCUS and PERCEPTION projects. Each project periodically presented results and challenges within the project; there were exchanges of ideas; questions and answer sessions. The initiative taken by ALIGN project to coordinate such meetings proved to be very useful for everyone involved. Social science research is vital in reducing nontechnical risk for CCUS implementation, e.g. by providing insights in narratives, arguments and visuals used in the media, relevant stakeholders and their perceptions, and determinants of public opinion – this will help in making site selection decisions and developing effective public engagement strategies.

Deviations from proposed work plan

After several project meetings ECO-BASE consortia identified need for modification of WP4 deliverables. The changes were presented and discussed with ACT consortia. The idea to merge outstanding WP4 deliverables into one was accepted. The proposed new deliverable will finalize SP4 activities. It will present the workflow for public involvement (earlier D4.1) coordinated with roadmaps in D2.3. The workflow will be built on questionnaire and local awareness analysis (earlier D4.8), outcomes of coordination with other ACT project and stakeholders meetings in March / April (earlier D4.5).

3. Project impact

The ECO-BASE project addressed the ACT calls thematic area of ‘Utilisation’. The ECO-BASE consortium represented a wide range of participants covering research, private and NGO sectors.

The project contributed to CCS knowledge transfer across Europe from Norway and Nederland to Turkey and Romania. At the same time the practical experience with ongoing CO₂-EOR projects in these countries and a real potential to expand utilisation of the CO₂ and combine it with permanent storage could become a turning point for EORStore to pave its way into the rest of Europe including offshore applications in Northern Europe.

ECO-BASE has taken into account the larger picture of CCUS through CO₂-EOR, not only by mining data, pairing emitters and sinks, but also by investigating field clusters and setting up a framework for roadmaps and a sophisticated and traceable way to rank CO₂-EOR potential.

A contact with potential stakeholders was established and an interest from oil and gas, energy, refinery and cement producing company was registered. The first draft of the next project application was made by the ECO-BASE team together with stakeholders and additional research partners from Greece and Denmark. The team is currently looking at financing possibilities in EU Innovation Fund or Horizon Europe.

4. Collaboration and coordination within the Consortium

Regular online meetings of the whole consortium to coordinate progress of the project were set up. The SP and WP teams had more regular meeting (for example weekly meetings of SP2 teams during the main activity period). In general, the scheme is quite effective.

The ECO-BASE project has profited through the transnational cooperation of its participants. The key cooperative added values have been:

- Exchanging the local knowledge and experience across project partners has created regional momentum and lowered the hurdle for implementation of CCUS through CO₂-EOR as a revenue stream for safe and reliable storage.
- Educating scientists and engineers via summer school and courses has broadened everyone's minds and has shown global perspective for CCUS.
- Feedback and support from ACT Consortium
- Positive experience of face to face meetings and knowledge and experience sharing

Project reporting system and requirements set up by ACT consortia allowed for low level of bureaucracy and maximisation of project resources dedicated to actual project work. Decentralized national budget reduce the reporting and money transfer load on the project coordinator, however it removes the management mechanism to redistribute budgets in case of underperforming or faulted partner.

5. Dissemination activities

During the project duration team members participated in a number of scientific and project events promoting the project in particular and CCUS in general.

4 newsletters were published and distributed to the public. The last 5th newsletter is being released at the same time with this report. The project website was established and updated with the events that took place during the project. In addition, the project partners had the responsibility to promote the project on their own websites and to dedicate space for its description in detail.

On 30 January 2018, AT Paris, France - Frank Wilschut and Phillip Neele presented the project during the IEA – KASPSARC Expert workshop CO₂-EOR

In April 2018 at SEE 2018 Upstream Annual Conference & Exhibition Offshore and Onshore Technology in the Black Sea Region, Dr. Constantin Sava presented ECO-BASE mentioning the most important aspects of the project.

In May 2018, in a comprehensive magazine called Energy Industry Review. ECO-BASE was extensively presented by Dr. Constantin Sava, Senior Geoscientist at GeoEcoMar, in an interview called *Carbon Capture and Storage - Impact, benefits and challenges*. The interview can be read at the following link: <https://energyindustryreview.com/interview/dr-constantin-stefan-sava-carbon-capture-and-storage-impact-benefits-and-challenges/>

Sixth edition of the International Sulcis Summer School on CCUS Technologies was held between 18 and 22 June 2018. Organized by ENEA, Sotacarbo, University of Cagliari in cooperation with IEA CCC, CO₂GeoNet, and ECO-BASE. 40 students from all over the world met at Sotacarbo Research Center of Carbonia (CI) get a broader view of all the possible issues that revolve around a theme of urgent relevance today, such as the reduction of carbon dioxide emissions into the atmosphere. Summer school also provided information and documenttion on all the technological sides of the CCUS subject, including an update of ongoing projects worldwide. ECO-BASE held a workshop about CO₂ Enhanced Oil Recovery where students gather around to establish a business case using the maps and obtained information during the school.

Project and early results were presented in November 2018 in Melbourne, Australia during GHGT- 14 Conference.

In December 2018 in Abu Dhabi, at a conference organized by Carbon Sequestration Leadership Forum (CSLF) Dr Constantin Sava presented the ECO-BASE project.

In April 2019 Energy Industry Review published an article called Prospects for strengthening CCUS implementation in Romania writed by Dr Sava Constantin (GeoEcoMar).

ECO-BASE continued to support the summer school in 2019, organised in Carbonia, at Sotacarbo Research Centre by organising the second CO₂-EOR workshop for the students.

In September 2019 an open two-day workshop on legal and regulatory framework was held in Bucharest, Romania. The seminar emphasized on legal, institutional and political frameworks at local, national and international level and how, why and under what conditions these (could) act as barriers or as enabling elements. Different stakeholders from Romania as well as international experts from the Netherlands, Norway, USA, Greece were present at the event. The workshop was announced in Energy Industry Review and on the project website, for registration.

In September 2019 Christian Bos (TNO) presented at Bruxelles - 'EORstore' as CCS market enabler at the STEMM-CCS Science-Policy showcase event.

Dr. Alexandra Dudu (GeoEcoMar) presented the project at the World Petroleum Council organised in Bucharest in October 2019 and some results from the project in July 2020 at the 20th International Multidisciplinary Scientific GeoConference SGEM 2020.

In December 2019 the project outcomes were presented by R. Berenblyum during the ZEP Advisory Council meeting in Brussels.

On 16 September 2020, METU PAL organised CO₂ – EOR Summer School: *ECO-BASE: Establishing CO₂ enhanced Oil recovery Business Advantages in South Eastern Europe*. Dr. Çağlar Sınayuç (METU-PAL) as well as other experts from Turkey were present at the event. The coordinator of the project, Dr Roman Berenblyum presented „*CCUS business case establishment. CO₂ EOR and CO₂ storage*” on the occasion of this meeting.

The project was also promoted during the BASRECCS forum (<https://bcforum.net/forum.php>) presentation by Roman Berenblyum in his presentation in October 2020.

Project outcomes were presented by Roman Berenblyum during Bergen CCUS 2020 webinar held online on 11.12.2020.

An abstract “CO₂-EOR business opportunities in Romania and Turkey” has been accepted to 15th International Conference on Greenhouse Gas Control Technologies GHGT-15.

The project is also referred to in “CO₂EOR as a pathway to create a CCS infrastructure” abstract also accepted to 15th International Conference on Greenhouse Gas Control Technologies GHGT-15.