

BUILDING MOMENTUM
FOR THE LONG-TERM CCS DEPLOYMENT
IN THE CEE REGION

Summary of CCS4CEE project

Croatia

Implemented by:



Co-financed by:



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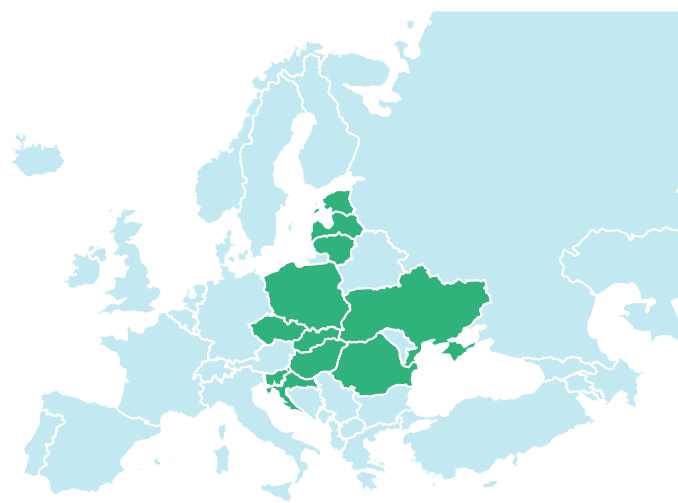


CCS4CEE project

PROJECT CONTEXT | Recent advances in several key areas (e.g., renewable energy sources, energy storage, electric vehicles) enable significant greenhouse gas (GHG) emission cuts but are not sufficient to reach deep decarbonisation consistent with Paris Agreement, as recognised by International Energy Agency in its technology assessments and various modelling studies by both European Union institutions and independent researchers. Carbon capture and storage (hereinafter – CCS)¹ deployment may reduce industrial emissions, provide low-carbon industrial heat and improve energy security by allowing dispatchable power sources to continue operating with low emissions. However, its large-scale implementation requires a long-term policy framework. At the moment, the topic of CCS is not present in the mainstream debate on climate policy in the Central and Eastern European (hereinafter – CEE) countries. This may lead to uneven progress in CCS deployment across Europe, resulting in increased catching-up costs as well as missed opportunities for national development and regional cooperation. This project is designed to counteract this scenario.

PROJECT GOAL | The project aims to renew the discussion on the long-term deployment of CCS in the CEE region, leading to new policies and joint projects. It is expected that building evidence-based consensus among key stakeholders will pave the way to implement concrete policies and ventures. This will be achieved through combining analytical work, in the form of a series of national and regional publications and events, with outreach, communication and capacity-building activities focused on the importance of timely CCS deployment and associated international cooperation.

SCOPE AND PHASES | The project covers Poland, Czech Republic, Slovakia, Hungary, Slovenia, Croatia, Romania, Lithuania, Latvia, Estonia and Ukraine.



¹ CCS refers to “the capture of CO₂ from industrial installations, its transport to a storage site and its injection into a suitable underground geological formation for the purposes of permanent storage”, as defined by the European Commission. On the other hand, in carbon capture and utilization (hereinafter – CCU), the captured CO₂ is transported to a facility in which it is utilized. CCU exhibits fundamental differences stemming from the fate of the captured and transported CO₂ – in CCU, it is embodied into products, whereas in CCS it is permanently stored in underground geological formations. The main focus of the CCS4CEE project is CCS.

The project is implemented by four stakeholders from the CEE region in cooperation with the expert partner from Norway:



WiseEuropa

WiseEuropa is an independent think-tank institute located in Warsaw. It is the lead partner of the project and coordinator of the work in Poland, Croatia and Slovenia.



Institute for
European
Integration

Institute for European Integration is a non-profit, non-partisan, and independent think tank focusing on European integration and cohesion. It coordinates the work in the Czech Republic and Slovakia.

CIVITTA

CIVITTA is a leading management consultancy from CEE. It coordinates the work in Lithuania, Latvia, Estonia and Ukraine.

EPG
ENERGY POLICY GROUP

Energy Policy Groups is a non-profit, non-partisan independent think-tank located in Bucharest. It coordinates the work in Romania and Hungary.

BELLONA
E U R O P A

The Bellona Foundation (expertise partner) is an independent non-profit organization that aims to provide expertise regarding the climate change issue by identifying and implementing sustainable environmental solutions.

The three phases are implemented in the project:

1. Determination of the starting point: assessment of the current state and potential of technological options, as well as European policy landscape and national contexts (Work Package 3, 2021);
2. Development of national roadmaps as well as regional cooperation roadmap for CCS deployment in the CEE region (Work Package 4, 2022);
3. Supporting implementation of the roadmaps through networking and capacity-building events (Work Package 5, 2023).

The project targets national and local policymakers, the business sector, research institutions and civil society. This will support the emergence of a socially accepted mix of appropriate policies, R&D and deployment activities. The project will ultimately benefit the CEE societies by supporting the timely implementation of CCS technologies which will ensure a smooth low-carbon transition.

PROJECT FUNDING | The project is funded by EEA and Norway Grants Fund for Regional Cooperation (project contract number 2018-1-1141).

ADDITIONAL INFORMATION ON THE PROJECT | Additional information about the project, including national and regional reports and deliverables, can be accessed on the project website: ccs4cee.eu

Opportunities and barriers for CCS deployment

CCS4CEE PROJECT COUNTRIES

Across project countries, several commonalities relevant to CCS have been identified:

- Many project countries rely on manufacturing sectors, while their energy production depends heavily on fossil fuels. This condition, coupled with sometimes distant or uncertain deadlines for emissions reduction targets, means that CCS for the energy sector cannot be ruled out in the CEE region.
- Various transportation methods may be available to move CO₂ from emitters to storage sites in project countries or within the region. However, CO₂ transportation infrastructure is mostly absent.
- Amongst the project countries, Ukraine has the highest estimated potential for geological storage of CO₂, followed by Romania and Poland. However, more research is needed to refine knowledge on storage potential, which often relies on theoretical estimates.
- Most project countries have a history of research (and occasionally testing) of CCS. Future projects would be supported by existing know-how and experience, including international cooperation.
- The regulatory environments of project countries are relatively underdeveloped, and many fail to provide certainty for CCS, particularly regarding storage and transportation.
- Funding support is available at the EU level, and frameworks such as Projects of Common Interest may lend themselves to large-scale regional CCS projects.
- Many stakeholders in project countries are cautious about deploying CCS due to its high costs, lack of clear government support and financing, and challenging administrative procedures. Many also tend to favour CCU over CCS due to perceived lower complexity and risks.
- An overall lack of public and institutional knowledge of CCS is an important feature evident in project countries.

Croatia

Emitters and stakeholders related to CCS

Although Croatia is not among the biggest emitters in Europe, many industrial stakeholders have expressed their interest in the implementation of CO₂ emission reduction technologies, mainly due to the expectations of future strict policies regarding the emissions and penalty system. As most of the emissions come from the energy sector and industrial processes and product use, mainly in the mineral (cement, lime, glass) and chemical industries (Figure 1), these areas have the most potential for emission reduction, and their representatives are highly motivated to get involved in CCS projects and activities. Therefore, they are considered the most important stakeholders along with the institutional (legislative and regulatory) bodies.

Current legislation insufficiently covers CCS, although it is recognized as a crucial means of emission mitigation. In addition, underground CO₂ storage is legislatively the most covered part of the CCS value chain, leaving unknowns about how capture and transport aspects will be regulated.

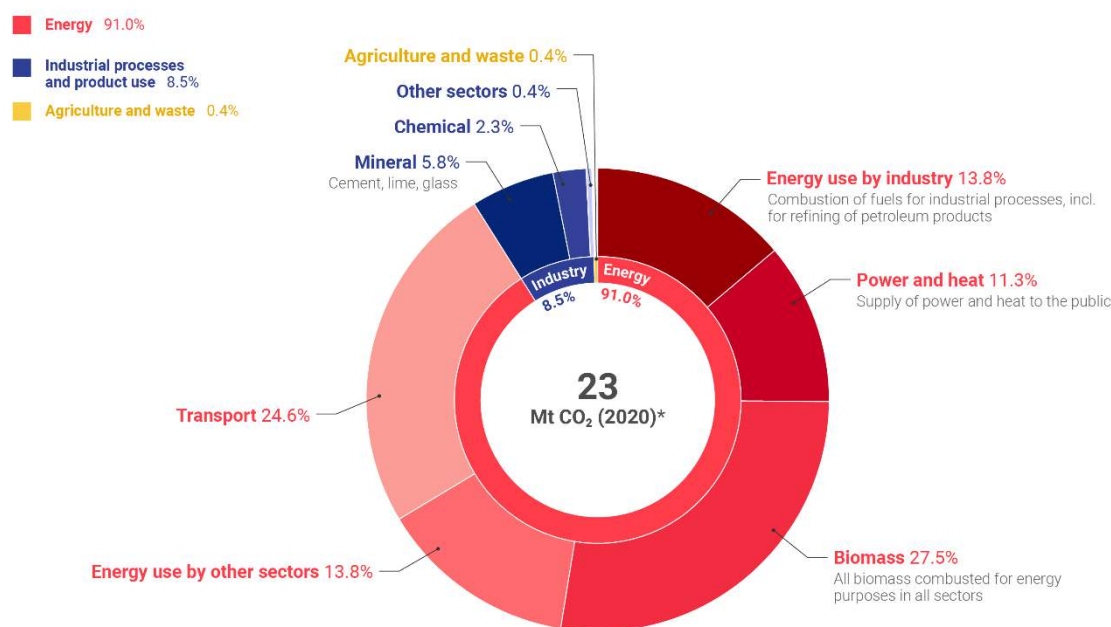
National Strategies and Financing Mechanisms

The Integrated National Energy and Climate Plan for the Republic of Croatia for the period 2021-2030 (NECP) introduced a financial, research and analytical measure “Establishing a platform for the collection, use and storage of CO₂” to accelerate decarbonization. The activities within the measure include developing/amending evaluation studies of storage capacities, implementing CO₂ storage projects and informing the public about CCS technology. NECP currently considers CCS in the context of coal and natural gas power plants not being advanced further technologically except through the development of CCS technologies within them. Although considering the coverage and the level of detail of this topic in the document compared with other GHG-reducing technologies, CCS could be considered pro forma in the current version of NECP. NECP is going to be updated by June 2023 (draft plans) and June 2024 (final plans), and, according to ongoing actions of the Croatian government and industry, CCS might get more recognition as an area where regional cooperation can be established in the future.

The Low Carbon Strategy (NN 63/21) envisages the application of CCS/CCU technology in gas-fired power plants and the cement industry after 2040 as part of the Strong transition scenario (NU2) scenario, while the Gradual transition scenario (NU1 scenario) is feasible without deploying CCS/CCU technologies. Croatia, being a member of the EU, shares the European Green Deal targets, which envisage a 55% reduction in GHG emissions until 2030. However, a framework for scenario building that forms the basis for such strategies does not include adequate CO₂ life cycle assessments (LCA) and realistic technology readiness levels (TRL) together with realistic learning factors.

Croatia’s Hydrogen Strategy until 2050 (NN 40/2022) considers CCS in connection with hydrogen production from fossil fuels, and it is stated that CCS technology and infrastructure would join the existing industry centres (e.g., refineries and petrochemical facilities) by using the storage potential of hydrocarbon fields.

CO₂ EMISSIONS IN CROATIA BY SECTORS



* Total emissions exclude LULUCF but include, for informational purposes, CO₂ emissions from all biomass combusted for energy production, which could partly be abated with CCS (Bioenergy with carbon capture and storage – BECCS)

Data source: European Environment Agency (2020), infographics by Fakta o klimatu

FIGURE 1 CROATIAN CO₂ EMISSIONS BY SECTORS (EEA, 2020)

Plans and projects of stakeholders

Having in mind the existing commercial CO₂-enhanced oil recovery (CO₂-EOR) projects in Croatia – Ivanić and Žutica implemented by the Hungarian – Croatian oil company INA-MOL, it is reasonable to believe that the technology is ready for permanent storage of CO₂ as more than 0.65 million tonnes of CO₂ per year is retained, meaning that more CO₂ is injected than it is produced (Strategy CCUS project, 2020). The company also aims to reuse data collected during hydrocarbon exploration and production and start the exploitation of geothermal potential associated with dry, old or abandoned wells. The second green-transition plan for INA-MOL is to improve their facilities to achieve “zero-emission CO₂-EOR” (by means that none of injected CO₂ will be left outside the reservoir). As the oil and gas production process is not a significant CO₂ emission source (Figure 2), it is justified to consider other CO₂-EOR candidate oil fields, mostly due to the well-known geological characterization of these fields and reservoirs, meaning that they can be further used as permanent storages. To finally recognize CO₂-EOR as storage, not only utilization, there is a need to conduct full LCA analyses of CO₂, including CO₂ produced by the combustion of additionally recovered oil.

There is interest from a petrochemical/fertiliser company Petrokemija (their project is included as a project of specific interest in the National Recovery and Resilience Plan 2021-2026), as well as cement and power generation companies in CO₂ injection, especially in north-eastern Croatia (Eastern Slavonia). Cement company

NEXE's project "Implementation of CCUS" is at the feasibility study level (with Norwegian partner Aker Carbon Capture) and is expected to reduce emissions by 70% (400 ktpa). The continuation of development resulted in the application for Projects of Common Interest (PCIs) as GEOTHERMAL CCS CROATIA, with Hydrocarbons Agency Croatia as project coordinator, NEXE and cross-border (Hungarian) industrial partner².

Almost at the same time, the announcement was posted for Just Transition Fund funding for the Holcim cement project in Istria.³

The energy company CRODUX has invested in the project for the construction of a hybrid power plant with a total capacity of 500 MW (combined cycle power plant) in combination with CCS/CCU and the production of hydrogen through electrolysis.

INA-MOL has also launched the project "Bio-Refinery - Industrial Capture and Underground Storage" in Sisak, which is currently in the demonstration phase and reduces CO₂ emissions by 60 ktpa, with a potential of over 300 ktpa in the future. As far as is known, there is no direct funding of this project by the Croatian government, but it might be expected in the future, especially in the case this project receives the status of national interest.

Cement companies are intensively studying the possibilities of CO₂ utilization through the storage and reuse of CO₂ from exhaust gases and biological CCUS through the cultivation of algae using CO₂.

Numerous regional studies, project proposals and projects are developed by NEXE, HOLCIM and other cement companies interested in CCS. These include pre-investment studies, CO₂ capture technology studies, and agreements with hydrocarbon field operators about CO₂ preparation, transport, and storage, but also increased activities in preparation of projects that will be submitted for various national and EU funding sources by the end of 2023. For example, fertilizer company Petrokemija Kutina announced a CO₂ capture project in collaboration with INA-MOL petroleum company that would be in charge of CO₂ storage. As INA-MOL is also an oil refining company, their project "Bio-Refinery - Industrial Capture and Underground Storage" (with INA-MOL as the storage operator) has great potential both from the energy production and emission reduction point of view. There is also a project of national interest in Draškovec (hybrid geothermal with gas production from geothermal water and CO₂ storage) that seems to have been idle for several years but has the legal status of an exploitation field and got an Innovation Fund Grant. Initiatives for cooperation with the cement sector in Croatia and Slovenia were announced at one of the panels of the HUNIG conference in Šibenik in October 2022, but this appears to be just an opportunity to try to start a more active dialogue.

² <https://ec.europa.eu/eusurvey/files/63d2dc29-db31-4ef8-b2c9-f2d94220da78/015043b3-23ca-477e-a77a-accf9bd3182c>

³ <https://twitter.com/SanderHappaerts/status/1600194576261607424>

THE BIGGEST EMITTERS IN CROATIA

EU ETS covered emissions of greenhouse gases in 2020 and 2021

INSTALLATIONS WITH EMISSIONS (Mt CO₂eq)

- above 250 000 tonnes of CO₂eq

Sectors:

- Heat and power
- Cement and lime
- Chemicals
- Oil refining

- 40 000–250 000 tonnes of CO₂eq

Sectors:

- Heat and power, Cement and Lime, Others

HOW TO READ MINI CHARTS

- 250 000 t CO₂eq = ■
- 1 000 000 t CO₂eq = ■■■■
- 2021
- 2020



7.1

Mt CO₂eq

of total emissions covered by EU ETS

Data source: EU ETS (2021), infographics by Fakta o klimatu

FIGURE 2 THE BIGGEST EMITTERS IN CROATIA (EU ETS, 2021)

Research projects and their connection to stakeholders' interests

Various aspects of CCS have been considered in a number of scientific research projects, most of which were aimed at exploring the storage potential (Faculty of Mining, Geology and Petroleum Engineering: EU FP and H2020 projects: EU GeoCapacity, CGS Europe, ENOS, Strategy CCUS, and the national research project ESCOM). Considering the whole chain, it was found that CO₂ capture is the most expensive part because it is industry and process-specific, which might discourage emitting stakeholders from investing in CO₂ capture facilities. However, following the example of CRODUX and its gas-fired power plant project, it is likely that new fossil fuel power plants will be equipped with CO₂ capture systems. The existing gas pipeline network makes the transport part of the chain more feasible, at least for the CO₂ emitters in northern Croatia. Pipeline transport from the city of Rijeka (and Istria) is also possible, although the distance from some emitters (like Holcim in Koromačno, Istria) to one of the nearest storage sites is up to 250 km, and emitters in Dalmatia are even further from onshore sites with the largest storage potential. Northern Croatia has the highest storage potential, according to estimates, amounting to 176 Mt in depleted hydrocarbon fields (17 units) and 3186 Mt in deep saline aquifers (six units). Although historically mostly focused on enhanced hydrocarbon recovery, recent

estimates from the company INA-MOL show that the break-even price for pure storage has already been reached⁴.

Based on the previous work packages of the CCS4CEE project, it was found that the general ambition of important stakeholders that are not CCS pace-setters is to receive EU funds and switch as soon as possible to renewable energy sources, having the support of generally not well-informed public.

Expected changes in legislation

According to the latest findings, it is expected that the **Regulation on the Concession Fee for the Exploration of Mineral Resources (OG 31/2014, 57/2020)** will be amended in a sense that the fees for the approved exploration and exploitation areas would be adjusted (based on the discussions and the views from the stakeholders expressed on the seminars organized within the CCS4CEE project).⁵

There might be modifications to some aspects in the **Law on Hydrocarbon Exploration and Exploitation (OG 52/2018, 52/2019, 30/2021)**, which governs every aspect of the process of exploration and exploitation of hydrocarbons and geothermal waters, storage of natural gas, and permanent storage of CO₂.

However, there are still some legislative acts that seem to prevent the rapid development of CCS (including regulations for CO₂ transport and capture), and these are the main points that will be the focus of the ongoing work package within the CCS4CEE project. The most hindering elements for successful CCS implementation are the vagueness and/or contradictions between the **Ordinance on the Permanent Storage of Carbon Dioxide in Geological Structures (OG95/2018)** and the **Law on Hydrocarbon Exploration and Exploitation (OG 52/2018, 52/2019, 30/2021)** regarding the time limits for storage operator licenses, maximum fines for rule violations or "concessionaire's liability," as well as liability regulation and liability transfer when the CO₂ storage (injection) stops.

A detailed assessment of the current state, past experiences and potential for CCS/CCU deployment in Croatia and other project countries is available on the project website: ccs4cee.eu

⁴ Based on the information obtained from company representatives.

⁵ Currently, the fees for CO₂ storage are the highest, higher than those for oil and gas exploration and for underground natural gas storage.

Policy roadmap for the scaled-up deployment of CCS in Croatia

Based on the assessment of past experiences and CCS potential, a national policy roadmap was prepared to outline how the future development of CCS technologies could proceed and under which enabling conditions. The roadmap provides an overview of various policy actions along the innovation cycle, from research and development to potential commercialization of these technologies in order to reach climate targets set by the EU and national strategies. While the roadmap aims to describe an enabling environment to deploy CCS projects, it also focuses on ways to develop transferable knowledge and skills by national stakeholders (governments, research organizations, academia, private sector) in one or more stages along the carbon capture, transport, storage and utilization chain, and create linkages to gain knowledge and experience from more experienced stakeholders across the globe.

Based on the developed roadmap, the next and immediate steps are highlighted for the further advancement of CCS in Croatia.

The lack of knowledge about CCS technologies is identified as the biggest obstacle to faster development in Croatia. Current strategies, funding and financial schemes, and legal framework are either inefficient or insufficient. One of the first steps would be the amendment of the legal documents, requiring explicit and consistent LCA procedures, as well as consistent TRL estimations. In addition, a knowledge platform should be established where all the findings should be properly provided.

Public awareness should be increased through clearly presented quantities of CO₂ avoided, reduced or removed by using CCS and compared to other low-carbon technologies, emphasizing climate impact, but also analyzing socio-economic (e.g., number of jobs created or lost, industrial competitiveness, an increase of taxes to private persons, income to local communities etc.), and financial aspects.

The clustering of smaller emitters is crucial for CCS implementation, meaning there should be a fiscal system in place, possibly even the national CCS market, cross-border business opportunities and information sharing, which will help assemble a critical mass of stakeholders with similar interests.

Given that CCS implementation necessitates the development of new types of experts in a variety of sectors (from emitters to transport and storage operators), a trustworthy, financially secure, and transparent system should be developed, with the most practical element being the availability of a permitting flowchart, along with cheat-sheets for the steps required to obtain financial support, begin CCS exploration, and finally begin operational CCS chain.

A detailed CCS national roadmap for Croatia and other project countries is available on the project website: ccs4cee.eu

